Village of Lincolnwood
Plan Commission

Meeting

Wednesday August 22, 2012
7:00 P.M.

in the

Council Chambers Room
Lincolnwood Village Hall - 6900 Lincoln Avenue

Meeting Agenda

1. **Call to Order/Roll Call**

2. **Pledge of Allegiance**

3. **Approval of Minutes**
   August 1, 2012 Meeting Minutes

4. **Public Hearing: 6950 Central Park Avenue – Text Amendment, Special Use, and Variations**
   (Remanded from the Village Board on July 17, 2012)
   Request: 1) Text Amendment to the Zoning Code to Add "Firearms Dealers" as a Special Use in the MB District; 2) Special Use Approval for a "Firearms Dealer" at the Subject Property; and 3) Consideration of Front and Side Yard Setback Variations to Permit an Addition to the Existing Building

5. **Next Meeting**

6. **Public Comment**

7. **Adjournment**

Additional information concerning these scheduled public hearings may be viewed at the Community Development Department "Pending Zoning Applications" section of the Village's website: www.lincolnwoodil.org

MEETING MINUTES OF THE
PLAN COMMISSION
August 1, 2012
7:00 P.M.

LINCOLNWOOD VILLAGE HALL **DRAFT**
COUNCIL CHAMBERS
6900 NORTH LINCOLN

MEMBERS PRESENT:
Chairman Paul Eisterhold
George Touras
Don Sampen
Steve Jakubowski
Mark Yohanna
Patricia Goldfein

MEMBERS ABSENT:
Sue Auerbach

STAFF PRESENT:
Community Development Director Timothy M. Clarke, AICP
Community Development Manager Aaron N. Cook, AICP
Community Development Coordinator Lauren Wolf

VILLAGE COUNSEL
Hart Passman

I. CALL TO ORDER

Chairman Eisterhold noted a quorum of five members present and called the meeting to order at 7:07 p.m.

II. APPROVAL OF MINUTES

Motion to approve the July 11, 2012 Plan Commission minutes was made by Commissioner Jakubowski and seconded by Commissioner Touras. Motion approved 6-0.

III. PUBLIC HEARING: 6501 N. Longmeadow Avenue – Reasonable Accommodation

Request: Reasonable Accommodation to Establish and Operate a Community Residence (Group Home) in R1 Residential District (Continued from June 6, 2012 and July 11, 2012)

Chairman Eisterhold read into the record an opening statement: This hearing is a continuance of a Plan Commission meeting held on 7/11/2012. At this hearing we will allow statements from those residents not addressing us at our previous meeting. If anyone who has not spoken before has any new information, you may have up to 2 minutes. At 30 seconds remaining you will see a green placard. This means 'wrap it up' or make your close in the 30 seconds remaining. At the 2 minute mark you will see a red placard. As the meeting of the 11th of last month contained some disruptive behavior by a number of attendees. That meeting at its close served as the time for venting. Tonight's

meeting will adhere to a stricter following of decorum. Thus if there are any outbursts from the audience at any time, you will be immediately ejected from the building. These proceedings are going to be civil and also conducted with fairness. I hope that we do not need to eject anyone from the building for misconduct. Those comments tendered at the last meeting along with documents submitted have become part of the official record. The applicant will have as much time as needed to make their summation or to call witnesses. Remember this is a public hearing. Each speaker does not need to use the entire allotted time. I do request that speakers identify themselves for the record with their name and address. If your points have been covered already, then come forward state your name and address and your position as for or against, the petitioners request for a reasonable accommodation at this location. After Misericordia's summation and speakers (if any), the commission will deliberate on this issue. You will not be allowed to address the board during this process unless a board member asks the chair to have you address the commission. At that time you may come forward to speak. To all the commission members: You do not need to comment on any speakers address. You must be careful not to engage in debate, only clarification. To the audience and commission members, as the chair I may cut off any comments or discussion, thus be judicious with any comments being made, as it may be your last allowed.

Village Attorney Passman reminded everyone of the standards that were set forth at the previous July 11, 2012 hearing: the Commission is here to hear and accept testimony considering the pending request and the standards set forth by the Village Board in the Zoning Ordinance for consideration of a Reasonable Accommodation any information presented beyond those standards are recommended not relevant and do not consider information that is not relevant to the standards in the Zoning Code. Any statements that were made on July 11, 2012 or made tonight by the applicant or by the public are not to be considered statements by the Plan Commission or by the Village. Any statements by the applicant or by the public are to be considered only those by the person or persons making the statement. If members of the Commission or village staff or representatives do not specifically respond to a statement that silence should not be interpreted by approval or disapproval.

Chairman Eisterhold opened the meeting for public comment.

The following Village residents offered testimony and comments concerning the application:

In Support:
Alan Goldstein – 7044 Kenton
John Vodopic – 6915 East Prairie
Judy Abelson – 6537 Keating
Margie Weinstein – 7010 Keystone

Against:
Marcie Ruben - 6511 Longmeadow
Stephen Ruben - 6511 Longmeadow – Submitted 101 Petitions Against into record.
Robert Stulac – 6481 Longmeadow

Irene Dominelli – 6648 Sauganash
Jerry O'Neill - 6610 Tower Circle Drive

Peter Moy – 7001 Kilpatrick- Spoke in a general nature, neither for or against the application.

Village Attorney Passman clarified the time line of facts. The issue of the proposed group home at 6501 Longmeadow was first raised to the Village's attention in 2011, through a letter sent by Misericordia to Staff asking whether or not it was permissible to open a group home at the subject property. The Village Attorneys reviewed the Zoning Code and at that time determined under the then-applicable Zoning Code that the use was prohibited. The Village Attorneys expressed concerns to the Village Board that the then-existing Zoning Code may have not been consistent with the Fair Housing Act. The Village Board asked the Attorneys to expand upon their research and investigate more fully the legal options the Village had. The Village Attorneys researched numerous options for potential Zoning Code amendments - including the option to make no amendment and to leave the then-existing Code as it was. The public hearings concerning proposed Zoning Code amendments began in August 2011 and continued between the Plan Commission and Board of Trustees through March 2012. At that meeting the Village Board adopted the now-current Reasonable Accomodation Ordinance.

Ms. O'Keefe, attorney for Misericordia, concluded testimony with a PowerPoint presentation. The proposed group home complies with the standards with the Village of Lincolnwood Reasonable Accomodation Ordinance. Ms. O'Keefe addressed an earlier public comment that the group home is not a licensed facility under the Illinois Community-Integrated Living Arrangements Licensure and Certification Act ("CILA"). It will be a licensed CILA before opening operation. Expert testimony that proposed group home is therapeutically necessary to allow optimum environment for disabled residents. Expert testimony that there are no alternative accommodations available in Lincolnwood to provide equivalent benefit. Expert testimony that proposed reasonable accommodation is consistent with the purpose and intent of the underlying R-1 residential district. Based on 16 years of experience with other Misericordia group homes, expert testimony that the proposed use would not impose an undue financial or administrative burden on the Village. Expert testimony that the proposed use will not adversely affect parking or traffic on the adjacent streets or within the surrounding neighborhood. Expert testimony that residents are developmentally disabled and members of a protected class. Expert testimony that the proposed use will not require a fundamental alteration from the regulations governing the underlying R-1 Zoning district. Expert testimony given there are no alternative reasonable accommodation alternatives because there are no other group homes. Expert testimony that there will only be a positive effect on the physical attributes of the subject property. The factual evidence presented shows the proposed group home meets all the standards for the Village of Lincolnwood Reasonable Accommodation Ordinance. Even though the standards do not address property values, expert testimony was given from Mary Wagner stating that a group home does not have an adverse effect on property values.

Chairman Eisterhold suggested that the Traffic Commission review the neighbors' concerns about parking on Longmeadow Avenue and related safety concerns on five other cul-de-sacs.

Commissioner Yohanna questioned Attorney Passman regarding Section 4.06(3)(i)(i) of the Reasonable Accomodation Ordinance. Attorney Passman stated that the intent of this paragraph is to prohibit operation of a Community Residence until the Residence is licensed pursuant to CILA. Attorney Passman stated further that Section 4.06(3)(o) reflects the need for a Community Residence to maintain its CILA licensure.

Commissioner Sampen questioned the petition that was submitted. He asked about the basis for the objection to eight residents within the proposed Community Residence. Ms. O'Keefe stated that the state allows eight residents and additional support staff. She explained that are five bedrooms and four bathrooms in the home.

Commissioner Touras stated that by adding bedrooms it changes the home into more of a dormitory living. This violates the spirit of R-1 zoning. It would be reasonable to allow six adults and support staff. Must protect the integrity of the Zoning Code. Misericordia Home is the owner of record, but the CILA license is Misericordia Mercy. Ms. O'Keefe clarified for the record legal name is Misericordia Home, but go by Misericordia Heart of Mercy, and that it is the same organization.

The Commission then considered the following factors that are to be considered pursuant to the Reasonable Accomodation Ordinance:
i. Whether the housing that is the subject of the request will be used by an individual or a group of individuals considered disabled or handicapped under the FHA – Commission agreed.
ii. Whether the accommodation requested is financially, therapeutically, or otherwise necessary to make specific housing available to the individual or group of individuals with a disability or handicap under the FHA – Commissioner Jakubowski stated this is necessary because without the disability they would have been able to have access to the benefits desired. The Commission agreed.
iii. Whether there are alternative reasonable accommodations available that would provide an equivalent level of benefit – Commission agreed that there were no such alternatives.
iv. Whether alternative accommodations would be suitable based on the circumstances of the particular application – Commission agreed that there were no such alternatives.
v. Whether the requested reasonable accommodation would be consistent with the general purpose and intent of the zoning district in which the property is located –The majority of the Commissioners agreed that the request would be consistent with the underlying zoning district. Commissioner Touras disagreed.
vi. Whether the requested reasonable accommodation would impose an undue financial or administrative burden on the Village – The Commission agreed that any burden imposed by the requested reasonable accommodation would be minor.
vii. Whether the requested reasonable accommodation will adversely affect vehicular traffic or parking on the subject property or on the streets adjacent to the subject property, or in the neighborhood in which the subject property is located – Commissioner

Jakubowski stated that the Commission had heard testimony on this issue and that there are no prohibitions affecting any neighbors' rights to park in the area. The Commission agreed, and suggested again that the Traffic Commission review parking conditions in the neighborhood.
viii. Whether the requested reasonable accommodation would require a fundamental alteration in the nature of the regulations set forth in this Zoning Ordinance – Commission agreed that the request would not require such a fundamental alteration.
ix. Whether the requested reasonable accommodation substantially affects the physical attributes of the subject property – The Commission agreed that the proposed improvements to the residential structure on the property would improve the property.

Commissioner Jakubowski made a motion to recommend approval to grant a Reasonable Accommodation to establish and operate a Community Residence at 6501 Longmeadow Avenue,conditioned upon receipt by Misericordia of a CILA license before opening and operating the home. The motion was seconded by Commissioner Goldfein. Motion approved 5-1. This case will be heard by the Village Board on August 21, 2012 at 7:30 PM.

IV. PUBLIC HEARING: Restaurant Parking – Zoning Code Text Amendment (Continued from July 11, 2012 June 6, 2012 & May 2, 2012)
Request: Text Amendment to Modify the Minimum Off-Street Parking Requirements for Eating & Drinking Establishments

Commissioner Sampen made a motion to continue this Public Hearing to a date certain of September 5, 2012 at 7:00 PM and seconded by Commissioner Goldfein. Motion passes 5-0.

V. PUBLIC HEARING: Commercial Masonry Requirements – Zoning Code Text Amendment
Request: Text Amendment to Modify the Commercial Design Standards Relative to Masonry Requirements and to Consider Definition of "Masonry"

Commissioner Sampen made a motion to continue this Public Hearing to a date certain of September 5, 2012 at 7:00 PM and seconded by Commissioner Touras. Motion passes 5-0.

VI. PUBLIC COMMENT: None.

VII. ADOURNMENT:
The next Plan Commission meeting is scheduled for August 22, 2012 at 7:00 PM. Hearing no further business, Motion to adjourn made by Commissioner Jakubowski. Seconded by Commissioner Sampen. Motion approved unanimously 5-0. Meeting adjourned at 9:05 PM.

Respectfully submitted,

Lauren Wolf
Community Development Department Coordinator

Staff Report
Plan Commission
August 22, 2012

Subject Property:
6950 Central Park Avenue



Zoning District: M-B Light Manufacturing/Business District

Petitioner: Shore Galleries, Tenant & Platform I, LLC. - Property Owner

Nature of Request: The petitioner seeks text amendments, special use approval and variations to permit the relocation of "Firearms Dealer" to the subject property.

Requested Action:

1) **Zoning Code Text Amendments to Add:**
   A) "Firearms Dealer" as a Special Use in the MB District (Section 4.05 Table 4.01.1)
   B) Definition of "Firearms Dealer" (Section 2.02)
   C) Off-Street Parking Requirements for "Firearms Dealer" (Section 7.10 Table 7.10.01)
2) **Special Use** approval for a "Firearms Dealer" as per Amended Section 4.05 Table 4.01.1;
3) **Variations to Permit:**
   A) An Addition to Encroach into the Required Front & Side Yard Setback (Section 4.14)
   B) A "Firearms Dealer" to operate with fewer than the required Minimum Off-Street Parking Spaces (Section 7.10/Table 7.10.01)

Notification: Consistent with Village requirements, previous notice of the June 6, 2012 scheduled public hearing was made in the Lincolnwood Review dated May 17, 2012, by Public Hearing Sign Installed at 6950 Central Park Avenue, and by regular US Mail to Properties within 250 Feet of the subject property. The August 22, 2012 meeting of the Plan Commission is not considered a Public Hearing, however courtesy notice of this meeting was sent by regular US Mail to Properties within 250 Feet of the subject property, by regular US mail to those citizens who spoke at the July 17, 2012 Village Board meeting on this matter and courtesy notice was also delivered to School District #74 and the Lincolnwood Public Library District. In addition, various recommending bodies of the Village Board have received a copy of the Commission's August 22, 2012 meeting packet.

Action Since June 6 Plan Commission Meeting

The Plan Commission held is Public Hearing and rendered its original recommendation on this matter on June 6, 2012. This recommendation was considered by the Village Board on July

17th. At the July 17th meeting, the Village Board received significant additional public comment regarding this matter. Upon deliberation, the Village Board at their July 17, 2012 regular meeting remanded Shore Galleries request for Text Amendments, Special Use, and certain Variations back to the Plan Commission for further deliberation. For reference, attached are the minutes from the July 17 Village Board meeting. The Village Board raised several items for further deliberation:

1. Is the expansion/addition of a shooting range appropriate in Lincolnwood?
2. What is the environmental impact of firing weapons and what regulations are in place?
3. Is the number of shooting stations proposed appropriate?
4. Is there adequate parking provided by the applicant and/or in the general area?
5. What are the specific proposed hours of operation?
6. What general security measures are proposed (overnight storage of guns)?
7. Consideration of a third party review of the acoustical studies submitted by Shore Galleries and Ravenswood Studios.

Supplemental Information

In response to the request for additional information, the applicant has prepared an "Application Supplement Part II" for consideration. Contained within this supplement are responses to the items which the Village Board requested additional information:

Hours of Operation: Monday-Friday 9am-9pm; Saturday 9am-5pm; and Sunday 10am-4pm.

Parking Spaces: Due to the dimension requirements of the Zoning Ordinance the subject property does not have any zoning compliant off-street parking spaces. None-the-less Shore Galleries has submitted a site plan and believes that a total of 14 parking spaces can be situation to the north and the rear of the existing building. Staff has concerns regarding the general layout of parking spaces particularly to the rear of the building. However this area may be appropriate for use by employees only and therefore a condition of approval to consider is to require all employees to park to the rear of the building.

Currently, to the front of the existing building within the right-of-way are nine parking spaces. With the proposed addition eliminating the loading berth and drive, Shore Galleries proposes an additional three parking spaces for a total of 12 parking spaces to the front of the building.

The proposed use with generate parking demand from sixteen shooting range stalls, retail sales area, and classrooms. Additionally, a maximum of five employees with generate parking demand.

Number of Employees: Shore Galleries indicates an average of four employees at any one time with a maximum of five on the premises. Shore Galleries has obtained employment information on Resillo Press Pads, the previous occupant of the building. The owner of Resillo Press Pads, Leo Pearl, has advised Shore Galleries that at peak operation they had over 50 employees. However, most recently Resillo employed 32 employees.

Use of Property: To review and address concerns relative to peak or maximum occupancy of the proposed facility, Shore Galleries has provided a Parking Projection Study prepared by Ament Design. Contained within this study are parking space use counts for the two nearest Municipal Parking Lots and a Parking Demand table. Shore Galleries' data indicates peak use

hours to be late afternoon and evenings during the week as well as Saturdays. The study concludes that the maximum projection for the number of parking stalls needed is 29 spaces during the week and 30 on the weekends. As stated previously, Shore Galleries has submitted a Site Plan identifying a total of 26 nonconforming parking spaces.

Security Plan: The applicant has indicated that due to sensitive nature of their business, they have submitted the security plan/procedures directly to the Chief of Police. Shore Galleries indicates that they have never had a robbery in the history of their operation at 3318 West Devon Avenue. In support of their application on the matter of security, Shore Galleries submits a letter from Donald K. Whiteman, former Mayor of Northfield.

Number of Shooting Stalls: Shore Galleries has provided a general explanation for their proposed number of shooting stalls. In essence, the explanation provided is due to economics and constructing a safe and secure shooting range. A comparison of revenue generated by shooting ranges with 14, 15, and 16 stalls is included.

Design and Environmental Standards: The applicant has provided significant amount of information relative to safety and design standards. They have been included in the packet for review.

Third Party Review: The Village Board desired third party review of the acoustical engineering studies that were submitted by Shore Galleries and Ravenswood Studios. Staff contacted Schomer and Associates, Inc. to perform this third party review. Mr. Paul D. Schomer conducted the review and concluded validity of both studies. Mr. Schomer upon this conclusion offers several recommendations:

1. Occupancy is subject to conducting performance tests to determine compliance with Lincolnwood Sound Level Limits
2. Require performance measurements upon request after six months of operation.
3. Additional performance measurements at intervals of two-five years.

Table 6.20.01 of the Zoning Ordinance provides the maximum sound level limits.

Monday – Friday	A-Weighted Sound Level Limits	
District Classification	Time of Day	Max. "A-Weighted" Sound Level
Residential Districts	7:00 AM to 6:00 PM	50 db(A)
	6:00 PM to 7:00 AM	45 db(A)
All Others	7:00 AM to 11:00 PM	60 db(A)
	11:00 PM to 7:00 AM	55 db(A)
Saturday – Sunday	Time of Day	Max. "A-Weighted" Sound Level
Residential Districts	7:00 AM to 12:00 PM	50 db(A)
All Others	7:00 AM to 11:00 PM	60 db(A)

Prior to finalizing and distributing the Plan Commission packet, Micheal Shapiro submitted additional information. Attached is a letter dated August 17, 2012 and attached an Acoustics Report dated August 17, 2012 and A Preliminary Acoustical Analysis of Existing Indoor

Firing Ranges dated February 1990. Staff has not had an opportunity to review this information. Staff intends to send an email on Monday, August 20th with any review comments.

Nearby Communities

Shooting ranges and firearms dealers are not common land uses throughout the region. Based upon staff's research it appears that the majority of new or relocated shooting range/firearms dealer required Special/Conditional use approval. Des Plaines, Lombard, and Crystal Lake have authorized Special/Conditional use approval for such uses in Industrial/Manufacturing Districts. Included in the attached staff memorandum are the ordinances approving these shooting ranges/firearms dealer. Each community placed conditions of approval on the shooting range/firearms dealer. Common conditions of approval include approval of a security plan, soundproofing of the building, delineating employee parking, and general site improvements.

Staff contacted Skokie to determine if the proposed Wal-Mart on Touhy Avenue will sell firearms. Skokie staff confirmed that the Wal-Mart was not approved for the sale of firearms. During previous deliberations, Bass Pro Shop in Gurnee was referenced. According to the Village of Gurnee, Bass Pro Shop has five shooting stalls. Gurnee staff indicates that the shooting stalls were allowed as an ancillary use to the main retail facility and did not require any separate zoning and/or Village action to approve.

Conclusion

Also attached is the original packet sent to the Plan Commission for the June 6, 2012 meeting. The Plan Commission at that meeting recommended approval of the Shore Galleries application for text amendments, Special Use, and certain variations by a vote of 5-1. This matter has been remanded back to the Plan Commission for further deliberation. The petitioner seeks text amendments, special use approval and variations in order to relocate the business to 6950 Central Park Avenue.

The text amendments requested are necessary to add "Firearms Dealer" as a special use in the MB District, add a definition of "Firearms Dealer" in the Zoning Code, and add minimum off-street parking requirements for "Firearms Dealers". If favorable consideration is received on the text amendments, Shore Galleries seeks Special Use approval per the amended Zoning Code to operate a "Firearms Dealer" in the MB District at 6950 Central Park Avenue. Shore Galleries also seeks approval of front and side yard variations to permit an addition to the existing building while also seeking a parking variation.

Documents Attached

1. Memorandum from Andrea Litzhoff, Dated August 17, 2012
2. Shore Galleries Prepared Public Hearing Application Supplement Part II
    a. Parking Site Plan for 6950 Central Park Avenue
    b. Letter from Donald K. Whiteman
    c. Parking Projection Study: Ament Design, Inc. Dated August 2, 2012
    d. Lincolnwood Revenue for Shooting Range – Prepared by Shore Galleries
3. Shooting Range Sound Isolation from David Braslau Associates, Inc. Dated August 14, 2012
4. OSHA Lead Standards 1926.62

5. OSHA 29 CFR 1910.1025
6. NIOSH Lead Exposure and Design Consideration for Indoor Firing Ranges U.S. Department of Health, Education, and Welfare December 1975
7. Environmental Protection Agency Part 50 – National Primary and Secondary Ambient Air Quality Standards: Revised as of July 1, 2000
8. Appendix G to Part 50 – Reference Method for the Determination of Lead in Suspended Particulate Matter Collected from Ambient Air: Current as of July 27, 2012
9. Engineering Technical Letter (ETL) 11-18: Small Arms Range Design and Construction Dated April 19, 2011
10. Unified Facilities Criteria (UFC) Draft Design and Maintenance: Small Arms Range Facilities Dated March 15, 2002
11. Small Arms Range Ventilation Standards prepared by Carey's Heating & Air Condition, Inc.
12. Action Target Drawing: 25 Yard Range Section
13. Schomer and Associates, Inc. Review Letter Dated August 12, 2012 and Resume
14. Letter of Opposition from Michael Shapiro dated August 17, 2012
    a. Acoustics Report Prepared by Pin Drop Acoustics Dated August 17, 2012
    b. A Preliminary Acoustical Analysis of Existing Indoor Firing Ranges February 1990
15. Village Board Minutes July 17, 2012
16. Plan Commission Minutes June 6, 2012
17. Notices to Lincolnwood School District
18. Notices to Lincolnwood Public Library
19. Property Owner Notification Dated July 25, 2012
20. Letters of Support from Terry G. Hillard, Gerald T Brandt, Jeremy D. Margolis, Richard Eddington, and Claude M. Casaletto
21. Letter of Concern from Jean Moy
22. Letter of Opposition from Judith Snyder Dated July 30, 2012
23. Chicagotribune.com Article July 19, 2012: "Des Plaines gun shop, firing range gets OK for move, expansion"
24. Journal-topics.com Article: "Shooting Range Cleared to Move"
25. Lincolnwood Review Article June 12, 1997: "Zoning panel recommends gun shop move"
26. Lincolnwood Review Article June 26, 1997: "Gun shop relocation shot down"
27. Staff Report to Plan Commission June 6, 2012
28. Map – Parcels Not Within 800 Feet of 'R' or 'P' Zoned Properties
29. Map – Parcels in MB at least 800 Feet From 6950 Central Park Avenue
30. Application for Text Amendment
31. Application for Special Use
    a. Plat of Survey
    b. Site Plan
    c. Proof of Ownership
    d. Floor Plan
    e. Petitioner Submitted Photographs
32. Application for Variation
33. Police Chief Memorandum – June 1, 2012
34. Committee of the Whole Memorandum Dated March 26, 2012
35. Public Hearing Application Supplement

36. Map – 800 Feet Ring from 6950 Central Park Avenue
37. Map – 800 Feet Ring from 3318 West Devon Avenue
38. Letter from Michael Shapiro Dated July 6, 2012
39. Report from Kirkegaard Dated June 15, 2012
40. Email in Opposition from Marvin Cooper Dated July 8, 2012
41. Letter in Support from Walter J. Klinger Dated June 20, 2012
42. Service Request Suggestion/Issue from Stan Wilk
43. Draft Park Board Minutes, July 10, 2012

MEMORANDUM

To: Tim Clarke, AICP, Community Development Director

Cc: Aaron N. Cook, AICP, Community Development Manager

From: Andrea Litzhoff, Community Development Intern

Re: Local Shooting Range Regulations

Date: August 17, 2012

Introduction
Staff was tasked with gathering zoning and code regulations on indoor shooting ranges and accessory retail of firearm products from other communities in Illinois. Shooting ranges and firearms sales are not a common use in Chicagoland, and many shooting ranges have been grandfathered-in to communities in their present locations. Staff spoke with planning and zoning officials from Highland Park, Gurnee, Des Plaines, Elmwood Park, Franklin Park, Lombard, and Chicago Ridge to obtain information on code regulations, environmental standards, and community issues for shooting ranges.

Highland Park
The city of Highland Park has a Firearm's Training Center, which is a standalone shooting range facility for police use only. Staff spoke with a police lieutenant on occupational and operational hazards of the shooting range. The facility must properly manage lead exposure in the air. Highland Park contracts with Best Technologies who removes lead from air filters in the facility's ventilation system. Lead is an environmental hazard in shooting ranges. OSHA views lead as a risk for workers in shooting ranges.

Elmwood Park
Illinois Gun Works is located in Elmwood Park and open to the public. It a long time establishment and has been grandfathered in at its current location in a business district.

On June 11, 2012, OSHA cited Illinois Gun Works for 27 serious violations. Thirteen of those violations were failures to meet the lead standard. Some of these lead standard violations included failure to reduce exposure, measure effectiveness of the ventilation system to control lead exposure, provide protective clothing, ensure exposed workers wash hands and face before lunches, and provide separate storage facilities for changing clothes and storage.

Gurnee

The Bass Pro Shop in Gurnee, IL contains a shooting range. In order to use the shooting range, customers must present their Firearm Owners Identification card (or FOID card). The shooting range has 5 stalls. Staff spoke with Tracy Velkover, Planning Manager at Gurnee, who indicated that the shooting range in the Bass Pro Shop was allowed as an ancillary use to the main retail facility and did not need any separate special approvals. Gurnee does not currently have any zoning requirements for shooting ranges or gun shops as principle uses.

Gurnee staff commented that the federal Bureau of Alcohol, Tobacco, and Firearms has done some monitoring of the facility over the years. Gurnee staff stated that the Bass Pro Shop has collected old and used guns, which benefited community control of guns.

Des Plaines

Maxon Shooters, a long time business in Des Plaines, recently applied for a conditional use permit to relocate from a manufacturing district to another manufacturing district. In its application for a conditional use permit, Maxon Shooters provided a traffic study to estimate the amount of traffic generated in the proposed location. On July 16, 2012, Des Plaines approved an ordinance granting Maxon Shooters a conditional use permit to relocate and expand its business within a manufacturing district. Des Plaines placed the following conditions on Maxon Shooters:

- Applicant must submit a landscape plan with areas of new and constructed parking lot.
- Applicant must submit a security plan including a security system with direct call to city's 9-1-1 system, reinforcement of interior and exterior doors, and locking mechanisms for all firearms sales.
- Applicant must improve the parking lot and interior landscaping in new and reconstructed areas and a sidewalk for pedestrians
- Applicant's security plan must meet the satisfaction of the Chief of Police
- Landscaping materials must be in good condition to present a healthy and orderly appearance
- All parking areas shall be surfaced and striped to meet building code hard surface requirements.

Des Plaines defines an indoor shooting range as the use of a structure for archery and/or the discharging of firearms for the purposes of target practice, military/law enforcement training, or temporary competitions. An indoor shooting range may include accessory firearms sales. Indoor shooting ranges are conditional uses in Des Plaines' M-2 Manufacturing District.

Franklin Park

Franklin Park allows firearm ranges and firearm sales as a permitted use in the O'Hare Corridor Business Opportunity Overlay District in the Northwest Industrial Corridor. Currently, there are no shooting ranges in Franklin Park.

Lombard

Article II is a firearms dealer and shooting range open to the public located in Lombard. Staff spoke with Mike Toth, Planner, about the shooting range. Mike Toth indicated that shooting ranges with ancillary retail sales are permitted as a conditional use in Lombard's limited industrial district. Indoor shooting galleries and ranges with ancillary retail sales of associated product are defined as an establishment for the practicing of target shooting on an established target range(s) within an enclosed building to prevent any projectiles beyond the confines of the building, and the sale of firearms may be permitted as an accessory use. Staff located the conditional use ordinance for Article II shooting range in Lombard. Article II shooting range must maintain the following conditions to stay compliant to the ordinance:

- Soundproofing for proposed firing positions
- Satisfactorily address comments from Inter-Departmental Review
- Secure a building permit for required site improvements
- Driveway apron must be reconstructed to Lombard Village Standards
- Dumpsters must be screened
- Maximum occupancy of 103 persons
- Provide a minimum of 6 employee parking spaces

One community issue with the shooting range is required parking. Mike Toth commented that shooting ranges are not a common use in the Chicagoland area and have a steady stream of faithful clientele.

Crystal Lake

Shooting ranges are permitted as a special use in Crystal Lake in 3 zoning districts: Neighborhood Commercial District; Limited Manufacturing District; and Manufacturing District. Straight Shooters Gallery is located in Crystal Lake and open to the public. In November of 2010, Crystal Lake approved a special use permit for Straight Shooter's Gallery. The special use permit was issued approved with the following conditions:

- Approved Plans
- Revised parking lot layout
- Final landscape plan meeting Unified Development Ordinance requirements
- Detailed trash enclosure plan for review
- Mechanical equipment on roof or ground must be screened
- A sign variation for a bulls eye logo as designed and not counted toward the total wall signage
- Petitioner must comply with requirements from Engineering and Building, Fire, Police, Public Works, Planning, and Economic Development
- Petitioner must comply with all state and federal regulatory agency requirements

- And developer must work with staff on acceptable and qualified environmental consulting and yearly inspection report.

In Crystal Lake, shooting ranges are only permitted as a special use if they are indoors, all shooters present FOID cards, have ceiling and wall sound barriers, a controlled number of shooters, appropriate ammunition storage, compliance with state and local laws. Firearms sales can be an incidental use.

Chicago Ridge
Chicago Ridge's Municipal code regulates firearms sales business licenses much similar to Lincolnwood's municipal code. New firearm establishments built after 1995, cannot be located within a quarter mile of school grounds or public parks and facilities. Retail establishments of firearms must obtain a license every 5 years. Chicago Ridge does not currently have any shooting ranges.

Analysis
To summarize, shooting ranges are not a common use in the Chicagoland area. Crystal Lake, Des Plaines, and Lombard have regulated this use through conditional and special use permits. Conditional use permits for shooting ranges contain similar characteristics: sound proofing, appropriate staff training, compliance with state and local laws, and an enclosed, structurally sound range. Highland Park maintains OSHA standards at its municipal shooting range to avoid occupational hazards associated with exposure to lead.

Attachments
1. Des Plaines Conditional Use Ordinance
2. Lombard Conditional Use Ordinance
3. Crystal Lake Special Use Permit Ordinance
4. OSHA-Illinois Gun Works Press Release

CITY OF DES PLAINES

ORDINANCE Z - 22 - 12

AN ORDINANCE GRANTING A CONDITIONAL USE PERMIT UNDER SECTION 7.4-5 C. OF THE ZONING ORDINANCE TO PERMIT THE OPERATION OF AN INDOOR SHOOTING RANGE WITH ACCESSORY FIREARM SALES AT 75 BRADROCK DRIVE, DES PLAINES, ILLINOIS. (CASE #12-033-CU).

WHEREAS, application was made by Barry and Claudia Levin to the City of Des Plaines Department of Community Development for authorization by the City Council of a Conditional Use Permit to permit the operation of a Indoor Shooting Range with Accessory Firearm Sales, under Section 7.4-5 C. of the Zoning Ordinance, in a M-2, General Manufacturing District, at 75 Bradrock Drive, Des Plaines, Illinois; and

WHEREAS, the existing zoning is M-2, General Manufacturing District; and

WHEREAS, within fifteen (15) days of the receipt thereof, said application was referred by the Department of Community Development to the Zoning Board of Appeals of the City of Des Plaines; and

WHEREAS, within ninety (90) days from the date of said application a public hearing was held by the Zoning Board of Appeals on June 26, 2012 pursuant to publication in the Journal on June 8, 2012 and notice was mailed to all property owners within 300 feet of the subject property of the consideration of the Conditional Use so proposed by the Petitioner; and

WHEREAS, said hearing of the Zoning Board of Appeals was held June 26, 2012 pursuant to notice published as required by law, wherein competent testimony and evidence was given with respect to how said Petitioner intended to meet the provisions of the Zoning Ordinance. Said Zoning Board of Appeals filed a written report to the Mayor and City Council on June 26, 2012 of such testimony and evidence and their recommendations, by a vote of 6-0, approving the operation of an Indoor Shooting Range with Accessory Firearm Sales, under Section 7.4-5 C. of the Zoning Ordinance, in a M-2, General Manufacturing District, at 75 Bradrock Drive, Des Plaines, Illinois; and

WHEREAS, said Petitioner made certain commitments to the Zoning Board of Appeals with respect to the requested Conditional Use Permit, which representations are hereby found by the City Council to be material and upon which the City Council relies in granting this request for a Conditional Use Permit subject to certain terms and conditions; and

WHEREAS, the City Council has studied the respective written reports of the Zoning Board of Appeals, together with the applicable standards set forth in the Zoning Ordinance, the Staff Report dated June 27, 2012, including the Conditional Use Application completed by the Petitioner, the Plat of Survey, and the Floor and Site Plans, together with the exhibits to the Staff

Report, which include a Location Map, Site and Context Photos, Plan of Operation, The Petitioner's Request for Waiver of Traffic Study, the Draft Minutes of the June 26, 2012 Zoning Board of Appeals Hearing, and the Letter from the Zoning Board of Appeals to the Mayor and City Council, which form part of the basis for this ordinance;

NOW, THEREFORE, BE IT ORDAINED, by the City Council of the City of Des Plaines, Cook County Illinois, in the exercise of its Home Rule powers, as follows:

SECTION 1: That the recitals set forth above are incorporated herein by reference and made a part hereof, the same constituting the factual basis for this Ordinance. The Conditional Use granted herein is consistent with and the same as a "special use" within the meaning of Public Act 94-1027.

SECTION 2: That based upon the written reports of the Zoning Board of Appeals, the applicable standards set forth in the Zoning Ordinance, the representation to the Zoning Board of Appeals made by the Petitioner, the Plat of Survey prepared by John M. Henriksen, dated May 23, 2012, a copy of which is attached hereto and made a part hereof as Exhibit "A," and the Floor and Site Plans prepared by George D. Baker, dated May 25, 2012, copies of which are attached hereto and made a part hereof as Exhibit "B," the City Council hereby grants a Conditional Use Permit to permit the operation of an Indoor Shooting Range with Accessory Firearm Sales, under Section 7.4-5 C. of the Zoning Ordinance, in a M-2, General Manufacturing District, at 75 Bradrock Drive in Des Plaines, Illinois.

SECTION 3: That the following Limitations on Conditional Uses shall apply in accordance with the City of Des Plaines Zoning Code, Sections 3.4-8 "Limitations on Conditional Uses" and 3.4-9 "Effect of Approval".

3.4-8: A. No conditional use permit shall be valid for a period longer than one year unless a building permit is issued and construction is actually begun within that period and is thereafter diligently pursued to completion. However, the City Council may extend the one-year period to a mutually agreed upon time.

B. The approval of a proposed conditional use permit by the City Council shall be deemed to authorize only that particular use at that particular location for which the conditional use was issued.

C. Except when otherwise provided for, this Ordinance, a conditional use shall be deemed to relate to, and be for the benefit of, the use and lot in question, rather than the owner or operator of such use or lot.

3.4-9: The approval of a conditional use permit application by the City Council shall not authorize the development, construction, reconstruction, alteration or moving of any building or structure, but shall merely authorize the preparation, filing and processing of applications for such permits or approvals as may be required by the regulations of the City, including but not limited to a Zoning Certificate and a building permit.

SECTION 4: The Zoning Board of Appeals recommendations, findings and conditions found in the June 26, 2012 memorandum from Arnie Seegers, Chairman of the Zoning Board of Appeals, are incorporated herein by reference as if fully set forth herein.

SECTION 5: That the property at 75 Bradrock Drive, which is the subject of this Ordinance, is located within the legally described subject parcel described as follows:

THE EAST 130 FEET OF LOT 11, AND THE WEST 35 FEET OF LOT 10 IN ANDERSON-MILLER DES PLAINES INDUSTRIAL PARK UNIT NO. 3, BEING A RESUBDIVISION OF LOTS 2, 3, 4 AND PART OF LOTS 5 AND 6 IN GREWE'S SUBDIVISION OF THAT PART OF THE NORTHWEST FRACTIONAL QUARTER AND THE WEST HALF OF THE WEST HALF OF THE NORTHEAST QUARTER OF SECTION 30, TOWNSHIP 41 NORTH, RANGE 12, EAST OF THE THIRD PRINCIPAL MERIDIAN, LYING NORTH OF A LINE 14.70 FEET NORTH OF EAST AND WEST CENTER LINE OF THE NORTH HALF OF SAID SECTION (EXCEPT RIGHT OF WAY OF DES PLAINES VALLEY RAILWAY) EXCEPT THAT PART TAKEN FOR OAKTON STREET BY DOCUMENT 10627381; TOGETHER WITH THE EAST 102 FEET OF LOT 1 AND THAT PART OF LOT 6 LYING NORTHERLY OF A 19 FOOT SWITCH TRACK EASEMENT IN GEORGE H. GEIL'S SUBDIVISION OF THAT PART OF THE SOUTH HALF OF THE NORTH HALF AND THE SOUTH 14.70 FEET OF THE NORTH HALF OF THE NORTH HALF OF SECTION 30, TOWNSHIP 41 NORTH, RANGE 12 EAST OF THE THIRD PRINCIPAL MERIDIAN, LYING WEST OF RIGHT OF WAY OF DES PLAINES RAILWAY AS SHOWN ON THE PLAT RECORDED SEPTEMBER 10, 1928 AS DOCUMENT 10142179 IN COOK COUNTY, ILLINOIS.

PIN: 09-30-100-047-0000

SECTION 6: That granting of the Conditional Use Permit for the address of 75 Bradrock Drive within the subject property is granted upon the conditions set forth below. Upon failure of the Petitioner to act upon this authorization within twelve (12) months of the date of this Ordinance, the granting of the Conditional Use Permit for the subject property shall be automatically revoked; provided, however, that upon request in writing of the Petitioner prior to the expiration of the twelve (12) month period, the City Council may at any time, or from time to time by resolution duly adopted at any meeting of the City Council, extend said period of time. In addition to the foregoing, the Petitioner must meet the following conditions:

1. Prior to issuance of the Conditional Use Permit, the applicant shall submit a Landscape Plan with areas of new and reconstructed parking lot in compliance with Interior Parking Lot Landscaping requirements per Section 10.8-2 of the Zoning Ordinance.
2. Prior to issuance of the Conditional Use Permit, a revised Site Plan shall be submitted with diagonal pavement striping, minimum 4' wide, along the west side of the building for pedestrians to walk along so that they are out of the traffic lanes, and a sidewalk connection from the street sidewalk to the front entrance to the satisfaction of the Directors of Community and Economic Development and Public Works and Engineering.
3. Prior to issuance of the Conditional Use Permit, the applicant shall submit a security plan, including a security system with direct call to the City's 9-1-1 system, reinforcement of exterior and interior doors, and locking mechanisms for all firearms to the satisfaction of the Chief of Police.
4. Prior to issuance of the business license, the applicant shall improve the parking lot with interior landscaping in new and reconstructed areas, with diagonal pavement striping, minimum 4' wide, along the west side of the building for pedestrians to walk along so that they are out of the traffic lanes, and install a sidewalk connection from the street sidewalk to the front entrance.
5. Prior to issuance of the business license, all security measures included in the security plan shall be in place to the satisfaction of the Chief of Police.
6. All landscaping materials shall be maintained in good condition so as to present a healthy and orderly appearance, and plant material not in this condition shall be replaced when necessary and shall be kept free of refuse and debris.
7. All parking areas shall be surfaced and striped to meet all applicable Building Code hard surface requirements.

SECTION 7: That any person, firm or corporation who violates, disobeys, omits, neglects or refuses to comply with or resists the enforcement of any of the provisions of this Ordinance shall be fined not less than Seventy-five Dollars ($75.00) or more than Seven

Hundred and Fifty Dollars ($750.00) for each offense. Each and every day that a violation of the Ordinance is allowed to remain in effect shall constitute a complete and separate offense. In addition, the appropriate authorities of the City may take such other action as they deem proper to enforce the terms and conditions of this Ordinance, including, without limitation, an action in equity to compel compliance with its terms. That any person, firm or corporation violating the terms of this Ordinance shall be subject, in addition to the foregoing penalties, to the payment of court costs and reasonable attorneys' fees.

SECTION 8: That within 60 days of the passage of said Ordinance, the executed, original Ordinance shall be returned to the City Clerk's office.

SECTION 9: If any paragraph, section, clause or provision of this ordinance is held invalid, the remainder shall continue in full force and effect without affecting the validity of the remaining portions of the contract.

SECTION 10: That this Ordinance shall be in full force and effect from and after its passage, approval and publication in pamphlet form according to law.

PASSED this _____day of _____, 2012.

APPROVED this _____ day of _____, 2012.

VOTE: AYES _____ NAYS _____ ABSENT _____

_____
MAYOR

ATTEST:

_____
CITY CLERK

FRED BUCHOLZ
DUPAGE COUNTY RECORDER
JUL.01,2009 3:13 PM
OTHER 03-31-404-005
005 PAGES R2009-101452

60148

ORDINANCE 6343

GRANTING A CONDITIONAL USE PURSUANT TO TITLE 15, CHAPTER 155, SECTION 155.420 (C) OF THE LOMBARD ZONING ORDINANCE

PIN: 03-31-404-005

Address: 250 Cortland Avenue, Lombard, IL

Return To:

Village of Lombard
255 E. Wilson Avenue
Lombard, IL 60148

ORDINANCE NO.6343

AN ORDINANCE GRANTING A CONDITIONAL USE PURSUANT TO TITLE 15, CHAPTER 155, SECTION 155.420 (C) OF THE LOMBARD ZONING ORDINANCE

(PC 09-12: 250 Cortland Avenue)

WHEREAS, the President and Board of Trustees of the Village of Lombard have heretofore adopted the Lombard Zoning Ordinance, otherwise known as Title 15, Chapter 155 of the Code of Lombard, Illinois; and,

WHEREAS, the Subject Properties as defined below is zoned I – Limited Industrial District; and,

WHEREAS, an application has been filed requesting approval of a conditional use, pursuant to Section 155.420 (C)(31) of the Zoning Ordinance, to allow to allow a Shooting Gallery & Range, Indoor (with ancillary retail sales of associated product) at the property described below in Section 2; and

WHEREAS, a public hearing on the forgoing application were conducted by the Village of Lombard Plan Commission on May 18, 2009 pursuant to appropriate and legal notice; and,

WHEREAS, the Plan Commission has filed its recommendations with the President and Board of Trustees recommending approval of the conditional use described herein, subject to conditions; and,

WHEREAS, the President and Board of Trustees approve and adopt the findings and recommendations of the Plan Commission and incorporate such findings and recommendations herein by reference as if they were fully set forth herein;

NOW, THEREFORE, BE IT ORDAINED BY THE PRESIDENT AND BOARD OF TRUSTEES OF THE VILLAGE OF LOMBARD, DU PAGE COUNTY, ILLINOIS, as follows:

SECTION 1: That a conditional use from Section 155.420 (C)(31) of the Zoning Ordinance, to allow a Shooting Gallery & Range, Indoor (with ancillary retail sales of associated product) is hereby granted for the Property, as described in Section 2 below and subject to the conditions set forth in Section 3 below.

SECTION 2: The approval granted in Section 1 above shall be limited and restricted to the property located at 250 Cortland Avenue, Lombard, Illinois and legally described as follows:

THE WESTERLY 144.43 FEET, MEASURED AT RIGHT ANGLES THERETO, OF LOT 1 IN ARTISTIC IMPRESSIONS CONSOLIDATION OF LOTS 1 AND 2 IN PECORA'S RESUBDIIVISION OF PART OF THE SOUTHEAST QUARTER OF SECTION 31, TOWNSHIP 40 NORTH, RANGE 11, EAST OF THE THIRD PRINCIPAL MERIDIAN, ACCORDING TO THE PLAT OF SAID ARTISTIC IMPRESSIONS CONSOLIDATION RECORDED NOVEMBER 4, 1994 AS DOCUMENT NUMBER R94-216981, IN DUPAGE COUNTY, ILLINOIS.

Parcel Number: 03-31-404-005

SECTION 3: The conditional use, as provided for in Sections 1 of this Ordinance shall be granted subject to compliance with the following conditions:

1. The subject property shall be developed in substantial compliance with Floor Plan/Site Plan, prepared by Thomas Budzik Architecture PC, dated April 13, 2009, except as such plans may be changed to meet Village Codes and the following conditions below:

2. Soundproofing for the proposed firing positions shall be provided so as to eliminate any external noise.

3. All comments in the Inter-Departmental Review Committee Report shall be satisfactorily addressed.

4. The petitioner shall secure a building permit from the Village for all required improvements.

5. The existing commercial driveway apron shall be reconstructed to Village standards.

6. All dumpsters located on the subject property shall be screened pursuant to Section 155.710 of the Zoning Ordinance.

7. Occupancy shall be based on the lesser of the two (2) options:

    a. 103 persons, or

    b. As determined by the Building Code

8. A minimum of six (6) employee parking spaces shall be delineated with the proper signage in the northern portion of the parking lot, in a manner acceptable to the Director of Community Development.

SECTION 4: This Ordinance, upon approval, shall be recorded by the Village with the Office of County Recorder.

SECTION 5: This ordinance shall be in full force and effect from and after its passage, approval, and publication in pamphlet form as provided by law.

Passed on first reading this _____ day of _____, 2009.

First reading waived by action of the Board of Trustees this 4th day of June, 2009.

Passed on second reading this 4th day of June, 2009, pursuant to a roll call vote as follows:

Ayes: Trustees Gron, Tross, Moreau, Fitzpatrick and Ware

Nayes: None

Absent: Wilson

Approved by me this 4th day of June, 2009.

William J. Mueller. Village President

ATTEST:

Barbara A Johnson Dputy
Brigitte O'Brien, Village Clerk

Published in pamphlet from this 8th day of June, 2009

Barbara A Johnson Dputy
Brigitte O'Brien, Village Clerk

ORDINANCE NO. 6618
FILE NO. 440

AN ORDINANCE GRANTING A SPECIAL USE PERMIT
AT 560 BEECHCRAFT LANE

WHEREAS, pursuant to the terms of a Petition (File #2010-60) before the Crystal Lake Planning and Zoning Commission, the Petitioner has requested the issuance of a Special Use Permit (Article 2 Section 2-300) to allow a commercial recreation use for a shooting range for the property located at 560 Beechcraft Lane; and

WHEREAS, it is in the best interests of the CITY OF CRYSTAL LAKE that the Special Use Permit be issued as requested in said Petition.

BE IT ORDAINED BY THE MAYOR AND CITY COUNCIL OF THE CITY OF CRYSTAL LAKE, McHENRY COUNTY, ILLINOIS, as follows:

Section I: That a Special Use Permit be issued to allow a commercial recreation use for a shooting range for the property commonly known as 560 Beechcraft Lane, Crystal Lake, Illinois.

Section II: Said Special Use is issued with the following conditions:

1. Approved plans, reflecting staff and advisory board recommendations, as approved by the City Council:
   A. Application (Charles River Development, received 10/01/10)
   B. Site Plan package (Gillespie Design Group, dated 10/01/10, received 10/01/10)

2. The granting of the Special Use Permit is for an indoor shooting range, as presented in the petition and public hearing. If the use is increased in intensity or significantly modified, an amendment to the Special Use Permit shall be required.

3. Site Plan
   A. Label the front landscape setback correctly.
   B. Revise the parking lot layout and dimensions to comply with required parking stall dimensional standards.
   C. Stormwater will need to be reviewed by the City's consultant. In addition, an offsite easement will be required from ComEd to allow discharge to the north as illustrated by the engineer.

D. Eliminate 5 parking spaces along Beechcraft to meet required 20 foot parking lot setback.

4. A final landscape plan shall be provided which meets all the requirements of the UDO.

5. Provide details of the trash enclosure for review and approval by staff.

6. All mechanical equipment whether on the ground or on the roof, must be screened per the UDO.

7. Extend a gravel, asphalt or grasscrete block from the parking lot north to the end of the building to allow for fire apparatus. Lane must be 20 feet in width.

8. A variation from Article 4-1000 Signage to allow the bullseye logo as designed and not counted towards the total wall signage permitted.

9. The petitioner shall comply with all of the requirements of the Engineering and Building, Fire Rescue, Police, Public Works and Planning and Economic Development Departments. All Federal and State regulatory agency requirements shall be adhered to.

10. The developer shall work with staff on selecting an acceptable and qualified environmental consulting firm that will provide as part of the City's annual life safety inspection a yearly inspection report that verifies the use is in compliance with all applicable Federal and State requirements, including the ventilation system. The developer shall be responsible for this yearly expense.

Section III: That the City Clerk be and is hereby directed to amend the official zoning map of the City of Crystal Lake and all pertinent records of the City of Crystal Lake to show the issuance of a Special Use Permit in accordance with the provisions of this Ordinance, as provided by law.

Section IV: That this Ordinance shall be in full force and effect from and after its passage and approval as provided by law.

DATED at Crystal Lake, Illinois, this 2nd day of November, 2010.

MAYOR

ATTEST:

CITY CLERK

Published in pamphlet form by the authority of the Mayor and City Council of the City of Crystal Lake.

OSHA Regional News Release

U.S. Department of Labor
Office of Public Affairs **Region 5**

Region 5 News Release: 12-1052-CHI
June 11, 2012
Contact: Scott Allen Rhonda Burke
Phone: 312-353-6976
Email: allen.scott@dol.gov burke.rhonda@dol.gov

US Department of Labor's OSHA cites Illinois Gun Works for exposing workers to lead, other hazards at Elmwood Park, Ill., plant

ELMWOOD PARK, Ill. – The U.S. Department of Labor's Occupational Safety and Health Administration has cited Illinois Gun Works Ltd. for 28 alleged health violations following a Jan. 21 inspection referred by the Illinois Department of Public Health that found two gun range operators were exposed to airborne lead levels up to 12 times the permissible level. Proposed fines total $111,000.

"Illinois Gun Works has a responsibility to protect the health of its employees by ensuring that they operate in a manner which eliminates or minimizes lead hazards, including exposure," said Diane Turek, director of OSHA's Chicago North Area Office in Des Plaines. "OSHA is committed to protecting employees' safety and health."

A total of 27 serious violations include 13 for violating the lead standard, including failing to implement engineering and work practice controls to reduce exposure, collect full shift personal samples for monitoring, measure effectiveness of the ventilation system to control exposure, provide clean protective clothing, dispose of or replace protective clothing, provide clean changing rooms or separate storage facilities for protective work clothing to prevent cross-contamination with street clothes, require workers exposed to lead to shower at the end of a shift or to ensure workers washed hands and faces prior to consuming food during breaks, and implement a medical surveillance program for all employees who were exposed to lead at or above the action levels, including biological monitoring such as blood sampling.

The remaining serious violations include failing to implement a hazard communication program, train workers on hazardous chemicals present in the work environment, label chemical bottles with contents and a hazard warning, administer an effective hearing conservation program, train in the use of personal protective equipment and implement a respirator protection program that includes, fit testing and training. A serious violation occurs when there is substantial probability that death or serious physical harm could result from a hazard about which the employer knew or should have known.

One other-than-serious violation has been cited for failing to provide a written certification that a hazard assessment had been performed. An other-than-serious violation is one that has a direct relationship to job safety and health, but probably would not cause death or serious physical harm.

The citations may be viewed at http://www.osha.gov/ooc/citations/IllinoisGunWorksLtd_110282_0608_12.pdf*.

Illinois Gun Works operates a gun sales business, a shooting range and gun safety training. The company has 15 business days from receipt of its citations and penalties to comply, request an informal conference with OSHA's area director or contest the findings before the independent Occupational Safety and Health Review Commission.

To ask questions, obtain compliance assistance, file a complaint, or report workplace hospitalizations, fatalities or situations posing imminent danger to workers, the public should call OSHA's toll-free hotline at 800-321-OSHA (6742) or the agency's Chicago North office at 847-803-4800.

Under the Occupational Safety and Health Act of 1970, employers are responsible for providing safe and healthful workplaces for their employees. OSHA's role is to ensure these conditions for America's working men and women by setting and enforcing standards, and providing training, education and assistance. For more information, visit http://www.osha.gov.

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U.S. Department of Labor news materials are accessible at http://www.dol.gov. The information above is available in large print, Braille, audio tape or disc from the COAST office upon request by calling 202-693-7828 or TTY 202-693-7755.

* **Accessibility Assistance** Contact OSHA's Office of Communications at 202-693-1999 for assistance accessing PDF materials.

VILLAGE OF LINCOLNWOOD Public Hearing Application

Community Development Department Application Supplement Part II

On behalf of the applicant, we hereby submit our responses to questions raised by: the Village Board, The Village's Plan Commission, or Village staff communicated to us by Aaron Cook. The questions posed to us are:

1. What will be the hours of operation for Shore at the new location.
2. Provide a clear site plan demonstrating the parking.
3. Number of employees on site.
4. Provide a security plan/procedures.
5. Number of employees for the existing use.
6. Representation of how Shore Galleries anticipates its clients will use the new building.
7. Explanation for the appropriate number of stalls for the ranges.
8. Provide specific data on environmental standards.
9. Provide description as to how the safety systems work in the ranges.

We welcome the opportunity to further present our information and facts regarding the proposed use.

The over riding theme or topic for the questions above, can be summarized as: How will the proposed move impact the community, the immediate neighbors, and is this good for the Village of Lincolnwood. As we have done with the first Supplement provided to the Village Board, we will document our position with facts, not rhetoric.

1. What will be the hours of operation for Shore at the new location? As stated in our Parking Projection Study prepared by Ament Design, authorities in Municipal Engineering, Traffic and Transportation Engineering in both Iowa and Illinois, the hours of operation at the proposed site shall be:

Weekdays	9.00 am - 9.00 pm
Saturday	9.00 am - 5.00 pm
Sunday	10.00 am - 4.00 pm

The hours of operations for our neighbors are:

Ravenswood Studio

Monday - Friday	7.00 am - 4.00 pm

Econcare

Monday - Thursday	9.00 am - 5.00 pm
Friday	9.00 am - 4.00 pm

2. Provide a clear site plan demonstrating the parking Please find attached the proposed site plan and designated parking. Please note, the total number of spaces remain the same as previously represented. Due to the recommendation by Ament Design, we

have accommodated a handicapped space in the front in lieu of the rear. So the configuration of spaces is slightly different, nevertheless the total number of spaces is as has been previously represented.

3. Number of employees on site? As stated in Ament's report, the store is planning on adding one employee, the Range Master. Shore Galleries, on average, has four employees working at any given time.

4. Provide a security plan/procedures Since 1956, Shore Galleries has taken extensive safety measures for store, community, and neighbors safety. As a result, there has never been a robbery in their history. Due to the nature of the public hearing format, and the sensitive nature of the security plan, we have submitted the plan/procedures directly to the Chief of Police. We request you accept his recommendation. In addition, please find attached a letter from the former Mayor of Northfield, Donald K. Whiteman, regarding Shore Galleries, and addresses gun safety issues when Northfield annexed a club which allowed the use of weapons.

5. Number of employees for the existing use? Resillo Press Pads has been the sole tenant, operator, and owner of the building since its inception. At the height of their operations they have had over 50 employees. Within the last year, they have employed 32 employees. As documented in the Parking Projection Study prepared by Illinois Licensed Traffic and Transportation engineer Ament, the parking demands from Shore Galleries will be far below even the recent 12 months of operation by Resillo Press Pads as they transition from the site. The owner, Leo Pearl, is prepared to make a statement regarding such at the public meeting.

6. Representation of how Shore Galleries anticipates its clients will use the new building? As outlined in the Parking Projection Study presented by Ament Design, and in the 2011 - 2012 Village of Lincolnwood Budget Section Key Issues No. 10 & 11, the proposed location is an ideal fit for Shore Galleries and the Village of Lincolnwood. The peak time for clients compliments the neighboring industrial companies. The bulk of the neighboring companies will be in full operation at or before Shore Galleries opens. The peak usage is later in the day as the neighboring companies are concluding their work day. The ranges will be primarily for training, and will support the retail operations. The peak operations on primarily on weekends when the neighboring business are typically closed. Nevertheless, the parking demands and occupancy (retail, range and employees) is substantially less than either the previous owner's usage or the current next door neighbors.

   To suggest or imply that Shore Gallery will place unnecessary demand beyond the "normal" use within the neighborhood is not supported by empirical data of the neighborhood nor data collected from similar operations.

7. Explanation for the appropriate number of stalls for the ranges The dimensions of the range stem from function over form. The business practices of tactical training with different firearms determine the minimum safety, and economics. The sizes of each range (long and short) allow training to happen in real life situations that will keep police officers safe and alive. Operating a modern range has many factors. The two most important are. 1: The best equipment. (Bullet traps, armament for the walls and ceiling, noise containment, HVAC with HEPA filters, lighting and cleanliness. 2: In order for a

range to have the best equipment and to maintain its high standards the economics must work. We have attached a spread sheet showing the revenue generated from the range and the retail operation that directly effect the Village of Lincolnwood.

8. Provide specific data on environmental standards. As we have stated through out, we will be building and operating the ranges in compliance with all local and federal rules and regulations. In an email previously sent to Aaron Cook on 7.30.12, we have provided and documented all OSHA, NIOSH, and EPA standards which we must compile. In all, the documents we forwarded total 227 pages of regulations. As noted in the Village Board meeting by numerous law enforcement officers, and firearms safety instructors, Mitch Shore has an impeccable reputation as a certified law enforcement and civilian firearm training and safety instructor.

9. Provide description as to how the safety systems work in the ranges Under previous email, we have provided the Village with complete safety standards as well as range drawings which prove the ranges meet all national and local safety standards.

In summary, the Village's Comprehensive Plan and TIF guidelines mandate the Light Manufacturing District be utilized in a manner consistent with the proposed operations by Shore Gallery. Furthermore, the proposed use is fully compliant with the goals and intentions of the TIF by generating significant sales tax revenues for the Village. The Village has recognized that there is a parking issue in the Manufacturing District and the Village is attempting to solve. Nevertheless, the proposed use, hours of operation, and clientele will add no additional burden on the District.

To suggest, imply or implicitly state that the relocation of Shore Galleries to 6950 N Central Park Avenue will decrease property values, create an unsafe environment, or cause business to relocate is not based upon any objective facts.

1. Shore Galleries has operated in the Village with an impeccable record since 1956. From the exterior perspective, there will be no difference in use between the Devon location and the Central Park Location other than Shore's clients will be able to park *much* closer and convenient to its store front. Clients will be entering and leaving with guns in a similar manner that has been occurring since 1956 on a tremendously busy retail roadway.
2. Since their founding, Action Target has never had an incident where a bullet as penetrated their safety measures and exited the building. Is there a difference between the operations on Devon and Central Park - absolutely, *training*. Due to all the state of the art safety measures, HVAC equipment, and acoustical measures there will be no indication of the mandated training that is occurring. Significant machinery and presses have been operating in that space since the 1950's.

   In order to insure the accuracy of our acoustical data, we retained the services of a second acoustical engineer, Dr. David Braslau, founder and firm president, received his Bachelor of Science Degree from the Massachusetts Institute of Technology in 1956, and his Master of Science and Doctor of Philosophy Degrees from the University of California at Berkeley in 1960 and 1966, respectively. He taught at the University of Minnesota from 1966 until 1971, when he founded the firm of David Braslau Associates. Dr. Braslau is a Registered Professional Engineer in the state of Minnesota. Society memberships include the Acoustical Society of America and the Institute for Noise Control Engineering.

The parking is consistent with what has proceeded in the space, the acoustical performance will be in compliance with all Village requirements, and there will be no indication that a range is in operation from the exterior. There is no data or facts to suggest this operation will hinder anyone's business, safety or welfare.

3. As it has been stated numerous times, this facility will be catering to the same law enforcement officers and agencies as Shore Galleries has done on Devon for many decades. There will not be a safer place in the Village other than the Police Department. Citizens who will seek training are Illinois State Police Authorized law abiding individuals

We appreciate the Plan Commission's previous favorable recommendations to the Board, and this additional opportunity to shed light on the issues that have been raised. The attached documents as well as Application Supplement document the acoustical studies, and safety of ranges across Illinois (including the range at Gurnee Mills which has over 20 million shoppers annually).

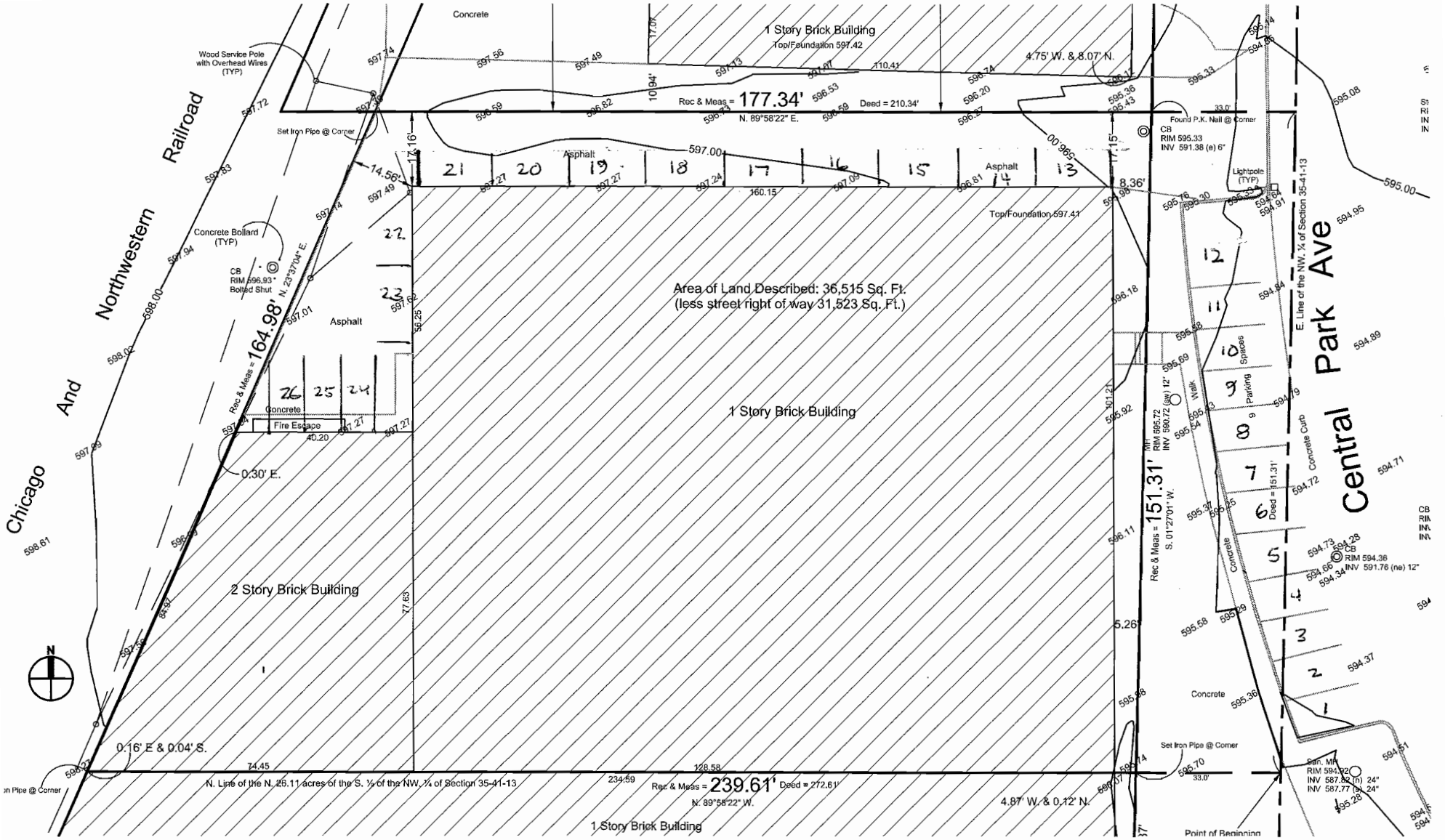
Thank you for your consideration of this matter.
Sincerely,

Platform I - Shore, LLC

Steve Siegel
Manager

Shore Galleries

Mitch Shore
President



Shore Galleries

SITE PLAN

4.10.2012

CODA LLC.

6590 CENTRAL PARK AVE.,
LINCOLNWOOD, IL

1" = 20'-0"

A100

Donald K. Whiteman
545 Happ Road
Northfield, IL 60093

Mayor Gerald Turry
Village of Lincolnwood
6900 N. Lincoln Avenue
Lincolnwood, IL 60093

Dear Mayor Turry,

I am an old friend of Mitch Shore and I have known his family for over 30 years. I am also their financial advisor and a long time customer of Shore Galleries. I am writing to express my support for their request to relocate and expand within your village.

From 1997 to 2005 I served for two terms as village president of the Village of Northfield, a town very similar to Lincolnwood, so I completely understand the concerns and issues that you and your board are currently experiencing with this request. Having grown up in Northfield as a child, I remember well a Northfield business called the Fix-It Shop that sold firearms. My father and I were regular customers for our skeet and trap shooting needs. During my tenure on our village board, we annexed the Sunset Ridge Country Club that has a very active skeet shooting program during the fall and winter months. That annexation process led to much discussion about their skeet range, shotgun firing and how Northfield once had a gun store for many years within its business district. While the discussion during the council hearing was spirited and lively, as you might imagine, the bottom line was that the Fix-It Shop was never a problem to the village while it was in business and the annexation of the Sunset Ridge Country Club was unanimously approved, skeet range, noise and all. Incidentally, I wish we still had the Fix-It Shop and would gladly have welcomed a Shore Galleries into our town.

Shore Galleries has a superb, well earned reputation with its customers that include not only the Northfield Police Department, but also many other area law enforcement agencies and civilian sportsmen alike. Their relocation and expansion will not only permit them to serve their loyal customer base more effectively, but perhaps more importantly, will benefit Lincolnwood by retaining a highly visible, well regarded, successful business within its community. I suspect it will likely also lead to an increase in tax and fee revenue for Lincolnwood, something that should not be overlooked in these times.

I sincerely urge you and your board to approve Shore Galleries' relocation and expansion request so they can continue to be one of area's premiere sporting goods retailers.

Sincerely,

Donald K. Whiteman

Parking Projection Study

Shore Galleries
6950 N. Central Park Avenue
Lincolnwood, IL 60712

Prepared for:
CODA, LLC
631 Lake Avenue
Wilmette, IL 60091

Prepared by:

Ament INC
DESIGN
• Civil Engineering •

August 2, 2012

Parking Projection Study
Proposed Shore Galleries Facility
6950 N. Central Park Avenue
Lincolnwood, IL

Introduction:
Our firm has been employed by CODA, LLC, Architect for the proposed Shore Galleries facility, to perform analysis to project the parking demand the proposed facility will have at 69850 North Central Park Avenue.

The location of the proposed project site is shown on **Exhibit One – Site Location Map**. Our study includes evaluation of the proposed site in terms of the number of parking spaces that will be required by the proposed business.

Existing Site:
The study site, located at 6950 North Central Park Avenue on the west side of the street in an existing 30,340 square foot building that is currently zoned light industrial. Adjacent to the site on the west is a vacant railroad right of way, along the north side and south, industrial facilities and North Central Park Avenue along the east side. A 25 car municipal lot is located just south of the site along the south side of North Central Park Avenue. Another municipal parking lot with 80 parking spaces is located north of the site near the public works facility and there are 15 on street easement spaces located approximately 300' north of the site. This makes 120 municipal parking spaces in the general vicinity of the study site. The subject site is located approximately 4 blocks west and 5 blocks north of the existing Shore Galleries location.

Existing Shore Galleries Store:
Shore Galleries is an existing business that has resided in Lincolnwood since it opened its doors in 1956. Since that time it has been a member of the local business community and today Shore Galleries is primarily a law enforcement supplier catering to the law enforcement community.

It is currently located at 3318 West Devon Avenue on the north side of the street. Adjacent to the site on the north are residential properties, along the east and west are existing businesses and Devon Avenue on the south. On the south side of Devon Avenue is a bank and Home Depot. Currently the only parking that is available is shared on-street parallel parking in front of the store consisting of 2 spaces.

Parking Requirements – Current Zoning:
The existing 30,340 square foot building is currently zoned light industrial. Parking requirements for this land use is 1 parking space for every 1,000 square feet which equates to 30 parking spaces. Currently there are 9 off street spaces along the east side of the building, space for 9 vehicles to parallel park along the north side of the building and space for 5 vehicles to park at the rear of the building. There is a deficiency of seven parking space for the building as it is currently zoned. The Village Code does allow up to a 15% reduction in the parking requirement (5 spaces) if certain requirements are met. Since there is a municipal parking lot less than 300' away from the site it appears that that reduction could be credited. Even with the 15% reduction the existing site does not have adequate parking based on the requirements.

It should be noted that 12 months ago the current building tenant had 50 employees and for the last 6 months has employed 42 people. Operating hours for the current tenant are from 7 am – 3 pm Monday through Friday.

Adjacent Businesses:
Based on our observations on July 30 site visit the adjacent buildings appeared to contain the following businesses:

#6970 Appears to be for lease
#6990 Econocare 9 am – 5 pm Mon. – Thur. and 9 am – 4 pm on Fri.
#6900 Ravenswood Studios 7 am - 4 pm Mon. – Fri.

At the time of our visit (1:30 pm) there were vacant parking spaces in the Econocare parking lot and in the parking stalls perpendicular to the street along the frontage of 6970 and 6990 North Central Park Avenue. The municipal lot south of the proposed Shore Galleries location had 7 vacant parking spaces and it also appeared that the Ravenswood Studios (6900 North Central Park Avenue) parking lot was not full.

Municipal Parking Lots:
There are two municipal parking lots in the general area with one of the lots (25 car capacity) located approximately 175 feet southeast of the site and the other lot (80 car capacity) within approximately 1,200 foot walking distance. There are 15 additional on street easement parking along the west side of Central Park Avenue approximately 300' north of the subject site.

Manual counts for the two municipal parking lots were taken between Monday July 23, 2012 and Sunday July 29, 2012. Parked vehicles were counted each hour at both of the lots from 7am to 10 pm and the information is in the following tables:

South Municipal Parking Lot with 25 parking spaces:

	Monday July 23	Tuesday July 24	Wednesday July 25	Thursday July 26	Friday July 27	Saturday July 28	Sunday July 29
7:00 am	5	7	6	6	5	-	-
8:00 am	9	10	6	6	6	-	-
9:00 am	15	15	12	14	15	3	0
10:00 am	15	13	14	14	15	2	0
11:00 am	14	13	14	15	14	1	0
12:00 pm	10	10	9	15	14	1	0
1:00 pm	8	9	9	10	11	1	0
2:00 pm	10	11	12	14	14	1	0
3:00 pm	12	12	12	4	14	0	0
4:00 pm	12	12	12	6	13	0	0
5:00 pm	11	10	7	6	13	0	0
6:00 pm	2	3	2	6	5	0	0
7:00 pm	8	5	6	6	3	0	0
8:00 pm	8	5	6	3	3	0	0
9:00 pm	8	8	6	3	3	0	0
10:00 pm	0	0	0	0	0	0	0

As illustrated by the data above this parking lot had a maximum occupancy of 15 vehicles leaving a minimum of 10 available parking spaces during the week long counts.

North Municipal Parking Lot with 80 parking spaces

	Monday July 23	Tuesday July 24	Wednesday July 25	Thursday July 26	Friday July 27	Saturday July 28	Sunday July 29
7:00 am	15	15	17	15	15	-	-
8:00 am	22	25	20	20	18	-	-
9:00 am	28	30	28	34	31	4	1
10:00 am	35	35	36	36	35	4	1
11:00 am	38	35	37	38	38	4	0
12:00 pm	34	31	28	38	39	5	0
1:00 pm	34	33	31	30	30	5	0
2:00 pm	34	34	29	30	28	5	0
3:00 pm	34	34	33	36	12	5	0
4:00 pm	12	15	20	17	17	2	0
5:00 pm	12	15	15	12	12	0	0
6:00 pm	4	4	7	5	3	0	0
7:00 pm	4	4	3	5	3	0	0
8:00 pm	5	4	1	2	3	0	0
9:00 pm	0	0	1	2	0	0	0
10:00 pm	0	0	0	0	0	0	0

As illustrated by the data above this parking lot had a maximum occupancy of 39 vehicles leaving a minimum of approximately 49 available parking spaces during the week long counts.

Proposed Facility:

The proposed Shore Galleries facility will occupy approximately 30,000 square feet of floor space consisting of 7,449 square feet of retail and display area, 764 square feet for storage and the remaining 17,000 square feet would primarily be for the target ranges and classrooms. Along the front of the building adjacent to Central Park Avenue there are 12 spaces proposed with 9 parallel parking stalls along the north side of the building and 5 spaces at the rear of the building. According to conversations with the Architect, Shore Galleries anticipates having a maximum of 5 employees on site during peak operating times.

Proposed Hours of Operation:

The operating hours of the proposed facility will be:
9 am – 9pm Tuesday through Friday
9 am – 5 pm Saturday
10 am – 4pm Sunday

Parking Demand – Proposed Use:
Customer counts that were taken between July 20 and July 27 at the existing Store to determine the number of customers that came in to the store and the time that they came into the store. This information is contained in the following table:

	Friday 7/20/12	Saturday 7/21/12	Tuesday 7/24/12	Wednesday 7/25/12	Thursday 7/26/12	Friday 7/27/12
10 am – 11 am	3	10	6	3	8	3
11 am – 12 pm	4	10	6	7	2	5
12 pm – 1 pm	2	7	7	7	5	6
1 pm – 2 pm	5	8	10	4	6	7
2 pm – 3 pm	4	6	8	6	6	6
3 pm – 4 pm	6	11	4	5	3	5
4 pm – 5 pm	5	-	6	7	6	5
5 pm – 6 pm	2	-	3	6	7	4
6 pm – 7 pm	0	-	8	-	9	8
7 pm – 8 pm	-	-	5	-	8	-

According to the data obtained, the peak weekday hour consisted of 10 customers and the peak Saturday hour consisted of 11 customers. The estimated number of parked vehicles is projected by dividing the number of customers by an estimated number of customers per vehicle. For this study, we have assigned a factor of 1.25 customers per vehicle because some customers will come alone in their vehicle while others will come together in the same vehicle. Please note that on duty police officers coming to the facility to train will always have 2 officers in the car. Based on these numbers, we project the peak retail parking demand to be 8 spaces during the peak weekday hour and 9 spaces on Saturday. Parking demand on Sundays is not anticipated to exceed Saturday parking demand.

It should be noted that the space in the proposed facility has been allocated based on areas that are necessary for the operation of the short & long ranges with the remaining space for retail and display. Space required for the retail component of the facility is much less than the space that is shown on the building floor plan. Had the building originally been designed for the proposed use, the additional space would not have been constructed. Based on this, we believe that the parking requirement for the retail operation should be based on the existing retail business rather than the square footage available for retail space shown on the floor plan.

A special use permit for an indoor shooting range in Crystal Lake, IL references a parking standard from the American Planning Association (APA). The APA Planning Advisory Service Manual for Parking Standards recommends that an indoor shooting range have one parking space per firing lane and one space per staff member. Based on this standard, the proposed indoor range would require 16 spaces plus one space per staff member.

We project the weekday parking demand for the proposed Shore Galleries facility to be 29 spaces and the weekend demand to be 30 spaces. These numbers are based on 16 spaces for the shooting range, 5 spaces for employees and 8 spaces for the retail operation (9 on the weekend).

The site plan proposes 26 parking stalls and our projections call for 29 parking stalls (30 on the weekends). According to 7.07.2 the Zoning officer may approve an administration adjustment reducing the off street parking requirements by 15%. If the reduction is granted the Shore Galleries site would receive a reduction of 4 spaces which would make the propose site compliant based on our parking demand projections.

Discussion:
It is our opinion that the proposed Shore Galleries facility would be a good fit in the proposed location. While weekday business hours overlap the existing businesses, the peak hours for the facility should be in the late afternoon and evenings when the adjacent businesses are closed. Weekend business will not have an impact on the adjacent businesses since they are closed on the weekends.

It should be noted that some of the existing retail customers will become users of the shooting range and patrons of the shooting range will also be customers of the retail business. This coupled with the fact that the only likely time for the shooting range to achieve 100 percent usage would be during the evening and weekend hours.

The proposed Shore Galleries facility will provide adequate parking for its customers. This should be welcomed since the "Business Park Owner/Tenant Survey" that was conducted during the TIF study for the Northeast Business Park concluded that parking was a problem for half the businesses in the area.

Conclusions:
Based on our evaluation of the projected parking required for the Shore Galleries facility the proposed use is a good fit for the location. Projected site generated traffic during the peak hours on the adjacent streets is extremely low and will allow for vehicles entering and exiting to safely make their movements. We do not anticipate any significant impact on the existing traffic flow along North Central Park Avenue or impact the parking lots of neighboring businesses or their ability to use the municipal parking lots in the area.

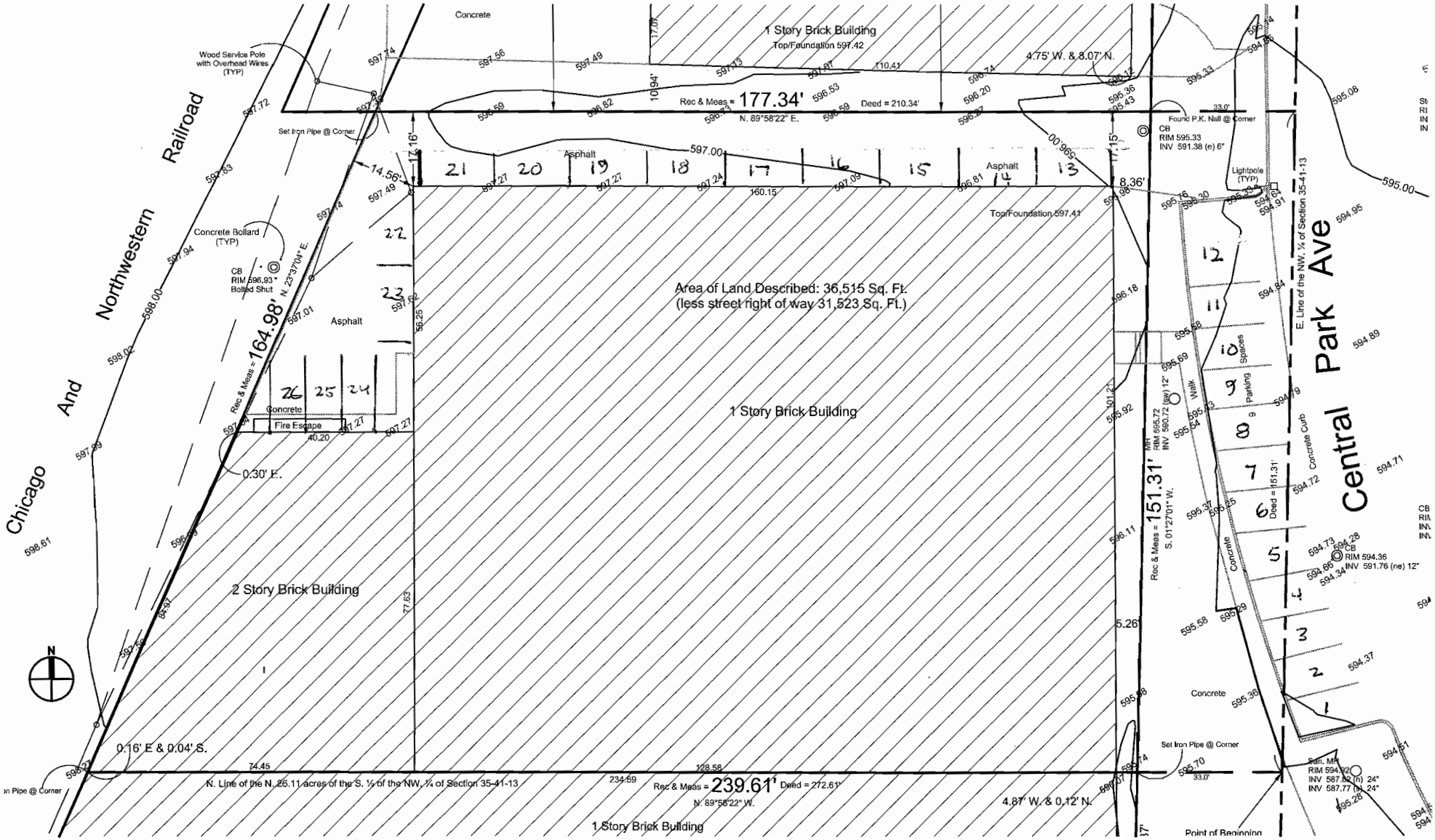
The proposed facility will also assist the Village in achieving one of the objectives of the Village of Lincolnwood Strategic Planning Report "attracting and developing business" as this is a business that will generate retail sales which will benefit the community.

Respectfully submitted,



Mark S. Olesen, P.E.
Ament, Inc.


MUNICIPAL PARKING LOT
80 SPACES
MUNICIPAL PARKING
15 SPACES
ECONOCARE
SHORE
GALLERIES
RAVENSWOOD
STUDIOS
MUNICIPAL PARKING LOT
25 SPACES
© 2012 Google
42°00'28.55" N 87°43'01.02" W elev 595 ft



Shore Galleries

SITE PLAN

4.10.2012

CODA LLC.

6590 CENTRAL PARK AVE.,
LINCOLNWOOD, IL

1" = 20'-0"

A100

VILLAGE OF LINCOLNWOOD REVENUE FOR SHOOTING RANGE AND PERCENTAGE OF RETAIL TAX
SHORE GALLERIES LOCATED AT 6950 CENTRAL PARK LINCOLNWOOD, IL
PERMIT FEE VS. 5% TAX
NET ADDITIONAL TAXES

16 POSITION:

NUMBER OF PATRONS	61472	46104	30736	15368
CAPACITY	100%	75%	50%	25%
REVENUE	$ 1,352,384.00	$ 1,014,288.00	$ 676,192.00	$ 338,096.00
*DIRECT REVENUE FOR THE VILLAGE OF LINCOLNWOOD	**$ 122,944.00**	**$ 92,208.00**	**$ 61,472.00**	**$ 30,736.00**
**DIRECT REVENUE FOR THE VILLAGE OF LINCOLNWOOD	**$ 67,619.20**	**$ 50,714.40**	**$ 33,809.60**	**$ 16,904.80**

15 POSITIONS

NUMBER OF PATRONS	57630	43222.5	28815	14407.5
CAPACITY	100%	75%	50%	25%
REVENUE	$ 1,267,860.00	$ 950,895.00	$ 633,930.00	$ 316,965.00
*DIRECT REVENUE FOR THE VILLAGE OF LINCOLNWOOD	**$ 115,260.00**	**$ 86,445.00**	**$ 57,630.00**	**$ 28,815.00**
**DIRECT REVENUE FOR THE VILLAGE OF LINCOLNWOOD	**$ 63,393.00**	**$ 47,544.75**	**$ 31,696.50**	**$ 15,848.25**

14 POSITIONS

NUMBER OF PATRONS	53788	40341	26894	13447
CAPACITY	100%	75%	50%	25%
REVENUE	$ 1,183,336.00	$ 887,502.00	$ 591,668.00	$ 295,834.00
*DIRECT REVENUE FOR THE VILLAGE OF LINCOLNWOOD	**$ 107,576.00**	**$ 80,682.00**	**$ 53,788.00**	**$ 26,894.00**
**DIRECT REVENUE FOR THE VILLAGE OF LINCOLNWOOD	**$ 59,166.80**	**$ 44,375.10**	**$ 29,583.40**	**$ 14,791.70**

NET ADDITONAL TAXES TO THE VILLAGE OF LINCOLNWOOD
1% of Other Retail Sales That are Taxable $30,000.00
9% of Property Taxes $ 4,500.00
5% Utility Tax $5,000.00
6% Telecommunication Tax $800.00

TOTAL NET ADDITONAL TAXES ABOVE RANGE FEE. **$ 40,300.00**

* A FEE OF $2.00 WILL BE CHARGED TO EACH PATRON PER VISIT.
** OR A 5% TAX WILL BE ADDED TO EACH PATRON PER VIST.
CALCULATIONS ARE BASED ON A 365 DAY CALENDAR.
REVENUE IS BASED ON THE AVERAGE CHARGE OF $22.00 PER HOUR.
INCREASE IN RETAIL SALES TAX ARE BEST ESTIMATES

At 100% capacity using sixteen positions with a $ 2.00 permit fee, plus additional taxes above the range fee. The Village of Lincolnwood would benefit. **$ 163,244.00**
All numbers are subject to change without notice. ***NET PER YEAR***

Shooting Range Sound Isolation

Shore Galleries
6950 N. Central Park Avenue
Lincolnwood, IL

14 August 2012

David Braslau Associates, Inc.
6603 Queen Ave. S. Suite N
Richfield, MN 55423
david@braslau.com

Introduction

The objectives of this report are

-To review the Spinnaker feasibility report and to build on that report.

-To identify a range of hand weapons that could be used the range with associated sound levels from and extensive data base.

-To review the SoundFlow results and compare with a more basic model that can also address potential structural coupling effects on performance.

-To confirm the proposed design or recommend measures needed to maintain the high transmission loss values predicted by the SoundFlow model.

-To demonstrate, that with attention to details, the 60 dBA limit of the ordinance can be achieved.

Proposed Layout and Design

Layout of the two shooting ranges in Shore Galleries is shown on Figure 1.

Of primary interest in this noise assessment is the long range which is adjacent to the wall separating Shore Galleries from Ravenswood Studio. This range is outlined with a dashed red line.

If it can be demonstrated that the Lincolnwood zoning noise limit of 60 dBA can be met with weapons fired in long range, then it should also be met in the short range which is separated from the Ravenswood Studio the long range space.

Eight shooting stalls are proposed for the long range, each 42 inches in width.

It is assumed that sound absorption material will be used where feasible within the shooting ranges.

Figure 2 shows the existing wall section with the addition of a new concrete-filled concrete block wall, separated from the existing wall by 2' 9". The structural ceiling height is 14 feet. Two layers 5/8" gypsum board will be attached to the bottom of joists, which are 14 inches deep. Thus the new gypsum ceiling height will be just under 13 feet. The new concrete wall will extended up to the gypsum board ceiling.

Figure 1 Shooting Range Layout

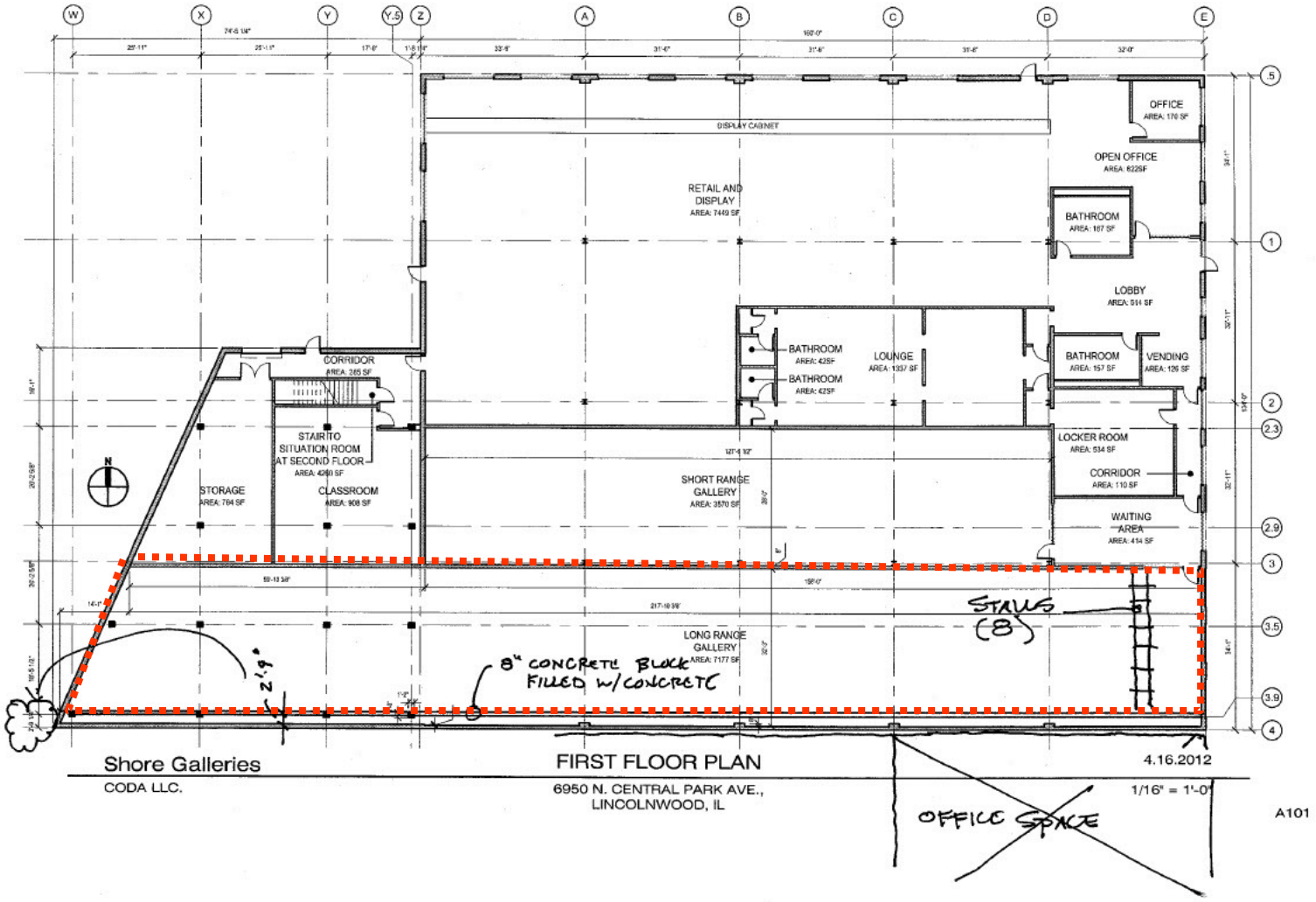
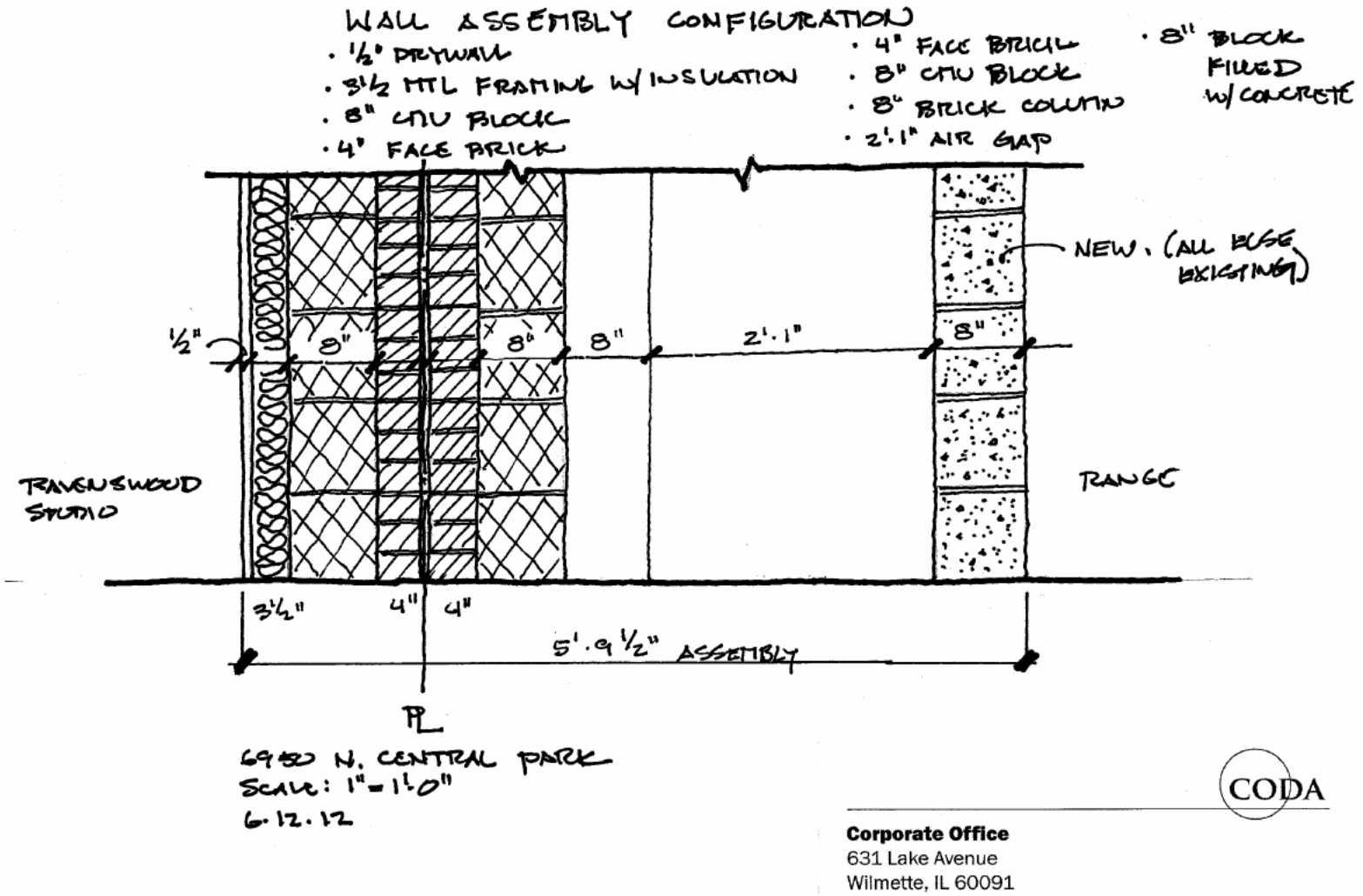


Figure 2 Existing Wall Section with Proposed New Wall



CODA

Corporate Office
631 Lake Avenue
Wilmette, IL 60091

Firearm Sound Levels

A review of an extensive data base developed in Denmark for use with European Union noise directives has been used to establish reliable sound levels weapons to be used in the proposed range. Of special interest is the AR15 rifle to be used most frequently in the long firing range. The AR15 is a civilian version of the M16 rifle contained in the data base.

In addition to data for the AR15 sound levels, data have been collected for three other rifles including one of the highest sound levels, and for four pistols including the commonly used S&W 357 magnum handgun which is one of the loudest commonly used in the United States, and the Sig Saure 9mm pistol which has one of the highest sound levels for pistols. These are listed in Table 1.

The data based includes octave band levels, the A-Weighted equivalent levels (LAE) used in community noise studies and unweighted peak levels in shooter hearing protection studies. All readings are specified at 10 m from the breach at 0, 45, 90, 135, and 180 degrees from the firing direction. The 45 degree data have been used here which are exceeded only by the 0 degree level, since this is the highest level to which the side wall is exposed.

The A-weighted equivalent levels of the data based are increased by 7 dBA to yield the maximum sound level referenced in the zoning code, based upon a previous comparative study of gunfire sound level metrics.

Table 1 Selected Weapons for Possible Analysis

RIFLES

Weapon	Caliber	Ammunition	LAE	LA max	Lp,peak
Rifle M/87 (precision)	7,62mm	7,62mm sharp M/75	110.8	117.8	149.5
Rifle ('gevær') M/95	5,56 mm	5,56 mm PPT M/95	109.9	116.9	146.9
Rifle AK 47 7,62x39	7,62mm	Laupa 7,62x39 sharp	109.1	116.1	148.8
Rifle (aut.)Colt M/16-A2	5,56mm	5,56mm sharp	107.4	114.4	149.2

HANDGUNS

Weapon	Caliber	Ammunition	LAE	LA max	Lp,peak
Sig-Sauer 228 Police	9mm	Action 3, 9mmx19 Sintox	108.8	115.8	146.3
Glock 17/ 9mm	9mm	Norma 9mm Luger safety	107.4	114.4	144.9
Smith&Wesson cal.357 Magnum	cal.357	cal.357 Magnum 10,2g soft point flat nose	106.9	113.9	144.1
Smith&Wesson cal.357 Magnum	cal.357	Norma .38 special	98.4	105.4	133.7

Selected-Weapons.xls Sheet Sorted

Firearm Sound Levels (continued)

An initial comparison of two rifles and two pistols has been made. This includes the commonly used AR15 and the loudest M87 rifles, and the commonly use S&W 357 magnum and the loudest Sig Saure 9 mm pistol.

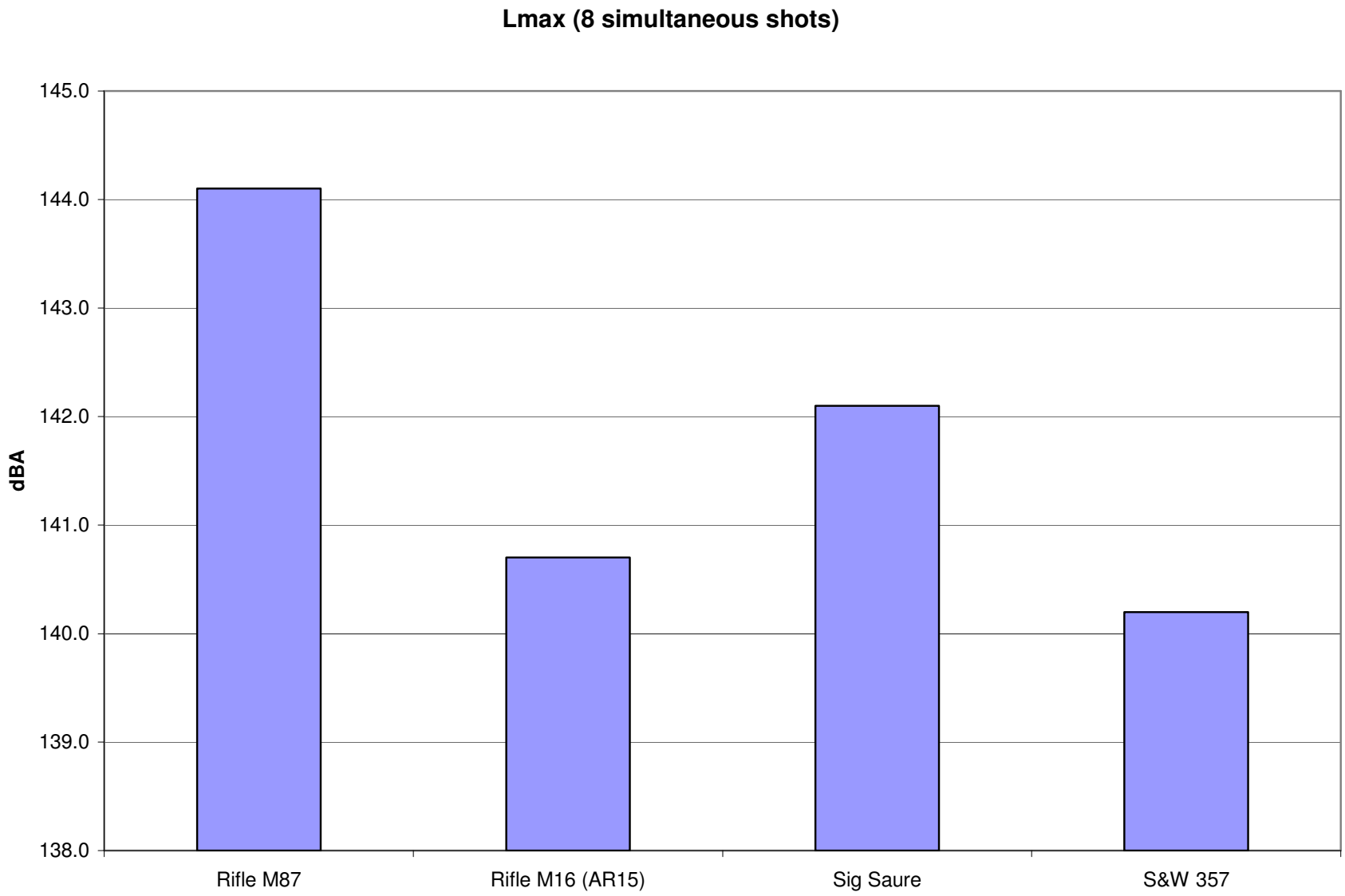
A comparison of the estimated Lmax sound level at the wall, assuming simultaneous firing of all eight weapons at once has been made, assuming there are no barriers between the firing stalls to reduce sound level. Since the stalls are perpendicular the new wall, the sound level of each weapon decreases in distance shown on Table 2.

Table 2 Distance of Firing Lines from the Wall

Stall	Distance from wall (ft)
1	1.75
2	5.25
3	8.75
4	12.25
5	15.75
6	19.25
7	22.75
8	26.25

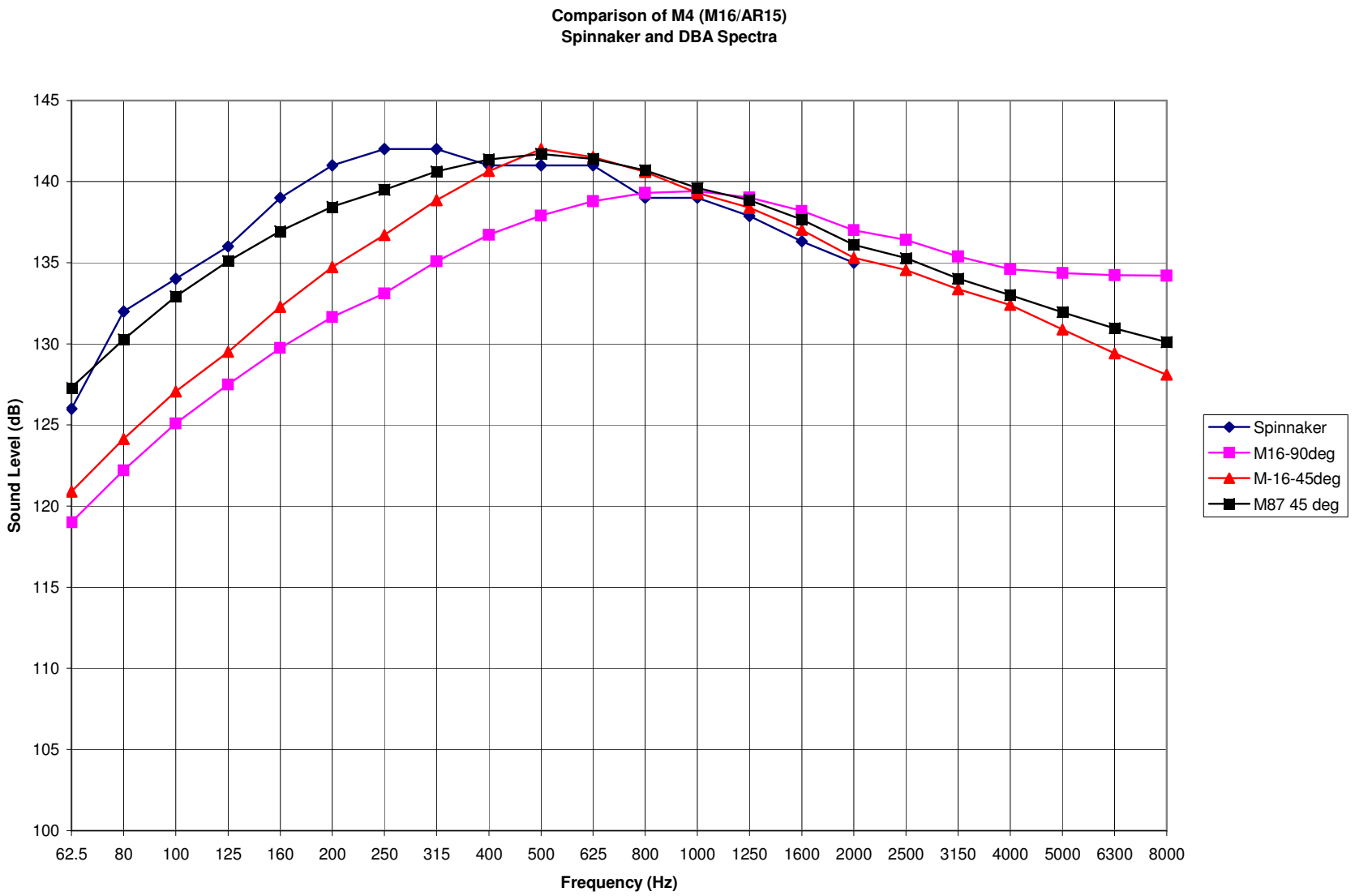
A comparison of these Lmax levels for the selected rifles and handguns is shown on Figure 3. A comparison of the one-third octave band spectra for files (estimated from the octave band data) with the previously assumed sound level spectrum by Spinnaker is shown on Figure 4. To show the average and maximum expected levels at the Ravenswood Studio, the remainder of this report will address sound levels from the AR15 and M87 rifles. Estimated levels at the proposed gypsum ceiling below the joists are 137 dBA for the M16 rifle and 142 dBA for the M87 rifle.

Figure 3 Comparison of Lmax at the Adjacent Wall



Selected-Weapons.xls C-Lmax

Figure 4 Comparison of Rifle One-Third Octave Band Spectra



Transmission Loss

The SoundFlow model used by Spinnaker if a state-of-the-art computer model that can analyze partitions with multiple layers. Other common models that predict transmission loss for complex structures are limited to two primary layers.

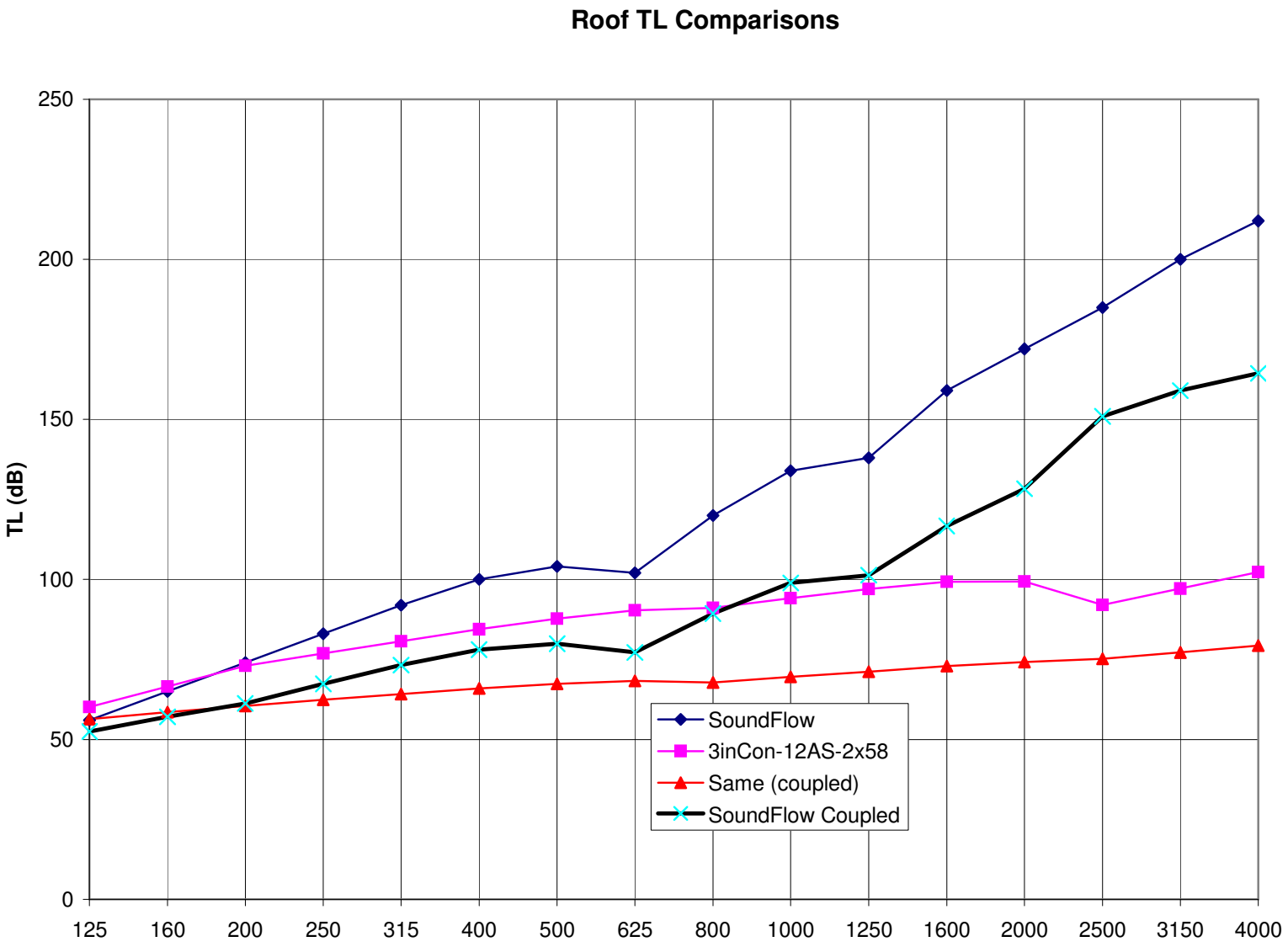
One limitation of the SoundFlow model is that it currently does not account for coupling between any of the layers which can reduce the transmission loss. The other models include the coupling option and can provide some guidance on how the SoundFlow data can be adjusted to account for coupling.

The wall will be a self standing wall 2'9" from the existing wall. If the wall is braced or supported by the joists, it could be coupled to the existing wall. By keeping this vibration isolated from the joists, the wall will remained uncoupled and the SoundFlow estimates of through-the-wall levels should be reasonable.

The two layers of gypsum board attached to the joists would be coupled to the roof. A simple two-component model was used to approximate the ceiling transmission loss uncoupled and coupled. This was then used to adjust the SoundFlow data to a coupled situation. A comparison between the simple model and SoundFlow adjusted for coupling is shown on Figure 5.

.

Figure 5 Comparison of Transmission Loss Spectra for the Roof



TLSTCvsSoundFlow.xls C-RoofComp

Estimated Ravenswood Sound Levels

Estimated Lmax levels in the Ravenswood Studio from the four weapons compared on Figure 3, using the transmission loss curves that have been evaluated using the uncoupled SoundFlow values for the wall and uncoupled and coupled SoundFlow and TLSTC model values for the roof. These are presented in the following figures:

Figure 6 Estimated Level via the Wall for the M16 and M87 Rifles (8 simultaneous)

The predicted uncoupled levels are very close for the two models, while the coupled values are somewhat better for the adjusted SoundFlow model results.

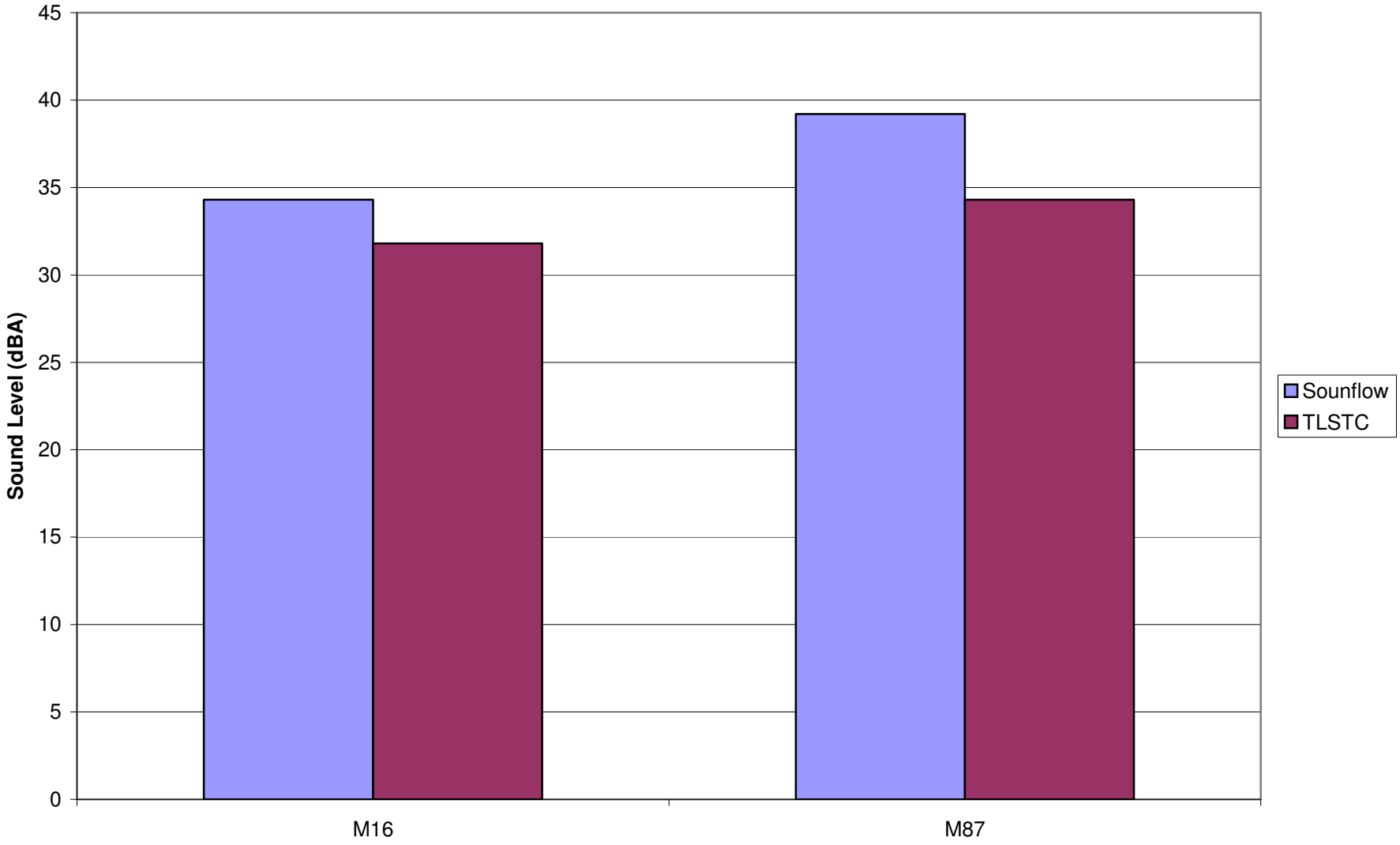
Figure 7 Estimated Level on the Roof for the M16 (8 simultaneous)

The levels via the roof are considerably higher with both models and are at or close to 60 dBA. However, the level will be lower at the Ravenswood Studio as discussed below.

Figure 8 Estimated Level on the Roof for the M87 (8 simultaneous)

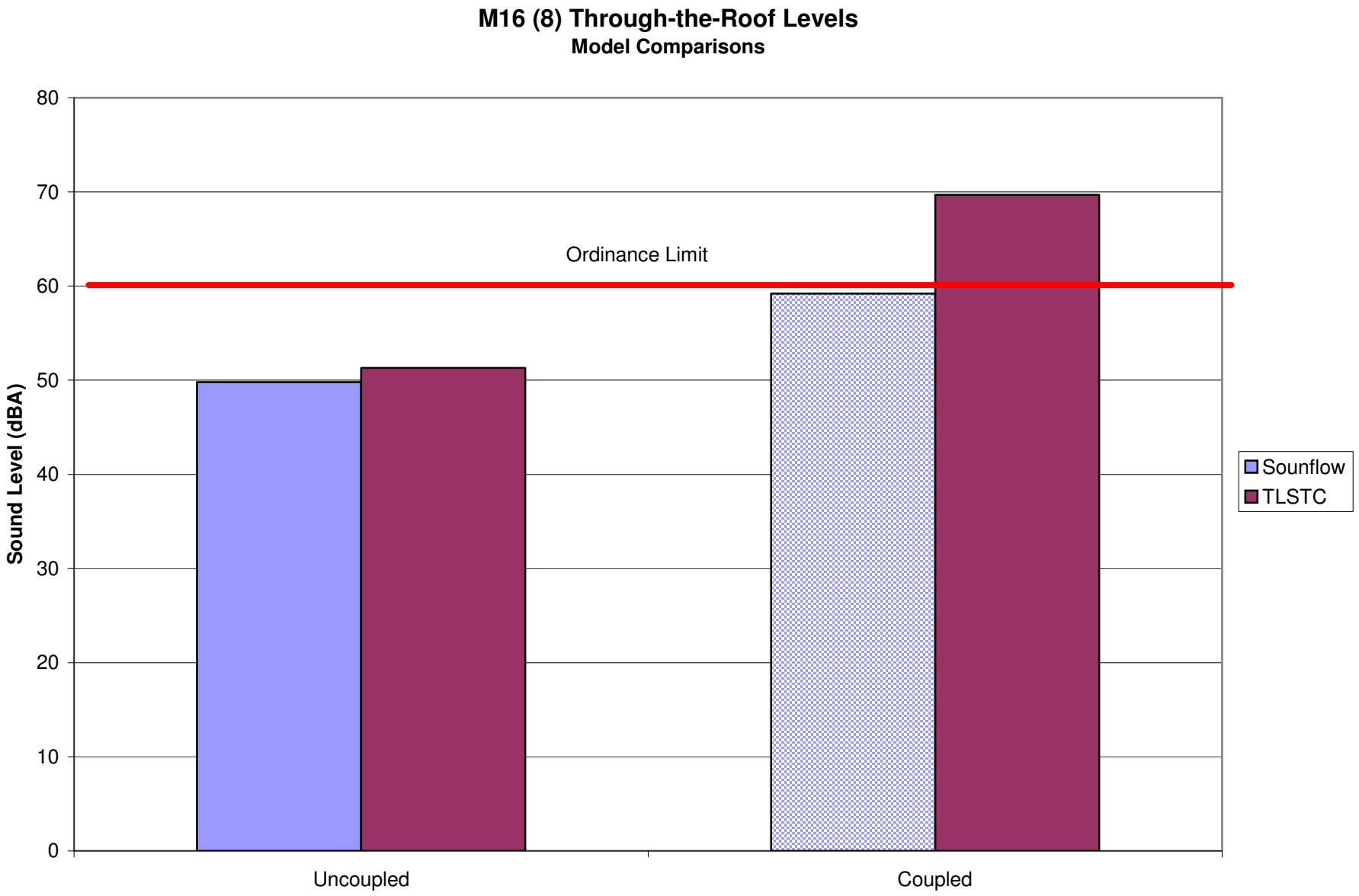
The predicted roof level is above the 60 dBA limit in the uncoupled case and similar to the wall path for the coupled case. However, the level at the Ravenswood Studio will be lower as discussed below.

Figure 6 Estimated Ravenswood Level via the Wall for M16 and M87 Rifles



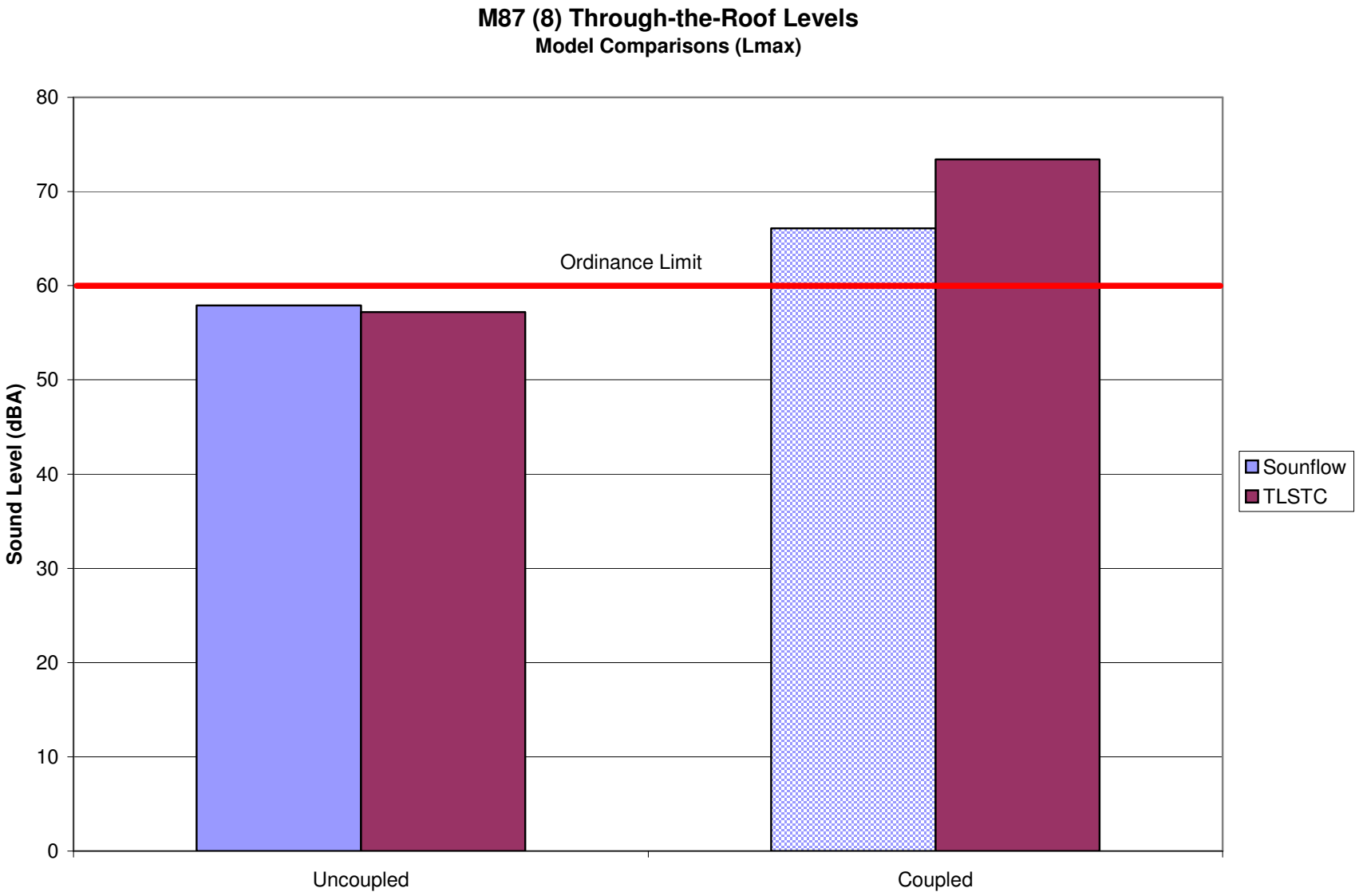
TLSTCvsSoundFlow.xls C-M16(8) via Wall

Figure 7 Estimated Ravenswood Level via the Roof for M16 Rifles



TLSTCvsSoundFlow.xls C-M16(8) via Roof

Figure 8 Estimated Ravenswood Level via the Roof for M87 Rifles



TLSTCvsSoundFlow.xls C-M87(8) via Roof

Estimated Ravenswood Studio Sound Levels (continued)

As noted in the Spinnaker feasibility study, noise through the roof of the shooting range must still propagate to the Ravenswood Studio building roof and then penetrate the roof into the studio. A somewhat more conservative estimate of sound level decay could be made assuming that the sound source is an narrow area or line source as seen by the adjacent building and there decays by 4.5 dBA if unimpeded and 2.25 or 2 dBA over a plane surface. The sound level would decay then only by 8 instead of 12 dBA.

For the M87, the worst case coupled level at the Shore Galleries roof would be 71 dBA and 63 dBA at the skylight. If the skylights account for 5% if the roof area with a transmission loss of only 15 dBA but the roof has a transmission loss of 20 dBA, the composite loss is still 20 dBA. Therefore inside the Ravenswood Studio, a level of 63-20=43 could be expected which is below the 60 dBA limit..

Conclusions and Recommendations

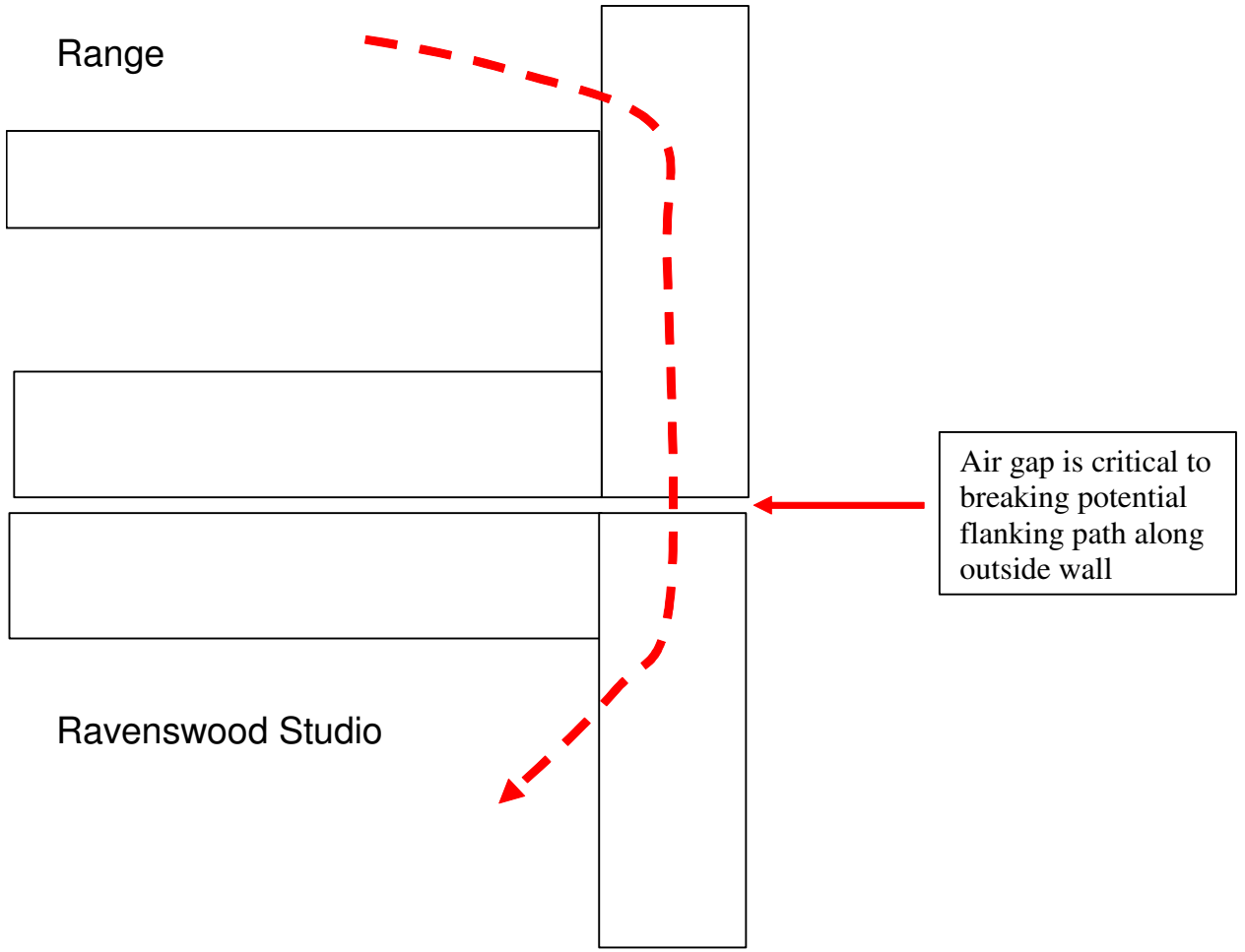
Sound levels from an extensive data based on hand weapon sound levels have been used in lieu of the shooter's ear data upon which the Spinnaker study was based. One of rifles with the highest sound level has been evaluated along with the most common expected at the long range which is the AR15 or civilian model of the M16 rifle.

The wall-to-wall sound levels estimated by Spinnaker should be valid assuming the new concrete wall is vibration isolated from the joists and extending to the new gypsum ceiling below the joists. A gap between the new wall and gypsum ceiling should be filled with a non-setting acoustical caulk.

The roof-to-roof sound levels estimated Spinnaker did not account for coupling of the gypsum ceiling and roof structure which can reduce the estimated transmission loss by about 8 dBA. However, even conservative assumptions as to transmission of sound from the Shore Galleries roof into the Ravenswood Studio, indicate that the shoot range sound levels will fall below the 60 dBA limit. Therefore, the gypsum ceiling can be mounted directly on the ceiling joists and do no have to be isolated.

A potential concern relates to the exterior building walls separating Shore Galleries from Ravenswood Studio. An air space separating these walls should minimize any sound transmission along this flanking path (shown schematically on Figure 9).

The assumption use here is that weapons are being fired simultaneously from all of the eight stalls, which has a very low probability of ever occurring. However, the level that can be expected from just a weapon in the stall immediately adjacent to the wall is only slightly lower that all weapons firing at the same time, so that the levels evaluated here could be expected.


Range
Air gap is critical to breaking potential flanking path along outside wall
Ravenswood Studio

OSHA 29 CFR 1926.62

• **Part Number:**	1926
• **Part Title:**	Safety and Health Regulations for Construction
• **Subpart:**	D
• **Subpart Title:**	Occupational Health and Environmental Controls
• **Standard Number:**	1926.62
• **Title:**	Lead
• **Appendix:**	A , B , C , D

1926.62(a)
"Scope". This section applies to all construction work where an employee may be occupationally exposed to lead. All construction work excluded from coverage in the general industry standard for lead by 29 CFR 1910.1025(a)(2) is covered by this standard. Construction work is defined as work for construction, alteration and/or repair, including painting and decorating. It includes but is not limited to the following:
1926.62(a)(1)
Demolition or salvage of structures where lead or materials containing lead are present;
1926.62(a)(2)
Removal or encapsulation of materials containing lead;
1926.62(a)(3)
New construction, alteration, repair, or renovation of structures, substrates, or portions thereof, that contain lead, or materials containing lead;
1926.62(a)(4)
Installation of products containing lead;
1926.62(a)(5)
Lead contamination/emergency cleanup;
1926.62(a)(6)
Transportation, disposal, storage, or containment of lead or materials containing lead on the site or location at which construction activities are performed, and
1926.62(a)(7)
Maintenance operations associated with the construction activities described in this paragraph.
1926.62(b)
"Definitions".

"Action level" means employee exposure, without regard to the use of respirators, to an airborne concentration of lead of 30 micrograms per cubic meter of air (30 ug/m(3)) calculated as an 8-hour time-weighted average (TWA).

"Assistant Secretary" means the Assistant Secretary of Labor for Occupational Safety and Health, U.S. Department of Labor, or designee.

"Competent person" means one who is capable of identifying existing and predictable lead hazards in the surroundings or working conditions and who has authorization to take prompt corrective measures to eliminate them.

"Director" means the Director, National Institute for Occupational Safety and Health (NIOSH), U.S. Department of Health and Human Services, or designee.

"Lead" means metallic lead, all inorganic lead compounds, and organic lead soaps. Excluded from this definition are all other organic lead compounds.

"This section" means this standard.
1926.62(c)
"Permissible exposure limit".
1926.62(c)(1)
The employer shall assure that no employee is exposed to lead at concentrations greater than fifty micrograms per cubic meter of air (50 ug/m(3)) averaged over an 8-hour period.

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1926.62(c)(2)
If an employee is exposed to lead for more than 8 hours in any work day the employees' allowable exposure, as a time weighted average (TWA) for that day, shall be reduced according to the following formula:

Allowable employee exposure (in ug/m(3)) = 400 divided by hours worked in the day.
1926.62(c)(3)
When respirators are used to limit employee exposure as required under paragraph (c) of this section and all the requirements of paragraphs (e)(1) and (f) of this section have been met, employee exposure may be considered to be at the level provided by the protection factor of the respirator for those periods the respirator is worn. Those periods may be averaged with exposure levels during periods when respirators are not worn to determine the employee's daily TWA exposure.
1926.62(d)
"Exposure assessment".
1926.62(d)(1)
"General".
1926.62(d)(1)(i)
Each employer who has a workplace or operation covered by this standard shall initially determine if any employee may be exposed to lead at or above the action level.
1926.62(d)(1)(ii)
For the purposes of paragraph (d) of this section, employee exposure is that exposure which would occur if the employee were not using a respirator.
1926.62(d)(1)(iii)
With the exception of monitoring under paragraph (d)(3), where monitoring is required under this section, the employer shall collect personal samples representative of a full shift including at least one sample for each job classification in each work area either for each shift or for the shift with the highest exposure level.
1926.62(d)(1)(iv)
Full shift personal samples shall be representative of the monitored employee's regular, daily exposure to lead.
1926.62(d)(2)
"Protection of employees during assessment of exposure".
1926.62(d)(2)(i)
With respect to the lead related tasks listed in this paragraph (d)(2)(i) of this section, where lead is present, until the employer performs an employee exposure assessment as required in paragraph (d) of this section and documents that the employee performing any of the listed tasks is not exposed above the PEL, the employer shall treat the employee as if the employee were exposed above the PEL, and not in excess of ten (10) times the PEL, and shall implement employee protective measures prescribed in paragraph (d)(2)(v) of this section. The tasks covered by this requirement are:
1926.62(d)(2)(i)(A)
Where lead containing coatings or paint are present: Manual demolition of structures (e.g, dry wall), manual scraping, manual sanding, heat gun applications, and power tool cleaning with dust collection systems;
1926.62(d)(2)(i)(B)
Spray painting with lead paint
1926.62(d)(2)(ii)
In addition, with regard to tasks not listed in paragraph (d)(2)(i), where the employer has any reason to believe that an employee performing the task may be exposed to lead in excess of the PEL, until the employer performs an employee exposure assessment as required by paragraph (d) of this section and documents that the employee's lead exposure is not above the PEL the employer shall treat the employee as if the employee were exposed above the PEL and shall implement employee protective measures as prescribed in paragraph (d)(2)(v) of this section.
1926.62(d)(2)(iii)
With respect to the tasks listed in this paragraph (d)(2)(iii) of this section, where lead is present, until the employer performs an employee exposure assessment as required in paragraph (d) of this section, and documents that the employee performing any of the listed

tasks is not exposed in excess of 500 ug/m(3), the employer shall treat the employee as if the employee were exposed to lead in excess of 500 ug/m(3) and shall implement employee protective measures as prescribed in paragraph (d)(2)(v) of this section. Where the employer does establish that the employee is exposed to levels of lead below 500 ug/m(3), the employer may provide the exposed employee with the appropriate respirator prescribed for such use at such lower exposures, in accordance with Table 1 of this section. The tasks covered by this requirement are:

1926.62(d)(2)(iii)(A)

Using lead containing mortar; lead burning

1926.62(d)(2)(iii)(B)

Where lead containing coatings or paint are present: rivet busting; power tool cleaning without dust collection systems; cleanup activities where dry expendable abrasives are used; and abrasive blasting enclosure movement and removal.

1926.62(d)(2)(iv)

With respect to the tasks listed in this paragraph (d)(2)(iv) of this section, where lead is present, until the employer performs an employee exposure assessment as required in paragraph (d) of this section and documents that the employee performing any of the listed tasks is not exposed to lead in excess of 2,500 ug/m(3) (50 x PEL), the employer shall treat the employee as if the employee were exposed to lead in excess of 2,500 ug/m(3) and shall implement employee protective measures as prescribed in paragraph (d)(2)(v) of this section. Where the employer does establish that the employee is exposed to levels of lead below 2,500 ug/m(3), the employer may provide the exposed employee with the appropriate respirator prescribed for use at such lower exposures, in accordance with Table I of this section. Interim protection as described in this paragraph is required where lead containing coatings or paint are present on structures when performing:

1926.62(d)(2)(iv)(A)

Abrasive blasting,

1926.62(d)(2)(iv)(B)

Welding,

1926.62(d)(2)(iv)(C)

Cutting, and

1926.62(d)(2)(iv)(D)

Torch burning.

1926.62(d)(2)(v)

Until the employer performs an employee exposure assessment as required under paragraph (d) of this section and determines actual employee exposure, the employer shall provide to employees performing the tasks described in paragraphs (d)(2)(i), (d)(2)(ii), (d)(2)(iii) and (d)(2)(iv) of this section with interim protection as follows:

1926.62(d)(2)(v)(A)

Appropriate respiratory protection in accordance with paragraph (f) of this section.

1926.62(d)(2)(v)(B)

Appropriate personal protective clothing and equipment in accordance with paragraph (g) of this section.

1926.62(d)(2)(v)(C)

Change areas in accordance with paragraph (i)(2) of this section.

1926.62(d)(2)(v)(D)

Hand washing facilities in accordance with paragraph (i)(5) of this section.

1926.62(d)(2)(v)(E)

Biological monitoring in accordance with paragraph (j)(1)(i) of this section, to consist of blood sampling and analysis for lead and zinc protoporphyrin levels, and

1926.62(d)(2)(v)(F)

Training as required under paragraph (l)(1)(i) of this section regarding 29 CFR 1926.59, Hazard Communication; training as required under paragraph (1)(2)(iii) of this section, regarding use of respirators; and training in accordance with 29 CFR 1926.21, Safety training and education.

1926.62(d)(3)

"Basis of initial determination".

1926.62(d)(3)(i)

Except as provided under paragraphs (d)(3)(iii) and (d)(3)(iv) of this section the employer shall monitor employee exposures and shall base initial determinations on the employee

exposure monitoring results and any of the following, relevant considerations:

1926.62(d)(3)(i)(A)

Any information, observations, or calculations which would indicate employee exposure to lead;

1926.62(d)(3)(i)(B)

Any previous measurements of airborne lead; and

1926.62(d)(3)(i)(C)

Any employee complaints of symptoms which may be attributable to exposure to lead.

1926.62(d)(3)(ii)

Monitoring for the initial determination where performed may be limited to a representative sample of the exposed employees who the employer reasonably believes are exposed to the greatest airborne concentrations of lead in the workplace.

1926.62(d)(3)(iii)

Where the employer has previously monitored for lead exposures, and the data were obtained within the past 12 months during work operations conducted under workplace conditions closely resembling the processes, type of material, control methods, work practices, and environmental conditions used and prevailing in the employer's current operations, the employer may rely on such earlier monitoring results to satisfy the requirements of paragraphs (d)(3)(i) and (d)(6) of this section if the sampling and analytical methods meet the accuracy and confidence levels of paragraph (d)(10) of this section.

1926.62(d)(3)(iv)

Where the employer has objective data, demonstrating that a particular product or material containing lead or a specific process, operation or activity involving lead cannot result in employee exposure to lead at or above the action level during processing, use, or handling, the employer may rely upon such data instead of implementing initial monitoring.

1926.62(d)(3)(iv)(A)

The employer shall establish and maintain an accurate record documenting the nature and relevancy of objective data as specified in paragraph (n)(4) of this section, where used in assessing employee exposure in lieu of exposure monitoring.

1926.62(d)(3)(iv)(B)

Objective data, as described in this paragraph (d)(3)(iv) of this section, is not permitted to be used for exposure assessment in connection with paragraph (d)(2) of this section.

1926.62(d)(4)

"Positive initial determination and initial monitoring".

1926.62(d)(4)(i)

Where a determination conducted under paragraphs (d)(1), (2) and (3) of this section shows the possibility of any employee exposure at or above the action level the employer shall conduct monitoring which is representative of the exposure for each employee in the workplace who is exposed to lead.

1926.62(d)(4)(ii)

Where the employer has previously monitored for lead exposure, and the data were obtained within the past 12 months during work operations conducted under workplace conditions closely resembling the processes, type of material, control methods, work practices, and environmental conditions used and prevailing in the employer's current operations, the employer may rely on such earlier monitoring results to satisfy the requirements of paragraph (d)(4)(i) of this section if the sampling and analytical methods meet the accuracy and confidence levels of paragraph (d)(10) of this section.

1926.62(d)(5)

"Negative initial determination". Where a determination, conducted under paragraphs (d)(1), (2), and (3) of this section is made that no employee is exposed to airborne concentrations of lead at or above the action level the employer shall make a written record of such determination. The record shall include at least the information specified in paragraph (d)(3)(i) of this section and shall also include the date of determination, location within the worksite, and the name and social security number of each employee monitored.

1926.62(d)(6)

"Frequency".

1926.62(d)(6)(i)

If the initial determination reveals employee exposure to be below the action level further exposure determination need not be repeated except as otherwise provided in paragraph

(d)(7) of this section.

1926.62(d)(6)(ii)

If the initial determination or subsequent determination reveals employee exposure to be at or above the action level but at or below the PEL the employer shall perform monitoring in accordance with this paragraph at least every 6 months. The employer shall continue monitoring at the required frequency until at least two consecutive measurements, taken at least 7 days apart, are below the action level at which time the employer may discontinue monitoring for that employee except as otherwise provided in paragraph (d)(7) of this section.

1926.62(d)(6)(iii)

If the initial determination reveals that employee exposure is above the PEL the employer shall perform monitoring quarterly. The employer shall continue monitoring at the required frequency until at least two consecutive measurements, taken at least 7 days apart, are at or below the PEL but at or above the action level at which time the employer shall repeat monitoring for that employee at the frequency specified in paragraph (d)(6)(ii) of this section, except as otherwise provided in paragraph (d)(7) of this section. The employer shall continue monitoring at the required frequency until at least two consecutive measurements, taken at least 7 days apart, are below the action level at which time the employer may discontinue monitoring for that employee except as otherwise provided in paragraph (d)(7) of this section.

1926.62(d)(7)

"Additional exposure assessments". Whenever there has been a change of equipment, process, control, personnel or a new task has been initiated that may result in additional employees being exposed to lead at or above the action level or may result in employees already exposed at or above the action level being exposed above the PEL, the employer shall conduct additional monitoring in accordance with this paragraph.

1926.62(d)(8)

"Employee notification".

1926.62(d)(8)(i)

The employer must, as soon as possible but no later than 5 working days after the receipt of the results of any monitoring performed under this section, notify each affected employee of these results either individually in writing or by posting the results in an appropriate location that is accessible to employees.

1926.62(d)(8)(ii)

Whenever the results indicate that the representative employee exposure, without regard to respirators, is at or above the PEL the employer shall include in the written notice a statement that the employees exposure was at or above that level and a description of the corrective action taken or to be taken to reduce exposure to below that level.

1926.62(d)(9)

"Accuracy of measurement". The employer shall use a method of monitoring and analysis which has an accuracy (to a confidence level of 95 percent) of not less than plus or minus 25 percent for airborne concentrations of lead equal to or greater than 30 ug/m(3).

1926.62(e)

"Methods of compliance"

1926.62(e)(1)

"Engineering and work practice controls." The employer shall implement engineering and work practice controls, including administrative controls, to reduce and maintain employee exposure to lead to or below the permissible exposure limit to the extent that such controls are feasible. Wherever all feasible engineering and work practices controls that can be instituted are not sufficient to reduce employee exposure to or below the permissible exposure limit prescribed in paragraph (c) of this section, the employer shall nonetheless use them to reduce employee exposure to the lowest feasible level and shall supplement them by the use of respiratory protection that complies with the requirements of paragraph (f) of this section.

1926.62(e)(2)

"Compliance program".

1926.62(e)(2)(i)

Prior to commencement of the job each employer shall establish and implement a written

compliance program to achieve compliance with paragraph (c) of this section.

1926.62(e)(2)(ii)

Written plans for these compliance programs shall include at least the following:

1926.62(e)(2)(ii)(A)

A description of each activity in which lead is emitted; e.g. equipment used, material involved, controls in place, crew size, employee job responsibilities, operating procedures and maintenance practices;

1926.62(e)(2)(ii)(B)

A description of the specific means that will be employed to achieve compliance and, where engineering controls are required engineering plans and studies used to determine methods selected for controlling exposure to lead;

1926.62(e)(2)(ii)(C)

A report of the technology considered in meeting the PEL;

1926.62(e)(2)(ii)(D)

Air monitoring data which documents the source of lead emissions;

1926.62(e)(2)(ii)(E)

A detailed schedule for implementation of the program, including documentation such as copies of purchase orders for equipment, construction contracts, etc.;

1926.62(e)(2)(ii)(F)

A work practice program which includes items required under paragraphs (g), (h) and (i) of this section and incorporates other relevant work practices such as those specified in paragraph (e)(5) of this section;

1926.62(e)(2)(ii)(G)

An administrative control schedule required by paragraph (e)(4) of this section, if applicable;

1926.62(e)(2)(ii)(H)

A description of arrangements made among contractors on multi-contractor sites with respect to informing affected employees of potential exposure to lead and with respect to responsibility for compliance with this section as set-forth in 1926.16.

1926.62(e)(2)(ii)(I)

Other relevant information.

1926.62(e)(2)(iii)

The compliance program shall provide for frequent and regular inspections of job sites, materials, and equipment to be made by a competent person.

1926.62(e)(2)(iv)

Written programs shall be submitted upon request to any affected employee or authorized employee representatives, to the Assistant Secretary and the Director, and shall be available at the worksite for examination and copying by the Assistant Secretary and the Director.

1926.62(e)(2)(v)

Written programs must be revised and updated at least annually to reflect the current status of the program.

1926.62(e)(3)

"Mechanical ventilation". When ventilation is used to control lead exposure, the employer shall evaluate the mechanical performance of the system in controlling exposure as necessary to maintain its effectiveness.

1926.62(e)(4)

"Administrative controls". If administrative controls are used as a means of reducing employees TWA exposure to lead, the employer shall establish and implement a job rotation schedule which includes:

1926.62(e)(4)(i)

Name or identification number of each affected employee;

1926.62(e)(4)(ii)

Duration and exposure levels at each job or work station where each affected employee is located; and

1926.62(e)(4)(iii)

Any other information which may be useful in assessing the reliability of administrative controls to reduce exposure to lead.

1926.62(e)(5)

The employer shall ensure that, to the extent relevant, employees follow good work practices such as described in Appendix B of this section.

1926.62(f)

Respiratory protection.

OSHA 29 CFR 1926.62

1926.62(f)(1)

General. For employees who use respirators required by this section, the employer must provide respirators that comply with the requirements of this paragraph. Respirators must be used during:

1926.62(f)(1)(i)

Periods when an employee's exposure to lead exceeds the PEL.

1926.62(f)(1)(ii)

Work operations for which engineering and work-practice controls are not sufficient to reduce employee exposures to or below the PEL.

1926.62(f)(1)(iii)

Periods when an employee requests a respirator.

1926.62(f)(1)(iv)

Periods when respirators are required to provide interim protection of employees while they perform the operations specified in paragraph (d)(2) of this section.

1926.62(f)(2)

Respirator program.

1926.62(f)(2)(i)

The employer must implement a respiratory protection program in accordance with 29 CFR 1910.134 (b) through (d) (except (d)(1)(iii)), and (f) through (m).

1926.62(f)(2)(ii)

If an employee has breathing difficulty during fit testing or respirator use, the employer must provide the employee with a medical examination in accordance with paragraph (j)(3)(i)(B) of this section to determine whether or not the employee can use a respirator while performing the required duty.

1926.62(f)(3)

Respirator selection.

1926.62(f)(3)(i)

Employers must:

1926.62(f)(3)(i)(A)

Select, and provide to employees, the appropriate respirators specified in paragraph (d)(3)(i)(A) of 29 CFR 1910.134.

1926.62(f)(3)(i)(B)

Provide employees with a full facepiece respirator instead of a half mask respirator for protection against lead aerosols that may cause eye or skin irritation at the use concentrations.

1926.62(f)(3)(i)(C)

Provide HEPA filters for powered and non-powered air-purifying respirators.

1926.62(f)(3)(ii)

The employer must provide a powered air-purifying respirator when an employee chooses to use such a respirator and it will provide adequate protection to the employee.

1926.62(g)

"Protective work clothing and equipment".

1926.62(g)(1)

"Provision and use". Where an employee is exposed to lead above the PEL without regard to the use of respirators, where employees are exposed to lead compounds which may cause

skin or eye irritation (e.g. lead arsenate, lead azide), and as interim protection for employees performing tasks as specified in paragraph (d)(2) of this section, the employer shall provide at no cost to the employee and assure that the employee uses appropriate protective work clothing and equipment that prevents contamination of the employee and the employee's garments such as, but not limited to:

1926.62(g)(1)(i)

Coveralls or similar full-body work clothing;

1926.62(g)(1)(ii)

Gloves, hats, and shoes or disposable shoe coverlets; and

1926.62(g)(1)(iii)

Face shields, vented goggles, or other appropriate protective equipment which complies with 1910.133 of this chapter.

1926.62(g)(2)

"Cleaning and replacement".

1926.62(g)(2)(i)

The employer shall provide the protective clothing required in paragraph (g)(1) of this section in a clean and dry condition at least weekly, and daily to employees whose exposure levels without regard to a respirator are over 200 ug/m(3) of lead as an 8-hour TWA.

1926.62(g)(2)(ii)

The employer shall provide for the cleaning, laundering, and disposal of protective clothing and equipment required by paragraph (g)(1) of this section.

1926.62(g)(2)(iii)

The employer shall repair or replace required protective clothing and equipment as needed to maintain their effectiveness.

1926.62(g)(2)(iv)

The employer shall assure that all protective clothing is removed at the completion of a work shift only in change areas provided for that purpose as prescribed in paragraph (i)(2) of this section.

1926.62(g)(2)(v)

The employer shall assure that contaminated protective clothing which is to be cleaned, laundered, or disposed of, is placed in a closed container in the change area which prevents dispersion of lead outside the container.

1926.62(g)(2)(vi)

The employer shall inform in writing any person who cleans or launders protective clothing or equipment of the potentially harmful effects of exposure to lead.

1926.62(g)(2)(vii)

The employer shall assure that the containers of contaminated protective clothing and equipment required by paragraph (g)(2)(v) of this section are labelled as follows:
Caution: Clothing contaminated with lead. Do not remove dust by blowing or shaking. Dispose of lead contaminated wash water in accordance with applicable local, state, or federal regulations.

1926.62(g)(2)(viii)

The employer shall prohibit the removal of lead from protective clothing or equipment by blowing, shaking, or any other means which disperses lead into the air.

1926.62(h)

"Housekeeping".

1926.62(h)(1)

"All surfaces shall be maintained as free as practicable of accumulations of lead".

1926.62(h)(2)

Clean-up of floors and other surfaces where lead accumulates shall wherever possible, be cleaned by vacuuming or other methods that minimize the likelihood of lead becoming airborne.

1926.62(h)(3)

Shoveling, dry or wet sweeping, and brushing may be used only where vacuuming or other equally effective methods have been tried and found not to be effective.

1926.62(h)(4)

Where vacuuming methods are selected, the vacuums shall be equipped with HEPA filters and used and emptied in a manner which minimizes the reentry of lead into the workplace.

1926.62(h)(5)

Compressed air shall not be used to remove lead from any surface unless the compressed air

is used in conjunction with a ventilation system designed to capture the airborne dust created by the compressed air.

1926.62(i)

"Hygiene facilities and practices."

1926.62(i)(1)

The employer shall assure that in areas where employees are exposed to lead above the PEL without regard to the use of respirators, food or beverage is not present or consumed, tobacco products are not present or used, and cosmetics are not applied.

1926.62(i)(2)

"Change areas".

1926.62(i)(2)(i)

The employer shall provide clean change areas for employees whose airborne exposure to lead is above the PEL, and as interim protection for employees performing tasks as specified in paragraph (d)(2) of this section, without regard to the use of respirators.

1926.62(i)(2)(ii)

The employer shall assure that change areas are equipped with separate storage facilities for protective work clothing and equipment and for street clothes which prevent cross-contamination.

1926.62(i)(2)(iii)

The employer shall assure that employees do not leave the workplace wearing any protective clothing or equipment that is required to be worn during the work shift.

1926.62(i)(3)

"Showers".

1926.62(i)(3)(i)

The employer shall provide shower facilities, where feasible, for use by employees whose airborne exposure to lead is above the PEL.

1926.62(i)(3)(ii)

The employer shall assure, where shower facilities are available, that employees shower at the end of the work shift and shall provide an adequate supply of cleansing agents and towels for use by affected employees.

1926.62(i)(4)

"Eating facilities".

1926.62(i)(4)(i)

The employer shall provide lunchroom facilities or eating areas for employees whose airborne exposure to lead is above the PEL, without regard to the use of respirators.

1926.62(i)(4)(ii)

The employer shall assure that lunchroom facilities or eating areas are as free as practicable from lead contamination and are readily accessible to employees.

1926.62(i)(4)(iii)

The employer shall assure that employees whose airborne exposure to lead is above the PEL, without regard to the use of a respirator, wash their hands and face prior to eating, drinking, smoking or applying cosmetics.

1926.62(i)(4)(iv)

The employer shall assure that employees do not enter lunchroom facilities or eating areas with protective work clothing or equipment unless surface lead dust has been removed by vacuuming, downdraft booth, or other cleaning method that limits dispersion of lead dust.

1926.62(i)(5)

"Hand Washing facilities".

1926.62(i)(5)(i)

The employer shall provide adequate handwashing facilities for use by employees exposed to lead in accordance with 29 CFR 1926.51(f).

1926.62(i)(5)(ii)

Where showers are not provided the employer shall assure that employees wash their hands and face at the end of the work-shift.

1926.62(j)

"Medical surveillance".

1926.62(j)(1)

"General".

1926.62(j)(1)(i)

The employer shall make available initial medical surveillance to employees occupationally exposed on any day to lead at or above the action level. Initial medical surveillance consists

of biological monitoring in the form of blood sampling and analysis for lead and zinc protoporphyrin levels.

1926.62(j)(1)(ii)

The employer shall institute a medical surveillance program in accordance with paragraphs (j)(2) and (j)(3) of this section for all employees who are or may be exposed by the employer at or above the action level for more than 30 days in any consecutive 12 months;

1926.62(j)(1)(iii)

The employer shall assure that all medical examinations and procedures are performed by or under the supervision of a licensed physician.

1926.62(j)(1)(iv)

The employer shall make available the required medical surveillance including multiple physician review under paragraph (j)(3)(iii) without cost to employees and at a reasonable time and place.

1926.62(j)(2)

"Biological monitoring".

1926.62(j)(2)(i)

"Blood lead and ZPP level sampling and analysis". The employer shall make available biological monitoring in the form of blood sampling and analysis for lead and zinc protoporphyrin levels to each employee covered under paragraphs (j)(1)(i) and (ii) of this section on the following schedule:

1926.62(j)(2)(i)(A)

For each employee covered under paragraph (j)(1)(ii) of this section, at least every 2 months for the first 6 months and every 6 months thereafter;

1926.62(j)(2)(i)(B)

For each employee covered under paragraphs (j)(1)(i) or (ii) of this section whose last blood sampling and analysis indicated a blood lead level at or above 40 ug/dl, at least every two months. This frequency shall continue until two consecutive blood samples and analyses indicate a blood lead level below 40 ug/dl; and

1926.62(j)(2)(i)(C)

For each employee who is removed from exposure to lead due to an elevated blood lead level at least monthly during the removal period.

1926.62(j)(2)(ii)

"Follow-up blood sampling tests". Whenever the results of a blood lead level test indicate that an employee's blood lead level exceeds the numerical criterion for medical removal under paragraph (k)(1)(i) of this section, the employer shall provide a second (follow-up) blood sampling test within two weeks after the employer receives the results of the first blood sampling test.

1926.62(j)(2)(iii)

"Accuracy of blood lead level sampling and analysis". Blood lead level sampling and analysis provided pursuant to this section shall have an accuracy (to a confidence level of 95 percent) within plus or minus 15 percent or 6 ug/dl, whichever is greater, and shall be conducted by a laboratory approved by OSHA.

1926.62(j)(2)(iv)

"Employee notification".

1926.62(j)(2)(iv)(A)

Within five working days after the receipt of biological monitoring results, the employer shall notify each employee in writing of his or her blood lead level; and

1926.62(j)(2)(iv)(B)

the employer shall notify each employee whose blood lead level exceeds 40 ug/dl that the standard requires temporary medical removal with Medical Removal Protection benefits when an employee's blood lead level exceeds the numerical criterion for medical removal under paragraph (k)(1)(i) of this section.

1926.62(j)(3)

"Medical examinations and consultations".

1926.62(j)(3)(i)

"Frequency". The employer shall make available medical examinations and consultations to each employee covered under paragraph (j)(1)(ii) of this section on the following schedule:

1926.62(j)(3)(i)(A)

At least annually for each employee for whom a blood sampling test conducted at any time during the preceding 12 months indicated a blood lead level at or above 40 ug/dl;

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1926.62(j)(3)(i)(B)
As soon as possible, upon notification by an employee either that the employee has developed signs or symptoms commonly associated with lead intoxication, that the employee desires medical advice concerning the effects of current or past exposure to lead on the employee's ability to procreate a healthy child, that the employee is pregnant, or that the employee has demonstrated difficulty in breathing during a respirator fitting test or during use; and
1926.62(j)(3)(i)(C)
As medically appropriate for each employee either removed from exposure to lead due to a risk of sustaining material impairment to health, or otherwise limited pursuant to a final medical determination.
1926.62(j)(3)(ii)
"Content". The content of medical examinations made available pursuant to paragraph (j)(3)(i)(B)-(C) of this section shall be determined by an examining physician and, if requested by an employee, shall include pregnancy testing or laboratory evaluation of male fertility. Medical examinations made available pursuant to paragraph (j)(3)(i)(A) of this section shall include the following elements:
1926.62(j)(3)(ii)(A)
A detailed work history and a medical history, with particular attention to past lead exposure (occupational and non-occupational), personal habits (smoking, hygiene), and past gastrointestinal, hematologic, renal, cardiovascular, reproductive and neurological problems;
1926.62(j)(3)(ii)(B)
A thorough physical examination, with particular attention to teeth, gums, hematologic, gastrointestinal, renal, cardiovascular, and neurological systems. Pulmonary status should be evaluated if respiratory protection will be used;
1926.62(j)(3)(ii)(C)
A blood pressure measurement;
1926.62(j)(3)(ii)(D)
A blood sample and analysis which determines:
1926.62(j)(3)(ii)(D)(1)
Blood lead level;
1926.62(j)(3)(ii)(D)(2)
Hemoglobin and hematocrit determinations, red cell indices, and examination of peripheral smear morphology;
1926.62(j)(3)(ii)(D)(3)
Zinc protoporphyrin;
1926.62(j)(3)(ii)(D)(4)
Blood urea nitrogen; and,
1926.62(j)(3)(ii)(D)(5)
Serum creatinine;
1926.62(j)(3)(ii)(E)
A routine urinalysis with microscopic examination; and
1926.62(j)(3)(ii)(F)
Any laboratory or other test relevant to lead exposure which the examining physician deems necessary by sound medical practice.
1926.62(j)(3)(iii)
"Multiple physician review mechanism."
1926.62(j)(3)(iii)(A)
If the employer selects the initial physician who conducts any medical examination or consultation provided to an employee under this section, the employee may designate a second physician:
1926.62(j)(3)(iii)(A)(1)
To review any findings, determinations or recommendations of the initial physician; and
1926.62(j)(3)(iii)(A)(2)
To conduct such examinations, consultations, and laboratory tests as the second physician deems necessary to facilitate this review.
1926.62(j)(3)(iii)(B)
The employer shall promptly notify an employee of the right to seek a second medical opinion after each occasion that an initial physician conducts a medical examination or consultation pursuant to this section. The employer may condition its participation in, and payment for, the multiple physician review mechanism upon the employee doing the

following within fifteen (15) days after receipt of the foregoing notification, or receipt of the initial physician's written opinion, whichever is later:

1926.62(j)(3)(iii)(B)(1)

The employee informing the employer that he or she intends to seek a second medical opinion, and

1926.62(j)(3)(iii)(B)(2)

The employee initiating steps to make an appointment with a second physician.

1926.62(j)(3)(iii)(C)

If the findings, determinations or recommendations of the second physician differ from those of the initial physician, then the employer and the employee shall assure that efforts are made for the two physicians to resolve any disagreement.

1926.62(j)(3)(iii)(D)

If the two physicians have been unable to quickly resolve their disagreement, then the employer and the employee through their respective physicians shall designate a third physician:

1926.62(j)(3)(iii)(D)(1)

To review any findings, determinations or recommendations of the prior physicians; and

1926.62(j)(3)(iii)(D)(2)

To conduct such examinations, consultations, laboratory tests and discussions with the prior physicians as the third physician deems necessary to resolve the disagreement of the prior physicians.

1926.62(j)(3)(iii)(E)

The employer shall act consistent with the findings, determinations and recommendations of the third physician, unless the employer and the employee reach an agreement which is otherwise consistent with the recommendations of at least one of the three physicians.

1926.62(j)(3)(iv)

"Information provided to examining and consulting physicians".

1926.62(j)(3)(iv)(A)

The employer shall provide an initial physician conducting a medical examination or consultation under this section with the following information:

1926.62(j)(3)(iv)(A)(1)

A copy of this regulation for lead including all Appendices;

1926.62(j)(3)(iv)(A)(2)

A description of the affected employee's duties as they relate to the employee's exposure;

1926.62(j)(3)(iv)(A)(3)

The employee's exposure level or anticipated exposure level to lead and to any other toxic substance (if applicable);

1926.62(j)(3)(iv)(A)(4)

A description of any personal protective equipment used or to be used;

1926.62(j)(3)(iv)(A)(5)

Prior blood lead determinations; and

1926.62(j)(3)(iv)(A)(6)

All prior written medical opinions concerning the employee in the employer's possession or control.

1926.62(j)(3)(iv)(B)

The employer shall provide the foregoing information to a second or third physician conducting a medical examination or consultation under this section upon request either by the second or third physician, or by the employee.

1926.62(j)(3)(v)

"Written medical opinions".

1926.62(j)(3)(v)(A)

The employer shall obtain and furnish the employee with a copy of a written medical opinion from each examining or consulting physician which contains only the following information:

1926.62(j)(3)(v)(A)(1)

The physician's opinion as to whether the employee has any detected medical condition which would place the employee at increased risk of material impairment of the employee's health from exposure to lead;

1926.62(j)(3)(v)(A)(2)

Any recommended special protective measures to be provided to the employee, or limitations to be placed upon the employee's exposure to lead;

1926.62(j)(3)(v)(A)(3)

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Any recommended limitation upon the employee's use of respirators, including a determination of whether the employee can wear a powered air purifying respirator if a physician determines that the employee cannot wear a negative pressure respirator; and
1926.62(j)(3)(v)(A)(4)
The results of the blood lead determinations.
1926.62(j)(3)(v)(B)
The employer shall instruct each examining and consulting physician to:
1926.62(j)(3)(v)(B)(1)
Not reveal either in the written opinion or orally, or in any other means of communication with the employer, findings, including laboratory results, or diagnoses unrelated to an employee's occupational exposure to lead; and
1926.62(j)(3)(v)(B)(2)
Advise the employee of any medical condition, occupational or nonoccupational, which dictates further medical examination or treatment.
1926.62(j)(3)(vi)
"Alternate physician determination mechanisms". The employer and an employee or authorized employee representative may agree upon the use of any alternate physician determination mechanism in lieu of the multiple physician review mechanism provided by paragraph (j)(3)(iii) of this section so long as the alternate mechanism is as expeditious and protective as the requirements contained in this paragraph.
1926.62(j)(4)
"Chelation".
1926.62(j)(4)(i)
The employer shall assure that any person whom he retains, employs, supervises or controls does not engage in prophylactic chelation of any employee at any time.
1926.62(j)(4)(ii)
If therapeutic or diagnostic chelation is to be performed by any person in paragraph (j)(4)(i) of this section, the employer shall assure that it be done under the supervision of a licensed physician in a clinical setting with thorough and appropriate medical monitoring and that the employee is notified in writing prior to its occurrence.
1926.62(k)
"Medical removal protection".
1926.62(k)(1)
"Temporary medical removal and return of an employee".
1926.62(k)(1)(i)
"Temporary removal due to elevated blood lead level". The employer shall remove an employee from work having an exposure to lead at or above the action level on each occasion that a periodic and a follow-up blood sampling test conducted pursuant to this section indicate that the employee's blood lead level is at or above 50 ug/dl; and,
1926.62(k)(1)(ii)
"Temporary removal due to a final medical determination".
1926.62(k)(1)(ii)(A)
The employer shall remove an employee from work having an exposure to lead at or above the action level on each occasion that a final medical determination results in a medical finding, determination, or opinion that the employee has a detected medical condition which places the employee at increased risk of material impairment to health from exposure to lead.
1926.62(k)(1)(ii)(B)
For the purposes of this section, the phrase "final medical determination" means the written medical opinion on the employees' health status by the examining physician or, where relevant, the outcome of the multiple physician review mechanism or alternate medical determination mechanism used pursuant to the medical surveillance provisions of this section.
1926.62(k)(1)(ii)(C)
Where a final medical determination results in any recommended special protective measures for an employee, or limitations on an employee's exposure to lead, the employer shall implement and act consistent with the recommendation.
1926.62(k)(1)(iii)
"Return of the employee to former job status".
1926.62(k)(1)(iii)(A)

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The employer shall return an employee to his or her former job status:
1926.62(k)(1)(iii)(A)(1)
For an employee removed due to a blood lead level at or above 50 ug/dl when two consecutive blood sampling tests indicate that the employee's blood lead level is at or below 40 ug/dl;
1926.62(k)(1)(iii)(A)(2)
For an employee removed due to a final medical determination, when a subsequent final medical determination results in a medical finding, determination, or opinion that the employee no longer has a detected medical condition which places the employee at increased risk of material impairment to health from exposure to lead.
1926.62(k)(1)(iii)(B)
For the purposes of this section, the requirement that an employer return an employee to his or her former job status is not intended to expand upon or restrict any rights an employee has or would have had, absent temporary medical removal, to a specific job classification or position under the terms of a collective bargaining agreement.
1926.62(k)(1)(iv)
"Removal of other employee special protective measure or limitations". The employer shall remove any limitations placed on an employee or end any special protective measures provided to an employee pursuant to a final medical determination when a subsequent final medical determination indicates that the limitations or special protective measures are no longer necessary.
1926.62(k)(1)(v)
"Employer options pending a final medical determination". Where the multiple physician review mechanism, or alternate medical determination mechanism used pursuant to the medical surveillance provisions of this section, has not yet resulted in a final medical determination with respect to an employee, the employer shall act as follows:
1926.62(k)(1)(v)(A)
"Removal". The employer may remove the employee from exposure to lead, provide special protective measures to the employee, or place limitations upon the employee, consistent with the medical findings, determinations, or recommendations of any of the physicians who have reviewed the employee's health status.
1926.62(k)(1)(v)(B)
"Return". The employer may return the employee to his or her former job status, end any special protective measures provided to the employee, and remove any limitations placed upon the employee, consistent with the medical findings, determinations, or recommendations of any of the physicians who have reviewed the employee's health status, with two exceptions.
1926.62(k)(1)(v)(B)(1)
If the initial removal, special protection, or limitation of the employee resulted from a final medical determination which differed from the findings, determinations, or recommendations of the initial physician or;
1926.62(k)(1)(v)(B)(2)
If the employee has been on removal status for the preceding eighteen months due to an elevated blood lead level, then the employer shall await a final medical determination.
1926.62(k)(2)
"Medical removal protection benefits".
1926.62(k)(2)(i)
"Provision of medical removal protection benefits". The employer shall provide an employee up to eighteen (18) months of medical removal protection benefits on each occasion that an employee is removed from exposure to lead or otherwise limited pursuant to this section.
1926.62(k)(2)(ii)
"Definition of medical removal protection benefits". For the purposes of this section, the requirement that an employer provide medical removal protection benefits means that, as long as the job the employee was removed from continues, the employer shall maintain the total normal earnings, seniority and other employment rights and benefits of an employee, including the employee's right to his or her former job status as though the employee had not been medically removed from the employee's job or otherwise medically limited.
1926.62(k)(2)(iii)
"Follow-up medical surveillance during the period of employee removal or limitation." During

the period of time that an employee is medically removed from his or her job or otherwise medically limited, the employer may condition the provision of medical removal protection benefits upon the employee's participation in follow-up medical surveillance made available pursuant to this section.

1926.62(k)(2)(iv)

"Workers' compensation claims". If a removed employee files a claim for workers' compensation payments for a lead-related disability, then the employer shall continue to provide medical removal protection benefits pending disposition of the claim. To the extent that an award is made to the employee for earnings lost during the period of removal, the employer's medical removal protection obligation shall be reduced by such amount. The employer shall receive no credit for workers' compensation payments received by the employee for treatment-related expenses.

1926.62(k)(2)(v)

"Other credits". The employer's obligation to provide medical removal protection benefits to a removed employee shall be reduced to the extent that the employee receives compensation for earnings lost during the period of removal either from a publicly or employer-funded compensation program, or receives income from employment with another employer made possible by virtue of the employee's removal.

1926.62(k)(2)(vi)

"Voluntary removal or restriction of an employee". Where an employer, although not required by this section to do so, removes an employee from exposure to lead or otherwise places limitations on an employee due to the effects of lead exposure on the employee's medical condition, the employer shall provide medical removal protection benefits to the employee equal to that required by paragraph (k)(2)(i) and (ii) of this section.

1926.62(l)

"Employee information and training".

1926.62(l)(1)

"General"

1926.62(l)(1)(i)

The employer shall communicate information concerning lead hazards according to the requirements of OSHA's Hazard Communication Standard for the construction industry, 29 CFR 1926.59, including but not limited to the requirements concerning warning signs and labels, material safety data sheets (MSDS), and employee information and training. In addition, employers shall comply with the following requirements:

1926.62(l)(1)(ii)

For all employees who are subject to exposure to lead at or above the action level on any day or who are subject to exposure to lead compounds which may cause skin or eye irritation (e.g. lead arsenate, lead azide), the employer shall provide a training program in accordance with paragraph (l)(2) of this section and assure employee participation.

1926.62(l)(1)(iii)

The employer shall provide the training program as initial training prior to the time of job assignment or prior to the start up date for this requirement, whichever comes last.

1926.62(l)(1)(iv)

The employer shall also provide the training program at least annually for each employee who is subject to lead exposure at or above the action level on any day.

1926.62(l)(2)

"Training program". The employer shall assure that each employee is trained in the following:

1926.62(l)(2)(i)

The content of this standard and its appendices;

1926.62(l)(2)(ii)

The specific nature of the operations which could result in exposure to lead above the action level;

1926.62(l)(2)(iii)

The purpose, proper selection, fitting, use, and limitations of respirators;

1926.62(l)(2)(iv)

The purpose and a description of the medical surveillance program, and the medical removal protection program including information concerning the adverse health effects associated with excessive exposure to lead (with particular attention to the adverse reproductive effects on both males and females and hazards to the fetus and additional precautions for

employees who are pregnant);
1926.62(l)(2)(v)
The engineering controls and work practices associated with the employee's job assignment including training of employees to follow relevant good work practices described in Appendix B of this section;
1926.62(l)(2)(vi)
The contents of any compliance plan in effect;
1926.62(l)(2)(vii)
Instructions to employees that chelating agents should not routinely be used to remove lead from their bodies and should not be used at all except under the direction of a licensed physician; and
1926.62(l)(2)(viii)
The employee's right of access to records under 29 CFR 1910.20.
1926.62(l)(3)
"Access to information and training materials."
1926.62(l)(3)(i)
The employer shall make readily available to all affected employees a copy of this standard and its appendices.
1926.62(l)(3)(ii)
The employer shall provide, upon request, all materials relating to the employee information and training program to affected employees and their designated representatives, and to the Assistant Secretary and the Director.
1926.62(m)
"Signs".
1926.62(m)(1)
"General".
1926.62(m)(1)(i)
The employer may use signs required by other statutes, regulations or ordinances in addition to, or in combination with, signs required by this paragraph.
1926.62(m)(1)(ii)
The employer shall assure that no statement appears on or near any sign required by this paragraph which contradicts or detracts from the meaning of the required sign.
1926.62(m)(2)
"Signs".
1926.62(m)(2)(i)
The employer shall post the following warning signs in each work area where an employees exposure to lead is above the PEL.

WARNING
LEAD WORK AREA
POISON
NO SMOKING OR EATING

1926.62(m)(2)(ii)
The employer shall assure that signs required by this paragraph are illuminated and cleaned as necessary so that the legend is readily visible.
1926.62(n)
"Recordkeeping".
1926.62(n)(1)
"Exposure assessment".
1926.62(n)(1)(i)
The employer shall establish and maintain an accurate record of all monitoring and other data used in conducting employee exposure assessments as required in paragraph (d) of this section.
1926.62(n)(1)(ii)
Exposure monitoring records shall include:
1926.62(n)(1)(ii)(A)
The date(s), number, duration, location and results of each of the samples taken if any, including a description of the sampling procedure used to determine representative employee exposure where applicable;
1926.62(n)(1)(ii)(B)
A description of the sampling and analytical methods used and evidence of their accuracy;

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1926.62(n)(1)(ii)(C)
The type of respiratory protective devices worn, if any;
1926.62(n)(1)(ii)(D)
Name, social security number, and job classification of the employee monitored and of all other employees whose exposure the measurement is intended to represent; and
1926.62(n)(1)(ii)(E)
The environmental variables that could affect the measurement of employee exposure.
1926.62(n)(1)(iii)
The employer shall maintain monitoring and other exposure assessment records in accordance with the provisions of 29 CFR 1926.33.
1926.62(n)(2)
"Medical surveillance".
1926.62(n)(2)(i)
The employer shall establish and maintain an accurate record for each employee subject to medical surveillance as required by paragraph (j) of this section.
1926.62(n)(2)(ii)
This record shall include:
1926.62(n)(2)(ii)(A)
The name, social security number, and description of the duties of the employee;
1926.62(n)(2)(ii)(B)
A copy of the physician's written opinions;
1926.62(n)(2)(ii)(C)
Results of any airborne exposure monitoring done on or for that employee and provided to the physician; and
1926.62(n)(2)(ii)(D)
Any employee medical complaints related to exposure to lead.
1926.62(n)(2)(iii)
The employer shall keep, or assure that the examining physician keeps, the following medical records:
1926.62(n)(2)(iii)(A)
A copy of the medical examination results including medical and work history required under paragraph (j) of this section;
1926.62(n)(2)(iii)(B)
A description of the laboratory procedures and a copy of any standards or guidelines used to interpret the test results or references to that information;
1926.62(n)(2)(iii)(C)
A copy of the results of biological monitoring.
1926.62(n)(2)(iv)
The employer shall maintain or assure that the physician maintains medical records in accordance with the provisions of 29 CFR 1926.33.
1926.62(n)(3)
"Medical removals".
1926.62(n)(3)(i)
The employer shall establish and maintain an accurate record for each employee removed from current exposure to lead pursuant to paragraph (k) of this section.
1926.62(n)(3)(ii)
Each record shall include:
1926.62(n)(3)(ii)(A)
The name and social security number of the employee;
1926.62(n)(3)(ii)(B)
The date of each occasion that the employee was removed from current exposure to lead as well as the corresponding date on which the employee was returned to his or her former job status;
1926.62(n)(3)(ii)(C)
A brief explanation of how each removal was or is being accomplished; and
1926.62(n)(3)(ii)(D)
A statement with respect to each removal indicating whether or not the reason for the removal was an elevated blood lead level.
1926.62(n)(3)(iii)
The employer shall maintain each medical removal record for at least the duration of an employee's employment.
1926.62(n)(4)

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"Objective data for exemption from requirement for initial monitoring".

1926.62(n)(4)(i)

For purposes of this section, objective data are information demonstrating that a particular product or material containing lead or a specific process, operation, or activity involving lead cannot release dust or fumes in concentrations at or above the action level under any expected conditions of use. Objective data can be obtained from an industry-wide study or from laboratory product test results from manufacturers of lead containing products or materials. The data the employer uses from an industry-wide survey must be obtained under workplace conditions closely resembling the processes, types of material, control methods, work practices and environmental conditions in the employer's current operations.

1926.62(n)(4)(ii)

The employer shall maintain the record of the objective data relied upon for at least 30 years.

1926.62(n)(5)

"Availability". The employer shall make available upon request all records required to be maintained by paragraph (n) of this section to affected employees, former employees, and their designated representatives, and to the Assistant Secretary and the Director for examination and copying.

1926.62(n)(6)

"Transfer of records".

1926.62(n)(6)(i)

Whenever the employer ceases to do business, the successor employer shall receive and retain all records required to be maintained by paragraph (n) of this section.

1926.62(n)(6)(ii)

Whenever the employer ceases to do business and there is no successor employer to receive and retain the records required to be maintained by this section for the prescribed period, these records shall be transmitted to the Director.

1926.62(n)(6)(iii)

At the expiration of the retention period for the records required to be maintained by this section, the employer shall notify the Director at least 3 months prior to the disposal of such records and shall transmit those records to the Director if requested within the period.

1926.62(n)(6)(iv)

The employer shall also comply with any additional requirements involving transfer of records set forth in 29 CFR 1926.33(h).

1926.62(o)

"Observation of monitoring".

1926.62(o)(1)

Employee observation. The employer shall provide affected employees or their designated representatives an opportunity to observe any monitoring of employee exposure to lead conducted pursuant to paragraph (d) of this section.

1926.62(o)(2)

"Observation procedures".

1926.62(o)(2)(i)

Whenever observation of the monitoring of employee exposure to lead requires entry into an area where the use of respirators, protective clothing or equipment is required, the employer shall provide the observer with and assure the use of such respirators, clothing and equipment, and shall require the observer to comply with all other applicable safety and health procedures.

1926.62(o)(2)(ii)

Without interfering with the monitoring, observers shall be entitled to:

1926.62(o)(2)(ii)(A)

Receive an explanation of the measurement procedures;

1926.62(o)(2)(ii)(B)

Observe all steps related to the monitoring of lead performed at the place of exposure; and

1926.62(o)(2)(ii)(C)

Record the results obtained or receive copies of the results when returned by the laboratory.

1926.62(p)

"Appendices". The information contained in the appendices to this section is not intended by itself, to create any additional obligations not otherwise imposed by this standard nor detract from any existing obligation.

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Appendix A

• **Part Number:**	1926
• **Part Title:**	Safety and Health Regulations for Construction
• **Subpart:**	D
• **Subpart Title:**	Occupational Health and Environmental Controls
• **Standard Number:**	1926.62 App A
• **Title:**	Substance Data Sheet for Occupational Exposure to Lead

I. SUBSTANCE IDENTIFICATION

A. "Substance": Pure lead (Pb) is a heavy metal at room temperature and pressure and is a basic chemical element. It can combine with various other substances to form numerous lead compounds.

B. "Compounds Covered by the Standard": The word "lead" when used in this interim final standard means elemental lead, all inorganic lead compounds and a class of organic lead compounds called lead soaps. This standard does not apply to other organic lead compounds.

C. "Uses": Exposure to lead occurs in several different occupations in the construction industry, including demolition or salvage of structures where lead or lead - containing materials are present; removal or encapsulation of lead - containing materials, new construction, alteration, repair, or renovation of structures that contain lead or materials containing lead; installation of products containing lead. In addition, there are construction related activities where exposure to lead may occur, including transportation, disposal, storage, or containment of lead or materials containing lead on construction sites, and maintenance operations associated with construction activities.

D. "Permissible Exposure": The permissible exposure limit (PEL) set by the standard is 50 micrograms of lead per cubic meter of air (50 ug/m(3)), averaged over an 8-hour workday.

E. "Action Level": The interim final standard establishes an action level of 30 micrograms of lead per cubic meter of air (30 ug/m(3)), averaged over an 8-hour workday. The action level triggers several ancillary provisions of the standard such as exposure monitoring, medical surveillance, and training.

II. HEALTH HAZARD DATA

A. "Ways in which lead enters your body". When absorbed into your body in certain doses, lead is a toxic substance. The object of the lead standard is to prevent absorption of harmful quantities of lead. The standard is intended to protect you not only from the immediate toxic

effects of lead, but also from the serious toxic effects that may not become apparent until years of exposure have passed. Lead can be absorbed into your body by inhalation (breathing) and ingestion (eating). Lead (except for certain organic lead compounds not covered by the standard, such as tetraethyl lead) is not absorbed through your skin. When lead is scattered in the air as a dust, fume, or mist it can be inhaled and absorbed through you lungs and upper respiratory tract. Inhalation of airborne lead is generally the most important source of occupational lead absorption. You can also absorb lead through your digestive system if lead gets into your mouth and is swallowed. If you handle food, cigarettes, chewing tobacco, or make-up which have lead on them or handle them with hands contaminated with lead, this will contribute to ingestion. A significant portion of the lead that you inhale or ingest gets into your blood stream. Once in your blood stream, lead is circulated throughout your body and stored in various organs and body tissues. Some of this lead is quickly filtered out of your body and excreted, but some remains in the blood and other tissues. As exposure to lead continues, the amount stored in your body will increase if you are absorbing more lead than your body is excreting. Even though you may not be aware of any immediate symptoms of disease, this lead stored in your tissues can be slowly causing irreversible damage, first to individual cells, then to your organs and whole body systems.

B. "Effects of overexposure to lead" - (1) "Short term (acute) overexposure". Lead is a potent, systemic poison that serves no known useful function once absorbed by your body. Taken in large enough doses, lead can kill you in a matter of days. A condition affecting the brain called acute encephalopathy may arise which develops quickly to seizures, coma, and death from cardiorespiratory arrest. A short term dose of lead can lead to acute encephalopathy. Short term occupational exposures of this magnitude are highly unusual, but not impossible. Similar forms of encephalopathy may, however, arise from extended, chronic exposure to lower doses of lead. There is no sharp dividing line between rapidly developing acute effects of lead, and chronic effects which take longer to acquire. Lead adversely affects numerous body systems, and causes forms of health impairment and disease which arise after periods of exposure as short as days or as long as several years.

(2) "Long-term (chronic) overexposure". Chronic overexposure to lead may result in severe damage to your blood - forming, nervous, urinary and reproductive systems. Some common symptoms of chronic overexposure include loss of appetite, metallic taste in the mouth, anxiety, constipation, nausea, pallor, excessive tiredness, weakness, insomnia, headache, nervous irritability, muscle and joint pain or soreness, fine tremors, numbness, dizziness, hyperactivity and colic. In lead colic there may be severe abdominal pain. Damage to the central nervous system in general and the brain (encephalopathy) in particular is one of the most severe forms of lead poisoning. The most severe, often fatal, form of encephalopathy may be preceded by vomiting, a feeling of dullness progressing to drowsiness and stupor, poor memory, restlessness, irritability, tremor, and convulsions. It may arise suddenly with the onset of seizures, followed by coma, and death. There is a tendency for muscular weakness to develop at the same time. This weakness may progress to paralysis often observed as a characteristic "wrist drop" or "foot drop" and is a manifestation of a disease to the nervous system called peripheral neuropathy. Chronic overexposure to lead also results in kidney disease with few, if any, symptoms appearing until extensive and most likely permanent kidney damage has occurred. Routine laboratory tests reveal the presence of this

kidney disease only after about two-thirds of kidney function is lost. When overt symptoms of urinary dysfunction arise, it is often too late to correct or prevent worsening conditions, and progression to kidney dialysis or death is possible. Chronic overexposure to lead impairs the reproductive systems of both men and women. Overexposure to lead may result in decreased sex drive, impotence and sterility in men. Lead can alter the structure of sperm cells raising the risk of birth defects. There is evidence of miscarriage and stillbirth in women whose husbands were exposed to lead or who were exposed to lead themselves. Lead exposure also may result in decreased fertility, and abnormal menstrual cycles in women. The course of pregnancy may be adversely affected by exposure to lead since lead crosses the placental barrier and poses risks to developing fetuses. Children born of parents either one of whom were exposed to excess lead levels are more likely to have birth defects, mental retardation, behavioral disorders or die during the first year of childhood. Overexposure to lead also disrupts the blood - forming system resulting in decreased hemoglobin (the substance in the blood that carries oxygen to the cells) and ultimately anemia. Anemia is characterized by weakness, pallor and fatigability as a result of decreased oxygen carrying capacity in the blood.

(3) "Health protection goals of the standard". Prevention of adverse health effects for most workers from exposure to lead throughout a working lifetime requires that a worker's blood lead level (BLL, also expressed as PbB) be maintained at or below forty micrograms per deciliter of whole blood (40 ug/dl). The blood lead levels of workers (both male and female workers) who intend to have children should be maintained below 30 ug/dl to minimize adverse reproductive health effects to the parents and to the developing fetus. The measurement of your blood lead level (BLL) is the most useful indicator of the amount of lead being absorbed by your body. Blood lead levels are most often reported in units of milligrams (mg) or micrograms (ug) of lead (1 mg=1000 ug) per 100 grams (100g), 100 milliliters (100 ml) or deciliter (dl) of blood. These three units are essentially the same. Sometime BLLs are expressed in the form of mg percent or ug percent. This is a shorthand notation for 100g, 100 ml, or dl. (References to BLL measurements in this standard are expressed in the form of ug/dl.)

BLL measurements show the amount of lead circulating in your blood stream, but do not give any information about the amount of lead stored in your various tissues. BLL measurements merely show current absorption of lead, not the effect that lead is having on your body or the effects that past lead exposure may have already caused. Past research into lead - related diseases, however, has focused heavily on associations between BLLs and various diseases. As a result, your BLL is an important indicator of the likelihood that you will gradually acquire a lead - related health impairment or disease.

Once your blood lead level climbs above 40 ug/dl, your risk of disease increases. There is a wide variability of individual response to lead, thus it is difficult to say that a particular BLL in a given person will cause a particular effect. Studies have associated fatal encephalopathy with BLLs as low as 150 ug/dl. Other studies have shown other forms of diseases in some workers with BLLs well below 80 ug/dl. Your BLL is a crucial indicator of the risks to your health, but one other factor is also extremely important. This factor is the length of time you have had elevated BLLs. The longer you have an elevated BLL, the greater the risk that large

quantities of lead are being gradually stored in your organs and tissues (body burden). The greater your overall body burden, the greater the chances of substantial permanent damage. The best way to prevent all forms of lead - related impairments and diseases -- both short term and long term -- is to maintain your BLL below 40 ug/dl. The provisions of the standard are designed with this end in mind.

Your employer has prime responsibility to assure that the provisions of the standard are complied with both by the company and by individual workers. You, as a worker, however, also have a responsibility to assist your employer in complying with the standard. You can play a key role in protecting your own health by learning about the lead hazards and their control, learning what the standard requires, following the standard where it governs your own actions, and seeing that your employer complies with provisions governing his or her actions.

(4) "Reporting signs and symptoms of health problems". You should immediately notify your employer if you develop signs or symptoms associated with lead poisoning or if you desire medical advice concerning the effects of current or past exposure to lead or your ability to have a healthy child. You should also notify your employer if you have difficulty breathing during a respirator fit test or while wearing a respirator. In each of these cases, your employer must make available to you appropriate medical examinations or consultations. These must be provided at no cost to you and at a reasonable time and place. The standard contains a procedure whereby you can obtain a second opinion by a physician of your choice if your employer selected the initial physician.

[57 FR 26627, May 4, 1993, as amended at 58 FR 34218, June 24, 1993]

Appendix B

• **Part Number:**	1926
• **Part Title:**	Safety and Health Regulations for Construction
• **Subpart:**	D
• **Subpart Title:**	Occupational Health and Environmental Controls
• **Standard Number:**	1926.62 App B
• **Title:**	Employee Standard Summary

This appendix summarizes key provisions of the interim final standard for lead in construction that you as a worker should become familiar with.

I. Permissible Exposure Limit (PEL) - Paragraph (C)

The standard sets a permissible exposure limit (PEL) of 50 micrograms of lead per cubic meter of air (50 ug/m(3)), averaged over an 8-hour workday which is referred to as a time-weighted average (TWA). This is the highest level of lead in air to which you may be permissibly exposed over an 8-hour workday. However, since this is an 8-hour average, short exposures above the PEL are permitted so long as for each 8-hour work day your average exposure does not exceed this level. This interim final standard, however, takes into account the fact that your daily exposure to lead can extend beyond a typical 8-hour

workday as the result of overtime or other alterations in your work schedule. To deal with this situation, the standard contains a formula which reduces your permissible exposure when you are exposed more than 8 hours. For example, if you are exposed to lead for 10 hours a day, the maximum permitted average exposure would be 40 ug/m(3).

II. Exposure Assessment - Paragraph (D)

If lead is present in your workplace in any quantity, your employer is required to make an initial determination of whether any employee's exposure to lead exceeds the action level (30 ug/m(3) averaged over an 8-hour day). Employee exposure is that exposure which would occur if the employee were not using a respirator. This initial determination requires your employer to monitor workers' exposures unless he or she has objective data which can demonstrate conclusively that no employee will be exposed to lead in excess of the action level. Where objective data is used in lieu of actual monitoring the employer must establish and maintain an accurate record, documenting its relevancy in assessing exposure levels for current job conditions. If such objective data is available, the employer need proceed no further on employee exposure assessment until such time that conditions have changed and the determination is no longer valid.

Objective date may be compiled from various sources, e.g., insurance companies and trade associations and information from suppliers or exposure data collected from similar operations. Objective data may also comprise previously - collected sampling data including area monitoring. If it cannot be determined through using objective data that worker exposure is less than the action level, your employer must conduct monitoring or must rely on relevant previous personal sampling, if available. Where monitoring is required for the initial determination, it may be limited to a representative number of employees who are reasonably expected to have the highest exposure levels. If your employer has conducted appropriate air sampling for lead in the past 12 months, he or she may use these results, provided they are applicable to the same employee tasks and exposure conditions and meet the requirements for accuracy as specified in the standard. As with objective data, if such results are relied upon for the initial determination, your employer must establish and maintain a record as to the relevancy of such data to current job conditions.

If there have been any employee complaints of symptoms which may be attributable to exposure to lead or if there is any other information or observations which would indicate employee exposure to lead, this must also be considered as part of the initial determination.

If this initial determination shows that a reasonable possibility exists that any employee may be exposed, without regard to respirators, over the action level, your employer must set up an air monitoring program to determine the exposure level representative of each employee exposed to lead at your workplace. In carrying out this air monitoring program, your employer is not required to monitor the exposure of every employee, but he or she must monitor a representative number of employees and job types. Enough sampling must be done to enable each employee's exposure level to be reasonably represent full shift exposure. In addition, these air samples must be taken under conditions which represent each employee's regular, daily exposure to lead. Sampling performed in the past 12 months may be used to determine exposures above the action level if such sampling was conducted during work activities essentially similar to present work conditions.

The standard lists certain tasks which may likely result in exposures to lead in excess of the PEL and, in some cases, exposures in excess of 50 times the PEL. If you are performing any of these tasks, your employer must provide you with appropriate respiratory protection, protective clothing and equipment, change areas, hand washing facilities, biological monitoring, and training until such time that an exposure assessment is conducted which demonstrates that your exposure level is below the PEL.

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If you are exposed to lead and air sampling is performed, your employer is required to notify you in writing within 5 working days of the air monitoring results which represent your exposure. If the results indicate that your exposure exceeds the PEL (without regard to your use of a respirator), then your employer must also notify you of this in writing, and provide you with a description of the corrective action that has been taken or will be taken to reduce your exposure.

Your exposure must be rechecked by monitoring, at least every six months if your exposure is at or over the action level but below the PEL. Your employer may discontinue monitoring for you if 2 consecutive measurements, taken at least 7 days apart, are at or below the action level. Air monitoring must be repeated every 3 months if you are exposed over the PEL. Your employer must continue monitoring for you at this frequency until 2 consecutive measurements, taken at least 7 days apart, are below the PEL but above the action level, at which time your employer must repeat monitoring of your exposure every six months and may discontinue monitoring only after your exposure drops to or below the action level. However, whenever there is a change of equipment, process, control, or personnel or a new type of job is added at your workplace which may result in new or additional exposure to lead, your employer must perform additional monitoring.

III. Methods of Compliance - Paragraph (E)

Your employer is required to assure that no employee is exposed to lead in excess of the PEL as an 8-hour TWA. The interim final standard for lead in construction requires employers to institute engineering and work practice controls including administrative controls to the extent feasible to reduce employee exposure to lead. Where such controls are feasible but not adequate to reduce exposures below the PEL they must be used nonetheless to reduce exposures to the lowest level that can be accomplished by these means and then supplemented with appropriate respiratory protection.

Your employer is required to develop and implement a written compliance program prior to the commencement of any job where employee exposures may reach the PEL as an 8-hour TWA. The interim final standard identifies the various elements that must be included in the plan. For example, employers are required to include a description of operations in which lead is emitted, detailing other relevant information about the operation such as the type of equipment used, the type of material involved, employee job responsibilities, operating procedures and maintenance practices. In addition, your employer's compliance plan must specify the means that will be used to achieve compliance and, where engineering controls are required, include any engineering plans or studies that have been used to select the control methods. If administrative controls involving job rotation are used to reduce employee exposure to lead, the job rotation schedule must be included in the compliance plan. The plan must also detail the type of protective clothing and equipment, including respirators, housekeeping and hygiene practices that will be used to protect you from the adverse effects of exposure to lead.

The written compliance program must be made available, upon request, to affected employees and their designated representatives, the Assistant Secretary and the Director.

Finally, the plan must be reviewed and updated at least every 6 months to assure it reflects the current status in exposure control.

IV. Respiratory Protection - Paragraph (F)

Your employer is required to provide and assure your use of respirators when your exposure to lead is not controlled below the PEL by other means. The employer must pay the cost of the respirator. Whenever you request one, your employer is also required to provide you a respirator even if your air exposure level is not above the PEL. You might desire a respirator

when, for example, you have received medical advice that your lead absorption should be decreased. Or, you may intend to have children in the near future, and want to reduce the level of lead in your body to minimize adverse reproductive effects. While respirators are the least satisfactory means of controlling your exposure, they are capable of providing significant protection if properly chosen, fitted, worn, cleaned, maintained, and replaced when they stop providing adequate protection.

Your employer is required to select respirators from the types listed in Table I of the Respiratory Protection section of the standard. Any respirator chosen must be approved by the Mine Safety and Health Administration (MSHA) or the National Institute for Occupational Safety and Health (NIOSH). This respirator selection table will enable your employer to choose a type of respirator which will give you a proper amount of protection based on your airborne lead exposure. Your employer may select a type of respirator that provides greater protection than that required by the standard; that is, one recommended for a higher concentration of lead than is present in your workplace. For example, a powered air purifying respirator (PAPR) is much more protective than a typical negative pressure respirator, and may also be more comfortable to wear. A PAPR has a filter, cartridge or canister to clean the air, and a power source which continuously blows filtered air into your breathing zone. Your employer might make a PAPR available to you to ease the burden of having to wear a respirator for long periods of time. The standard provides that you can obtain a PAPR upon request.

Your employer must also start a Respiratory Protection Program. This program must include written procedures for the proper selection, use, cleaning, storage, and maintenance of respirators.

Your employer is required to select respirators from the types listed in Table I of the Respiratory Protection section of the standard (Sec. 1926.62 (f)). Any respirator chosen must be approved by the National Institute for Occupational Safety and Health (NIOSH) under the provisions of 42 CFR part 84. This respirator selection table will enable your employer to choose a type of respirator that will give you a proper amount of protection based on your airborne lead exposure. Your employer may select a type of respirator that provides greater protection than that required by the standard; that is, one recommended for a higher concentration of lead than is present in your workplace. For example, a powered air-purifying respirator (PAPR) is much more protective than a typical negative pressure respirator, and may also be more comfortable to wear. A PAPR has a filter, cartridge, or canister to clean the air, and a power source that continuously blows filtered air into your breathing zone. Your employer might make a PAPR available to you to ease the burden of having to wear a respirator for long periods of time. The standard provides that you can obtain a PAPR upon request.

You must also receive from your employer proper training in the use of respirators. Your employer is required to teach you how to wear a respirator, to know why it is needed, and to understand its limitations.

Your employer must ensure that your respirator facepiece fits properly. Proper fit of a respirator facepiece is critical to your protection from airborne lead. Obtaining a proper fit on each employee may require your employer to make available several different types of respirator masks. To ensure that your respirator fits properly and that facepiece leakage is minimal, your employer must give you either a qualitative or quantitative fit test as specified in Appendix A of the Respiratory Protection standard located at 29 CFR 1910.134.

The standard provides that if your respirator uses filter elements, you must be given an opportunity to change the filter elements whenever an increase in breathing resistance is detected. You also must be permitted to periodically leave your work area to wash your face and respirator facepiece whenever necessary to prevent skin irritation. If you ever have

difficulty in breathing during a fit test or while using a respirator, your employer must make a medical examination available to you to determine whether you can safely wear a respirator. The result of this examination may be to give you a positive pressure respirator (which reduces breathing resistance) or to provide alternative means of protection.

V. Protective Work Clothing and Equipment - Paragraph (G)

If you are exposed to lead above the PEL as an 8-hour TWA, without regard to your use of a respirator, or if you are exposed to lead compounds such as lead arsenate or lead azide which can cause skin and eye irritation, your employer must provide you with protective work clothing and equipment appropriate for the hazard. If work clothing is provided, it must be provided in a clean and dry condition at least weekly, and daily if your airborne exposure to lead is greater than 200 ug/m(3). Appropriate protective work clothing and equipment can include coveralls or similar full-body work clothing, gloves, hats, shoes or disposable shoe coverlets, and face shields or vented goggles. Your employer is required to provide all such equipment at no cost to you. In addition, your employer is responsible for providing repairs and replacement as necessary, and also is responsible for the cleaning, laundering or disposal of protective clothing and equipment.

The interim final standard requires that your employer assure that you follow good work practices when you are working in areas where your exposure to lead may exceed the PEL. With respect to protective clothing and equipment, where appropriate, the following procedures should be observed prior to beginning work:

1. Change into work clothing and shoe covers in the clean section of the designated changing areas;

2. Use work garments of appropriate protective gear, including respirators before entering the work area; and

3. Store any clothing not worn under protective clothing in the designated changing area.

Workers should follow these procedures upon leaving the work area:

1. HEPA vacuum heavily contaminated protective work clothing while it is still being worn. At no time may lead be removed from protective clothing by any means which result in uncontrolled dispersal of lead into the air;

2. Remove shoe covers and leave them in the work area;

3. Remove protective clothing and gear in the dirty area of the designated changing area. Remove protective coveralls by carefully rolling down the garment to reduce exposure to dust.

4. Remove respirators last; and

5. Wash hands and face.

Workers should follow these procedures upon finishing work for the day (in addition to procedures described above):

1. Where applicable, place disposal coveralls and shoe covers with the abatement waste;

2. Contaminated clothing which is to be cleaned, laundered or disposed of must be placed in closed containers in the change room.

3. Clean protective gear, including respirators, according to standard procedures;

4. Wash hands and face again. If showers are available, take a shower and wash hair. If shower facilities are not available at the work site, shower immediately at home and wash hair.

VI. Housekeeping - Paragraph (H)

Your employer must establish a housekeeping program sufficient to maintain all surfaces as free as practicable of accumulations of lead dust. Vacuuming is the preferred method of meeting this requirement, and the use of compressed air to clean floors and other surfaces is generally prohibited unless removal with compressed air is done in conjunction with ventilation systems designed to contain dispersal of the lead dust. Dry or wet sweeping, shoveling, or brushing may not be used except where vacuuming or other equally effective methods have been tried and do not work. Vacuums must be used equipped with a special filter called a high-efficiency particulate air (HEPA) filter and emptied in a manner which minimizes the reentry of lead into the workplace.

VII. Hygiene Facilities and Practices - Paragraph (I)

The standard requires that hand washing facilities be provided where occupational exposure to lead occurs. In addition, change areas, showers (where feasible), and lunchrooms or eating areas are to be made available to workers exposed to lead above the PEL. Your employer must assure that except in these facilities, food and beverage is not present or consumed, tobacco products are not present or used, and cosmetics are not applied, where airborne exposures are above the PEL. Change rooms provided by your employer must be equipped with separate storage facilities for your protective clothing and equipment and street clothes to avoid cross-contamination. After showering, no required protective clothing or equipment worn during the shift may be worn home. It is important that contaminated clothing or equipment be removed in change areas and not be worn home or you will extend your exposure and expose your family since lead from your clothing can accumulate in your house, car, etc.

Lunchrooms or eating areas may not be entered with protective clothing or equipment unless surface dust has been removed by vacuuming, downdraft booth, or other cleaning method. Finally, workers exposed above the PEL must wash both their hands and faces prior to eating, drinking, smoking or applying cosmetics.

All of the facilities and hygiene practices just discussed are essential to minimize additional sources of lead absorption from inhalation or ingestion of lead that may accumulate on you, your clothes, or your possessions. Strict compliance with these provisions can virtually eliminate several sources of lead exposure which significantly contribute to excessive lead absorption.

VIII. Medical surveillance - Paragraph (J)

The medical surveillance program is part of the standard's comprehensive approach to the prevention of lead-related disease. Its purpose is to supplement the main thrust of the standard which is aimed at minimizing airborne concentrations of lead and sources of ingestion. Only medical surveillance can determine if the other provisions of the standard have effectively protected you as an individual. Compliance with the standard's provision will protect most workers from the adverse effects of lead exposure, but may not be satisfactory to protect individual workers (1) who have high body burdens of lead acquired over past years, (2) who have additional uncontrolled sources of non-occupational lead exposure, (3) who exhibit unusual variations in lead absorption rates, or (4) who have specific non-work related medical conditions which could be aggravated by lead exposure (e.g., renal disease,

anemia). In addition, control systems may fail, or hygiene and respirator programs may be inadequate. Periodic medical surveillance of individual workers will help detect those failures. Medical surveillance will also be important to protect your reproductive ability - regardless of whether you are a man or woman.

All medical surveillance required by the interim final standard must be performed by or under the supervision of a licensed physician. The employer must provide required medical surveillance without cost to employees and at a reasonable time and place. The standard's medical surveillance program has two parts -- periodic biological monitoring and medical examinations. Your employer's obligation to offer you medical surveillance is triggered by the results of the air monitoring program. Full medical surveillance must be made available to all employees who are or may be exposed to lead in excess of the action level for more than 30 days a year and whose blood lead level exceeds 40 ug/dl. Initial medical surveillance consisting of blood sampling and analysis for lead and zinc protoporphyrin must be provided to all employees exposed at any time (1 day) above the action level.

Biological monitoring under the standard must be provided at least every 2 months for the first 6 months and every 6 months thereafter until your blood lead level is below 40 ug/dl. A zinc protoporphyrin (ZPP) test is a very useful blood test which measures an adverse metabolic effect of lead on your body and is therefore an indicator of lead toxicity.

If your BLL exceeds 40 ug/dl the monitoring frequency must be increased from every 6 months to at least every 2 months and not reduced until two consecutive BLLs indicate a blood lead level below 40 ug/dl. Each time your BLL is determined to be over 40 ug/dl, your employer must notify you of this in writing within five working days of his or her receipt of the test results. The employer must also inform you that the standard requires temporary medical removal with economic protection when your BLL exceeds 50 ug/dl. (See Discussion of Medical Removal Protection - Paragraph (k).) Anytime your BLL exceeds 50 ug/dl your employer must make available to you within two weeks of receipt of these test results a second follow-up BLL test to confirm your BLL. If the two tests both exceed 50 ug/dl, and you are temporarily removed, then your employer must make successive BLL tests available to you on a monthly basis during the period of your removal.

Medical examinations beyond the initial one must be made available on an annual basis if your blood lead level exceeds 40 ug/dl at any time during the preceding year and you are being exposed above the airborne action level of 30 ug/m(3) for 30 or more days per year. The initial examination will provide information to establish a baseline to which subsequent data can be compared.

An initial medical examination to consist of blood sampling and analysis for lead and zinc protoporphyrin must also be made available (prior to assignment) for each employee being assigned for the first time to an area where the airborne concentration of lead equals or exceeds the action level at any time. In addition, a medical examination or consultation must be made available as soon as possible if you notify your employer that you are experiencing signs or symptoms commonly associated with lead poisoning or that you have difficulty breathing while wearing a respirator or during a respirator fit test. You must also be provided a medical examination or consultation if you notify your employer that you desire medical advice concerning the effects of current or past exposure to lead on your ability to procreate a healthy child.

Finally, appropriate follow-up medical examinations or consultations may also be provided for employees who have been temporarily removed from exposure under the medical removal protection provisions of the standard. (See Part IX, below.)

The standard specifies the minimum content of pre-assignment and annual medical examinations. The content of other types of medical examinations and consultations is left up

to the sound discretion of the examining physician. Pre-assignment and annual medical examinations must include (1) a detailed work history and medical history; (2) a thorough physical examination, including an evaluation of your pulmonary status if you will be required to use a respirator; (3) a blood pressure measurement; and (4) a series of laboratory tests designed to check your blood chemistry and your kidney function. In addition, at any time upon your request, a laboratory evaluation of male fertility will be made (microscopic examination of a sperm sample), or a pregnancy test will be given.

The standard does not require that you participate in any of the medical procedures, tests, etc. which your employer is required to make available to you. Medical surveillance can, however, play a very important role in protecting your health. You are strongly encouraged, therefore, to participate in a meaningful fashion. The standard contains a multiple physician review mechanism which will give you a chance to have a physician of your choice directly participate in the medical surveillance program. If you are dissatisfied with an examination by a physician chosen by your employer, you can select a second physician to conduct an independent analysis. The two doctors would attempt to resolve any differences of opinion, and select a third physician to resolve any firm dispute. Generally your employer will choose the physician who conducts medical surveillance under the lead standard - unless you and your employer can agree on the choice of a physician or physicians. Some companies and unions have agreed in advance, for example, to use certain independent medical laboratories or panels of physicians. Any of these arrangements are acceptable so long as required medical surveillance is made available to workers.

The standard requires your employer to provide certain information to a physician to aid in his or her examination of you. This information includes (1) the standard and its appendices, (2) a description of your duties as they relate to occupational lead exposure, (3) your exposure level or anticipated exposure level, (4) a description of any personal protective equipment you wear, (5) prior blood lead level results, and (6) prior written medical opinions concerning you that the employer has. After a medical examination or consultation the physician must prepare a written report which must contain (1) the physician's opinion as to whether you have any medical condition which places you at increased risk of material impairment to health from exposure to lead, (2) any recommended special protective measures to be provided to you, (3) any blood lead level determinations, and (4) any recommended limitation on your use of respirators. This last element must include a determination of whether you can wear a powered air purifying respirator (PAPR) if you are found unable to wear a negative pressure respirator.

The medical surveillance program of the interim lead standard may at some point in time serve to notify certain workers that they have acquired a disease or other adverse medical condition as a result of occupational lead exposure. If this is true, these workers might have legal rights to compensation from public agencies, their employers, firms that supply hazardous products to their employers, or other persons. Some states have laws, including worker compensation laws, that disallow a worker who learns of a job - related health impairment to sue, unless the worker sues within a short period of time after learning of the impairment. (This period of time may be a matter of months or years.) An attorney can be consulted about these possibilities. It should be stressed that OSHA is in no way trying to either encourage or discourage claims or lawsuits. However, since results of the standard's medical surveillance program can significantly affect the legal remedies of a worker who has acquired a job - related disease or impairment, it is proper for OSHA to make you aware of this.

The medical surveillance section of the standard also contains provisions dealing with chelation. Chelation is the use of certain drugs (administered in pill form or injected into the body) to reduce the amount of lead absorbed in body tissues. Experience accumulated by the medical and scientific communities has largely confirmed the effectiveness of this type of therapy for the treatment of very severe lead poisoning. On the other hand, it has also been

established that there can be a long list of extremely harmful side effects associated with the use of chelating agents. The medical community has balanced the advantages and disadvantages resulting from the use of chelating agents in various circumstances and has established when the use of these agents is acceptable. The standard includes these accepted limitations due to a history of abuse of chelation therapy by some lead companies. The most widely used chelating agents are calcium disodium EDTA, (Ca Na2 EDTA), Calcium Disodium Versenate (Versenate), and d-penicillamine (penicillamine or Cupramine).

The standard prohibits "prophylactic chelation" of any employee by any person the employer retains, supervises or controls. "Prophylactic chelation" is the routine use of chelating or similarly acting drugs to prevent elevated blood levels in workers who are occupationally exposed to lead, or the use of these drugs to routinely lower blood lead levels to predesignated concentrations believed to be "safe". It should be emphasized that where an employer takes a worker who has no symptoms of lead poisoning and has chelation carried out by a physician (either inside or outside of a hospital) solely to reduce the worker's blood lead level, that will generally be considered prophylactic chelation. The use of a hospital and a physician does not mean that prophylactic chelation is not being performed. Routine chelation to prevent increased or reduce current blood lead levels is unacceptable whatever the setting.

The standard allows the use of "therapeutic" or "diagnostic" chelation if administered under the supervision of a licensed physician in a clinical setting with thorough and appropriate medical monitoring. Therapeutic chelation responds to severe lead poisoning where there are marked symptoms. Diagnostic chelation involved giving a patient a dose of the drug then collecting all urine excreted for some period of time as an aid to the diagnosis of lead poisoning.

In cases where the examining physician determines that chelation is appropriate, you must be notified in writing of this fact before such treatment. This will inform you of a potentially harmful treatment, and allow you to obtain a second opinion.

IX. Medical Removal Protection - Paragraph (K)

Excessive lead absorption subjects you to increased risk of disease. Medical removal protection (MRP) is a means of protecting you when, for whatever reasons, other methods, such as engineering controls, work practices, and respirators, have failed to provide the protection you need. MRP involves the temporary removal of a worker from his or her regular job to a place of significantly lower exposure without any loss of earnings, seniority, or other employment rights or benefits. The purpose of this program is to cease further lead absorption and allow your body to naturally excrete lead which has previously been absorbed. Temporary medical removal can result from an elevated blood lead level, or a medical opinion. For up to 18 months, or for as long as the job the employee was removed from lasts, protection is provided as a result of either form of removal. The vast majority of removed workers, however, will return to their former jobs long before this eighteen month period expires.

You may also be removed from exposure even if your blood lead level is below 50 ug/dl if a final medical determination indicates that you temporarily need reduced lead exposure for medical reasons. If the physician who is implementing your employers medical program makes a final written opinion recommending your removal or other special protective measures, your employer must implement the physician's recommendation. If you are removed in this manner, you may only be returned when the doctor indicates that it is safe for you to do so.

The standard does not give specific instructions dealing with what an employer must do with a removed worker. Your job assignment upon removal is a matter for you, your employer

and your union (if any) to work out consistent with existing procedures for job assignments. Each removal must be accomplished in a manner consistent with existing collective bargaining relationships. Your employer is given broad discretion to implement temporary removals so long as no attempt is made to override existing agreements. Similarly, a removed worker is provided no right to veto an employer's choice which satisfies the standard.

In most cases, employers will likely transfer removed employees to other jobs with sufficiently low lead exposure. Alternatively, a worker's hours may be reduced so that the time weighted average exposure is reduced, or he or she may be temporarily laid off if no other alternative is feasible.

In all of these situation, MRP benefits must be provided during the period of removal - i.e., you continue to receive the same earnings, seniority, and other rights and benefits you would have had if you had not been removed. Earnings includes more than just your base wage; it includes overtime, shift differentials, incentives, and other compensation you would have earned if you had not been removed. During the period of removal you must also be provided with appropriate follow-up medical surveillance. If you were removed because your blood lead level was too high, you must be provided with a monthly blood test. If a medical opinion caused your removal, you must be provided medical tests or examinations that the doctor believes to be appropriate. If you do not participate in this follow up medical surveillance, you may lose your eligibility for MRP benefits.

When you are medically eligible to return to your former job, your employer must return you to your "former job status." This means that you are entitled to the position, wages, benefits, etc., you would have had if you had not been removed. If you would still be in your old job if no removal had occurred that is where you go back. If not, you are returned consistent with whatever job assignment discretion your employer would have had if no removal had occurred. MRP only seeks to maintain your rights, not expand them or diminish them.

If you are removed under MRP and you are also eligible for worker compensation or other compensation for lost wages, your employer's MRP benefits obligation is reduced by the amount that you actually receive from these other sources. This is also true if you obtain other employment during the time you are laid off with MRP benefits.

The standard also covers situations where an employer voluntarily removes a worker from exposure to lead due to the effects of lead on the employee's medical condition, even though the standard does not require removal. In these situations MRP benefits must still be provided as though the standard required removal. Finally, it is important to note that in all cases where removal is required, respirators cannot be used as a substitute. Respirators may be used before removal becomes necessary, but not as an alternative to a transfer to a low exposure job, or to a lay-off with MRP benefits.

X. Employee Information and Training - Paragraph (L)

Your employer is required to provide an information and training program for all employees exposed to lead above the action level or who may suffer skin or eye irritation from lead compounds such as lead arsenate or lead azide. The program must train these employees regarding the specific hazards associated with their work environment, protective measures which can be taken, including the contents of any compliance plan in effect, the danger of lead to their bodies (including their reproductive systems), and their rights under the standard. All employees must be trained prior to initial assignment to areas where there is a possibility of exposure over the action level .

This training program must also be provided at least annually thereafter unless further exposure above the action level will not occur.

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XI. Signs - Paragraph (M)

The standard requires that the following warning sign be posted in work areas where the exposure to lead exceeds the PEL:

WARNING
LEAD WORK AREA
POISON
NO SMOKING OR EATING

These signs are to be posted and maintained in a manner which assures that the legend is readily visible.

XII. Recordkeeping - Paragraph (N)

Your employer is required to keep all records of exposure monitoring for airborne lead. These records must include the name and job classification of employees measured, details of the sampling and analytical techniques, the results of this sampling, and the type of respiratory protection being worn by the person sampled. Such records are to be retained for at least 30 years. Your employer is also required to keep all records of biological monitoring and medical examination results. These records must include the names of the employees, the physician's written opinion, and a copy of the results of the examination. Medical records must be preserved and maintained for the duration of employment plus 30 years. However, if the employee's duration of employment is less than one year, the employer need not retain that employee's medical records beyond the period of employment if they are provided to the employee upon termination of employment.

Recordkeeping is also required if you are temporarily removed from your job under the medical removal protection program. This record must include your name and social security number, the date of your removal and return, how the removal was or is being accomplished, and whether or not the reason for the removal was an elevated blood lead level. Your employer is required to keep each medical removal record only for as long as the duration of an employee's employment.

The standard requires that if you request to see or copy environmental monitoring, blood lead level monitoring, or medical removal records, they must be made available to you or to a representative that you authorize. Your union also has access to these records. Medical records other than BLL's must also be provided upon request to you, to your physician or to any other person whom you may specifically designate. Your union does not have access to your personal medical records unless you authorize their access.

XIII. Observation of Monitoring - Paragraph (O)

When air monitoring for lead is performed at your workplace as required by this standard, your employer must allow you or someone you designate to act as an observer of the monitoring. Observers are entitled to an explanation of the measurement procedure, and to record the results obtained. Since results will not normally be available at the time of the monitoring, observers are entitled to record or receive the results of the monitoring when returned by the laboratory. Your employer is required to provide the observer with any personal protective devices required to be worn by employees working in the area that is being monitored. The employer must require the observer to wear all such equipment and to comply with all other applicable safety and health procedures.

XIV. For Additional Information

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A. A copy of the interim standard for lead in construction can be obtained free of charge by calling or writing the OSHA Office of Publications, room N-3101, United States Department of Labor, Washington, D.C. 20210: Telephone (202) 219-4667 .

B. Additional information about the standard, its enforcement, and your employer's compliance can be obtained from the nearest OSHA Area Office listed in your telephone directory under United States Government/Department of Labor.
[57 FR 26627, May 4, 1993, as amended at 58 FR 34218, June 24, 1993; 63 FR 1152, Jan. 8, 1998; 71 FR 16674, April 3, 2006]

Appendix C

• **Part Number:**	1926
• **Part Title:**	Safety and Health Regulations for Construction
• **Subpart:**	D
• **Subpart Title:**	Occupational Health and Environmental Controls
• **Standard Number:**	1926.62 App C
• **Title:**	Medical Surveillance Guidelines

Introduction

The primary purpose of the Occupational Safety and Health Act of 1970 is to assure, so far as possible, safe and healthful working conditions for every working man and woman. The interim final occupational health standard for lead in construction is designed to protect workers exposed to inorganic lead including metallic lead, all inorganic lead compounds and organic lead soaps.

Under this interim final standard occupational exposure to inorganic lead is to be limited to 50 ug/m(3) (micrograms per cubic meter) based on an 8 hour time-weighted average (TWA). This permissible exposure limit (PEL) must be achieved through a combination of engineering, work practice and administrative controls to the extent feasible. Where these controls are in place but are found not to reduce employee exposures to or below the PEL, they must be used nonetheless, and supplemented with respirators to meet the 50 ug/m(3) exposure limit.

The standard also provides for a program of biological monitoring for employees exposed to lead above the action level at any time, and additional medical surveillance for all employees exposed to levels of inorganic lead above 30 ug/m(3) (TWA) for more than 30 days per year and whose BLL exceeds 40 ug/dl.

The purpose of this document is to outline the medical surveillance provisions of the interim standard for inorganic lead in construction, and to provide further information to the physician regarding the examination and evaluation of workers exposed to inorganic lead.

Section 1 provides a detailed description of the monitoring procedure including the required frequency of blood testing for exposed workers, provisions for medical removal protection (MRP), the recommended right of the employee to a second medical opinion, and

notification and recordkeeping requirements of the employer. A discussion of the requirements for respirator use and respirator monitoring and OSHA's position on prophylactic chelation therapy are also included in this section.

Section 2 discusses the toxic effects and clinical manifestations of lead poisoning and effects of lead intoxication on enzymatic pathways in heme synthesis. The adverse effects on both male and female reproductive capacity and on the fetus are also discussed.

Section 3 outlines the recommended medical evaluation of the worker exposed to inorganic lead, including details of the medical history, physical examination, and recommended laboratory tests, which are based on the toxic effects of lead as discussed in Section 2.

Section 4 provides detailed information concerning the laboratory tests available for the monitoring of exposed workers. Included also is a discussion of the relative value of each test and the limitations and precautions which are necessary in the interpretation of the laboratory results.

I. Medical Surveillance and Monitoring Requirements for Workers Exposed to Inorganic Lead

Under the interim final standard for inorganic lead in the construction industry, initial medical surveillance consisting of biological monitoring to include blood lead and ZPP level determination shall be provided to employees exposed to lead at or above the action level on any one day. In addition, a program of biological monitoring is to be made available to all employees exposed above the action level at any time and additional medical surveillance is to be made available to all employees exposed to lead above 30 ug/m(3) TWA for more than 30 days each year and whose BLL exceeds 40 ug/dl. This program consists of periodic blood sampling and medical evaluation to be performed on a schedule which is defined by previous laboratory results, worker complaints or concerns, and the clinical assessment of the examining physician.

Under this program, the blood lead level (BLL) of all employees who are exposed to lead above 30 ug/m(3) for more than 30 days per year or whose blood lead is above 40 ug/dl but exposed for no more than 30 days per year is to be determined at least every two months for the first six months of exposure and every six months thereafter. The frequency is increased to every two months for employees whose last blood lead level was 40 ug/dl or above. For employees who are removed from exposure to lead due to an elevated blood lead, a new blood lead level must be measured monthly. A zinc protoporphyrin (ZPP) measurement is strongly recommended on each occasion that a blood lead level measurement is made.

An annual medical examination and consultation performed under the guidelines discussed in Section 3 is to be made available to each employee exposed above 30 ug/m(3) for more than 30 days per year for whom a blood test conducted at any time during the preceding 12 months indicated a blood lead level at or above 40 ug/dl. Also, an examination is to be given to all employees prior to their assignment to an area in which airborne lead concentrations reach or exceed the 30 ug/m(3) for more than 30 days per year. In addition, a medical

examination must be provided as soon as possible after notification by an employee that the employee has developed signs or symptoms commonly associated with lead intoxication, that the employee desires medical advice regarding lead exposure and the ability to procreate a healthy child, or that the employee has demonstrated difficulty in breathing during a respirator fitting test or during respirator use. An examination is also to be made available to each employee removed from exposure to lead due to a risk of sustaining material impairment to health, or otherwise limited or specially protected pursuant to medical recommendations.

Results of biological monitoring or the recommendations of an examining physician may necessitate removal of an employee from further lead exposure pursuant to the standard's medical removal protection (MRP) program. The object of the MRP program is to provide temporary medical removal to workers either with substantially elevated blood lead levels or otherwise at risk of sustaining material health impairment from continued substantial exposure to lead.

Under the standard's ultimate worker removal criteria, a worker is to be removed from any work having an eight hour TWA exposure to lead of 30 ug/m(3) when his or her blood lead level reaches 50 ug/dl and is confirmed by a second follow-up blood lead level performed within two weeks after the employer receives the results of the first blood sampling test. Return of the employee to his or her job status depends on a worker's blood lead level declining to 40 ug/dl.

As part of the interim standard, the employer is required to notify in writing each employee whose blood lead level exceeds 40 ug/dl. In addition each such employee is to be informed that the standard requires medical removal with MRP benefits, discussed below, when an employee's blood lead level exceeds the above defined limit.

In addition to the above blood lead level criterion, temporary worker removal may also take place as a result of medical determinations and recommendations. Written medical opinions must be prepared after each examination pursuant to the standard. If the examining physician includes a medical finding, determination or opinion that the employee has a medical condition which places the employee at increased risk of material health impairment from exposure to lead, then the employee must be removed from exposure to lead at or above 30 ug/m(3). Alternatively, if the examining physician recommends special protective measures for an employee (e.g., use of a powered air purifying respirator) or recommends limitations on an employee's exposure to lead, then the employer must implement these recommendations.

Recommendations may be more stringent than the specific provisions of the standard. The examining physician, therefore, is given broad flexibility to tailor special protective procedures to the needs of individual employees. This flexibility extends to the evaluation and management of pregnant workers and male and female workers who are planning to raise children. Based on the history, physical examination, and laboratory studies, the physician might recommend special protective measures or medical removal for an employee who is pregnant or who is planning to conceive a child when, in the physician's judgment, continued

exposure to lead at the current job would pose a significant risk. The return of the employee to his or her former job status, or the removal of special protections or limitations, depends upon the examining physician determining that the employee is no longer at increased risk of material impairment or that special measures are no longer needed.

During the period of any form of special protection or removal, the employer must maintain the worker's earnings, seniority, and other employment rights and benefits (as though the worker had not been removed) for a period of up to 18 months or for as long as the job the employee was removed from lasts if less than 18 months. This economic protection will maximize meaningful worker participation in the medical surveillance program, and is appropriate as part of the employer's overall obligation to provide a safe and healthful workplace. The provisions of MRP benefits during the employee's removal period may, however, be conditioned upon participation in medical surveillance.

The lead standard provides for a multiple physician review in cases where the employee wishes a second opinion concerning potential lead poisoning or toxicity. If an employee wishes a second opinion, he or she can make an appointment with a physician of his or her choice. This second physician will review the findings, recommendations or determinations of the first physician and conduct any examinations, consultations or tests deemed necessary in an attempt to make a final medical determination. If the first and second physicians do not agree in their assessment they must try to resolve their differences. If they cannot reach an agreement then they must designate a third physician to resolve the dispute.

The employer must provide examining and consulting physicians with the following specific information: a copy of the lead regulations and all appendices, a description of the employee's duties as related to exposure, the exposure level or anticipated level to lead and any other toxic substances (if applicable), a description of personal protective equipment used, blood lead levels, and all prior written medical opinions regarding the employee in the employer's possession or control. The employer must also obtain from the physician and provide the employee with a written medical opinion containing blood lead levels, the physician's opinion as to whether the employee is at risk of material impairment to health, any recommended protective measures for the employee if further exposure is permitted, as well as any recommended limitations upon an employee's use of respirators.

Employers must instruct each physician not to reveal to the employer in writing or in any other way his or her findings, laboratory results, or diagnoses which are felt to be unrelated to occupational lead exposure. They must also instruct each physician to advise the employee of any occupationally or non-occupationally related medical condition requiring further treatment or evaluation.

The standard provides for the use of respirators where engineering and other primary controls are not effective. However, the use of respirator protection shall not be used in lieu of temporary medical removal due to elevated blood lead levels or findings that an employee is at risk of material health impairment. This is based on the numerous inadequacies of respirators including skin rash where the facepiece makes contact with the skin, unacceptable stress to breathing in some workers with underlying cardiopulmonary impairment, difficulty

in providing adequate fit, the tendency for respirators to create additional hazards by interfering with vision, hearing, and mobility, and the difficulties of assuring the maximum effectiveness of a complicated work practice program involving respirators. Respirators do, however, serve a useful function where engineering and work practice controls are inadequate by providing supplementary, interim, or short-term protection, provided they are properly selected for the environment in which the employee will be working, properly fitted to the employee, maintained and cleaned periodically, and worn by the employee when required.

In its interim final standard on occupational exposure to inorganic lead in the construction industry, OSHA has prohibited prophylactic chelation. Diagnostic and therapeutic chelation are permitted only under the supervision of a licensed physician with appropriate medical monitoring in an acceptable clinical setting. The decision to initiate chelation therapy must be made on an individual basis and take into account the severity of symptoms felt to be a result of lead toxicity along with blood lead levels, ZPP levels, and other laboratory tests as appropriate. EDTA and penicillamine which are the primary chelating agents used in the therapy of occupational lead poisoning have significant potential side effects and their use must be justified on the basis of expected benefits to the worker. Unless frank and severe symptoms are present, therapeutic chelation is not recommended, given the opportunity to remove a worker from exposure and allow the body to naturally excrete accumulated lead. As a diagnostic aid, the chelation mobilization test using CA-EDTA has limited applicability. According to some investigators, the test can differentiate between lead - induced and other nephropathies. The test may also provide an estimation of the mobile fraction of the total body lead burden.

Employers are required to assure that accurate records are maintained on exposure assessment, including environmental monitoring, medical surveillance, and medical removal for each employee. Exposure assessment records must be kept for at least 30 years. Medical surveillance records must be kept for the duration of employment plus 30 years except in cases where the employment was less than one year. If duration of employment is less than one year, the employer need not retain this record beyond the term of employment if the record is provided to the employee upon termination of employment. Medical removal records also must be maintained for the duration of employment. All records required under the standard must be made available upon request to the Assistant Secretary of Labor for Occupational Safety and Health and the Director of the National Institute for Occupational Safety and Health. Employers must also make environmental and biological monitoring and medical removal records available to affected employees and to former employees or their authorized employee representatives. Employees or their specifically designated representatives have access to their entire medical surveillance records.

In addition, the standard requires that the employer inform all workers exposed to lead at or above 30 ug/m(3) of the provisions of the standard and all its appendices, the purpose and description of medical surveillance and provisions for medical removal protection if temporary removal is required. An understanding of the potential health effects of lead exposure by all exposed employees along with full understanding of their rights under the

lead standard is essential for an effective monitoring program.

II. Adverse Health Effects of Inorganic Lead

Although the toxicity of lead has been known for 2,000 years, the knowledge of the complex relationship between lead exposure and human response is still being refined. Significant research into the toxic properties of lead continues throughout the world, and it should be anticipated that our understanding of thresholds of effects and margins of safety will be improved in future years. The provisions of the lead standard are founded on two prime medical judgments: first, the prevention of adverse health effects from exposure to lead throughout a working lifetime requires that worker blood lead levels be maintained at or below 40 ug/dl and second, the blood lead levels of workers, male or female, who intend to parent in the near future should be maintained below 30 ug/dl to minimize adverse reproductive health effects to the parents and developing fetus. The adverse effects of lead on reproduction are being actively researched and OSHA encourages the physician to remain abreast of recent developments in the area to best advise pregnant workers or workers planning to conceive children.

The spectrum of health effects caused by lead exposure can be subdivided into five developmental stages: normal, physiological changes of uncertain significance, pathophysiological changes, overt symptoms (morbidity), and mortality. Within this process there are no sharp distinctions, but rather a continuum of effects. Boundaries between categories overlap due to the wide variation of individual responses and exposures in the working population. OSHA's development of the lead standard focused on pathophysiological changes as well as later stages of disease.

1. Heme Synthesis Inhibition. The earliest demonstrated effect of lead involves its ability to inhibit at least two enzymes of the heme synthesis pathway at very low blood levels. Inhibition of delta aminolevulinic acid dehydrase (ALA-D) which catalyzes the conversion of delta-aminolevulinic acid (ALA) to protoporphyrin is observed at a blood lead level below 20 ug/dl. At a blood lead level of 40 ug/dl, more than 20 percent of the population would have 70 percent inhibition of ALA-D. There is an exponential increase in ALA excretion at blood lead levels greater than 40 ug/dl.

Another enzyme, ferrochelatase, is also inhibited at low blood lead levels. Inhibition of ferrochelatase leads to increased free erythrocyte protoporphyrin (FEP) in the blood which can then bind to zinc to yield zinc protoporphyrin. At a blood lead level of 50 ug/dl or greater, nearly 100 percent of the population will have an increase in FEP. There is also an exponential relationship between blood lead levels greater than 40 ug/dl and the associated ZPP level, which has led to the development of the ZPP screening test for lead exposure.

While the significance of these effects is subject to debate, it is OSHA's position that these enzyme disturbances are early stages of a disease process which may eventually result in the clinical symptoms of lead poisoning. Whether or not the effects do progress to the later stages of clinical disease, disruption of these enzyme processes over a working lifetime is

considered to be a material impairment of health.

One of the eventual results of lead - induced inhibition of enzymes in the heme synthesis pathway is anemia which can be asymptomatic if mild but associated with a wide array of symptoms including dizziness, fatigue, and tachycardia when more severe. Studies have indicated that lead levels as low as 50 ug/dl can be associated with a definite decreased hemoglobin, although most cases of lead - induced anemia, as well as shortened red-cell survival times, occur at lead levels exceeding 80 ug/dl. Inhibited hemoglobin synthesis is more common in chronic cases whereas shortened erythrocyte life span is more common in acute cases.

In lead - induced anemias, there is usually a reticulocytosis along with the presence of basophilic stippling, and ringed sideroblasts, although none of the above are pathognomonic for lead - induced anemia.

2. Neurological Effects. Inorganic lead has been found to have toxic effects on both the central and peripheral nervous systems. The earliest stages of lead - induced central nervous system effects first manifest themselves in the form of behavioral disturbances and central nervous system symptoms including irritability, restlessness, insomnia and other sleep disturbances, fatigue, vertigo, headache, poor memory, tremor, depression, and apathy. With more severe exposure, symptoms can progress to drowsiness, stupor, hallucinations, delirium, convulsions and coma.

The most severe and acute form of lead poisoning which usually follows ingestion or inhalation of large amounts of lead is acute encephalopathy which may arise precipitously with the onset of intractable seizures, coma, cardiorespiratory arrest, and death within 48 hours.

While there is disagreement about what exposure levels are needed to produce the earliest symptoms, most experts agree that symptoms definitely can occur at blood lead levels of 60 ug/dl whole blood and therefore recommend a 40 ug/dl maximum. The central nervous system effects frequently are not reversible following discontinued exposure or chelation therapy and when improvement does occur, it is almost always only partial.

The peripheral neuropathy resulting from lead exposure characteristically involves only motor function with minimal sensory damage and has a marked predilection for the extensor muscles of the most active extremity. The peripheral neuropathy can occur with varying degrees of severity. The earliest and mildest form which can be detected in workers with blood lead levels as low as 50 ug/dl is manifested by slowing of motor nerve conduction velocity often without clinical symptoms. With progression of the neuropathy there is development of painless extensor muscle weakness usually involving the extensor muscles of the fingers and hand in the most active upper extremity, followed in severe cases by wrist drop or, much less commonly, foot drop.

In addition to slowing of nerve conduction, electromyographical studies in patients with blood lead levels greater than 50 ug/dl have demonstrated a decrease in the number of acting

motor unit potentials, an increase in the duration of motor unit potentials, and spontaneous pathological activity including fibrillations and fasciculations. Whether these effects occur at levels of 40 ug/dl is undetermined.

While the peripheral neuropathies can occasionally be reversed with therapy, again such recovery is not assured particularly in the more severe neuropathies and often improvement is only partial. The lack of reversibility is felt to be due in part to segmental demyelination.

3. Gastrointestinal. Lead may also affect the gastrointestinal system producing abdominal colic or diffuse abdominal pain, constipation, obstipation, diarrhea, anorexia, nausea and vomiting. Lead colic rarely develops at blood lead levels below 80 ug/dl.

4. Renal. Renal toxicity represents one of the most serious health effects of lead poisoning. In the early stages of disease nuclear inclusion bodies can frequently be identified in proximal renal tubular cells. Renal function remains normal and the changes in this stage are probably reversible. With more advanced disease there is progressive interstitial fibrosis and impaired renal function. Eventually extensive interstitial fibrosis ensues with sclerotic glomeruli and dilated and atrophied proximal tubules; all represent end stage kidney disease. Azotemia can be progressive, eventually resulting in frank uremia necessitating dialysis. There is occasionally associated hypertension and hyperuricemia with or without gout.

Early kidney disease is difficult to detect. The urinalysis is normal in early lead nephropathy and the blood urea nitrogen and serum creatinine increase only when two-thirds of kidney function is lost. Measurement of creatinine clearance can often detect earlier disease as can other methods of measurement of glomerular filtration rate. An abnormal Ca-EDTA mobilization test has been used to differentiate between lead - induced and other nephropathies, but this procedure is not widely accepted. A form of Fanconi syndrome with aminoaciduria, glycosuria, and hyperphosphaturia indicating severe injury to the proximal renal tubules is occasionally seen in children.

5. Reproductive effects. Exposure to lead can have serious effects on reproductive function in both males and females. In male workers exposed to lead there can be a decrease in sexual drive, impotence, decreased ability to produce healthy sperm, and sterility. Malformed sperm (teratospermia), decreased number of sperm (hypospermia), and sperm with decreased motility (asthenospermia) can all occur. Teratospermia has been noted at mean blood lead levels of 53 ug/dl and hypospermia and asthenospermia at 41 ug/dl. Furthermore, there appears to be a dose - response relationship for teratospermia in lead exposed workers.

Women exposed to lead may experience menstrual disturbances including dysmenorrhea, menorrhagia and amenorrhea. Following exposure to lead, women have a higher frequency of sterility, premature births, spontaneous miscarriages, and stillbirths.

Germ cells can be affected by lead and cause genetic damage in the egg or sperm cells before conception and result in failure to implant, miscarriage, stillbirth, or birth defects.

Infants of mothers with lead poisoning have a higher mortality during the first year and suffer

from lowered birth weights, slower growth, and nervous system disorders.

Lead can pass through the placental barrier and lead levels in the mother's blood are comparable to concentrations of lead in the umbilical cord at birth. Transplacental passage becomes detectable at 12-14 weeks of gestation and increases until birth.

There is little direct data on damage to the fetus from exposure to lead but it is generally assumed that the fetus and newborn would be at least as susceptible to neurological damage as young children. Blood lead levels of 50-60 ug/dl in children can cause significant neurobehavioral impairments and there is evidence of hyperactivity at blood levels as low as 25 ug/dl. Given the overall body of literature concerning the adverse health effects of lead in children, OSHA feels that the blood lead level in children should be maintained below 30 ug/dl with a population mean of 15 ug/dl. Blood lead levels in the fetus and newborn likewise should not exceed 30 ug/dl.

Because of lead's ability to pass through the placental barrier and also because of the demonstrated adverse effects of lead on reproductive function in both the male and female as well as the risk of genetic damage of lead on both the ovum and sperm, OSHA recommends a 30 ug/dl maximum permissible blood lead level in both males and females who wish to bear children.

6. Other toxic effects. Debate and research continue on the effects of lead on the human body. Hypertension has frequently been noted in occupationally exposed individuals although it is difficult to assess whether this is due to lead's adverse effects on the kidney or if some other mechanism is involved. Vascular and electrocardiographic changes have been detected but have not been well characterized. Lead is thought to impair thyroid function and interfere with the pituitary-adrenal axis, but again these effects have not been well defined.

III. Medical Evaluation

The most important principle in evaluating a worker for any occupational disease including lead poisoning is a high index of suspicion on the part of the examining physician. As discussed in Section 2, lead can affect numerous organ systems and produce a wide array of signs and symptoms, most of which are non-specific and subtle in nature at least in the early stages of disease. Unless serious concern for lead toxicity is present, many of the early clues to diagnosis may easily be overlooked.

The crucial initial step in the medical evaluation is recognizing that a worker's employment can result in exposure to lead. The worker will frequently be able to define exposures to lead and lead containing materials but often will not volunteer this information unless specifically asked. In other situations the worker may not know of any exposures to lead but the suspicion might be raised on the part of the physician because of the industry or occupation of the worker. Potential occupational exposure to lead and its compounds occur in many occupations in the construction industry, including demolition and salvaging operations, removal or encapsulation of materials containing lead, construction, alteration, repair or renovation of structures containing lead, transportation, disposal, storage or containment of

lead or lead - containing materials on construction sites, and maintenance operations associated with construction activities.

Once the possibility for lead exposure is raised, the focus can then be directed toward eliciting information from the medical history, physical exam, and finally from laboratory data to evaluate the worker for potential lead toxicity.

A complete and detailed work history is important in the initial evaluation. A listing of all previous employment with information on job description, exposure to fumes or dust, known exposures to lead or other toxic substances, a description of any personal protective equipment used, and previous medical surveillance should all be included in the worker's record. Where exposure to lead is suspected, information concerning on-the-job personal hygiene, smoking or eating habits in work areas, laundry procedures, and use of any protective clothing or respiratory protection equipment should be noted. A complete work history is essential in the medical evaluation of a worker with suspected lead toxicity, especially when long term effects such as neurotoxicity and nephrotoxicity are considered.

The medical history is also of fundamental importance and should include a listing of all past and current medical conditions, current medications including proprietary drug intake, previous surgeries and hospitalizations, allergies, smoking history, alcohol consumption, and also non-occupational lead exposures such as hobbies (hunting, riflery). Also known childhood exposures should be elicited. Any previous history of hematological, neurological, gastrointestinal, renal, psychological, gynecological, genetic, or reproductive problems should be specifically noted.

A careful and complete review of systems must be performed to assess both recognized complaints and subtle or slowly acquired symptoms which the worker might not appreciate as being significant. The review of symptoms should include the following:

1. General - weight loss, fatigue, decreased appetite.

2. Head, Eyes, Ears, Nose, Throat (HEENT) - headaches, visual disturbances or decreased visual acuity, hearing deficits or tinnitus, pigmentation of the oral mucosa, or metallic taste in mouth.

3. Cardio-pulmonary - shortness of breath, cough, chest pains, palpitations, or orthopnea.

4. Gastrointestinal - nausea, vomiting, heartburn, abdominal pain, constipation or diarrhea.

5. Neurologic - irritability, insomnia, weakness (fatigue), dizziness, loss of memory, confusion, hallucinations, incoordination, ataxia, decreased strength in hands or feet, disturbances in gait, difficulty in climbing stairs, or seizures.

6. Hematologic - pallor, easy fatigability, abnormal blood loss, melena.

7. Reproductive (male and female and spouse where relevant) - history of infertility,

impotence, loss of libido, abnormal menstrual periods, history of miscarriages, stillbirths, or children with birth defects.

8. Musculo-skeletal - muscle and joint pains.

The physical examination should emphasize the neurological, gastrointestinal, and cardiovascular systems. The worker's weight and blood pressure should be recorded and the oral mucosa checked for pigmentation characteristic of a possible Burtonian or lead line on the gingiva. It should be noted, however, that the lead line may not be present even in severe lead poisoning if good oral hygiene is practiced.

The presence of pallor on skin examination may indicate an anemia which, if severe, might also be associated with a tachycardia. If an anemia is suspected, an active search for blood loss should be undertaken including potential blood loss through the gastrointestinal tract.

A complete neurological examination should include an adequate mental status evaluation including a search for behavioral and psychological disturbances, memory testing, evaluation for irritability, insomnia, hallucinations, and mental clouding. Gait and coordination should be examined along with close observation for tremor. A detailed evaluation of peripheral nerve function including careful sensory and motor function testing is warranted. Strength testing particularly of extensor muscle groups of all extremities is of fundamental importance.

Cranial nerve evaluation should also be included in the routine examination.

The abdominal examination should include auscultation for bowel sounds and abdominal bruits and palpation for organomegaly, masses, and diffuse abdominal tenderness.

Cardiovascular examination should evaluate possible early signs of congestive heart failure. Pulmonary status should be addressed particularly if respirator protection is contemplated.

As part of the medical evaluation, the interim lead standard requires the following laboratory studies:

1. Blood lead level

2. Hemoglobin and hematocrit determinations, red cell indices, and examination of the peripheral blood smear to evaluate red blood cell morphology

3. Blood urea nitrogen

4. Serum creatinine

5. Routine urinalysis with microscopic examination.

6. A zinc protoporphyrin level.

In addition to the above, the physician is authorized to order any further laboratory or other tests which he or she deems necessary in accordance with sound medical practice. The evaluation must also include pregnancy testing or laboratory evaluation of male fertility if requested by the employee. Additional tests which are probably not warranted on a routine basis but may be appropriate when blood lead and ZPP levels are equivocal include delta aminolevulinic acid and coproporphyrin concentrations in the urine, and dark-field illumination for detection of basophilic stippling in red blood cells.

If an anemia is detected further studies including a careful examination of the peripheral smear, reticulocyte count, stool for occult blood, serum iron, total iron binding capacity, bilirubin, and, if appropriate, vitamin B12 and folate may be of value in attempting to identify the cause of the anemia.

If a peripheral neuropathy is suspected, nerve conduction studies are warranted both for diagnosis and as a basis to monitor any therapy.

If renal disease is questioned, a 24 hour urine collection for creatinine clearance, protein, and electrolytes may be indicated. Elevated uric acid levels may result from lead - induced renal disease and a serum uric acid level might be performed.

An electrocardiogram and chest x-ray may be obtained as deemed appropriate.

Sophisticated and highly specialized testing should not be done routinely and where indicated should be under the direction of a specialist.

IV. Laboratory Evaluation

The blood lead level at present remains the single most important test to monitor lead exposure and is the test used in the medical surveillance program under the lead standard to guide employee medical removal. The ZPP has several advantages over the blood lead level. Because of its relatively recent development and the lack of extensive data concerning its interpretation, the ZPP currently remains an ancillary test.

This section will discuss the blood lead level and ZPP in detail and will outline their relative advantages and disadvantages. Other blood tests currently available to evaluate lead exposure will also be reviewed.

The blood lead level is a good index of current or recent lead absorption when there is no anemia present and when the worker has not taken any chelating agents. However, blood lead levels along with urinary lead levels do not necessarily indicate the total body burden of lead and are not adequate measures of past exposure. One reason for this is that lead has a high affinity for bone and up to 90 percent of the body's total lead is deposited there. A very important component of the total lead body burden is lead in soft tissue (liver, kidney, and brain). This fraction of the lead body burden, the biologically active lead, is not entirely

reflected by blood lead levels since it is a function of the dynamics of lead absorption, distribution, deposition in bone and excretion. Following discontinuation of exposure to lead, the excess body burden is only slowly mobilized from bone and other relatively stable body stores and excreted. Consequently, a high blood lead level may only represent recent heavy exposure to lead without a significant total body excess and likewise a low blood lead level does not exclude an elevated total body burden of lead.

Also due to its correlation with recent exposures, the blood lead level may vary considerably over short time intervals.

To minimize laboratory error and erroneous results due to contamination, blood specimens must be carefully collected after thorough cleaning of the skin with appropriate methods using lead - free blood containers and analyzed by a reliable laboratory. Under the standard, samples must be analyzed in laboratories which are approved by OSHA. Analysis is to be made using atomic absorption spectrophotometry, anodic stripping voltammetry or any method which meets the accuracy requirements set forth by the standard.

The determination of lead in urine is generally considered a less reliable monitoring technique than analysis of whole blood primarily due to individual variability in urinary excretion capacity as well as the technical difficulty of obtaining accurate 24 hour urine collections. In addition, workers with renal insufficiency, whether due to lead or some other cause, may have decreased lead clearance and consequently urine lead levels may underestimate the true lead burden. Therefore, urine lead levels should not be used as a routine test.

The zinc protoporphyrin test, unlike the blood lead determination, measures an adverse metabolic effect of lead and as such is a better indicator of lead toxicity than the level of blood lead itself. The level of ZPP reflects lead absorption over the preceding 3 to 4 months, and therefore is a better indicator of lead body burden. The ZPP requires more time than the blood lead to read significantly elevated levels; the return to normal after discontinuing lead exposure is also slower. Furthermore, the ZPP test is simpler, faster, and less expensive to perform and no contamination is possible. Many investigators believe it is the most reliable means of monitoring chronic lead absorption.

Zinc protoporphyrin results from the inhibition of the enzyme ferrochelatase which catalyzes the insertion of an iron molecule into the protoporphyrin molecule, which then becomes heme. If iron is not inserted into the molecule then zinc, having a greater affinity for protoporphyrin, takes the place of the iron, forming ZPP.

An elevation in the level of circulating ZPP may occur at blood lead levels as low as 20-30 ug/dl in some workers. Once the blood lead level has reached 40 ug/dl there is more marked rise in the ZPP value from its normal range of less than 100 ug/dl 100 ml. Increases in blood lead levels beyond 40 ug/100 g are associated with exponential increases in ZPP.

Whereas blood lead levels fluctuate over short time spans, ZPP levels remain relatively stable. ZPP is measured directly in red blood cells and is present for the cell's entire 120 day

life-span. Therefore, the ZPP level in blood reflects the average ZPP production over the previous 3-4 months and consequently the average lead exposure during that time interval.

It is recommended that a hematocrit be determined whenever a confirmed ZPP of 50 ug/100 ml whole blood is obtained to rule out a significant underlying anemia. If the ZPP is in excess of 100 ug/100 ml and not associated with abnormal elevations in blood lead levels, the laboratory should be checked to be sure that blood leads were determined using atomic absorption spectrophotometry anodic stripping voltammetry, or any method which meets the accuracy requirements set forth by the standard by an OSHA approved laboratory which is experienced in lead level determinations. Repeat periodic blood lead studies should be obtained in all individuals with elevated ZPP levels to be certain that an associated elevated blood lead level has not been missed due to transient fluctuations in blood leads.

ZPP has a characteristic fluorescence spectrum with a peak at 594 nm which is detectable with a hematofluorimeter. The hematofluorimeter is accurate and portable and can provide on-site, instantaneous results for workers who can be frequently tested via a finger prick.

However, careful attention must be given to calibration and quality control procedures. Limited data on blood lead-ZPP correlations and the ZPP levels which are associated with the adverse health effects discussed in Section 2 are the major limitations of the test. Also it is difficult to correlate ZPP levels with environmental exposure and there is some variation of response with age and sex. Nevertheless, the ZPP promises to be an important diagnostic test for the early detection of lead toxicity and its value will increase as more data is collected regarding its relationship to other manifestations of lead poisoning.

Levels of delta-aminolevulinic acid (ALA) in the urine are also used as a measure of lead exposure. Increasing concentrations of ALA are believed to result from the inhibition of the enzyme delta-aminolevulinic acid dehydrase (ALA-D). Although the test is relatively easy to perform, inexpensive, and rapid, the disadvantages include variability in results, the necessity to collect a complete 24 hour urine sample which has a specific gravity greater than 1.010, and also the fact that ALA decomposes in the presence of light.

The pattern of porphyrin excretion in the urine can also be helpful in identifying lead intoxication. With lead poisoning, the urine concentrations of coproporphyrins I and II, porphobilinogen and uroporphyrin I rise. The most important increase, however, is that of coproporphyrin III; levels may exceed 5,000 ug/1 in the urine in lead poisoned individuals, but its correlation with blood lead levels and ZPP are not as good as those of ALA. Increases in urinary porphyrins are not diagnostic of lead toxicity and may be seen in porphyria, some liver diseases, and in patients with high reticulocyte counts.

Summary. The Occupational Safety and Health Administration's interim standard for inorganic lead in the construction industry places significant emphasis on the medical surveillance of all workers exposed to levels of inorganic lead above 30 ug/m(3) TWA. The physician has a fundamental role in this surveillance program, and in the operation of the medical removal protection program.

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Even with adequate worker education on the adverse health effects of lead and appropriate training in work practices, personal hygiene and other control measures, the physician has a primary responsibility for evaluating potential lead toxicity in the worker. It is only through a careful and detailed medical and work history, a complete physical examination and appropriate laboratory testing that an accurate assessment can be made. Many of the adverse health effects of lead toxicity are either irreversible or only partially reversible and therefore early detection of disease is very important.

This document outlines the medical monitoring program as defined by the occupational safety and health standard for inorganic lead. It reviews the adverse health effects of lead poisoning and describes the important elements of the history and physical examinations as they relate to these adverse effects. Finally, the appropriate laboratory testing for evaluating lead exposure and toxicity is presented.

It is hoped that this review and discussion will give the physician a better understanding of the OSHA standard with the ultimate goal of protecting the health and well-being of the worker exposed to lead under his or her care.

[57 FR 26627, May 4, 1993, as amended at 58 FR 34218, June 24, 1993]

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I. SUBSTANCE IDENTIFICATION

A. Substance: Pure lead (Pb) is a heavy metal at room temperature and pressure and is a basic chemical element. It can combine with various other substances to form numerous lead compounds.

B. Compounds Covered by the Standard: The word "lead" when used in this standard means elemental lead, all inorganic lead compounds and a class of organic lead compounds called lead soaps. This standard does not apply to other organic lead compounds.

C. Uses: Exposure to lead occurs in at least 120 different occupations, including primary and secondary lead smelting, lead storage battery manufacturing, lead pigment manufacturing and use, solder manufacturing and use, shipbuilding and ship repairing, auto manufacturing, and printing.

D. Permissible Exposure: The Permissible Exposure Limit (PEL) set by the standard is 50 micrograms of lead per cubic meter of air (50 ug/m(3)), averaged over an 8-hour workday.

E. Action Level: The standard establishes an action level of 30 micrograms per cubic meter of air (30 ug/m(3)), time weighted average, based on an 8-hour work-day. The action level initiates several requirements of the standard, such as exposure monitoring, medical surveillance, and training and education.

II. HEALTH HAZARD DATA

A. Ways in which lead enters your body. When absorbed into your body in certain doses lead is a toxic substance. The object of the lead standard is to prevent absorption of harmful quantities of lead. The standard is intended to protect you not only from the immediate toxic effects of lead, but also from the serious toxic effects that may not become apparent until years of exposure have passed.

Lead can be absorbed into your body by inhalation (breathing) and ingestion (eating). Lead (except for certain organic lead compounds not covered by the standard, such as tetraethyl lead) is not absorbed through your skin. When lead is scattered in the air as a dust, fume or mist it can be inhaled and absorbed through you lungs and upper respiratory tract. Inhalation of airborne lead is generally the most important source of occupational lead absorption. You can also absorb lead through your digestive system if lead gets into your mouth and is swallowed. If you handle food, cigarettes, chewing tobacco, or make-up which have lead on them or handle them with hands contaminated with lead, this will contribute to ingestion.

A significant portion of the lead that you inhale or ingest gets into your blood stream. Once in your blood stream, lead is circulated throughout your body and stored in various organs and body tissues. Some of this lead is quickly filtered out of your body and excreted, but some remains in the blood and other tissues. As exposure to lead continues, the amount stored in your body will increase if you are absorbing more lead than your body is excreting. Even though you may not be aware of any immediate symptoms of disease, this lead stored in your tissues can be slowly causing irreversible damage, first to individual cells, then to your organs and whole body systems.

B. Effects of overexposure to lead - (1) Short term (acute) overexposure. Lead is a potent, systemic poison that serves no known useful function once absorbed by your body. Taken in large enough doses, lead can kill you in a matter of days. A condition affecting the brain called acute encephalopathy may arise which develops quickly to seizures, coma, and death from cardiorespiratory arrest. A short term dose of lead can lead to acute encephalopathy. Short term occupational exposures of this magnitude are highly unusual, but not impossible. Similar forms of encephalopathy may, however, arise from extended, chronic exposure to lower doses of lead. There is no sharp dividing line between rapidly developing acute effects of lead, and chronic effects which take longer to acquire. Lead adversely affects numerous body systems, and causes forms of health impairment and disease which arise after periods of exposure as short as days or as long as several years.

(2) Long-term (chronic) overexposure. Chronic overexposure to lead may result in severe damage to your blood-forming, nervous, urinary and reproductive systems. Some common symptoms of chronic overexposure include loss of appetite, metallic taste in the mouth, anxiety, constipation, nausea, pallor, excessive tiredness, weakness, insomnia, headache, nervous irritability, muscle and joint pain or soreness, fine tremors, numbness, dizziness, hyperactivity and colic. In lead colic there may be severe abdominal pain.

Damage to the central nervous system in general and the brain (encephalopathy) in particular is one of the most severe forms of lead poisoning. The most severe, often fatal, form of encephalopathy may be preceded by vomiting, a feeling of dullness progressing to drowsiness and stupor, poor memory, restlessness, irritability, tremor, and convulsions. It may arise suddenly with the onset of seizures, followed by coma, and death. There is a tendency for muscular weakness to develop at the same time. This weakness may progress to paralysis often observed as a

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characteristic "wrist drop" or "foot drop" and is a manifestation of a disease to the nervous system called peripheral neuropathy.

Chronic overexposure to lead also results in kidney disease with few, if any, symptoms appearing until extensive and most likely permanent kidney damage has occurred. Routine laboratory tests reveal the presence of this kidney disease only after about two-thirds of kidney function is lost. When overt symptoms of urinary dysfunction arise, it is often too late to correct or prevent worsening conditions, and progression to kidney dialysis or death is possible.

Chronic overexposure to lead impairs the reproductive systems of both men and women. Overexposure to lead may result in decreased sex drive, impotence and sterility in men. Lead can alter the structure of sperm cells raising the risk of birth defects. There is evidence of miscarriage and stillbirth in women whose husbands were exposed to lead or who were exposed to lead themselves. Lead exposure also may result in decreased fertility, and abnormal menstrual cycles in women. The course of pregnancy may be adversely affected by exposure to lead since lead crosses the placental barrier and poses risks to developing fetuses. Children born of parents either one of whom were exposed to excess lead levels are more likely to have birth defects, mental retardation, behavioral disorders or die during the first year of childhood.

Overexposure to lead also disrupts the blood-forming system resulting in decreased hemoglobin (the substance in the blood that carries oxygen to the cells) and ultimately anemia. Anemia is characterized by weakness, pallor and fatigability as a result of decreased oxygen carrying capacity in the blood.

(3) Health protection goals of the standard. Prevention of adverse health effects for most workers from exposure to lead throughout a working lifetime requires that worker blood lead (PbB) levels be maintained at or below forty micrograms per one hundred grams of whole blood (40 ug/100g). The blood lead levels of workers (both male and female workers) who intend to have children should be maintained below 30 ug/100g to minimize adverse reproductive health effects to the parents and to the developing fetus.

The measurement of your blood lead level is the most useful indicator of the amount of lead being absorbed by your body. Blood lead levels (PbB) are most often reported in units of milligrams (mg) or micrograms (ug) of lead (1 mg=1000 ug) per 100 grams (100g), 100 milliters (100 ml) or deciliter (dl) of blood. These three units are essentially the same. Sometime PbB's are expressed in the form of mg% or ug%. This is a shorthand notation for 100g, 100 ml, or dl.

PbB measurements show the amount of lead circulating in your blood stream, but do not give any information about the amount of lead stored in your various tissues. PbB measurements merely show current absorption of lead, not the effect that lead is having on your body or the effects that past lead exposure may have already caused. Past research into lead-related diseases, however, has focused heavily on associations between PbBs and various diseases. As a result, your PbB is an important indicator of the likelihood that you will gradually acquire a lead-related health impairment or disease.

Once your blood lead level climbs above 40 ug/100g, your risk of disease increases. There is a wide variability of individual response to lead, thus it is difficult to say that a particular PbB in a given person will cause a particular effect. Studies have associated fatal encephalopathy with PbBs as low as 150 ug/100g. Other studies have shown other forms of diseases in some workers with PbBs well below 80 ug/100g. Your PbB is a crucial indicator of the risks to your health, but one other factor is also extremely important. This factor is the length of time you have had elevated PbBs. The longer you have an elevated PbB, the greater the risk that large quantities of lead are being gradually stored in your organs and tissues (body burden). The greater your overall body burden, the greater the chances of substantial permanent damage.

The best way to prevent all forms of lead-related impairments and diseases-both short term and long term- is to maintain your PbB below 40 ug/100g. The provisions of the standard are designed with this end in mind. Your employer has prime responsibility to assure that the provisions of the standard are complied with both by the company and by individual workers. You as a worker, however, also have a responsibility to assist your employer in complying with the standard. You can play a key role in protecting your own health by learning about the lead hazards and their control, learning what the standard requires, following the standard where it governs your own actions, and seeing that your employer complies with provisions governing his actions.

(4) Reporting signs and symptoms of health problems. You should immediately notify your employer if you develop signs or symptoms associated with lead poisoning or if you desire medical advice concerning the effects of current or past exposure to lead on your ability to have a healthy child. You should also notify your employer if you have difficulty breathing during a respirator fit test or while wearing a respirator. In each of these cases your employer

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must make available to you appropriate medical examinations or consultations. These must be provided at no cost to you and at a reasonable time and place.
The standard contains a procedure whereby you can obtain a second opinion by a physician of your choice if the employer selected the initial physician.
[56 FR 24686, May 31, 1991]

This appendix summarizes key provisions of the standard that you as a worker should become familiar with.
I. PERMISSIBLE EXPOSURE LIMIT (PEL) - PARAGRAPH (C)
The standards sets a permissible exposure limit (PEL) of fifty micrograms of lead per cubic meter of air (50 ug/m(3)), averaged over an 8-hour work-day. This is the highest level of lead in air to which you may be permissibly exposed over an 8-hour workday. Since it is an 8-hour average it permits short exposures above the PEL so long as for each 8-hour work day your average exposure does not exceed the PEL.
This standard recognizes that your daily exposure to lead can extend beyond a typical 8-hour workday as the result of overtime or other alterations in your work schedule. To deal with this, the standard contains a formula which reduces your permissible exposure when you are exposed more than 8 hours. For example, if you are exposed to lead for 10 hours a day, the maximum permitted average exposure would be 40 ug/m(3).
II. EXPOSURE MONITORING - PARAGRAPH (D)
If lead is present in the workplace where you work in any quantity, your employer is required to make an initial determination of whether the action level is exceeded for any employee. This initial determination must include instrument monitoring of the air for the presence of lead and must cover the exposure of a representative number of employees who are reasonably believed to have the highest exposure levels. If your employer has conducted appropriate air sampling for lead in the past year he may use these results. If there have been any employee complaints of symptoms which may be attributable to exposure to lead or if there is any other information or observations which would indicate employee exposure to lead, this must also be considered as part of the initial determination. This initial determination must have been completed by March 31, 1979. If this initial determination shows that a reasonable possibility exists that any employee may be exposed, without regard to respirators, over the action level (30 ug/m(3)) your employer must set up an air monitoring program to determine the exposure level of every employee exposed to lead at your workplace.
In carrying out this air monitoring program, your employer is not required to monitor the exposure of every employee, but he must monitor a representative number of employees and job types. Enough sampling must be done to enable each employee's exposure level to be reasonably represented by at least one full shift (at least 7 hours) air sample. In addition, these air samples must be taken under conditions which represent each employee's regular, daily exposure to lead. All initial exposure monitoring must have been completed by May 30, 1979.
If you are exposed to lead and air sampling is performed, your employer is required to quickly notify you in writing of air monitoring results which represent your exposure. If the results indicate your exposure exceeds the PEL (without regard to your use of respirators), then your employer must also notify you of this in writing, and provide you with a description of the corrective action that will be taken to reduce your exposure.
Your exposure must be rechecked by monitoring every six months if your exposure is over the action level but below the PEL. Air monitoring must be repeated every 3 months if you are exposed over the PEL. Your employer may discontinue monitoring for you if 2 consecutive measurements, taken at least two weeks apart, are below the action level. However, whenever there is a production, process, control, or personnel change at your workplace which may result in new or additional exposure to lead, or whenever there is any other reason to suspect a change which may result in new or additional exposure to lead, your employer must perform additional monitoring.
III. METHODS OF COMPLIANCE - PARAGRAPH (E)
Your employer is required to assure that no employee is exposed to lead in excess of the PEL. The standard establishes a priority of methods to be used to meet the PEL.
IV. RESPIRATORY PROTECTION - PARAGRAPH (F)
Your employer is required to provide and assure your use of respirators when your exposure to lead is not controlled below the PEL by other means. The employer must pay the cost of the respirator. Whenever you request one, your employer is also required to provide you a respirator even if your air exposure level does not exceed the PEL. You

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might desire a respirator when, for example, you have received medical advice that your lead absorption should be decreased. Or, you may intend to have children in the near future, and want to reduce the level of lead in your body to minimize adverse reproductive effects. While respirators are the least satisfactory means of controlling your exposure, they are capable of providing significant protection if properly chosen, fitted, worn, cleaned, maintained, and replaced when they stop providing adequate protection.

Your employer is required to select respirators from the seven types listed in Table II of the Respiratory Protection section of the standard (Sec. 1910.1025(f)). Any respirator chosen must be approved by the National Institute for Occupational Safety and Health (NIOSH) under the provisions of 42 CFR part 84. This respirator selection table will enable your employer to choose a type of respirator that will give you a proper amount of protection based on your airborne lead exposure. Your employer may select a type of respirator that provides greater protection than that required by the standard; that is, one recommended for a higher concentration of lead than is present in your workplace. For example, a powered air-purifying respirator (PAPR) is much more protective than a typical negative pressure respirator, and may also be more comfortable to wear. A PAPR has a filter, cartridge, or canister to clean the air, and a power source that continuously blows filtered air into your breathing zone. Your employer might make a PAPR available to you to ease the burden of having to wear a respirator for long periods of time. The standard provides that you can obtain a PAPR upon request.

Your employer must also start a Respiratory Protection Program. This program must include written procedures for the proper selection, use, cleaning, storage, and maintenance of respirators.

Your employer must ensure that your respirator facepiece fits properly. Proper fit of a respirator facepiece is critical to your protection from airborne lead. Obtaining a proper fit on each employee may require your employer to make available several different types of respirator masks. To ensure that your respirator fits properly and that facepiece leakage is minimal, your employer must give you either a qualitative or quantitative fit test as specified in Appendix A of the Respiratory Protection standard located at 29 CFR 1910.134.

You must also receive from your employer proper training in the use of respirators. Your employer is required to teach you how to wear a respirator, to know why it is needed, and to understand its limitations.

The standard provides that if your respirator uses filter elements, you must be given an opportunity to change the filter elements whenever an increase in breathing resistance is detected. You also must be permitted to periodically leave your work area to wash your face and respirator facepiece whenever necessary to prevent skin irritation. If you ever have difficulty in breathing during a fit test or while using a respirator, your employer must make a medical examination available to you to determine whether you can safely wear a respirator. The result of this examination may be to give you a positive pressure respirator (which reduces breathing resistance) or to provide alternative means of protection.

V. PROTECTIVE WORK CLOTHING AND EQUIPMENT - PARAGRAPH (G)

If you are exposed to lead above the PEL, or if you are exposed to lead compounds such as lead arsenate or lead azide which can cause skin and eye irritation, your employer must provide you with protective work clothing and equipment appropriate for the hazard. If work clothing is provided, it must be provided in a clean and dry condition at least weekly, and daily if your airborne exposure to lead is greater than 200 ug/m(3). Appropriate protective work clothing and equipment can include coveralls or similar full-body work clothing, gloves, hats, shoes or disposable shoe coverlets, and face shields or vented goggles. Your employer is required to provide all such equipment at no cost to you. He is responsible for providing repairs and replacement as necessary, and also is responsible for the cleaning, laundering or disposal of protective clothing and equipment. Contaminated work clothing or equipment must be removed in change rooms and not worn home or you will extend your exposure and expose your family since lead from your clothing can accumulate in your house, car, etc. Contaminated clothing which is to be cleaned, laundered or disposed of must be placed in closed containers in the change room. At no time may lead be removed from protective clothing or equipment by any means which disperses lead into the workroom air.

VI. HOUSEKEEPING - PARAGRAPH (H)

Your employer must establish a housekeeping program sufficient to maintain all surfaces as free as practicable of accumulations of lead dust. Vacuuming is the preferred method of meeting this requirement, and the use of compressed air to clean floors and other surfaces is absolutely prohibited. Dry or wet sweeping, shoveling, or brushing may not be used except where vacuuming or other equally effective methods have been tried and do not work. Vacuums must be used and emptied in a manner which minimizes the reentry of lead into the workplace.

VII. HYGIENE FACILITIES AND PRACTICES - PARAGRAPH (I)

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The standard requires that change rooms, showers, and filtered air lunchrooms be constructed and made available to workers exposed to lead above the PEL. These requirements have temporarily been delayed by the court of appeals in situations where new facilities must be constructed, or where substantial renovations must be made to existing facilities. When the PEL is exceeded, the employer must assure that food and beverage is not present or consumed, tobacco products are not present or used, and cosmetics are not applied, except in these facilities. Change rooms, showers, and lunchrooms, must be used by workers exposed in excess of the PEL. After showering, no clothing or equipment worn during the shift may be worn home, and this includes shoes and underwear. Your own clothing worn during the shift should be carried home and cleaned carefully so that it does not contaminate your home. Lunchrooms may not be entered with protective clothing or equipment unless surface dust has been removed by vacuuming, downdraft booth, or other cleaning method. Finally, workers exposed above the PEL must wash both their hands and faces prior to eating, drinking, smoking or applying cosmetics.

All of the facilities and hygiene practices just discussed are essential to minimize additional sources of lead absorption from inhalation or ingestion of lead that may accumulate on you, your clothes, or your possessions. Strict compliance with these provisions can virtually eliminate several sources of lead exposure which significantly contribute to excessive lead absorption.

VIII. MEDICAL SURVEILLANCE - PARAGRAPH (J)

The medical surveillance program is part of the standard's comprehensive approach to the prevention of lead-related disease. Its purpose is to supplement the main thrust of the standard which is aimed at minimizing airborne concentrations of lead and sources of ingestion. Only medical surveillance can determine if the other provisions of the standard have affectively protected you as an individual. Compliance with the standard's provision will protect most workers from the adverse effects of lead exposure, but may not be satisfactory to protect individual workers (1) who have high body burdens of lead acquired over past years, (2) who have additional uncontrolled sources of non-occupational lead exposure, (3) who exhibit unusual variations in lead absorption rates, or (4) who have specific non-work related medical conditions which could be aggravated by lead exposure (e.g., renal disease, anemia). In addition, control systems may fail, or hygiene and respirator programs may be inadequate. Periodic medical surveillance of individual workers will help detect those failures. Medical surveillance will also be important to protect your reproductive ability-regardless of whether you are a man or woman.

All medical surveillance required by the standard must be performed by or under the supervision of a licensed physician. The employer must provide required medical surveillance without cost to employees and at a reasonable time and place. The standard's medical surveillance program has two parts-periodic biological monitoring and medical examinations.

Your employer's obligation to offer you medical surveillance is triggered by the results of the air monitoring program. Medical surveillance must be made available to all employees who are exposed in excess of the action level for more than 30 days a year. The initial phase of the medical surveillance program, which includes blood lead level tests and medical examinations, must be completed for all covered employees no later than August 28, 1979. Priority within this first round of medical surveillance must be given to employees whom the employer believes to be at greatest risk from continued exposure (for example, those with the longest prior exposure to lead, or those with the highest current exposure). Thereafter, the employer must periodically make medical surveillance-both biological monitoring and medical examinations-available to all covered employees.

Biological monitoring under the standard consists of blood lead level (PbB) and zinc protoporphyrin tests at least every 6 months after the initial PbB test. A zinc protoporphyrin (ZPP) test is a very useful blood test which measures an effect of lead on your body. Thus biological monitoring under the standard is currently limited to PbB testing. If a worker's PbB exceeds 40 ug/100g the monitoring frequency must be increased from every 6 months to at least every 2 months and not reduced until two consecutive PbBs indicate a blood lead level below 40 ug/100g. Each time your PbB is determined to be over 40 ug/100g, your employer must notify you of this in writing within five working days of his receipt of the test results. The employer must also inform you that the standard requires temporary medical removal with economic protection when your PbB exceeds certain criteria. (See Discussion of Medical Removal Protection-Paragraph (k).) During the first year of the standard, this removal criterion is 80 ug/100g. Anytime your PbB exceeds 80 ug/100g your employer must make available to you a prompt follow-up PbB test to ascertain your PbB. If the two tests both exceed 80 ug/100g and you are temporarily removed, then your employer must make successive PbB tests available to you on a monthly basis during the period of your removal.

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Medical examinations beyond the initial one must be made available on an annual basis if your blood lead level exceeds 40 ug/100g at any time during the preceding year. The initial examination will provide information to establish a baseline to which subsequent data can be compared. An initial medical examination must also be made available (prior to assignment) for each employee being assigned for the first time to an area where the airborne concentration of lead equals or exceeds the action level. In addition, a medical examination or consultation must be made available as soon as possible if you notify your employer that you are experiencing signs or symptoms commonly associated with lead poisoning or that you have difficulty breathing while wearing a respirator or during a respirator fit test. You must also be provided a medical examination or consultation if you notify your employer that you desire medical advice concerning the effects of current or past exposure to lead on your ability to procreate a healthy child.

Finally, appropriate follow-up medical examinations or consultations may also be provided for employees who have been temporarily removed from exposure under the medical removal protection provisions of the standard. (See Part IX, below.)

The standard specifies the minimum content of pre-assignment and annual medical examinations. The content of other types of medical examinations and consultations is left up to the sound discretion of the examining physician. Pre-assignment and annual medical examinations must include (1) a detailed work history and medical history, (2) a thorough physical examination, and (3) a series of laboratory tests designed to check your blood chemistry and your kidney function. In addition, at any time upon your request, a laboratory evaluation of male fertility will be made (microscopic examination of a sperm sample), or a pregnancy test will be given.

The standard does not require that you participate in any of the medical procedures, tests, etc. which your employer is required to make available to you. Medical surveillance can, however, play a very important role in protecting your health. You are strongly encouraged, therefore, to participate in a meaningful fashion. The standard contains a multiple physician review mechanism which would give you a chance to have a physician of your choice directly participate in the medical surveillance program. If you were dissatisfied with an examination by a physician chosen by your employer, you could select a second physician to conduct an independent analysis. The two doctors would attempt to resolve any differences of opinion, and select a third physician to resolve any firm dispute. Generally your employer will choose the physician who conducts medical surveillance under the lead standard-unless you and your employer can agree on the choice of a physician or physicians. Some companies and unions have agreed in advance, for example, to use certain independent medical laboratories or panels of physicians. Any of these arrangements are acceptable so long as required medical surveillance is made available to workers.

The standard requires your employer to provide certain information to a physician to aid in his or her examination of you. This information includes (1) the standard and its appendices, (2) a description of your duties as they relate to lead exposure, (3) your exposure level, (4) a description of personal protective equipment you wear, (5) prior blood lead level results, and (6) prior written medical opinions concerning you that the employer has. After a medical examination or consultation the physician must prepare a written report which must contain (1) the physician's opinion as to whether you have any medical condition which places you at increased risk of material impairment to health from exposure to lead, (2) any recommended special protective measures to be provided to you, (3) any blood lead level determinations, and (4) any recommended limitation on your use of respirators. This last element must include a determination of whether you can wear a powered air purifying respirator (PAPR) if you are found unable to wear a negative pressure respirator.

The medical surveillance program of the lead standard may at some point in time serve to notify certain workers that they have acquired a disease or other adverse medical condition as a result of occupational lead exposure. If this is true, these workers might have legal rights to compensation from public agencies, their employers, firms that supply hazardous products to their employers, or other persons. Some states have laws, including worker compensation laws, that disallow a worker who learns of a job-related health impairment to sue, unless the worker sues within a short period of time after learning of the impairment. (This period of time may be a matter of months or years.) An attorney can be consulted about these possibilities. It should be stressed that OSHA is in no way trying to either encourage or discourage claims or lawsuits. However, since results of the standard's medical surveillance program can significantly affect the legal remedies of a worker who has acquired a job-related disease or impairment, it is proper for OSHA to make you aware of this.

The medical surveillance section of the standard also contains provisions dealing with chelation. Chelation is the use of certain drugs (administered in pill form or injected into the body) to reduce the amount of lead absorbed in body

tissues. Experience accumulated by the medical and scientific communities has largely confirmed the effectiveness of this type of therapy for the treatment of very severe lead poisoning. On the other hand, it has also been established that there can be a long list of extremely harmful side effects associated with the use of chelating agents. The medical community has balanced the advantages and disadvantages resulting from the use of chelating agents in various circumstances and has established when the use of these agents is acceptable. The standard includes these accepted limitations due to a history of abuse of chelation therapy by some lead companies. The most widely used chelating agents are calcium disodium EDTA, (Ca Na2 EDTA), Calcium Disodium Versenate (Versenate), and d-penicillamine (pencillamine or Cupramine).

The standard prohibits "prophylactic chelation" of any employee by any person the employer retains, supervises or controls. "Prophylactic chelation" is the routine use of chelating or similarly acting drugs to prevent elevated blood levels in workers who are occupationally exposed to lead, or the use of these drugs to routinely lower blood lead levels to predesignated concentrations believed to be `safe'. It should be emphasized that where an employer takes a worker who has no symptoms of lead poisoning and has chelation carried out by a physician (either inside or outside of a hospital) solely to reduce the worker's blood lead level, that will generally be considered prophylactic chelation. The use of a hospital and a physician does not mean that prophylactic chelation is not being performed. Routine chelation to prevent increased or reduce current blood lead levels is unacceptable whatever the setting.

The standard allows the use of "therapeutic" or "diagnostic" chelation if administered under the supervision of a licensed physician in a clinical setting with thorough and appropriate medical monitoring. Therapeutic chelation responds to severe lead poisoning where there are marked symptoms. Diagnostic chelation involved giving a patient a dose of the drug then collecting all urine excreted for some period of time as an aid to the diagnosis of lead poisoning.

In cases where the examining physician determines that chelation is appropriate, you must be notified in writing of this fact before such treatment. This will inform you of a potentially harmful treatment, and allow you to obtain a second opinion.

IX. MEDICAL REMOVAL PROTECTION - PARAGRAPH (K)

Excessive lead absorption subjects you to increased risk of disease. Medical removal protection (MRP) is a means of protecting you when, for whatever reasons, other methods, such as engineering controls, work practices, and respirators, have failed to provide the protection you need. MRP involves the temporary removal of a worker from his or her regular job to a place of significantly lower exposure without any loss of earnings, seniority, or other employment rights or benefits. The purpose of this program is to cease further lead absorption and allow your body to naturally excrete lead which has previously been absorbed. Temporary medical removal can result from an elevated blood lead level, or a medical opinion. Up to 18 months of protection is provided as a result of either form of removal. The vast majority of removed workers, however, will return to their former jobs long before this eighteen month period expires. The standard contains special provisions to deal with the extraordinary but possible case where a longterm worker's blood lead level does not adequately decline during eighteen months of removal.

During the first year of the standard, if your blood lead level is 80 ug/100g or above you must be removed from any exposure where your air lead level without a respirator would be 100 ug/m(3) or above. If you are removed from your normal job you may not be returned until your blood lead level declines to at least 60 ug/100g. These criteria for removal and return will change according to the following schedule:

	Removal blood lead (ug/100 g)	Air lead (ug/m(3))	Return blood lead (ug/100 g)
After Mar. 1, 1980..	70 and above....	50 and above.	At or below 50.
After Mar. 1, 1981..	60 and above....	30 and above.	At or below 40.
After Mar. 1, 1983..	50 and above averaged over six months.....	30 and above.	Do.

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You may also be removed from exposure even if your blood lead levels are below these criteria if a final medical determination indicates that you temporarily need reduced lead exposure for medical reasons. If the physician who is implementing your employers medical program makes a final written opinion recommending your removal or other special protective measures, your employer must implement the physician's recommendation. If you are removed in this manner, you may only be returned when the doctor indicates that it is safe for you to do so.

The standard does not give specific instructions dealing with what an employer must do with a removed worker. Your job assignment upon removal is a matter for you, your employer and your union (if any) to work out consistent with existing procedures for job assignments. Each removal must be accomplished in a manner consistent with existing collective bargaining relationships. Your employer is given broad discretion to implement temporary removals so long as no attempt is made to override existing agreements. Similarly, a removed worker is provided no right to veto an employer's choice which satisfies the standard.

In most cases, employers will likely transfer removed employees to other jobs with sufficiently low lead exposure. Alternatively, a worker's hours may be reduced so that the time weighted average exposure is reduced, or he or she may be temporarily laid off if no other alternative is feasible.

In all of these situation, MRP benefits must be provided during the period of removal - i.e., you continue to receive the same earnings, seniority, and other rights and benefits you would have had if you had not been removed. Earnings includes more than just your base wage; it includes overtime, shift differentials, incentives, and other compensation you would have earned if you had not been removed. During the period of removal you must also be provided with appropriate follow-up medical surveillance. If you were removed because your blood lead level was too high, you must be provided with a monthly blood test. If a medical opinion caused your removal, you must be provided medical tests or examinations that the doctor believes to be appropriate. If you do not participate in this follow up medical surveillance, you may lose your eligibility for MRP benefits.

When you are medically eligible to return to your former job, your employer must return you to your "former job status." This means that you are entitled to the position, wages, benefits, etc., you would have had if you had not been removed. If you would still be in your old job if no removal had occurred that is where you go back. If not, you are returned consistent with whatever job assignment discretion your employer would have had if no removal had occurred. MRP only seeks to maintain your rights, not expand them or diminish them.

If you are removed under MRP and you are also eligible for worker compensation or other compensation for lost wages, your employer's MRP benefits obligation is reduced by the amount that you actually receive from these other sources. This is also true if you obtain other employment during the time you are laid off with MRP benefits.

The standard also covers situations where an employer voluntarily removes a worker from exposure to lead due to the effects of lead on the employee's medical condition, even though the standard does not require removal. In these situations MRP benefits must still be provided as though the standard required removal. Finally, it is important to note that in all cases where removal is required, respirators cannot be used as a substitute. Respirators may be used before removal becomes necessary, but not as an alternative to a transfer to a low exposure job, or to a lay-off with MRP benefits.

X. EMPLOYEE INFORMATION AND TRAINING - PARAGRAPH (L)

Your employer is required to provide an information and training program for all employees exposed to lead above the action level or who may suffer skin or eye irritation from lead. This program must inform these employees of the specific hazards associated with their work environment, protective measures which can be taken, the danger of lead to their bodies (including their reproductive systems), and their rights under the standard. In addition your employer must make readily available to all employees, including those exposed below the action level, a copy of the standard and its appendices and must distribute to all employees any materials provided to the employer by the Occupational Safety and Health Administration (OSHA).

Your employer is required to complete this training program for all employees by August 28, 1979. After this date, all new employees must be trained prior to initial assignment to areas where there is a possibility of exposure over the action level.

This training program must also be provided at least annually thereafter.

XI. SIGNS - PARAGRAPH (M)

The standard requires that the following warning sign be posted in work areas where the exposure to lead exceeds the PEL:

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WARNING
LEAD WORK AREA
NO SMOKING OR EATING

XII. RECORDKEEPING - PARAGRAPH (N)

Your employer is required to keep all records of exposure monitoring for airborne lead. These records must include the name and job classification of employees measured, details of the sampling and analytic techniques, the results of this sampling, and the type of respiratory protection being worn by the person sampled. Your employer is also required to keep all records of biological monitoring and medical examination results. These must include the names of the employees, the physician's written opinion, and a copy of the results of the examination. All of the above kinds of records must be kept for 40 years, or for at least 20 years after your termination of employment, whichever is longer.

Recordkeeping is also required if you are temporarily removed from your job under the medical removal protection program. This record must include your name and social security number, the date of your removal and return, how the removal was or is being accomplished, and whether or not the reason for the removal was an elevated blood lead level. Your employer is required to keep each medical removal record only for as long as the duration of an employee's employment.

The standard requires that if you request to see or copy environmental monitoring, blood lead level monitoring, or medical removal records, they must be made available to you or to a representative that you authorize. Your union also has access to these records. Medical records other than PbB's must also be provided upon request to you, to your physician or to any other person whom you may specifically designate. Your union does not have access to your personal medical records unless you authorize their access.

XIII. OBSERVATIONS OF MONITORING - PARAGRAPH (O)

When air monitoring for lead is performed at your workplace as required by this standard, your employer must allow you or someone you designate to act as an observer of the monitoring. Observers are entitled to an explanation of the measurement procedure, and to record the results obtained. Since results will not normally be available at the time of the monitoring, observers are entitled to record or receive the results of the monitoring when returned by the laboratory. Your employer is required to provide the observer with any personal protective devices required to be worn by employees working in the area that is being monitored. The employer must require the observer to wear all such equipment and to comply with all other applicable safety and health procedures.

XIV. EFFECTIVE DATE - PARAGRAPH (P)

The standard's effective data is March 1, 1979, and employer obligations under the standard begin to come into effect as of that date.

XV. FOR ADDITIONAL INFORMATION

A. Copies of the Standard and explanatory material may be obtained by writing or calling the OSHA Docket Office, U.S. Department of Labor, room N2634, 200 Constitution Avenue, N.W., Washington DC 20210. Telephone: (202) 219-7894.

1. The standard and summary of the statement of reasons (preamble), Federal Register, Volume 43, pp. 52952-53014, November 14, 1978.
2. The full statement of reasons (preamble) Federal Register, vol. 43, pp. 54354-54509, November 21, 1978.
3. Partial Administrative Stay and Corrections to the standard, (44 FR 5446-5448) January 26, 1979.
4. Notice of the Partial Judicial Stay (44 FR 14554-14555) March 13, 1979.
5. Corrections to the preamble, Federal Register, vol. 44, pp. 20680-20681, April 6, 1979.
6. Additional correction to the preamble concerning the construction industry, Federal Register, vol. 44, p. 50338, August 28, 1979.
7. Appendices to the standard (Appendices A, B, C), Federal Register, Vol. 44, pp. 60980-60995, October 23, 1979.
8. Corrections to appendices, Federal Register, Vol. 44, 68828, November 30, 1979.
9. Revision to the standard and an additional appendix (Appendix D), Federal Register, Vol. 47, pp. 51117-51119, November 12, 1982.
10. Notice of reopening of lead rulemaking for nine remand industry sectors, Federal Register, vol. 53, pp. 11511-11513, April 7, 1988.
11. Statement of reasons, Federal Register, vol. 54, pp. 29142-29275, July 11, 1989.
12. Statement of reasons, Federal Register, vol. 55, pp. 3146-3167, January 30, 1990.

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13. Correction to appendix B, Federal Register, vol. 55, pp. 4998-4999, February 13, 1991.
14. Correction to appendices, Federal Register, vol. 56, p. 24686, May 31, 1991.
B. Additional information about the standard, its enforcement, and your employer's compliance can be obtained from the nearest OSHA Area Office listed in your telephone directory under United States Government/Department of Labor.
[60 FR 52856, Oct. 11, 1995; 63 FR 1152, Jan. 8, 1998]

INTRODUCTION
The primary purpose of the Occupational Safety and Health Act of 1970 is to assure, so far as possible, safe and healthful working conditions for every working man and woman. The occupational health standard for inorganic lead(1) was promulgated to protect workers exposed to inorganic lead including metallic lead, all inorganic lead compounds and organic lead soaps.

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Footnote(1) The term inorganic lead used throughout the medical surveillance appendices is meant to be synonymous with the definition of lead set forth in the standard.

Under this final standard in effect as of March 1, 1979, occupational exposure to inorganic lead is to be limited to 50 ug/m(3) (micrograms per cubic meter) based on an 8 hour time-weighted average (TWA). This level of exposure eventually must be achieved through a combination of engineering, work practice and other administrative controls. Periods of time ranging from 1 to 10 years are provided for different industries to implement these controls. The schedule which is based on individual industry considerations is given in Table 1. Until these controls are in place, respirators must be used to meet the 50 ug/m(3) exposure limit.
The standard also provides for a program of biological monitoring and medical surveillance for all employees exposed to levels of inorganic lead above the action level of 30 ug/m(3) (TWA) for more than 30 days per year.
The purpose of this document is to outline the medical surveillance provisions of the standard for inorganic lead, and to provide further information to the physician regarding the examination and evaluation of workers exposed to inorganic lead.
Section 1 provides a detailed description of the monitoring procedure including the required frequency of blood testing for exposed workers, provisions for medical removal protection (MRP), the recommended right of the employee to a second medical opinion, and notification and recordkeeping requirements of the employer. A discussion of the requirements for respirator use and respirator monitoring and OSHA's position on prophylactic chelation therapy are also included in this section.
Section 2 discusses the toxic effects and clinical manifestations of lead poisoning and effects of lead intoxication on enzymatic pathways in heme synthesis. The adverse effects on both male and female reproductive capacity and on the fetus are also discussed.
Section 3 outlines the recommended medical evaluation of the worker exposed to inorganic lead including details of the medical history, physical examination, and recommended laboratory tests, which are based on the toxic effects of lead as discussed in Section 2.
Section 4 provides detailed information concerning the laboratory tests available for the monitoring of exposed workers. Included also is a discussion of the relative value of each test and the limitations and precautions which are necessary in the interpretation of the laboratory results.

TABLE 1

	Effective date					
Permissible airborne lead levels by industry (ug/m(3)(1)	Mar 1, 1979	Mar 1, 1980	Mar 1, 1981	Mar 1, 1982	Mar 1, 1984	Mar 1, 1989 (final)

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1. Primary lead protection..	200	200	200	100	100	50
2. Secondary lead protection.....	200	200	200	100	50	50
3. Lead-acid battery manufacturing.....	200	200	100	100	50	50
4. Nonferrous foundries.....	200	100	100	100	50	50
5. Lead pigment manufacturing.....	200	200	200	100	50	50
6. All other industries.....	200	50	50	50	50	50

Footnote(1) Airborne levels to be achieved without reliance or respirator protection through a combination of engineering, work practice and other administrative controls. While these controls are being implemented respirators must be used to meet the 50 ug/m(3) exposure limit.

I. MEDICAL SURVEILLANCE AND MONITORING REQUIREMENTS FOR WORKERS EXPOSED TO INORGANIC LEAD

Under the occupational health standard for inorganic lead, a program of biological monitoring and medical surveillance is to be made available to all employees exposed to lead above the action level of 30 ug/m(3) TWA for more than 30 days each year. This program consists of periodic blood sampling and medical evaluation to be performed on a schedule which is defined by previous laboratory results, worker complaints or concerns, and the clinical assessment of the examining physician.

Under this program, the blood lead level of all employees who are exposed to lead above the action level of 30 ug/m(3) is to be determined at least every six months. The frequency is increased to every two months for employees whose last blood lead level was between 40 ug/100 g whole blood and the level requiring employee medical removal to be discussed below. For employees who are removed from exposure to lead due to an elevated blood lead, a new blood lead level must be measured monthly. A zinc protoporphyrin (ZPP) is required on each occasion that a blood lead level measurement is made.

An annual medical examination and consultation performed under the guidelines discussed in Section 3 is to be made available to each employee for whom a blood test conducted at any time during the preceding 12 months indicated a blood lead level at or above 40 ug/100 g. Also, an examination is to be given to all employees prior to their assignment to an area in which airborne lead concentrations reach or exceed the action level. In addition, a medical examination must be provided as soon as possible after notification by an employee that the employee has developed signs or symptoms commonly associated with lead intoxication, that the employee desires medical advice regarding lead exposure and the ability to procreate a healthy child, or that the employee has demonstrated difficulty in breathing during a respirator fitting test or during respirator use. An examination is also to be made available to each employee removed from exposure to lead due to a risk of sustaining material impairment to health, or otherwise limited or specially protected pursuant to medical recommendations.

Results of biological monitoring or the recommendations of an examining physician may necessitate removal of an employee from further lead exposure pursuant to the standard's medical removal protection (MRP) program. The object of the MRP program is to provide temporary medical removal to workers either with substantially elevated blood lead levels or otherwise at risk of sustaining material health impairment from continued substantial exposure to lead. The following guidelines which are summarized in Table 2 were created under the standard for the temporary removal of an exposed employee and his or her subsequent return to work in an exposure area.

TABLE 2

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	Effective date				
	Mar. 1, 1979	Mar. 1, 1980	Mar. 1, 1981	Mar. 1, 1982	Mar. 1, 1983 (final)
A. Blood lead level requiring employee medical removal. (Level must be confirmed with second follow-up blood lead level within two weeks of first report.	>than or = to 80 ug/100 g	>than or = to 70 ug/100 g	>than or = to 60 ug/100 g	>than or = to 60 ug/100 g	>than or = to 60 ug/100 g or average of last three blood samples or all blood samples over previous 6 months (whichever is over a longer time period) is 50 ug/100 g or greater unless last blood sample is 40 ug/100 g or less.
B. Frequency which employees exposed to action level of lead (30 ug/m(3) TWA) must have blood lead level checked (ZPP is also required in each occasion					

that a blood lead is obtained.):					
1. Last blood lead level less than 40 ug/100 g	Every 6 months	Every 6 months	Every 6 months	Every 6 months	Every 6 months.
2. Last blood lead level between 40 ug/100 g and level requiring medical removal (see A above).....	Every 2 months	Every 2 months	Every 2 months	Every 2 months	Every 2 months.
3. Employees removed from exposure to lead because of an elevated blood lead level.....	Every 1 months	Every 1 months	Every 1 months	Every 1 months	Every 1 months.
C. Permissible airborne exposure limit for workers removed from work due to an elevated blood lead level (without regard to respirator protection).	100 ug/m(3) 8 hr TWA.	50 ug/m(3) 8 hr TWA.	30 ug/m(3) 8 hr TWA.	30 ug/m(3) 8 hr TWA.	30 ug/m(3) 8 hr TWA.
D. Blood lead level confirmed with a second blood analysis, at which employee may return to	.60 ug/100 g	.50 ug/100 g	.40 ug/100 g	.40 ug/100 g	.40 ug/100 g

work. Permissible exposure without regard to respirator protection is listed by industry in Table 1.					

NOTE: When medical opinion indicates that an employee is at risk of material impairment from exposure to lead, the physician can remove an employee from exposures exceeding the action level (or less) or recommended special protective measures as deemed appropriate and necessary. Medical monitoring during the medical removal period can be more stringent than noted in the table above if the physician so specifies. Return to work or removal of limitations and special protections is permitted when the physician indicates that the worker is no longer at risk of material impairment.

Under the standard's ultimate worker removal criteria, a worker is to be removed from any work having any eight hour TWA exposure to lead of 30 ug/m(3) or more whenever either of the following circumstances apply: (1) a blood lead level of 60 ug/100 g or greater is obtained and confirmed by a second follow-up blood lead level performed within two weeks after the employer receives the results of the first blood sampling test, or (2) the average of the previous three blood lead determinations or the average of all blood lead determinations conducted during the previous six months, whichever encompasses the longest time period, equals or exceeds 50 ug/100 g, unless the last blood sample indicates a blood lead level at or below 40 ug/100 g in which case the employee need not be removed. Medical removal is to continue until two consecutive blood lead levels are 40 ug/100 g or less. During the first two years that the ultimate removal criteria are being phased in, the return criteria have been set to assure that a worker's blood lead level has substantially declined during the period of removal. From March 1, 1979 to March 1, 1980, the blood lead level requiring employee medical removal is 80 ug/100 g. Workers found to have a confirmed blood lead at this level or greater need only be removed from work having a daily 8 hour TWA exposure to lead at or above 100 ug/m(3). Workers so removed are to be returned to work when their blood lead levels are at or below 60 ug/100 g of whole blood. From March 1, 1980 to March 1, 1981, the blood lead level requiring medical removal is 70 ug/100 g. During this period workers need only be removed from jobs having a daily 8 hour TWA exposure to lead at or above 50 ug/m(3) and are to be returned to work when a level of 50 ug/100 g is achieved. Beginning March 1, 1981, return depends on a worker's blood lead level declining to 40 ug/100 g of whole blood. As part of the standard, the employer is required to notify in writing each employee whose blood lead level exceeds 40 ug/100 g. In addition each such employee is to be informed that the standard requires medical removal with MRP benefits, discussed below, when an employee's blood lead level exceeds the above defined limits.

In addition to the above blood lead level criteria, temporary worker removal may also take place as a result of medical determinations and recommendations. Written medical opinions must be prepared after each examination pursuant to the standard. If the examining physician includes a medical finding, determination or opinion that the employee has a medical condition which places the employee at increased risk of material health impairment from exposure to lead, then the employee must be removed from exposure to lead at or above the action level. Alternatively, if the examining physician recommends special protective measures for an employee (e.g., use of a powered air purifying respirator) or recommends limitations on an employee's exposure to lead, then the employer must implement these recommendations. Recommendations may be more stringent than the specific provisions of the standard. The examining physician, therefore, is given broad flexibility to tailor special protective procedures to the needs of individual employees. This flexibility extends to the evaluation and management of pregnant workers and male and female workers who are planning to raise children. Based on the history, physical examination, and laboratory studies, the physician might recommend special protective measures or medical removal for an employee

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who is pregnant or who is planning to conceive a child when, in the physician's judgment, continued exposure to lead at the current job would pose a significant risk. The return of the employee to his or her former job status, or the removal of special protections or limitations, depends upon the examining physician determining that the employee is no longer at increased risk of material impairment or that special measures are no longer needed.

During the period of any form of special protection or removal, the employer must maintain the worker's earnings, seniority, and other employment rights and benefits (as though the worker had not been removed) for a period of up to 18 months. This economic protection will maximize meaningful worker participation in the medical surveillance program, and is appropriate as part of the employer's overall obligation to provide a safe and healthful workplace. The provisions of MRP benefits during the employee's removal period may, however, be conditioned upon participation in medical surveillance.

On rare occasions, an employee's blood lead level may not acceptably decline within 18 months of removal. This situation will arise only in unusual circumstances, thus the standard relies on an individual medical examination to determine how to protect such an employee. This medical determination is to be based on both laboratory values, including lead levels, zinc protoporphyrin levels, blood counts, and other tests felt to be warranted, as well as the physician's judgment that any symptoms or findings on physical examination are a result of lead toxicity. The medical determination may be that the employee is incapable of ever safely returning to his or her former job status. The medical determination may provide additional removal time past 18 months for some employees or specify special protective measures to be implemented.

The lead standard provides for a multiple physician review in cases where the employee wishes a second opinion concerning potential lead poisoning or toxicity. If an employee wishes a second opinion, he or she can make an appointment with a physician of his or her choice. This second physician will review the findings, recommendations or determinations of the first physician and conduct any examinations, consultations or tests deemed necessary in an attempt to make a final medical determination. If the first and second physicians do not agree in their assessment they must try to resolve their differences. If they cannot reach an agreement then they must designate a third physician to resolve the dispute.

The employer must provide examining and consulting physicians with the following specific information: a copy of the lead regulations and all appendices, a description of the employee's duties as related to exposure, the exposure level to lead and any other toxic substances (if applicable), a description of personal protective equipment used, blood lead levels, and all prior written medical opinions regarding the employee in the employer's possession or control. The employer must also obtain from the physician and provide the employee with a written medical opinion containing blood lead levels, the physician's opinion as to whether the employee is at risk of material impairment to health, any recommended protective measures for the employee if further exposure is permitted, as well as any recommended limitations upon an employee's use of respirators.

Employers must instruct each physician not to reveal to the employer in writing or in any other way his or her findings, laboratory results, or diagnoses which are felt to be unrelated to occupational lead exposure. They must also instruct each physician to advise the employee of any occupationally or non-occupationally related medical condition requiring further treatment or evaluation.

The standard provides for the use of respirators where engineering and other primary controls have not been fully implemented. However, the use of respirator protection shall not be used in lieu of temporary medical removal due to elevated blood lead levels or findings that an employee is at risk of material health impairment. This is based on the numerous inadequacies of respirators including skin rash where the facepiece makes contact with the skin, unacceptable stress to breathing in some workers with underlying cardiopulmonary impairment, difficulty in providing adequate fit, the tendency for respirators to create additional hazards by interfering with vision, hearing, and mobility, and the difficulties of assuring the maximum effectiveness of a complicated work practice program involving respirators. Respirators do, however, serve a useful function where engineering and work practice controls are inadequate by providing supplementary, interim, or short-term protection, provided they are properly selected for the environment in which the employee will be working, properly fitted to the employee, maintained and cleaned periodically, and worn by the employee when required.

In its final standard on occupational exposure to inorganic lead, OSHA has prohibited prophylactic chelation. Diagnostic and therapeutic chelation are permitted only under the supervision of a licensed physician with appropriate medical monitoring in an acceptable clinical setting. The decision to initiate chelation therapy must be made on an individual basis and take into account the severity of symptoms felt to be a result of lead toxicity along

with blood lead levels, ZPP levels, and other laboratory tests as appropriate. EDTA and penicillamine which are the primary chelating agents used in the therapy of occupational lead poisoning have significant potential side effects and their use must be justified on the basis of expected benefits to the worker. Unless frank and severe symptoms are present, therapeutic chelation is not recommended given the opportunity to remove a worker from exposure and allow the body to naturally excrete accumulated lead. As a diagnostic aid, the chelation mobilization test using CA-EDTA has limited applicability. According to some investigators, the test can differentiate between lead-induced and other nephropathies. The test may also provide an estimation of the mobile fraction of the total body lead burden.

Employers are required to assure that accurate records are maintained on exposure monitoring, medical surveillance, and medical removal for each employee. Exposure monitoring and medical surveillance records must be kept for 40 years or the duration of employment plus 20 years, whichever is longer, while medical removal records must be maintained for the duration of employment. All records required under the standard must be made available upon request to the Assistant Secretary of Labor for Occupational Safety and Health and the Director of the National Institute for Occupational Safety and Health. Employers must also make environmental and biological monitoring and medical removal records available to affected employees and to former employees or their authorized employee representatives. Employees or their specifically designated representatives have access to their entire medical surveillance records.

In addition, the standard requires that the employer inform all workers exposed to lead at or above the action level of the provisions of the standard and all its appendices, the purpose and description of medical surveillance and provisions for medical removal protection if temporary removal is required. An understanding of the potential health effects of lead exposure by all exposed employees along with full understanding of their rights under the lead standard is essential for an effective monitoring program.

II. ADVERSE HEALTH EFFECTS OF INORGANIC LEAD

Although the toxicity of lead has been known for 2,000 years, the knowledge of the complex relationship between lead exposure and human response is still being refined. Significant research into the toxic properties of lead continues throughout the world, and it should be anticipated that our understanding of thresholds of effects and margins of safety will be improved in future years. The provisions of the lead standard are founded on two prime medical judgments: first, the prevention of adverse health effects from exposure to lead throughout a working lifetime requires that worker blood lead levels be maintained at or below 40 g/100 g and second, the blood lead levels of workers, male or female, who intend to parent in the near future should be maintained below 30 ug/100 g to minimize adverse reproductive health effects to the parents and developing fetus. The adverse effects of lead on reproduction are being actively researched and OSHA encourages the physician to remain abreast of recent developments in the area to best advise pregnant workers or workers planning to conceive children.

The spectrum of health effects caused by lead exposure can be subdivided into five developmental stages: normal, physiological changes of uncertain significance, pathophysiological changes, overt symptoms (morbidity), and mortality. Within this process there are no sharp distinctions, but rather a continuum of effects. Boundaries between categories overlap due to the wide variation of individual responses and exposures in the working population. OSHA's development of the lead standard focused on pathophysiological changes as well as later stages of disease.

1. Heme Synthesis Inhibition. The earliest demonstrated effect of lead involves its ability to inhibit at least two enzymes of the heme synthesis pathway at very low blood levels. Inhibition of delta aminolevulinic acid dehydrase (ALA-D) which catalyzes the conversion of delta-aminolevulinic acid (ALA) to protoporphyrin is observed at a blood lead level below 20 ug/100 g whole blood. At a blood lead level of 40 ug/100 g, more than 20% of the population would have 70% inhibition of ALA-D. There is an exponential increase in ALA excretion at blood lead levels greater than 40 ug/100 g.

Another enzyme, ferrochelatase, is also inhibited at low blood lead levels. Inhibition of ferrochelatase leads to increased free erythrocyte protoporphyrin (FEP) in the blood which can then bind to zinc to yield zinc protoporphyrin. At a blood lead level of 50 ug/100 g or greater, nearly 100% of the population will have an increase in FEP. There is also an exponential relationship between blood lead levels greater than 40 ug/100 g and the associated ZPP level, which has led to the development of the ZPP screening test for lead exposure.

While the significance of these effects is subject to debate, it is OSHA's position that these enzyme disturbances are early stages of a disease process which may eventually result in the clinical symptoms of lead poisoning. Whether or

not the effects do progress to the later stages of clinical disease, disruption of these enzyme processes over a working lifetime is considered to be a material impairment of health.

One of the eventual results of lead-induced inhibition of enzymes in the heme synthesis pathway is anemia which can be asymptomatic if mild but associated with a wide array of symptoms including dizziness, fatigue, and tachycardia when more severe. Studies have indicated that lead levels as low as 50 ug/100 g can be associated with a definite decreased hemoglobin, although most cases of lead-induced anemia, as well as shortened red-cell survival times, occur at lead levels exceeding 80 ug/100 g. Inhibited hemoglobin synthesis is more common in chronic cases whereas shortened erythrocyte life span is more common in acute cases.

In lead-induced anemias, there is usually a reticulocytosis along with the presence of basophilic stippling, and ringed sideroblasts, although none of the above are pathognomonic for lead-induced anemia.

2. Neurological Effects. Inorganic lead has been found to have toxic effects on both the central and peripheral nervous systems. The earliest stages of lead-induced central nervous system effects first manifest themselves in the form of behavioral disturbances and central nervous system symptoms including irritability, restlessness, insomnia and other sleep disturbances, fatigue, vertigo, headache, poor memory, tremor, depression, and apathy. With more severe exposure, symptoms can progress to drowsiness, stupor, hallucinations, delirium, convulsions and coma.

The most severe and acute form of lead poisoning which usually follows ingestion or inhalation of large amounts of lead is acute encephalopathy which may arise precipitously with the onset of intractable seizures, coma, cardiorespiratory arrest, and death within 48 hours.

While there is disagreement about what exposure levels are needed to produce the earliest symptoms, most experts agree that symptoms definitely can occur at blood lead levels of 60 ug/100 g whole blood and therefore recommend a 40 ug/100 g maximum. The central nervous system effects frequently are not reversible following discontinued exposure or chelation therapy and when improvement does occur, it is almost always only partial.

The peripheral neuropathy resulting from lead exposure characteristically involves only motor function with minimal sensory damage and has a marked predilection for the extensor muscles of the most active extremity. The peripheral neuropathy can occur with varying degrees of severity. The earliest and mildest form which can be detected in workers with blood lead levels as low as 50 ug/100 g is manifested by slowing of motor nerve conduction velocity often without clinical symptoms. With progression of the neuropathy there is development of painless extensor muscle weakness usually involving the extensor muscles of the fingers and hand in the most active upper extremity, followed in severe cases by wrist drop or, much less commonly, foot drop.

In addition to slowing of nerve conduction, electromyographical studies in patients with blood lead levels greater than 50 ug/100 g have demonstrated a decrease in the number of acting motor unit potentials, an increase in the duration of motor unit potentials, and spontaneous pathological activity including fibrillations and fasciculations. Whether these effects occur at levels of 40 ug/100 g is undetermined.

While the peripheral neuropathies can occasionally be reversed with therapy, again such recovery is not assured particularly in the more severe neuropathies and often improvement is only partial. The lack of reversibility is felt to be due in part to segmental demyelination.

3. Gastrointestinal. Lead may also affect the gastrointestinal system producing abdominal colic or diffuse abdominal pain, constipation, obstipation, diarrhea, anorexia, nausea and vomiting. Lead colic rarely develops at blood lead levels below 80 ug/100 g.

4. Renal. Renal toxicity represents one of the most serious health effects of lead poisoning. In the early stages of disease nuclear inclusion bodies can frequently be identified in proximal renal tubular cells. Renal function remains normal and the changes in this stage are probably reversible. With more advanced disease there is progressive interstitial fibrosis and impaired renal function. Eventually extensive interstitial fibrosis ensues with sclerotic glomeruli and dilated and atrophied proximal tubules; all represent end stage kidney disease. Azotemia can be progressive, eventually resulting in frank uremia necessitating dialysis. There is occasionally associated hypertension and hyperuricemia with or without gout.

Early kidney disease is difficult to detect. The urinalysis is normal in early lead nephropathy and the blood urea nitrogen and serum creatinine increase only when two-thirds of kidney function is lost. Measurement of creatinine clearance can often detect earlier disease as can other methods of measurement of glomerular filtration rate. An abnormal Ca-EDTA mobilization test has been used to differentiate between lead-induced and other nephropathies, but this procedure is not widely accepted. A form of Fanconi syndrome with aminoaciduria, glycosuria, and hyperphosphaturia indicating severe injury to the proximal renal tubules is occasionally seen in children.

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5. Reproductive effects. Exposure to lead can have serious effects on reproductive function in both males and females. In male workers exposed to lead there can be a decrease in sexual drive, impotence, decreased ability to produce healthy sperm, and sterility. Malformed sperm (teratospermia), decreased number of sperm (hypospermia), and sperm with decreased motility (asthenospermia) can all occur. Teratospermia has been noted at mean blood lead levels of 53 ug/100 g and hypospermia and asthenospermia at 41 ug/100 g. Furthermore, there appears to be a dose-response relationship for teratospermia in lead exposed workers.

Women exposed to lead may experience menstrual disturbances including dysmenorrhea, menorrhagia and amenorrhea. Following exposure to lead, women have a higher frequency of sterility, premature births, spontaneous miscarriages, and stillbirths.

Germ cells can be affected by lead and cause genetic damage in the egg or sperm cells before conception and result in failure to implant, miscarriage, stillbirth, or birth defects.

Infants of mothers with lead poisoning have a higher mortality during the first year and suffer from lowered birth weights, slower growth, and nervous system disorders.

Lead can pass through the placental barrier and lead levels in the mother's blood are comparable to concentrations of lead in the umbilical cord at birth. Transplacental passage becomes detectable at 12-14 weeks of gestation and increases until birth.

There is little direct data on damage to the fetus from exposure to lead but it is generally assumed that the fetus and newborn would be at least as susceptible to neurological damage as young children. Blood lead levels of 50-60 ug/100 g in children can cause significant neurobehavioral impairments and there is evidence of hyperactivity at blood levels as low as 25 ug/100 g. Given the overall body of literature concerning the adverse health effects of lead in children, OSHA feels that the blood lead level in children should be maintained below 30 ug/100 g with a population mean of 15 ug/100 g. Blood lead levels in the fetus and newborn likewise should not exceed 30 ug/100 g. Because of lead's ability to pass through the placental barrier and also because of the demonstrated adverse effects of lead on reproductive function in both the male and female as well as the risk of genetic damage of lead on both the ovum and sperm, OSHA recommends a 30 ug/100 g maximum permissible blood lead level in both males and females who wish to bear children.

6. Other toxic effects. Debate and research continue on the effects of lead on the human body. Hypertension has frequently been noted in occupationally exposed individuals although it is difficult to assess whether this is due to lead's adverse effects on the kidney or if some other mechanism is involved. Vascular and electrocardiographic changes have been detected but have not been well characterized. Lead is thought to impair thyroid function and interfere with the pituitary-adrenal axis, but again these effects have not been well defined.

III. MEDICAL EVALUATION

The most important principle in evaluating a worker for any occupational disease including lead poisoning is a high index of suspicion on the part of the examining physician. As discussed in Section 2, lead can affect numerous organ systems and produce a wide array of signs and symptoms, most of which are non-specific and subtle in nature at least in the early stages of disease. Unless serious concern for lead toxicity is present, many of the early clues to diagnosis may easily be overlooked.

The crucial initial step in the medical evaluation is recognizing that a worker's employment can result in exposure to lead. The worker will frequently be able to define exposures to lead and lead containing materials but often will not volunteer this information unless specifically asked. In other situations the worker may not know of any exposures to lead but the suspicion might be raised on the part of the physician because of the industry or occupation of the worker. Potential occupational exposure to lead and its compounds occur in at least 120 occupations, including lead smelting, the manufacture of lead storage batteries, the manufacture of lead pigments and products containing pigments, solder manufacture, shipbuilding and ship repair, auto manufacturing, construction, and painting.

Once the possibility for lead exposure is raised, the focus can then be directed toward eliciting information from the medical history, physical exam, and finally from laboratory data to evaluate the worker for potential lead toxicity.

A complete and detailed work history is important in the initial evaluation. A listing of all previous employment with information on work processes, exposure to fumes or dust, known exposures to lead or other toxic substances, respiratory protection used, and previous medical surveillance should all be included in the worker's record. Where exposure to lead is suspected, information concerning on-the-job personal hygiene, smoking or eating habits in work areas, laundry procedures, and use of any protective clothing or respiratory protection equipment should be noted. A

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complete work history is essential in the medical evaluation of a worker with suspected lead toxicity, especially when long term effects such as neurotoxicity and nephrotoxicity are considered.

The medical history is also of fundamental importance and should include a listing of all past and current medical conditions, current medications including proprietary drug intake, previous surgeries and hospitalizations, allergies, smoking history, alcohol consumption, and also non-occupational lead exposures such as hobbies (hunting, riflery). Also known childhood exposures should be elicited. Any previous history of hematological, neurological, gastrointestinal, renal, psychological, gynecological, genetic, or reproductive problems should be specifically noted.

A careful and complete review of systems must be performed to assess both recognized complaints and subtle or slowly acquired symptoms which the worker might not appreciate as being significant. The review of symptoms should include the following:

General-weight loss, fatigue, decreased appetite.

Head, Eyes, Ears, Nose, Throat (HEENT)-headaches, visual disturbances or decreased visual acuity, hearing deficits or tinnitus, pigmentation of the oral mucosa, or metallic taste in mouth.

Cardio-pulmonary-shortness of breath, cough, chest pains, palpitations, or orthopnea.

Gastrointestinal-nausea, vomiting, heartburn, abdominal pain, constipation or diarrhea.

Neurologic-irritability, insomnia, weakness (fatigue), dizziness, loss of memory, confusion, hallucinations, incoordination, ataxia, decreased strength in hands or feet, disturbances in gait, difficulty in climbing stairs, or seizures.

Hematologic-pallor, easy fatigability, abnormal blood loss, melena.

Reproductive (male and female and spouse where relevant)-history of infertility, impotence, loss of libido, abnormal menstrual periods, history of miscarriages, stillbirths, or children with birth defects.

Musculo-skeletal-muscle and joint pains.

The physical examination should emphasize the neurological, gastrointestinal, and cardiovascular systems. The worker's weight and blood pressure should be recorded and the oral mucosa checked for pigmentation characteristic of a possible Burtonian or lead line on the gingiva. It should be noted, however, that the lead line may not be present even in severe lead poisoning if good oral hygiene is practiced.

The presence of pallor on skin examination may indicate an anemia, which if severe might also be associated with a tachycardia. If an anemia is suspected, an active search for blood loss should be undertaken including potential blood loss through the gastrointestinal tract.

A complete neurological examination should include an adequate mental status evaluation including a search for behavioral and psychological disturbances, memory testing, evaluation for irritability, insomnia, hallucinations, and mental clouding. Gait and coordination should be examined along with close observation for tremor. A detailed evaluation of peripheral nerve function including careful sensory and motor function testing is warranted. Strength testing particularly of extensor muscle groups of all extremities is of fundamental importance.

Cranial nerve evaluation should also be included in the routine examination.

The abdominal examination should include auscultation for bowel sounds and abdominal bruits and palpation for organomegaly, masses, and diffuse abdominal tenderness.

Cardiovascular examination should evaluate possible early signs of congestive heart failure. Pulmonary status should be addressed particularly if respirator protection is contemplated.

As part of the medical evaluation, the lead standard requires the following laboratory studies:

1. Blood lead level
2. Hemoglobin and hematocrit determinations, red cell indices, and examination of the peripheral blood smear to evaluate red blood cell morphology
3. Blood urea nitrogen
4. Serum creatinine
5. Routine urinalysis with microscopic examination.
6. A zinc protoporphyrin level.

In addition to the above, the physician is authorized to order any further laboratory or other tests which he or she deems necessary in accordance with sound medical practice. The evaluation must also include pregnancy testing or laboratory evaluation of male fertility if requested by the employee.

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Additional tests which are probably not warranted on a routine basis but may be appropriate when blood lead and ZPP levels are equivocal include delta aminolevulinic acid and coproporphyrin concentrations in the urine, and dark-field illumination for detection of basophilic stippling in red blood cells.

If an anemia is detected further studies including a careful examination of the peripheral smear, reticulocyte count, stool for occult blood, serum iron, total iron binding capacity, bilirubin, and, if appropriate, vitamin B12 and folate may be of value in attempting to identify the cause of the anemia.

If a peripheral neuropathy is suspected, nerve conduction studies are warranted both for diagnosis and as a basis to monitor any therapy.

If renal disease is questioned, a 24 hour urine collection for creatinine clearance, protein, and electrolytes may be indicated. Elevated uric acid levels may result from lead-induced renal disease and a serum uric acid level might be performed.

An electrocardiogram and chest x-ray may be obtained as deemed appropriate.

Sophisticated and highly specialized testing should not be done routinely and where indicated should be under the direction of a specialist.

IV. LABORATORY EVALUATION

The blood lead level at present remains the single most important test to monitor lead exposure and is the test used in the medical surveillance program under the lead standard to guide employee medical removal. The ZPP has several advantages over the blood lead level. Because of its relatively recent development and the lack of extensive data concerning its interpretation, the ZPP currently remains an ancillary test.

This section will discuss the blood lead level and ZPP in detail and will outline their relative advantages and disadvantages. Other blood tests currently available to evaluate lead exposure will also be reviewed.

The blood lead level is a good index of current or recent lead absorption when there is no anemia present and when the worker has not taken any chelating agents. However, blood lead levels along with urinary lead levels do not necessarily indicate the total body burden of lead and are not adequate measures of past exposure. One reason for this is that lead has a high affinity for bone and up to 90% of the body's total lead is deposited there. A very important component of the total lead body burden is lead in soft tissue (liver, kidney, and brain). This fraction of the lead body burden, the biologically active lead, is not entirely reflected by blood lead levels since it is a function of the dynamics of lead absorption, distribution, deposition in bone and excretion. Following discontinuation of exposure to lead, the excess body burden is only slowly mobilized from bone and other relatively stable body stores and excreted. Consequently, a high blood lead level may only represent recent heavy exposure to lead without a significant total body excess and likewise a low blood lead level does not exclude an elevated total body burden of lead.

Also due to its correlation with recent exposures, the blood lead level may vary considerably over short time intervals.

To minimize laboratory error and erroneous results due to contamination, blood specimens must be carefully collected after thorough cleaning of the skin with appropriate methods using lead-free blood containers and analyzed by a reliable laboratory. Under the standard, samples must be analyzed in laboratories which are approved by the Center for Disease Control (CDC) or which have received satisfactory grades in proficiency testing by the CDC in the previous year. Analysis is to be made using atomic absorption spectrophotometry, anodic stripping voltammetry or any method which meets the accuracy requirements set forth by the standard.

The determination of lead in urine is generally considered a less reliable monitoring technique than analysis of whole blood primarily due to individual variability in urinary excretion capacity as well as the technical difficulty of obtaining accurate 24 hour urine collections. In addition, workers with renal insufficiency, whether due to lead or some other cause, may have decreased lead clearance and consequently urine lead levels may underestimate the true lead burden. Therefore, urine lead levels should not be used as a routine test.

The zinc protoporphyrin test, unlike the blood lead determination, measures an adverse metabolic effect of lead and as such is a better indicator of lead toxicity than the level of blood lead itself. The level of ZPP reflects lead absorption over the preceding 3 to 4 months, and therefore is a better indicator of lead body burden. The ZPP requires more time than the blood lead to read significantly elevated levels; the return to normal after discontinuing lead exposure is also slower. Furthermore, the ZPP test is simpler, faster, and less expensive to perform and no contamination is possible. Many investigators believe it is the most reliable means of monitoring chronic lead absorption.

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Zinc protoporphyrin results from the inhibition of the enzyme ferrochelatase which catalyzes the insertion of an iron molecule into the protoporphyrin molecule, which then becomes heme. If iron is not inserted into the molecule then zinc, having a greater affinity for protoporphyrin, takes the place of the iron, forming ZPP.
An elevation in the level of circulating ZPP may occur at blood lead levels as low as 20-30 ug/100 g in some workers. Once the blood lead level has reached 40 ug/100 g there is more marked rise in the ZPP value from its normal range of less than 100 ug/100 ml. Increases in blood lead levels beyond 40 ug/100 g are associated with exponential increases in ZPP.
Whereas blood lead levels fluctuate over short time spans, ZPP levels remain relatively stable. ZPP is measured directly in red blood cells and is present for the cell's entire 120 day life-span. Therefore, the ZPP level in blood reflects the average ZPP production over the previous 3-4 months and consequently the average lead exposure during that time interval.
It is recommended that a hematocrit be determined whenever a confirmed ZPP of 50 ug/100 ml whole blood is obtained to rule out a significant underlying anemia. If the ZPP is in excess of 100 ug/100 ml and not associated with abnormal elevations in blood lead levels, the laboratory should be checked to be sure that blood leads were determined using atomic absorption spectrophotometry anodic stripping voltammetry, or any method which meets the accuracy requirements set forth by the standard by a CDC approved laboratory which is experienced in lead level determinations. Repeat periodic blood lead studies should be obtained in all individuals with elevated ZPP levels to be certain that an associated elevated blood lead level has not been missed due to transient fluctuations in blood leads.
ZPP has a characteristic fluorescence spectrum with a peak at 594 nm which is detectable with a hematofluorimeter. The hematofluorimeter is accurate and portable and can provide on-site, instantaneous results for workers who can be frequently tested via a finger prick.
However, careful attention must be given to calibration and quality control procedures. Limited data on blood lead-ZPP correlations and the ZPP levels which are associated with the adverse health effects discussed in Section 2 are the major limitations of the test. Also it is difficult to correlate ZPP levels with environmental exposure and there is some variation of response with age and sex. Nevertheless, the ZPP promises to be an important diagnostic test for the early detection of lead toxicity and its value will increase as more data is collected regarding its relationship to other manifestations of lead poisoning.
Levels of delta-aminolevulinic acid (ALA) in the urine are also used as a measure of lead exposure. Increasing concentrations of ALA are believed to result from the inhibition of the enzyme delta-aminolevulinic acid dehydrase (ALA-D). Although the test is relatively easy to perform, inexpensive, and rapid, the disadvantages include variability in results, the necessity to collect a complete 24 hour urine sample which has a specific gravity greater than 1.010, and also the fact that ALA decomposes in the presence of light.
The pattern of porphyrin excretion in the urine can also be helpful in identifying lead intoxication. With lead poisoning, the urine concentrations of coproporphyrins I and II, porphobilinogen and uroporphyrin I rise. The most important increase, however, is that of coproporphyrin III; levels may exceed 5,000 ug/1 in the urine in lead poisoned individuals, but its correlation with blood lead levels and ZPP are not as good as those of ALA. Increases in urinary porphyrins are not diagnostic of lead toxicity and may be seen in porphyria, some liver diseases, and in patients with high reticulocyte counts.
Summary. The Occupational Safety and Health Administration's standard for inorganic lead places significant emphasis on the medical surveillance of all workers exposed to levels of inorganic lead above the action level of 30 ug/m(3) TWA. The physician has a fundamental role in this surveillance program, and in the operation of the medical removal protection program.
Even with adequate worker education on the adverse health effects of lead and appropriate training in work practices, personal hygiene and other control measures, the physician has a primary responsibility for evaluating potential lead toxicity in the worker. It is only through a careful and detailed medical and work history, a complete physical examination and appropriate laboratory testing that an accurate assessment can be made. Many of the adverse health effects of lead toxicity are either irreversible or only partially reversible and therefore early detection of disease is very important.
This document outlines the medical monitoring program as defined by the occupational safety and health standard for inorganic lead. It reviews the adverse health effects of lead poisoning and describes the important elements of the

history and physical examinations as they relate to these adverse effects. Finally, the appropriate laboratory testing for evaluating lead exposure and toxicity is presented.

It is hoped that this review and discussion will give the physician a better understanding of the OSHA standard with the ultimate goal of protecting the health and well-being of the worker exposed to lead under his or her care.

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LEAD EXPOSURE AND DESIGN CONSIDERATIONS FOR INDOOR FIRING RANGES

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ABSTRACT

Law enforcing agencies are demanding greater proficiency and accuracy in the use of handguns by their personnel. This has lead to an increase in the construction and use of indoor firing ranges.

Advantages of indoor ranges are: protection from the weather, control of the environment, and use of the facility around the clock. However, these indoor ranges can and do present health hazards in the form of lead poisoning due to improper ventilation control and high noise levels from poor acoustical treatment of the range. In addition to the lead and noise hazards problems from exposure to carbon monoxide and oxides of nitrogen, as well as psychological stress may exist.

This report attempts to point out the insufficiencies found in many indoor ranges from a health standpoint. Recommendations for design considerations and work practices are presented to reduce or eliminate health hazards associated with indoor firing ranges.

SUMMARY

During 1973 and 1974 the Industrial Hygiene Services Branch of the National Institute for Occupational Safety and Health conducted environmental surveys of nine indoor firing ranges. Environmental sampling was conducted to determine the airborne lead concentrations, noise levels, and ventilation rates.

The composite data indicated that a potential health hazard due to inorganic lead exposure existed at each range. In all ranges the concentration of lead increased as the number of shooters increased and it kept increasing after the number of shooters had been reduced, indicating that the ventilation system was incapable of preventing lead buildup in each range.

A total of 331 samples for airborne inorganic lead were taken during the surveys, of which 187 were personal samples and 144 were general area samples. The concentration of airborne lead contamination ranged from a low of 0.10 milligrams of lead per cubic meter of air (mg/M^3) to a high of 13.17 mg/M^3 for the area samples, and from a low of 0.01 mg/M^3 to a high of 34.50 mg/M^3 for personal samples. (Table 1)

In all the firing ranges surveyed, the ventilation was inadequate to keep airborne lead levels below the standard of 0.20 mg/M^3. In some ranges the supply air was greater than the exhaust causing a positive pressure within the range. In other ranges the situation was reversed. (Table 2) A properly designed ventilation system should maintain the lead concentration below the standard at all times. However, the amount of supplied air means very little if it is not properly utilized.

A possible health hazard also exists in these indoor ranges from impulse types of noise. Sound pressure level readings were taken of various weapons used in the ranges. Sound pressure levels ranged from a 143 dB peak for a 12 gauge shotgun to a 166 dB peak for a.45 caliber revolver. The sound pressure level for the .38 special was a 150 dB peak. (Table 3)

All the ranges surveyed seemed to have one outstanding feature in common; insufficient planning in regard to the location and design of each range. Consideration must be given to the proper placement and design of each range if safe and healthful working conditions for persons involved with the firing ranges are to be assured.

INTRODUCTION

During the past few years the handgun has achieved great popularity in the United States. Besides being used by law enforcement agencies, handgun shooting is being popularized as a recreational activity by the general public. Many police and other law enforcement agencies require their personnel to qualify for accuracy using the handgun, and it is advantageous for these agencies to construct indoor firing ranges. Indoor ranges offer several advantages over outdoor ranges such as protection from inclement weather and around-the-clock use of the facility under controlled environmental conditions. There are, however, disadvantages in using an indoor firing range. Indoor ranges can and

do present health hazards in the form of lead poisoning and high noise levels. In addition, there may be problems with exposure to carbon monoxide and oxides nitrogen.
Most indoor firing ranges are designed primarily with safety, efficiency, and versatility in mind. Usually the walls, floor, and ceiling are constructed of bullet-resistant materials and the shooter booths are bullet resistant and equipped with automatic target spotters. In most ranges, bullet resistant glass separates the shooter from the range officer station and spectators. All of these safety features have little to do with protecting the health of the shooters, range officers, or maintenance personnel.

An indoor range can be designed to protect the health as well as the safety of anyone connected with the range. Ranges should not be placed in basements or converted garages simply because the space is available. Prime consideration must be given to proper ventilation and noise control. However, lighting, psychological factors and stresses, as well as safety must also be considered. If this is done, the indoor range can be a modern up-to-date working facility meeting health and safety standards rather than a dungeon-like, dust-filled, inadequately ventilated enclosure.

DESCRIPTION OF FIRING RANGES

The firing ranges surveyed by NIOSH varied in length from 70 to 120 feet, in width from 20 to 80 feet, and in height from eight to ten feet. The number of firing booths varied from four to forty. Six of the ranges were located in basements or sub-basements, one on the first floor, and two on the top two floors of a building that previously housed a bank. Only two of the facilities were originally designed to be firing ranges. The rest: were installed in "available space." None of the ranges were designed for noise exposure control.

Each range was equipped for the firing of handguns, shotguns, rifles, and machine guns. The .38 caliber police special comprised approximately 90% of all firing of weapons, using .38 special 148 grain lead wad cutter ammunition.

The ventilation in all firing ranges surveyed was inadequate to purge the ranges and keep the lead levels below the standard of 0.20 mg/M^3. In some ranges the supply air was greater than the exhaust and in others the situation was reversed. (Table 2) For instance, the KCK facility had only 8% of its required supply air and was exhausting only 27% of the required amount. This condition created a high negative pressure in the range. The DEA #2 facility had 93% of its required supply air, but was exhausting only 27% of the required amount creating a positive pressure which caused areas adjacent to the range to become contaminated.

In some instances the supply openings were located above and slightly in front of the shooter with the exhaust grilles located approximately four feet away causing a "short-circuiting" effect of the ventilation system.

In one instance the air was supplied approximately at mid-range and was exhausted in the vicinity of the shooter. In two other ranges it was found that the exhaust system was part of the main ventilation system within the building where exhaust air from the range was recirculated to other parts of the building.

In all ranges tested the concentration of lead in the environment increased as the number of shooters increased and continued increasing after the number of shooters had been reduced. This indicated that the ventilation systems were incapable of preventing airborne lead "build-up" in the ranges. In most cases it took approximately one to two hours to purge the ranges and reduce the lead concentration to an acceptable level. A properly designed ventilation system should maintain the lead concentration below the existing standard at all times.

There have been many recommendations for the amount of air that should be supplied to the firing line, ranging from 25 to 100 feet per minute (fpm) [1,2,3]. However, the amount of air supplied means very little if the ventilation system is not balanced and the air flow pattern is not evenly distributed across the shooter.

While practicing or qualifying, the law enforcement personnel stand in bulletproof booths approximately 4 feet wide, 6 feet long, and 9 feet high. Each booth is equipped with an automatic target spotter that can be operated by the shooter or by the range officer. The distance from the firing line to the bullet trap is approximately 75 feet. Each range was equipped with a steel bullet trap where the spent lead was accumulated in a trough at the bottom of the trap. The spent lead is removed from the trough when necessary. In some cases it was found that the spent lead was being remelted after collection within the confines of the range facility and cast into small ingots which can cause an additional lead exposure burden.

Most ranges surveyed employ one or more full-time range officers who are always present when any firing takes place. In many instances the range officers also serve as instructors requiring them to remain in the firing area and outside of the range office for extended periods of time. Therefore, a range officers overall exposure to lead and noise is greater than any other individual using the range.

HOUSEKEEPING

The overall housekeeping of the ranges was poor including general clean up at the end of each day and the periodic cleaning of the bullet trap. In most instances the ranges were swept using a hand broom with dry sweeping compounds used occasionally by a janitor after the range was closed and the ventilation shut off.

Another part of the housekeeping operation included reclaiming, cleaning, and remelting of spent lead collected at the bullet trap. This can be a very hazardous operation if proper precautions are not followed. For cleaning and maintaining the bullet trap, a NIOSH approved respirator should be worn. Remelting of spent lead within the confines of the range should be prohibited.

SOURCES OF CONTAMINATION

There are many sources for lead dust and fume generation in the ranges during the firing of weapons. One Source is from the bullet primer. The primer contains approximately 25-30 milligrams of material, of which approximately 35% is lead styphnate and lead peroxide. The lead styphnate is used as a detonator. Other sources of lead generation are from vaporization (due to the heat of explosion) and fragmentation of the projectile (due to cylinder and barrel misalignments and gaps from wear and manufacturing tolerances) as it passes through the weapon after being fired. The 20000F temperature generated at firing causes the gases to expand creating a pressure build-up of approximately 18,000 to 20,000 PSI in the cylinder that literally blows the dust and fumes from the weapon, much of it at right angles to the direction of fire. This is commonly known as “side blast.” The side blast creates turbulence in the breathing zone of the shooter, thus increasing exposure to lead dust and fumes.

Another source of lead contamination is from fragmentation of the bullet as it strikes the bullet trap. The problem of personal exposure from this source is believed to be minimal since the distance between the shooter and the bullet trap is normally 75 feet or more away.

TOXICOLOGY AND HYGIENIC STANDARDS

Lead poisoning may occur through the inhalation and/or ingestion of lead fumes or dust. This results in the deposition of lead in the bones and tissues of the body and alterations in normal physiological functions. No single sign or symptom may be considered diagnostic of lead poisoning. Lead poisoning may present such symptoms as a metallic taste in the mouth, loss of appetite, indigestion, nausea, vomiting, constipation, abdominal cramps, nervousness and insomnia.

Many of the sources of lead poisoning are industrial, but man also absorbs lead in small amounts from his food and water, and from the air. These sources create the “normal” body burden of lead. The normal burden in workmen is 27-30 micrograms of lead per 100 milliliters of blood. Thus, the lead absorbed in the course of occupational exposure is super imposed on lead absorbed from other sources. Lead poisoning is preceded by a stage of lead absorption, but lead absorption is not always followed by lead poisoning.

The existing U.S. Department of Labor standard for inorganic lead exposures (29 CFR 1910.93 Table G2) is 0.20 mg/M^3 based on an eight hour time-weighted average* (TWA). Any exposure above 0.6 mg/M^3 for an eight hour time-weighted span is considered a serious violation by the U.S. Department of Labor. Although the current standard for inorganic lead is .0.20 mg/M^3, the American Conference of Governmental Industrial Hygienists Threshold Limit Value (TLV) Committee and the NIOSH criteria for a proposed standard on exposure to organic lead recommends that the standard be lowered to 0.15 mg/M^3. (10,11)

ENVIRONMENTAL STUDY PROCEDURES AND INSTRUMENTATION

Atmospheric samples for lead were collected on Millipore filters Type AA, ** with a 0.8u pore size. The filters were encased in a three-piece plastic field monitor cassette with the face cap removed and the filter completely exposed. The samples were taken at the operators breathing zone using battery powered Mine Safety Appliance (MSA) gravimetric pumps, Model G. The pumps and samplers were worn by the shooters and range officers. Area samples were also taken using a Research Appliance Corporation (RAC) sequential sampler with the same type of filters. The automatic sequential sampler was positioned behind the firing line. The sequential sampler collected samples for a 30-minute period. The procedure continues through the day, making it possible to determine how the lead levels fluctuate as a function of time and number of rounds fired. All samples were collected at a rate of 2.0 liters per minute (lpm). The samples were then analyzed in the NIOSH laboratory by atomic absorption spectrophotometry. The ventilation system was evaluated using an Alnor velometer and smoke tubes.

* The standard “is based on a computed time-weighted average exposure during any 8-hourll7ork shift of a 40-hour work week. The stand represents conditions under which it is believed that nearly all workers may be repeatedly exposed without adverse effects. Mention of commercial names or products does not constitute endorsement by the National Institute for Occupational Safety and Health.

INDOOR FIRING RANGE DESIGN CONSIDERATIONS

Ventilation

Effective control of lead dust and fumes and products of combustion in an indoor range can be achieved by utilizing a properly designed ventilation system. Caution must be exercised in design to insure even air flow across the shooting position. Excessive turbulence could cause the contaminant to be blown back into the shooters face.

An important factor in ventilation design is that the supply air intakes to the range should be located at that part of the building upwind from the exhaust stacks. In addition, increased heights of exhaust stacks with high outlet velocities will minimize the possibility of contaminated air being re-introduced and circulated throughout the range.

All supply air entering the range should be filtered and conditioned (heat and cool) depending upon the part of the country where the range is located. The higher the filtration efficiency, the better the efficiency of the heating and cooling coils and the lower the interference with air flow balance. The supply air temperatures are set to maintain the desired room temperature. Since this air is being relied upon for ventilation and replacement purposes, the usual temperature range will be 65-80 degrees. (8)

To control lead fumes, dust, and gaseous combustion products in the range a minimum ventilation rate of 50 feet per minute (fpm) should be maintained at the firing line with all of the air being exhausted at the bullet trap. This recommendation results from a study conducted by NIOSH and the American Air Filter Company to determine ventilation rates for indoor firing ranges.

The study also indicated that an optimum ventilation rate would be 75 fpm at the firing line. When using the rate of 75 fpm, 25% of the air should be exhausted 15-20 feet down range of the shooting position, and the remaining 75% at the bullet trap. However, 100% of the air may be exhausted at the bullet trap. For maximum efficiency the exhaust ducts should be placed behind and at the apex of the bullet trap. An alternative is to place the exhaust ducts on the side of the wall and slightly in front of the apex. All air being exhausted from the range should be filtered using a High Efficiency Particulate Filter (HEPA) or equivalent to insure that state regulations for airborne lead are not violated.

For optimum air distribution there should be a minimum distance of 15 feet from the shooters position to the wall directly behind the shooter. (Fig. 1) The supply air inlets should be placed on the back wall if possible, or placed in the ceiling. Proper placement of supply air inlets and the 15 feet distance from the back wall to the shooters position will insure an even air flow pattern across the shooter and minimize turbulence at the firing line.

Each range should have its own ventilation system so as to prevent circulation of contaminated air from the range into other areas of the building. The firing range should be maintained at a slight negative pressure with respect to adjacent areas (e.g. range office, other offices, halls, restrooms, lunch rooms, etc.) The supply and exhaust systems must be electrically interlocked. This eliminates the possibility of turning one system on and not the other. The system should operate on one fan speed and not on multiple fan speeds.

Noise

In addition to the lead fumes, dust, and products of combustion, another severe health hazard exists in the firing range. The hazard is noise. When fired, the bullet strikes the surrounding air breaking the sound barrier, resulting in the familiar “crack.” This particular type of noise is known as impulse noise. A secondary source of impulse noise is generated when the bullet strikes the bullet trap. However, the initial blast exceeds the noise generated at the bullet trap by so many orders of magnitude that the second impulse source contribution is minimal.

It should be kept: in mind that the shooter is exposed not only to the noise from their own gun, but to the noise from all the other shooters’ guns as well. This noise, although somewhat less intense, is generally more frequent.

Much of the secondary noise can be eliminated at the bullet trap by applying an epoxy resin or equivalent to the back side of the trap plates. Reducing the primary source of noise is much more difficult. (Table 3)

The latest regulation (29 CPR 1910.95, Vol.39 Part II June 27, 1974) from the Occupational Safety and Health Administration (OSHA) states that the peak impulse sound pressure levels (SPL) shall not exceed a 140 dB peak. However, peak impulse alone is not the sole factor in hearing damage. A report to the Committee on Hearing, Bioacoustics, and Biomechanics (CHABA) indicates that the duration of the impulse also bas an effect. (6) For example, CHABA calculated on the basis of tests that about 95% of the population could tolerate, without permanent hearing loss, 100 impulses per day of up to 164 dB, peak (without ear protection) as long as the impulse time was 2 microseconds or less. As duration increases, the peak permissible pressure decreases to a terminal level of 138 dB for 200-1000 millisecond impulses.

In further research, impulse noises were divided into two groups as shown in Fig. 2. Fig. 2A shows the pressure wave form that is observed when a gun is fired out-of-doors with no reflecting surfaces. Fig. 2B shows what occurs when a weapon is fired indoors. There is an initial series of dampened oscillations which maybe followed by a reflected wave at only a slightly lower level.

Many experiments have shown that gunfire can damage hearing.(6,7) The key parameters are peak sound pressure level, duration, and frequency of exposure. In an indoor range reverberation also becomes an important factor. This reverberation can be suppressed somewhat by using proper acoustical material on the walls and in the booths. However, the use or ear protectors must not be eliminated even after steps have been taken to reduce the noise.

To minimize the effect of peak sound pressure levels on individuals in indoor ranges, all reflecting walls should be covered with high efficiency sound absorbing material such as fiberglass insulation covered with perforated aluminum or steel sheets with openings equivalent to 10-15% of the area to permit sound absorption. The coverings should be designed to permit easy access to the acoustical material for periodic replacement due to accumulation of lead dust. The floors directly behind the shooter should be covered with acoustical flooring carpet.

The bullet trap should never be anchored or attached to any structural support for the building without appropriate energy-absorbing linkages. The energy of the bullet striking the trap can be transmitted as noise and vibration throughout the building.

A hearing conservation program should be instituted and periodic audio metric examinations given. Proper ear protection should be available for use at each indoor range which should be worn by all individuals in the range. The protectors should be selected to provide maximum protection.

Although either ear plugs or ear muffs can be used, muffs have the advantage of ease in monitoring usage, and are generally considered preferable by shooters. Each shooter should have their own personal ear protection and some variety should be provided to allow for individual variations and preferences. If ear plugs are used they must be properly fitted. In case of extremely loud handguns, it may be advisable to wear both plugs and muffs simultaneously.

Psychological

The psychological stresses associated with the position of range officer should be considered when designing a new range. By its very nature the job demands close confinement, constant watchfulness for safety violations, rote repetition, and exposure to high noise levels and to lead dust and fumes.

Although the stresses encountered in the range facility are difficult to eliminate, there is much that can be done to reduce them. The walls and surroundings could be painted in soft, contrasting pastel colors to reduce dungeon effect. The floor behind the shooters should be carpeted. The range should be equipped with sound attenuating material in the range officer's quarters, areas for cleaning of weapons, and storing materials. The range should also be equipped with complete toilet facilities. Other considerations that play an important role in reducing psychological stress are proper noise control, ventilation, lighting, and maintenance.

Floors

Floors are a vital part of the firing range from both a health and safety standpoint. The floor is the place where most of the lead dust and any other particulate contaminant finally come to rest. Therefore it is important that the floors be properly constructed.

Floors should be constructed of dense, continuous-poured concrete or steel of a thickness to withstand the impact of the most powerful weapon fired in the range. The concrete should be finished to a smooth surface to facilitate proper clean-up using. either the wet method or the vacuum cleaner method.

Each floor should be constructed with a floor drain. The drain should be placed approximately 20 feet down range of the firing line. The slope of the floor from the firing line to the drain should be 2 to 3 inches so that water will collect at the drain. Although the contaminants that will be washed down the drain will be thoroughly diluted, they may still constitute a health hazard according to the Federal Environmental Protection Agency standards. Therefore, it is essential that a collection trap be included in the drain.

Maintenance

To keep the range operating properly and to keep possible hazards to a minimum, a routine range maintenance program is essential. Accessibility of duct work and fans should become part of the overall design. Intake and exhaust velocities should be monitored periodically by performing pitot traverses of the duct to insure proper carrying velocities. Each range should be periodically inspected to determine repair requirements.

Removing spent lead from the bullet trap or making repairs on the trap can be extremely hazardous. While performing maintenance or removing lead from the trap, a NIOSH approved respirator must be worn by the employee. Personal hygiene should be practiced by all individuals using or maintaining the range to minimize the potential for lead ingestion. This can be accomplished by installing toilet and washing facilities within the range.

RECIRCULATION OF RANGE AIR

When large amounts of air are exhausted from a room in order to remove toxic dusts, gases, and fumes, an equivalent amount of fresh, tempered air should be supplied to the room. The supplied air must be heated in cold weather and heating costs may be large if sizeable amounts of air are handled. Attempts have been made to eliminate such heating costs by appropriate cleaning of the exhausted air prior to recirculation of the air into the room.

Most official health agencies do not recommend the recirculation of exhaust air it contaminant is a material which may have an effect on the health of the worker. However, recirculation in some cases may be the only feasible method of providing ventilation control.

Theory and preliminary test data developed by NIOSH and the American Air Filter company indicate that recirculation of the range air is feasible. However, test results are incomplete at this time. Further supporting data will be developed from actual installation testing and the results will be issued as an addendum to this report.

RECOMMENDATIONS AND DESIGN CONSIDERATIONS

To reduce and/or eliminate the health hazards associated with indoor firing ranges the following design considerations and work practices are recommended.

Design Considerations

1. An optimum air supply would be 75 fpm at the firing line.
   The minimum air supply must be 50 fpm at the firing line.

2. Filtered and conditioned air must be introduced behind the firing line to guarantee an evenly distributed flow of air through the shooting positions.

3. Supplied air inlets should be placed approximately 15 feet behind the shooters position.

4. The entire range facility should be maintained at a slightly negative pressure with respect to adjacent areas to prevent the escape of contaminants. This criteria suggests that exhaust air should exceed supplied air by 10%.

5. For maximum efficiency, exhaust ducts should be located behind and at the apex of the bullet trap.
   An alternative location is to place the exhaust ducts on the side walls slightly in front of the apex of the trap.

6. A minimum down range conveying velocity of 35 fpm must be maintained.

7. When the 75 fpm rate is used, a minimum of 25% of the air should be exhausted 15-20 feet down range of shooting position and the remaining 75% at the bullet trap.

8. When the 50 fpm rate is used, 100% of the air should be exhausted down range at the bullet trap.

9. Each range should have its own ventilation- system to prevent the circulation of contaminated air to other areas of the building.

10. The supply and exhaust systems must be electrically interlocked, thereby eliminating the error of turning one system on and not the other. The system should operate on one fan speed only and not on variable speeds.

11. Each range should be equipped with a floor drain and trap to facilitate cleaning by wet methods.
    The drain location should be approximately 20 feet down range of the firing line. The floor should slope 2-3 inches toward the drain.

12. To minimize the effect of peak sound pressure levels on individuals on the range, all reflecting walls should be covered with high efficiency sound absorbing material such as fiberglass insulation covered with perforated aluminum or steel sheets with openings equivalent to 10-15% of the area to permit sound absorption. The coverings should be designed to permit easy access to the acoustical material for periodic replacement.
    The floors directly behind the shooting booths should be covered with acoustical flooring (carpet that has good acoustical absorption characteristics].

13. Range officer quarters should be acoustically treated to reduce noise levels.

14. The bullet trap should never be anchored or attached to any structural support for the building.
    The energy of the bullet striking the trap can be transmitted as noise and vibration throughout the building.

15. The walls and surroundings could be painted in soft, contrasting pastel colors to reduce the dungeon effect.

16. The range should be equipped with range officer's quarters, areas for cleaning of weapons and storing materials, and with toilet and washing facilities.

17. All air being exhausted from the range should be filtered using a High Efficiency Particulate Filter (HEPA) or equivalent.

Work Practices

1. The ventilation system should be in operation at all times while the range is in use and during clean-up.

2. Sweeping the range should be accomplished by vacuum cleaning or wet methods. Use of a hand broom, even with dust suppression compounds, should be prohibited.

3. At all times while cleaning, repairing, or reclaiming lead in the bullet trap, a NIOSH approved respirator for the removal of lead dust and fumes must be worn.

4. Proper ear protection should be provided for and worn by all individuals inside the firing area. The ear protectors should be selected on the basis of offering maximum protection.

5. Ear plugs when worn must be properly fitted.

6. In case of extremely loud weapons, both plugs and muffs should be worn simultaneously.

7. A hearing conservation program should be instituted and yearly audiometric examinations given.

8. A rotation system should be instituted for the range officer position. It is suggested that one month of duty be followed by three months of alternate activity. This change is suggested not only to alleviate any possible lead absorption and prevent its accumulation, since this should be minimal following the engineering changes, but to prevent undue psychological stresses associated with the position.

9. Eating, drinking, and smoking in the range should be prohibited.

10. A specific schedule must be established to perform maintenance and repair work to keep the range facilities operational and free of hazardous conditions.

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8. American Conf. of Governmental Industrial Hygienists: *Industrial Ventilation Manual*. 14th Ed.

9. NIOSH: *Certified Personal Protective Equipment Manual*

10. *Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment* with intended changes; ACGIB

11. Criteria for a recommended standard: *Occupational Exposure to Inorganic Lead*; HEW Publication HSM: 73-11010, Second Printing.

TABLES

SUMMARY OF LEAD SAMPLING DATA

FACILITY	No. OF SAMPLES	PERSONAL SAMPLES	AREA SAMPLES	PERSONAL SAMPLES RANGE OF LEAD CONTAM. (mg / M³) LOW	HIGH	AVG.	AREA SAMPLES RANGE OF LEAD CONTAM. (mg / M³) LOW	HIGH	AVG.
ORL	56	27	29	1.90	12.12	4.52	0.45	7.76	2.69
ORL-F	24	18	6	0.01	0.42	0.10	0.02	0.13	0.07
IPA	66	36	30	0.23	5.10	1.48	0.20	1.22	0.51
KCK	44	27	17	1.42	24.43	7.44	0.03	3.25	0.99
KCM	42	30	12	0.30	34.50	7.77	0.10	13.17	3.36
OMA	30	16	14	0.38	2.53	0.93	0.02	0.59	0.40
PP	4	2	2	6.42	11.28	8.85	1.18	6.58	4.20
DEA*1	40	20	20	0.37	6.50	2.32	0.06	1.50	0.66
DEA*2	25	11	14	0.05	4.67	2.09	0.01	2.20	0.74

TABLE 1

VENTILATION SUMMARY

FACILITY	INTAKE (CFM) MEASURED	REQUIRED	MEASURED / REQUIRED %	EXHAUST (CFM) MEASURED	REQUIRED	MEASURED / REQUIRED %
ORL	6900	9500	73	4200	10,000	42
ORL-F	9800	9500	—	10,100	10,000	—
IPA	3800	33,000	12	3700	35,000	11
KCK	900	12,000	8	3500	13,000	27
KCM	3600	9000	40	500	9500	5
OMA	2100	6500	32	2700	7000	39
PP	1700	6000	28	1600	6700	24
DEA*1	6800	8000	85	2400	9000	27
DEA*2	7400	8000	93	2400	9000	27

TABLE 2

PEAK SOUND PRESSURE LEVELS OF FIREARMS

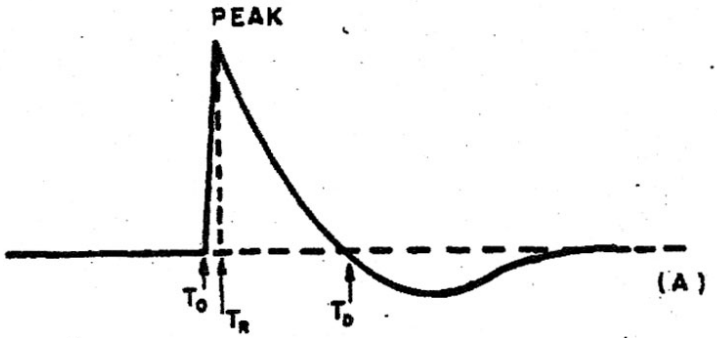
WEAPON	dB PEAK * SOUND PRES. LEVEL
12 — GAUGE SHOTGUN	141 - 143
.38 — SPECIAL SERVICE REVOLVER	147 - 150
.22 — CAL. REVOLVER	142 - 145
.357 — MAGNUM REVOLVER	161 - 166
.32 — SMITH & WESSON (S & W)	148 - 152
.45 — CAL. REVOLVER	160 - 164

*Measurements were taken using a Bruel & Kjaer 2209 SLM with impact analyzer. Measurements were taken inside the range.

TABLE 3

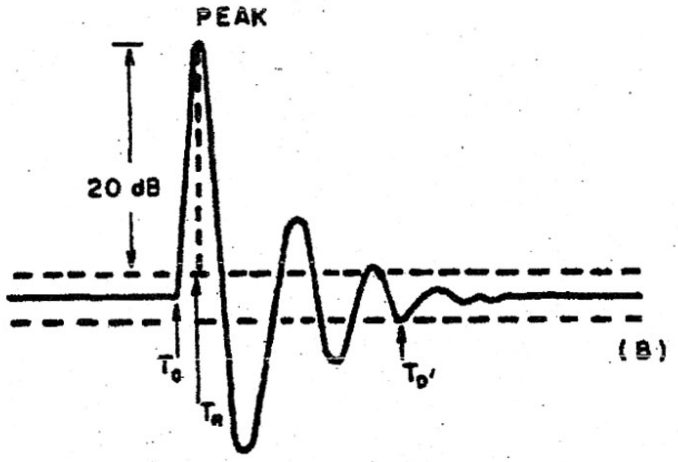
FIGURES

Fig. 2. Two principal types of impulse noise. (8)



1. T_0 IS START OF PRESSURE WAVE
2. T_R IS TIME REQUIRED FOR PRESSURE WAVE FORM TO GO FROM AMBIENT TO PEAK PRESSURE
3. T_D IS TIME REQUIRED FOR PRESSURE WAVE FORM TO FIRST REACH AMBIENT PRESSURE

2 A. Pressure wave form when gun is fired out of doors with no reflecting surfaces.



1. $T_{D'}$ IS TIME REQUIRED FOR ENVELOPE OF PRESSURE WAVE FORM TO REACH LEVEL 20dB BELOW PEAK SPL

TA-822522-208

2 B. Pressure wave form when gun is fired indoors with reflecting surfaces.

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[Title 40, Volume 2, Parts 50 to 51]
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TITLE 40--PROTECTION OF ENVIRONMENT

CHAPTER I--ENVIRONMENTAL PROTECTION AGENCY

PART 50--NATIONAL PRIMARY AND SECONDARY AMBIENT AIR QUALITY STANDARDS

Sec.

50.1 Definitions.
50.2 Scope.
50.3 Reference conditions.
50.4 National primary ambient air quality standards for sulfur oxides (sulfur dioxide).
50.5 National secondary ambient air quality standard for sulfur oxides (sulfur dioxide).
50.6 National primary and secondary ambient air quality standards for PM<INF>10</INF>.
50.7 National primary and secondary ambient air quality standards for particulate matter.
50.8 National primary ambient air quality standards for carbon monoxide.
50.9 National 1-hour primary and secondary ambient air quality standards for ozone.
50.10 National 8-hour primary and secondary ambient air quality standards for ozone.
50.11 National primary and secondary ambient air quality standards for nitrogen dioxide.
50.12 National primary and secondary ambient air quality standards for lead.

Appendix A to Part 50--Reference Method for the Determination of Sulfur Dioxide in the Atmosphere (Pararosaniline Method)
Appendix B to Part 50--Reference Method for the Determination of Suspended Particulate Matter in the Atmosphere (High-Volume Method)
Appendix C to Part 50--Measurement Principle and Calibration Procedure for the Measurement of Carbon Monoxide in the Atmosphere (Non-Dispersive Infrared Photometry)
Appendix D to Part 50--Measurement Principle and Calibration Procedure for the Measurement of Ozone in the Atmosphere
Appendix E to Part 50 [Reserved]
Appendix F to Part 50--Measurement Principle and Calibration Procedure for the Measurement of Nitrogen Dioxide in the Atmosphere (Gas Phase Chemiluminescence)
Appendix G to Part 50--Reference Method for the Determination of Lead in Suspended Particulate Matter Collected From Ambient Air
Appendix H to Part 50--Interpretation of the 1-Hour Primary and Secondary National Ambient Air Quality Standards for Ozone
Appendix I to Part 50--Interpretation of the 8-Hour Primary and Secondary National Ambient Air Quality Standards for Ozone

Appendix J to Part 50--Reference Method for the Determination of Particulate Matter as PM<INF>10</INF> in the Atmosphere
Appendix K to Part 50--Interpretation of the National Ambient Air Quality Standards for Particulate Matter
Appendix L to Part 50--Reference Method for the Determination of Fine Particulate Matter as PM<INF>2.5</INF> in the Atmosphere
Appendix M to Part 50--Reference Method for the Determination of Particulate Matter as PM<INF>10</INF> in the Atmosphere
Appendix N to Part 50--Interpretation of the National Ambient Air Quality Standards for Particulate Matter

Authority: 42 U.S.C. 7401, et seq.

Source: 36 FR 22384, Nov. 25, 1971, unless otherwise noted.

Sec. 50.1 Definitions.

(a) As used in this part, all terms not defined herein shall have the meaning given them by the Act.

(b) Act means the Clean Air Act, as amended (42 U.S.C. 1857-18571, as amended by Pub. L. 91-604).

(c) Agency means the Environmental Protection Agency.

(d) Administrator means the Administrator of the Environmental Protection Agency.

(e) Ambient air means that portion of the atmosphere, external to buildings, to which the general public has access.

(f) Reference method means a method of sampling and analyzing the ambient air for an air pollutant that is specified as a reference method in an appendix to this part, or a method that has been designated as a reference method in accordance with part 53 of this chapter; it does not include a method for which a reference method designation has been cancelled in accordance with Sec. 53.11 or Sec. 53.16 of this chapter.

(g) Equivalent method means a method of sampling and analyzing the ambient air for an air pollutant that has been designated as an equivalent method in accordance with part 53 of this chapter; it does not include a method for which an equivalent method designation has

been cancelled in accordance with Sec. 53.11 or Sec. 53.16 of this chapter.

(h) Traceable means that a local standard has been compared and certified either directly or via not more than one intermediate standard, to a primary standard such as a National Bureau of Standards Standard Reference Material (NBS SRM), or a USEPA/NBS-approved Certified Reference Material (CRM).

(i) Indian country is as defined in 18 U.S.C. 1151.

[36 FR 22384, Nov. 25, 1971, as amended at 41 FR 11253, Mar. 17, 1976; 48 FR 2529, Jan. 20, 1983; 63 FR 7274, Feb. 12, 1998]

Sec. 50.2 Scope.

(a) National primary and secondary ambient air quality standards under section 109 of the Act are set forth in this part.

(b) National primary ambient air quality standards define levels of air quality which the Administrator judges are necessary, with an

adequate margin of safety, to protect the public health. National secondary ambient air quality standards define levels of air quality which the Administrator judges necessary to protect the public welfare from any known or anticipated adverse effects of a pollutant. Such standards are subject to revision, and additional primary and secondary standards may be promulgated as the Administrator deems necessary to protect the public health and welfare.

(c) The promulgation of national primary and secondary ambient air quality standards shall not be considered in any manner to allow significant deterioration of existing air quality in any portion of any State or Indian country.

(d) The proposal, promulgation, or revision of national primary and secondary ambient air quality standards shall not prohibit any State or Indian country from establishing ambient air quality standards for that State or area under a tribal CAA program or any portion thereof which are more stringent than the national standards.

[36 FR 22384, Nov. 25, 1971, as amended at 63 FR 7274, Feb. 12, 1998]

Sec. 50.3 Reference conditions.

All measurements of air quality that are expressed as mass per unit volume (e.g., micrograms per cubic meter) other than for the particulate matter (PM<INF>10</INF> and PM<INF>2.5</INF>) standards contained in Sec. 50.7 shall be corrected to a reference temperature of 25 deg.C and a reference pressure of 760 millimeters of mercury (1,013.2 millibars). Measurements of PM<INF>10</INF> and PM<INF>2.5</INF> for purposes of comparison to the standards contained in Sec. 50.7 shall be reported based on actual ambient air volume measured at the actual ambient temperature and pressure at the monitoring site during the measurement period.

[62 FR 38711, July 18, 1997]

Sec. 50.4 National primary ambient air quality standards for sulfur oxides (sulfur dioxide).

(a) The level of the annual standard is 0.030 parts per million (ppm), not to be exceeded in a calendar year. The annual arithmetic mean shall be rounded to three decimal places (fractional parts equal to or greater than 0.0005 ppm shall be rounded up).

(b) The level of the 24-hour standard is 0.14 parts per million (ppm), not to be exceeded more than once per calendar year. The 24-hour averages shall be determined from successive nonoverlapping 24-hour blocks starting at midnight each calendar day and shall be rounded to two decimal places (fractional parts equal to or greater than 0.005 ppm shall be rounded up).

(c) Sulfur oxides shall be measured in the ambient air as sulfur dioxide by the reference method described in appendix A to this part or by an equivalent method designated in accordance with part 53 of this chapter.

(d) To demonstrate attainment, the annual arithmetic mean and the second-highest 24-hour averages must be based upon hourly data that are at least 75 percent complete in each calendar quarter. A 24-hour block average shall be considered valid if at least 75 percent of the hourly averages for the 24-hour period are available. In the event that only 18, 19, 20, 21, 22, or 23 hourly averages are available, the 24-hour

block average shall be computed as the sum of the available hourly

averages using 18, 19, etc. as the divisor. If fewer than 18 hourly averages are available, but the 24-hour average would exceed the level of the standard when zeros are substituted for the missing values, subject to the rounding rule of paragraph (b) of this section, then this shall be considered a valid 24-hour average. In this case, the 24-hour block average shall be computed as the sum of the available hourly averages divided by 24.

[61 FR 25579, May 22, 1996]

Sec. 50.5 National secondary ambient air quality standard for sulfur oxides (sulfur dioxide).

(a) The level of the 3-hour standard is 0.5 parts per million (ppm), not to be exceeded more than once per calendar year. The 3-hour averages shall be determined from successive nonoverlapping 3-hour blocks starting at midnight each calendar day and shall be rounded to 1 decimal place (fractional parts equal to or greater than 0.05 ppm shall be rounded up).

(b) Sulfur oxides shall be measured in the ambient air as sulfur dioxide by the reference method described in appendix A of this part or by an equivalent method designated in accordance with part 53 of this chapter.

(c) To demonstrate attainment, the second-highest 3-hour average must be based upon hourly data that are at least 75 percent complete in each calendar quarter. A 3-hour block average shall be considered valid only if all three hourly averages for the 3-hour period are available. If only one or two hourly averages are available, but the 3-hour average would exceed the level of the standard when zeros are substituted for the missing values, subject to the rounding rule of paragraph (a) of this section, then this shall be considered a valid 3-hour average. In all cases, the 3-hour block average shall be computed as the sum of the hourly averages divided by 3.

[61 FR 25580, May 22, 1996]

Sec. 50.6 National primary and secondary ambient air quality standards for PM<INF>10</INF>.

(a) The level of the national primary and secondary 24-hour ambient air quality standards for particulate matter is 150 micrograms per cubic meter (<greek-m>g/m\3\), 24-hour average concentration. The standards are attained when the expected number of days per calendar year with a 24-hour average concentration above 150 <greek-m>g/m\3\, as determined in accordance with appendix K to this part, is equal to or less than one.

(b) The level of the national primary and secondary annual standards for particulate matter is 50 micrograms per cubic meter (<greek-m>g/m\3\), annual arithmetic mean. The standards are attained when the expected annual arithmetic mean concentration, as determined in accordance with appendix K to this part, is less than or equal to 50 <greek-m>g/m\3\.

(c) For the purpose of determining attainment of the primary and

secondary standards, particulate matter shall be measured in the ambient air as PM<INF>10</INF> (particles with an aerodynamic diameter less than or equal to a nominal 10 micrometers) by:

(1) A reference method based on appendix J and designated in accordance with part 53 of this chapter, or

(2) An equivalent method designated in accordance with part 53 of this chapter.

(d) The PM<INF>10</INF> standards set forth in this section will no longer apply to an area not attaining these standards as of September 16, 1997, once EPA takes final action to promulgate a rule pursuant to section 172(e) of the Clean Air Act, as amended (42 U.S.C. 7472(e)) applicable to the area. The PM<INF>10</INF> standards set forth in this section will no longer apply to an area attaining these standards as of September 16, 1997, once EPA approves a State Implementation Plan (SIP) applicable to the area containing all PM<INF>10</INF> control measures adopted and implemented by the State prior to September 16, 1997, and a section 110 SIP implementing the PM standards published on July 18, 1997.

SIP approvals are codified in 40 CFR part 52.

[52 FR 24663, July 1, 1987, as amended at 62 FR 38711, July 18, 1997]

Sec. 50.7 National primary and secondary ambient air quality standards for particulate matter.

(a) The national primary and secondary ambient air quality standards for particulate matter are:

(1) 15.0 micrograms per cubic meter (<greek-m>g/m³) annual arithmetic mean concentration, and 65 <greek-m>g/m³ 24-hour average concentration measured in the ambient air as PM<INF>2.5</INF> (particles with an aerodynamic diameter less than or equal to a nominal 2.5 micrometers) by either:

(i) A reference method based on appendix L of this part and designated in accordance with part 53 of this chapter; or

(ii) An equivalent method designated in accordance with part 53 of this chapter.

(2) 50 micrograms per cubic meter (<greek-m>g/m³) annual arithmetic mean concentration, and 150 <greek-m>g/m³ 24-hour average concentration measured in the ambient air as PM<INF>10</INF> (particles with an aerodynamic diameter less than or equal to a nominal 10 micrometers) by either:

(i) A reference method based on appendix M of this part and designated in accordance with part 53 of this chapter; or

(ii) An equivalent method designated in accordance with part 53 of this chapter.

(b) The annual primary and secondary PM<INF>2.5</INF> standards are met when the annual arithmetic mean concentration, as determined in accordance with appendix N of this part, is less than or equal to 15.0 micrograms per cubic meter.

(c) The 24-hour primary and secondary PM<INF>2.5</INF> standards are met when the 98th percentile 24-hour concentration, as determined in accordance with appendix N of this part, is less than or equal to 65 micrograms per cubic meter.

(d) The annual primary and secondary PM<INF>10</INF> standards are

met when the annual arithmetic mean concentration, as determined in accordance with appendix N of this part, is less than or equal to 50 micrograms per cubic meter.

(e) The 24-hour primary and secondary PM<INF>10</INF> standards are met when the 99th percentile 24-hour concentration, as determined in accordance with appendix N of this part, is less than or equal to 150 micrograms per cubic meter.

[62 FR 38711, July 18, 1997]

Sec. 50.8 National primary ambient air quality standards for carbon monoxide.

(a) The national primary ambient air quality standards for carbon monoxide are:

(1) 9 parts per million (10 milligrams per cubic meter) for an 8-hour average concentration not to be exceeded more than once per year and

(2) 35 parts per million (40 milligrams per cubic meter) for a 1-hour average concentration not to be exceeded more than once per year.

(b) The levels of carbon monoxide in the ambient air shall be measured by:

(1) A reference method based on appendix C and designated in accordance with part 53 of this chapter, or

(2) An equivalent method designated in accordance with part 53 of this chapter.

(c) An 8-hour average shall be considered valid if at least 75 percent of the hourly average for the 8-hour period are available. In the event that only six (or seven) hourly averages are available, the 8-hour average shall be computed on the basis of the hours available using six (or seven) as the divisor.

(d) When summarizing data for comparision with the standards, averages shall be stated to one decimal place. Comparison of the data with the levels of the standards in parts per million shall be made in terms of integers with fractional parts of 0.5 or greater rounding up.

[50 FR 37501, Sept. 13, 1985]

Sec. 50.9 National 1-hour primary and secondary ambient air quality standards for ozone.

(a) The level of the national 1-hour primary and secondary ambient air quality standards for ozone measured

by a reference method based on appendix D to this part and designated in accordance with part 53 of this chapter, is 0.12 parts per million (235 <greek-m>g/m³). The standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 parts per million (235 <greek-m>g/m³) is equal to or less than 1, as determined by appendix H to this part.

(b) The 1-hour standards set forth in this section will no longer apply to an area once EPA determines that the area has air quality meeting the 1-hour standard. Area designations are codified in 40 CFR part 81.

[62 FR 38894, July 18, 1997]

Sec. 50.10 National 8-hour primary and secondary ambient air quality standards for ozone.

(a) The level of the national 8-hour primary and secondary ambient air quality standards for ozone, measured by a reference method based on appendix D to this part and designated in accordance with part 53 of this chapter, is 0.08 parts per million (ppm), daily maximum 8-hour average.

(b) The 8-hour primary and secondary ozone ambient air quality standards are met at an ambient air quality monitoring site when the average of the annual fourth-highest daily maximum 8-hour average ozone concentration is less than or equal to 0.08 ppm, as determined in accordance with appendix I to this part.

[62 FR 38894, July 18, 1997]

Sec. 50.11 National primary and secondary ambient air quality standards for nitrogen dioxide.

(a) The level of the national primary ambient air quality standard for nitrogen dioxide is 0.053 parts per million (100 micrograms per cubic meter), annual arithmetic mean concentration.

(b) The level of national secondary ambient air quality standard for nitrogen dioxide is 0.053 parts per million (100 micrograms per cubic meter), annual arithmetic mean concentration.

(c) The levels of the standards shall be measured by:

(1) A reference method based on appendix F and designated in accordance with part 53 of this chapter, or

(2) An equivalent method designated in accordance with part 53 of this chapter.

(d) The standards are attained when the annual arithmetic mean concentration in a calendar year is less than or equal to 0.053 ppm, rounded to three decimal places (fractional parts equal to or greater than 0.0005 ppm must be rounded up). To demonstrate attainment, an annual mean must be based upon hourly data that are at least 75 percent complete or upon data derived from manual methods that are at least 75 percent complete for the scheduled sampling days in each calendar quarter.

[50 FR 25544, June 19, 1985]

Sec. 50.12 National primary and secondary ambient air quality standards for lead.

National primary and secondary ambient air quality standards for lead and its compounds, measured as elemental lead by a reference method based on appendix G to this part, or by an equivalent method, are: 1.5 micrograms per cubic meter, maximum arithmetic mean averaged over a calendar quarter.

(Secs. 109, 301(a) Clean Air Act as amended (42 U.S.C. 7409, 7601(a)))

[43 FR 46258, Oct. 5, 1978]

Appendix A to Part 50--Reference Method for the Determination of Sulfur Dioxide in the Atmosphere (Pararosaniline Method)

1.0 Applicability.

1.1 This method provides a measurement of the concentration of sulfur dioxide (SO<INF>2</INF>) in ambient air for determining compliance with the primary and secondary national ambient air quality standards for sulfur oxides (sulfur dioxide) as specified in Sec. 50.4 and Sec. 50.5 of this chapter. The method is applicable to the measurement of ambient SO<INF>2</INF> concentrations using sampling periods ranging from 30 minutes to 24 hours. Additional quality assurance procedures and guidance are provided in part 58, appendixes A and B, of this chapter and in references 1 and 2.

2.0 Principle.

2.1 A measured volume of air is bubbled through a solution of 0.04 M potassium tetrachloromercurate (TCM). The SO<INF>2</INF> present in the air stream reacts with the TCM solution to form a stable monochlorosulfonatomercurate(3) complex. Once formed, this complex resists air oxidation(4,

5) and is stable in the presence of strong oxidants such as ozone and oxides of nitrogen. During subsequent analysis, the complex is reacted with acid-bleached pararosaniline dye and formaldehyde to form an intensely colored pararosaniline methyl sulfonic acid.(6) The optical density of this species is determined spectrophotometrically at 548 nm and is directly related to the amount of SO<INF>2</INF> collected. The total volume of air sampled, corrected to EPA reference conditions (25 deg.C, 760 mm Hg [101 kPa]), is determined from the measured flow rate and the sampling time. The concentration of SO<INF>2</INF> in the ambient air is computed and expressed in micrograms per standard cubic meter (<greek-m>g/std m³).

3.0 Range.

3.1 The lower limit of detection of SO<INF>2</INF> in 10 mL of TCM is 0.75 <greek-m>g (based on collaborative test results).(7) This represents a concentration of 25 <greek-m>g SO<INF>2</INF>/m³ (0.01 ppm) in an air sample of 30 standard liters (short-term sampling) and a concentration of 13 <greek-m>g SO<INF>2</INF>/m³ (0.005 ppm) in an air sample of 288 standard liters (long-term sampling). Concentrations less than 25 <greek-m>g SO<INF>2</INF>/m³ can be measured by sampling larger volumes of ambient air; however, the collection efficiency falls off rapidly at low concentrations.(8, 9) Beer's law is adhered to up to 34 <greek-m>g of SO<INF>2</INF> in 25 mL of final solution. This upper limit of the analysis range represents a concentration of 1,130 <greek-m>g SO<INF>2</INF>/m³ (0.43 ppm) in an air sample of 30 standard liters and a concentration of 590 <greek-m>g SO<INF>2</INF>/m³ (0.23 ppm) in an air sample of 288 standard liters. Higher concentrations can be measured by collecting a smaller volume of air, by increasing the volume of absorbing solution, or by diluting a suitable portion of the collected sample with absorbing solution prior to analysis.

4.0 Interferences.

4.1 The effects of the principal potential interferences have been minimized or eliminated in the following manner: Nitrogen oxides by the addition of sulfamic acid,(10, 11) heavy metals by the addition of ethylenediamine tetracetic acid disodium salt (EDTA) and phosphoric

acid,(10, 12) and ozone by time delay.(10) Up to 60 <greek-m>g Fe (III), 22 <greek-m>g V (V), 10 <greek-m>g Cu (II), 10 <greek-m>g Mn (II), and 10 <greek-m>g Cr (III) in 10 mL absorbing reagent can be tolerated in the procedure.(10) No significant interference has been encountered with 2.3 <greek-m>g NH<INF>3</INF>.(13)

5.0 Precision and Accuracy.

5.1 The precision of the analysis is 4.6 percent (at the 95 percent confidence level) based on the analysis of standard sulfite samples.(10)

5.2 Collaborative test results (14) based on the analysis of synthetic test atmospheres (SO<INF>2</INF> in scrubbed air) using the 24-hour sampling procedure and the sulfite-TCM calibration procedure show that:

<bullet> The replication error varies linearly with concentration from <plus-minus>2.5 <greek-m>g/m\3\ at concentrations of 100 <greek-m>g/m\3\ to <plus-minus>7 <greek-m>g/m\3\ at concentrations of 400 <greek-m>g/m\3\.
<bullet> The day-to-day variability within an individual laboratory (repeatability) varies linearly with concentration from <plus-minus>18.1 <greek-m>g/m\3\ at levels of 100 <greek-m>g/m\3\ to <plus-minus>50.9 <greek-m>g/m\3\ at levels of 400 <greek-m>g/m\3\.
<bullet> The day-to-day variability between two or more laboratories (reproducibility) varies linearly with concentration from <plus-minus>36.9 <greek-m>g/m\3\ at levels of 100 <greek-m>g/m\3\ to <plus-minus>103.5 <greek-m> g/m\3\ at levels of 400 <greek-m>g/m\3\.
<bullet> The method has a concentration-dependent bias, which becomes significant at the 95 percent confidence level at the high concentration level. Observed values tend to be lower than the expected SO<INF>2</INF> concentration level.

6.0 Stability.

6.1 By sampling in a controlled temperature environment of 15 deg.<plus-minus>10 deg.C, greater than 98.9 percent of the SO<INF>2</INF>-TCM complex is retained at the completion of sampling.(15) If kept at 5 deg.C following the completion of sampling, the collected sample has been found to be stable for up to 30 days.(10) The presence of EDTA enhances the stability of SO<INF>2</INF> in the TCM solution and the rate of decay is independent of the concentration of SO<INF>2</INF>.(16)

7.0 Apparatus.

7.1 Sampling.

7.1.1 Sample probe: A sample probe meeting the requirements of section 7 of 40 CFR part 58, appendix E (Teflon<Register> or glass with residence time less than 20 sec.) is used to transport ambient air to the sampling train location. The end of the probe should be designed or oriented to preclude the sampling of precipitation, large particles, etc. A suitable probe can be constructed from Teflon<Register> tubing connected to an inverted funnel.

7.1.2 Absorber--short-term sampling: An all glass midget impinger having a solution capacity of 30 mL and a stem clearance of 4<plus-minus>1 mm from the bottom of the vessel is used for sampling periods of 30 minutes and 1 hour (or any period considerably less than 24 hours). Such an impinger is shown in Figure 1. These impingers are commercially available from distributors such as Ace Glass, Incorporated.

7.1.3 Absorber--24-hour sampling: A polypropylene tube 32 mm in diameter and 164 mm long (available from Bel Art Products, Pequammock,

NJ) is used as the absorber. The cap of the absorber must be a polypropylene cap with two ports (rubber stoppers are unacceptable because the absorbing reagent can react with the stopper to yield erroneously high SO<INF>2</INF> concentrations). A glass impinger stem, 6 mm in diameter and 158 mm long, is inserted into one port of the absorber cap. The tip of the stem is tapered to a small diameter orifice (0.4<plus-minus>0.1 mm) such that a No. 79 jeweler's drill bit will pass through the opening but a No. 78 drill bit

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will not. Clearance from the bottom of the absorber to the tip of the stem must be 6<plus-minus>2 mm. Glass stems can be fabricated by any reputable glass blower or can be obtained from a scientific supply firm. Upon receipt, the orifice test should be performed to verify the orifice size. The 50 mL volume level should be permanently marked on the absorber. The assembled absorber is shown in Figure 2.

7.1.4 Moisture trap: A moisture trap constructed of a glass trap as shown in Figure 1 or a polypropylene tube as shown in Figure 2 is placed between the absorber tube and flow control device to prevent entrained liquid from reaching the flow control device. The tube is packed with indicating silica gel as shown in Figure 2. Glass wool may be substituted for silica gel when collecting short-term samples (1 hour or less) as shown in Figure 1, or for long term (24 hour) samples if flow changes are not routinely encountered.

7.1.5 Cap seals: The absorber and moisture trap caps must seal securely to prevent leaks during use. Heat-shrink material as shown in Figure 2 can be used to retain the cap seals if there is any chance of the caps coming loose during sampling, shipment, or storage.

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7.1.6 Flow control device: A calibrated rotameter and needle valve combination capable of maintaining and measuring air flow to within <plus-minus>2 percent is suitable for short-term sampling but may not be used for long-term sampling. A critical orifice can be used for regulating flow rate for both long-term and short-term sampling. A 22-gauge hypodermic needle 25 mm long may be used as a critical orifice to yield a flow rate of approximately 1 L/min for a 30-minute sampling period. When sampling for 1 hour, a 23-gauge hypodermic needle 16 mm in length will provide a flow rate of approximately 0.5 L/min. Flow control for a 24-hour sample may be provided by a 27-gauge hypodermic needle critical orifice that is 9.5 mm in length. The flow rate should be in the range of 0.18 to 0.22 L/min.

7.1.7 Flow measurement device: Device calibrated as specified in 9.4.1 and used to measure sample flow rate at the monitoring site.

7.1.8 Membrane particle filter: A membrane filter of 0.8 to 2 <greek-m>m porosity is used to protect the flow controller from particles during long-term sampling. This item is optional for short-

term sampling.

7.1.9 Vacuum pump: A vacuum pump equipped with a vacuum gauge and capable of maintaining at least 70 kPa (0.7 atm) vacuum differential across the flow control device at the specified flow rate is required for sampling.

7.1.10 Temperature control device: The temperature of the absorbing solution during sampling must be maintained at 15 deg. <plus-minus>10 deg.C. As soon as possible following sampling and until analysis, the temperature of the collected sample must be maintained at 5 deg. <plus-minus>5 deg.C. Where an extended period of time may elapse before the collected sample can be moved to the lower storage temperature, a collection temperature near the lower limit of the 15 <plus-minus> 10 deg.C range should be used to minimize losses during this period. Thermoelectric coolers specifically designed for this temperature control are available commercially and normally operate in the range of 5 deg. to 15 deg.C. Small refrigerators can be modified to provide the required temperature control; however, inlet lines must be insulated from the lower temperatures to prevent condensation when sampling under humid conditions. A small heating pad may be necessary when sampling at low temperatures (<7 deg.C) to prevent the absorbing solution from freezing.(17)

7.1.11 Sampling train container: The absorbing solution must be shielded from light during and after sampling. Most commercially available sampler trains are enclosed in a light-proof box.

7.1.12 Timer: A timer is recommended to initiate and to stop sampling for the 24-hour period. The timer is not a required piece of equipment; however, without the timer a technician would be required to start and stop the sampling manually. An elapsed time meter is also recommended to determine the duration of the sampling period.

7.2 Shipping.

7.2.1 Shipping container: A shipping container that can maintain a temperature of 5 deg. <plus-minus>5 deg.C is used for transporting the sample from the collection site to the analytical laboratory. Ice coolers or refrigerated shipping containers have been found to be satisfactory. The use of eutectic cold packs instead of ice will give a more stable temperature control. Such equipment is available from Cole-Parmer Company, 7425 North Oak Park Avenue, Chicago, IL 60648.

7.3 Analysis.

7.3.1 Spectrophotometer: A spectrophotometer suitable for measurement of absorbances at 548 nm with an effective spectral bandwidth of less than 15 nm is required for analysis. If the spectrophotometer reads out in transmittance, convert to absorbance as follows:

[GRAPHIC] [TIFF OMITTED] TC08NO91.000

where:

A = absorbance, and
T = transmittance (0<<gr-thn-eq>T<1).

A standard wavelength filter traceable to the National Bureau of Standards is used to verify the wavelength calibration according to the procedure enclosed with the filter. The wavelength calibration must be verified upon initial receipt of the instrument and after each 160 hours of normal use or every 6 months, whichever occurs first.

7.3.2 Spectrophotometer cells: A set of 1-cm path length cells suitable for use in the visible region is used during analysis. If the

cells are unmatched, a matching correction factor must be determined according to Section 10.1.

7.3.3 Temperature control device: The color development step during analysis must be conducted in an environment that is in the range of 20 deg. to 30 deg.C and controlled to <plus-minus>1 deg.C. Both calibration and sample analysis must be performed under identical conditions (within 1 deg.C). Adequate temperature control may be obtained by means of constant temperature baths, water baths with manual temperature control, or temperature controlled rooms.

7.3.4 Glassware: Class A volumetric glassware of various capacities is required for preparing and standardizing reagents and standards and for dispensing solutions during analysis. These included pipets, volumetric flasks, and burets.

7.3.5 TCM waste receptacle: A glass waste receptacle is required for the storage of spent TCM solution. This vessel should be stoppered and stored in a hood at all times.

8.0 Reagents.

8.1 Sampling.

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8.1.1 Distilled water: Purity of distilled water must be verified by the following procedure:(18)

<bullet> Place 0.20 mL of potassium permanganate solution (0.316 g/L), 500 mL of distilled water, and 1mL of concentrated sulfuric acid in a chemically resistant glass bottle, stopper the bottle, and allow to stand.

<bullet> If the permanganate color (pink) does not disappear completely after a period of 1 hour at room temperature, the water is suitable for use.

<bullet> If the permanganate color does disappear, the water can be purified by redistilling with one crystal each of barium hydroxide and potassium permanganate in an all glass still.

8.1.2 Absorbing reagent (0.04 M potassium tetrachloromercurate [TCM]): Dissolve 10.86 g mercuric chloride, 0.066 g EDTA, and 6.0 g potassium chloride in distilled water and dilute to volume with distilled water in a 1,000-mL volumetric flask. (Caution: Mercuric chloride is highly poisonous. If spilled on skin, flush with water immediately.) The pH of this reagent should be between 3.0 and 5.0 (10) Check the pH of the absorbing solution by using pH indicating paper or a pH meter. If the pH of the solution is not between 3.0 and 5.0, dispose of the solution according to one of the disposal techniques described in Section 13.0. The absorbing reagent is normally stable for 6 months. If a precipitate forms, dispose of the reagent according to one of the procedures described in Section 13.0.

8.2 Analysis.

8.2.1 Sulfamic acid (0.6%): Dissolve 0.6 g sulfamic acid in 100 mL distilled water. Perpare fresh daily.

8.2.2 Formaldehyde (0.2%): Dilute 5 mL formaldehyde solution (36 to 38 percent) to 1,000 mL with distilled water. Prepare fresh daily.

8.2.3 Stock iodine solution (0.1 N): Place 12.7 g resublimed iodine in a 250-mL beaker and add 40 g potassium iodide and 25 mL water. Stir until dissolved, transfer to a 1,000 mL volumetric flask and dilute to volume with distilled water.

8.2.4 Iodine solution (0.01 N): Prepare approximately 0.01 N iodine solution by diluting 50 mL of stock iodine solution (Section 8.2.3) to

500 mL with distilled water.

8.2.5 Starch indicator solution: Triturate 0.4 g soluble starch and 0.002 g mercuric iodide (preservative) with enough distilled water to form a paste. Add the paste slowly to 200 mL of boiling distilled water and continue boiling until clear. Cool and transfer the solution to a glass stopperd bottle.

8.2.6 1 N hydrochloric acid: Slowly and while stirring, add 86 mL of concentrated hydrochloric acid to 500 mL of distilled water. Allow to cool and dilute to 1,000 mL with distilled water.

8.2.7 Potassium iodate solution: Accurately weigh to the nearest 0.1 mg, 1.5 g (record weight) of primary standard grade potassium iodate that has been previously dried at 180 deg.C for at least 3 hours and cooled in a dessicator. Dissolve, then dilute to volume in a 500-mL volumetric flask with distilled water.

8.2.8 Stock sodium thiosulfate solution (0.1 N): Prepare a stock solution by dissolving 25 g sodium thiosulfate (Na<INF>2</INF> S<INF>2</INF> O<INF>3</INF><divide>5H<INF>2</INF> O) in 1,000 mL freshly boiled, cooled, distilled water and adding 0.1 g sodium carbonate to the solution. Allow the solution to stand at least 1 day before standardizing. To standardize, accurately pipet 50 mL of potassium iodate solution (Section 8.2.7) into a 500-mL iodine flask and add 2.0 g of potassium iodide and 10 mL of 1 N HCl. Stopper the flask and allow to stand for 5 minutes. Titrate the solution with stock sodium thiosulfate solution (Section 8.2.8) to a pale yellow color. Add 5 mL of starch solution (Section 8.2.5) and titrate until the blue color just disappears. Calculate the normality (N<INF>s</INF>) of the stock sodium thiosulfate solution as follows:

[GRAPHIC] [TIFF OMITTED] TC08NO91.001

where:

M = volume of thiosulfate required in mL, and
W = weight of potassium iodate in g (recorded weight in Section 8.2.7).

[GRAPHIC] [TIFF OMITTED] TC08NO91.002

8.2.9 Working sodium thiosulfate titrant (0.01 N): Accurately pipet 100 mL of stock sodium thiosulfate solution (Section 8.2.8) into a 1,000-mL volumetric flask and dilute to volume with freshly boiled, cooled, distilled water. Calculate the normality of the working sodium thiosulfate titrant (N<INF>T</INF>) as follows:

[GRAPHIC] [TIFF OMITTED] TC08NO91.003

8.2.10 Standardized sulfite solution for the preparation of working sulfite-TCM solution: Dissolve 0.30 g sodium metabisulfite (Na<INF>2</INF> S<INF>2</INF> O<INF>5</INF>) or 0.40 g sodium sulfite (Na<INF>2</INF> SO<INF>3</INF>) in 500 mL of recently boiled, cooled, distilled water. (Sulfite solution is unstable; it is therefore important to use water of the highest purity to minimize this instability.) This solution contains the equivalent of 320 to 400 <greek-m>g SO<INF>2</INF>/mL. The actual concentration of the solution is determined by adding excess iodine and back-titrating with standard sodium thiosulfate solution. To back-titrate, pipet 50 mL of the 0.01 N iodine solution (Section 8.2.4) into each of two 500-mL iodine flasks (A and B). To flask A (blank) add 25 mL distilled water, and to flask B (sample)

pipet 25 mL sulfite solution. Stopper the flasks and allow to stand for 5 minutes. Prepare the working sulfite-TCM solution (Section 8.2.11) immediately prior to adding the iodine solution to the flasks. Using a buret containing standardized 0.01 N thiosulfate titrant (Section 8.2.9), titrate the solution in each flask to a pale yellow color. Then add 5 mL starch solution (Section 8.2.5) and continue the titration until the blue color just disappears.

8.2.11 Working sulfite-TCM solution: Accurately pipet 5 mL of the standard sulfite solution (Section 8.2.10) into a 250-mL volumetric flask and dilute to volume with 0.04 M TCM. Calculate the concentration of sulfur dioxide in the working solution as follows:
[GRAPHIC] [TIFF OMITTED] TC08NO91.004

where:

A = volume of thiosulfate titrant required for the blank, mL;
B = volume of thiosulfate titrant required for the sample, mL;
N<INF>T</INF> = normality of the thiosulfate titrant, from equation (3);
32,000 = milliequivalent weight of SO<INF>2,</INF> <greek-m>g;
25 = volume of standard sulfite solution, mL; and
0.02 = dilution factor.

This solution is stable for 30 days if kept at 5 deg.C. (16) If not kept at 5 deg.C, prepare fresh daily.

8.2.12 Purified pararosaniline (PRA) stock solution (0.2% nominal):

8.2.12.1 Dye specifications--

<bullet> The dye must have a maximum absorbance at a wavelength of 540 nm when assayed in a buffered solution of 0.1 M sodium acetate-acetic acid;
<bullet> The absorbance of the reagent blank, which is temperature sensitive (0.015 absorbance unit/ deg.C), must not exceed 0.170 at 22 deg.C with a 1-cm optical path length when the blank is prepared according to the specified procedure;
<bullet> The calibration curve (Section 10.0) must have a slope equal to 0.030<plus-minus>0.002 absorbance unit/<greek-m>g SO<INF>2</INF> with a 1-cm optical path length when the dye is pure and the sulfite solution is properly standardized.

8.2.12.2 Preparation of stock PRA solution-- A specially purified (99 to 100 percent pure) solution of pararosaniline, which meets the above specifications, is commercially available in the required 0.20 percent concentration (Harleco Co.). Alternatively, the dye may be purified, a stock solution prepared, and then assayed according to the procedure as described below.(10)

8.2.12.3 Purification procedure for PRA--

1. Place 100 mL each of 1-butanol and 1 N HCl in a large separatory funnel (250-mL) and allow to equilibrate. Note: Certain batches of 1-butanol contain oxidants that create an SO<INF>2</INF> demand. Before using, check by placing 20 mL of 1-butanol and 5 mL of 20 percent potassium iodide (KI) solution in a 50-mL separatory funnel and shake thoroughly. If a yellow color appears in the alcohol phase, redistill the 1-butanol from silver oxide and collect the middle fraction or purchase a new supply of 1-butanol.

2. Weigh 100 mg of pararosaniline hydrochloride dye (PRA) in a small beaker. Add 50 mL of the equilibrated acid (drain in acid from the bottom of the separatory funnel in 1.) to the beaker and let stand for

several minutes. Discard the remaining acid phase in the separatory funnel.

3. To a 125-mL separatory funnel, add 50 mL of the equilibrated 1-butanol (draw the 1-butanol from the top of the separatory funnel in 1.). Transfer the acid solution (from 2.) containing the dye to the funnel and shake carefully to extract. The violet impurity will transfer to the organic phase.

4. Transfer the lower aqueous phase into another separatory funnel, add 20 mL of equilibrated 1-butanol, and extract again.

5. Repeat the extraction procedure with three more 10-mL portions of equilibrated 1-butanol.

6. After the final extraction, filter the acid phase through a cotton plug into a 50-mL volumetric flask and bring to volume with 1 N HCl. This stock reagent will be a yellowish red.

7. To check the purity of the PRA, perform the assay and adjustment of concentration (Section 8.2.12.4) and prepare a reagent blank (Section 11.2); the absorbance of this reagent blank at 540 nm should be less than 0.170 at 22 deg.C. If the absorbance is greater than 0.170 under these conditions, further extractions should be performed.

8.2.12.4 PRA assay procedure-- The concentration of pararosaniline hydrochloride (PRA) need be assayed only once after purification. It is also recommended that commercial solutions of pararosaniline be assayed when first purchased. The assay procedure is as follows:(10)

1. Prepare 1 M acetate-acetic acid buffer stock solution with a pH of 4.79 by dissolving

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13.61 g of sodium acetate trihydrate in distilled water in a 100-mL volumetric flask. Add 5.70 mL of glacial acetic acid and dilute to volume with distilled water.

2. Pipet 1 mL of the stock PRA solution obtained from the purification process or from a commercial source into a 100-mL volumetric flask and dilute to volume with distilled water.

3. Transfer a 5-mL aliquot of the diluted PRA solution from 2. into a 50-mL volumetric flask. Add 5mL of 1 M acetate-acetic acid buffer solution from 1. and dilute the mixture to volume with distilled water. Let the mixture stand for 1 hour.

4. Measure the absorbance of the above solution at 540 nm with a spectrophotometer against a distilled water reference. Compute the percentage of nominal concentration of PRA by

[GRAPHIC] [TIFF OMITTED] TC08NO91.005

where:

A = measured absorbance of the final mixture (absorbance units);
W = weight in grams of the PRA dye used in the assay to prepare 50 mL of stock solution (for example, 0.100 g of dye was used to prepare 50 mL of solution in the purification procedure; when obtained from commercial sources, use the stated concentration to compute W; for 98% PRA, W=.098 g.); and
K = 21.3 for spectrophotometers having a spectral bandwidth of less than 15 nm and a path length of 1 cm.

8.2.13 Pararosaniline reagent: To a 250-mL volumetric flask, add 20 mL of stock PRA solution. Add an additional 0.2 mL of stock solution for each percentage that the stock assays below 100 percent. Then add 25 mL

of 3 M phosphoric acid and dilute to volume with distilled water. The reagent is stable for at least 9 months. Store away from heat and light.

9.0 Sampling Procedure.

9.1 General Considerations. Procedures are described for short-term sampling (30-minute and 1-hour) and for long-term sampling (24-hour). Different combinations of absorbing reagent volume, sampling rate, and sampling time can be selected to meet special needs. For combinations other than those specifically described, the conditions must be adjusted so that linearity is maintained between absorbance and concentration over the dynamic range. Absorbing reagent volumes less than 10 mL are not recommended. The collection efficiency is above 98 percent for the conditions described; however, the efficiency may be substantially lower when sampling concentrations below 25<greek-m><greek-g>SO<INF>2</INF>/m\3\.(8,9)

9.2 30-Minute and 1-Hour Sampling. Place 10 mL of TCM absorbing reagent in a midget impinger and seal the impinger with a thin film of silicon stopcock grease (around the ground glass joint). Insert the sealed impinger into the sampling train as shown in Figure 1, making sure that all connections between the various components are leak tight. Greaseless ball joint fittings, heat shrinkable Teflon[□] tubing, or Teflon[□] tube fittings may be used to attain leakfree conditions for portions of the sampling train that come into contact with air containing SO<INF>2.</INF> Shield the absorbing reagent from direct sunlight by covering the impinger with aluminum foil or by enclosing the sampling train in a light-proof box. Determine the flow rate according to Section 9.4.2. Collect the sample at 1<plus-minus>0.10 L/min for 30-minute sampling or 0.500<plus-minus>0.05 L/min for 1-hour sampling. Record the exact sampling time in minutes, as the sample volume will later be determined using the sampling flow rate and the sampling time. Record the atmospheric pressure and temperature.

9.3 24-Hour Sampling. Place 50 mL of TCM absorbing solution in a large absorber, close the cap, and, if needed, apply the heat shrink material as shown in Figure 3. Verify that the reagent level is at the 50 mL mark on the absorber. Insert the sealed absorber into the sampling train as shown in Figure 2. At this time verify that the absorber temperature is controlled to 15<plus-minus>10 deg.C. During sampling, the absorber temperature must be controlled to prevent decomposition of the collected complex. From the onset of sampling until analysis, the absorbing solution must be protected from direct sunlight. Determine the flow rate according to Section 9.4.2. Collect the sample for 24 hours from midnight to midnight at a flow rate of 0.200<plus-minus>0.020 L/min. A start/stop timer is helpful for initiating and stopping sampling and an elapsed time meter will be useful for determining the sampling time.

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9.4 Flow Measurement.

9.4.1 Calibration: Flow measuring devices used for the on-site flow measurements required in 9.4.2 must be calibrated against a reliable flow or volume standard such as an NBS traceable bubble flowmeter or calibrated wet test meter. Rotameters or critical orifices used in the sampling train may be calibrated, if desired, as a quality control check, but such calibration shall not replace the on-site flow measurements required by 9.4.2. In-line rotameters, if they are to be

calibrated, should be calibrated in situ, with the appropriate volume of solution in the absorber.

9.4.2 Determination of flow rate at sampling site: For short-term samples, the standard flow rate is determined at the sampling site at the initiation and completion of sample collection with a calibrated flow measuring device connected to the inlet of the absorber. For 24-hour samples, the standard flow rate is determined at the time the absorber is placed in the sampling train and again when the absorber is removed from the train for shipment to the analytical laboratory with a calibrated flow measuring device connected to the inlet of the sampling train. The flow rate determination must be made with all components of the sampling system in operation (e.g., the absorber temperature controller and any sample box heaters must also be operating). Equation 6 may be used to determine the standard flow rate when a calibrated positive displacement meter is used as the flow measuring device. Other types of calibrated flow measuring devices may also be used to determine the flow rate at the sampling site provided that the user applies any appropriate corrections to devices for which output is dependent on temperature or pressure.

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[GRAPHIC] [TIFF OMITTED] TC08NO91.006

where:

Q<INF>std</INF> = flow rate at standard conditions, std L/min (25 deg.C and 760 mm Hg);
Q<INF>act</INF> = flow rate at monitoring site conditions, L/min;
P<INF>b</INF> = barometric pressure at monitoring site conditions, mm Hg or kPa;
RH = fractional relative humidity of the air being measured;
P<INF>H</INF>2<INF>O</INF> = vapor pressure of water at the temperature of the air in the flow or volume standard, in the same units as P<INF>b,</INF> (for wet volume standards only, i.e., bubble flowmeter or wet test meter; for dry standards, i.e., dry test meter, P<INF>H</INF>2<INF>O</INF>=0);
P<INF>std</INF> = standard barometric pressure, in the same units as P<INF>b</INF> (760 mm Hg or 101 kPa); and
T<INF>meter</INF> = temperature of the air in the flow or volume standard, deg.C (e.g., bubble flowmeter).

If a barometer is not available, the following equation may be used to determine the barometric pressure:
[GRAPHIC] [TIFF OMITTED] TC08NO91.007

where:

H = sampling site elevation above sea level in meters.

If the initial flow rate (Q<INF>i</INF>) differs from the flow rate of the critical orifice or the flow rate indicated by the flowmeter in the sampling train (Q<INF>c</INF>) by more than 5 percent as determined by equation (8), check for leaks and redetermine Q<INF>i</INF>.
[GRAPHIC] [TIFF OMITTED] TC08NO91.008

Invalidate the sample if the difference between the initial

(Q<INF>i</INF>) and final (Q<INF>f</INF>) flow rates is more than 5 percent as determined by equation (9):
[GRAPHIC] [TIFF OMITTED] TC08NO91.009

9.5 Sample Storage and Shipment. Remove the impinger or absorber from the sampling train and stopper immediately. Verify that the temperature of the absorber is not above 25 deg.C. Mark the level of the solution with a temporary (e.g., grease pencil) mark. If the sample will not be analyzed within 12 hours of sampling, it must be stored at 5 deg. <plus-minus>5 deg.C until analysis. Analysis must occur within 30 days. If the sample is transported or shipped for a period exceeding 12 hours, it is recommended that thermal coolers using eutectic ice packs, refrigerated shipping containers, etc., be used for periods up to 48 hours. (17) Measure the temperature of the absorber solution when the shipment is received. Invalidate the sample if the temperature is above 10 deg.C. Store the sample at 5 deg. <plus-minus>5 deg.C until it is analyzed.

10.0 Analytical Calibration.

10.1 Spectrophotometer Cell Matching. If unmatched spectrophotometer cells are used, an absorbance correction factor must be determined as follows:

1. Fill all cells with distilled water and designate the one that has the lowest absorbance at 548 nm as the reference. (This reference cell should be marked as such and continually used for this purpose throughout all future analyses.)

2. Zero the spectrophotometer with the reference cell.

3. Determine the absorbance of the remaining cells (A<INF>c</INF>) in relation to the reference cell and record these values for future use. Mark all cells in a manner that adequately identifies the correction.

The corrected absorbance during future analyses using each cell is determining as follows:
[GRAPHIC] [TIFF OMITTED] TC08NO91.010

where:

A = corrected absorbance,
A<INF>obs</INF> = uncorrected absorbance, and
A<INF>c</INF> = cell correction.

10.2 Static Calibration Procedure (Option 1). Prepare a dilute working sulfite-TCM solution by diluting 10 mL of the working sulfite-TCM solution (Section 8.2.11) to 100 mL with TCM absorbing reagent. Following the table below, accurately pipet the indicated volumes of the sulfite-TCM solutions into a series of 25-mL volumetric flasks. Add TCM absorbing reagent as indicated to bring the volume in each flask to 10 mL.

Sulfite-TCM solution	Volume of sulfite-TCM solution	Volume of TCM, mL	Total <greek-m>g SO<INF>2</INF> (approx.*

Working.....	4.0	6.0	28.8
Working.....	3.0	7.0	21.6
Working.....	2.0	8.0	14.4
Dilute working.....	10.0	0.0	7.2
Dilute working.....	5.0	5.0	3.6
	0.0	10.0	0.0

*Based on working sulfite-TCM solution concentration of 7.2 <greek-m>g SO<INF>2</INF>/mL; the actual total <greek-m>g SO<INF>2</INF> must be calculated using equation 11 below.

To each volumetric flask, add 1 mL 0.6% sulfamic acid (Section 8.2.1), accurately pipet 2 mL 0.2% formaldehyde solution (Section 8.2.2), then add 5 mL pararosaniline solution (Section 8.2.13). Start a laboratory timer that has been set for 30 minutes. Bring all flasks to volume with recently boiled and cooled distilled water and mix thoroughly. The color must be developed (during the 30-minute period) in a temperature environment in the range of 20 deg. to 30 deg.C, which is controlled to ^{plus-minus}1 deg.C. For increased precision, a constant temperature bath is recommended during the color development step. After 30 minutes, determine the corrected absorbance of each standard at 548 nm against a distilled water reference (Section 10.1). Denote this absorbance as (A). Distilled water is used in the reference cell rather than the reagant blank because of the temperature sensitivity of the reagent blank. Calculate the total micrograms SO<INF>2</INF> in each solution:

[GRAPHIC] [TIFF OMITTED] TC08NO91.011

where:

V<INF>TCM/SO</INF>2 = volume of sulfite-TCM solution used, mL;
C<INF>TCM/SO</INF>2 = concentration of sulfur dioxide in the working sulfite-TCM, <greek-m>g SO<INF>2</INF>/mL (from equation 4); and
D = dilution factor (D = 1 for the working sulfite-TCM solution; D = 0.1 for the diluted working sulfite-TCM solution).

A calibration equation is determined using the method of linear least squares (Section 12.1). The total micrograms SO<INF>2</INF> contained in each solution is the x variable, and the corrected absorbance (eq. 10) associated with each solution is the y variable. For the calibration to be valid, the slope must be in the range of 0.030 ^{plus-minus}0.002 absorbance unit/<greek-m>g SO<INF>2,</INF> the intercept as determined by the least squares method must be equal to or less than 0.170 absorbance unit when the color is developed at 22 deg.C (add 0.015 to this 0.170 specification for each deg.C above 22 deg.C) and the correlation coefficient must be greater than 0.998. If these criteria are not met, it may be the result of an impure dye and/or an improperly standardized sulfite-TCM solution. A calibration factor (B<INF>s</INF>) is determined by calculating the reciprocal of the slope and is subsequently used for calculating the sample concentration (Section 12.3).

10.3 Dynamic Calibration Procedures (Option 2). Atmospheres containing accurately known concentrations of sulfur dioxide are prepared using permeation devices. In the systems for generating these atmospheres, the permeation device emits gaseous SO<INF>2</INF> at a known, low, constant rate, provided the temperature of the device is

held constant (^{plus-minus}0.1 deg.C) and the device has been accurately calibrated at the temperature of use. The SO<INF>2</INF> permeating from the device is carried by a low flow of dry carrier gas to a mixing chamber where it is diluted with SO<INF>2</INF>-free air to the desired concentration and supplied to a vented manifold. A typical system is shown schematically in Figure 4 and this system and other similar systems have been described in detail by O'Keeffe and Ortman; (19) Scaringelli, Frey, and Saltzman, (20) and Scaringelli, O'Keeffe, Rosenberg, and Bell. (21) Permeation devices may be prepared or purchased and in both cases must be traceable either to a National Bureau of Standards (NBS) Standard Reference Material (SRM 1625, SRM 1626, SRM 1627) or to an NBS/EPA-approved commercially available Certified Reference Material (CRM). CRM's are described in Reference 22, and a list of CRM sources is available from the address shown for Reference 22. A recommended protocol for certifying a permeation device to an NBS SRM or CRM is given in Section 2.0.7 of Reference 2. Device permeation rates of 0.2 to 0.4 <greek-m>g/min, inert gas flows of about 50 mL/min, and dilution air flow rates from 1.1 to 15 L/min conveniently yield standard atmospheres in the range of 25 to 600 <greek-m>g SO<INF>2</INF>/m³ (0.010 to 0.230 ppm).

10.3.1 Calibration Option 2A (30-minute and 1-hour samples): Generate a series of six standard atmospheres of SO<INF>2</INF> (e.g., 0, 50, 100, 200, 350, 500, 750 <greek-m>g/m³) by adjusting the dilution flow rates appropriately. The concentration of SO<INF>2</INF> in each atmosphere is calculated as follows:
[GRAPHIC] [TIFF OMITTED] TR31AU93.014

where:

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C<INF>a</INF> = concentration of SO<INF>2</INF> at standard conditions, <greek-m>g/m³;
P<INF>r</INF> = permeation rate, <greek-m>g/min;
Q<INF>d</INF> = flow rate of dilution air, std L/min; and
Q<INF>p</INF> = flow rate of carrier gas across permeation device, std L/min.
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Be sure that the total flow rate of the standard exceeds the flow demand of the sample train, with the excess flow vented at atmospheric pressure. Sample each atmosphere using similar apparatus as shown in Figure 1 and under the same conditions as field sampling (i.e., use same absorbing reagent volume and sample same volume of air at an equivalent flow rate). Due to the length of the sampling periods required, this method is not recommended for 24-hour sampling. At the completion of sampling, quantitatively transfer the contents of each impinger to one of a series of 25-mL volumetric flasks (if 10 mL of absorbing solution was used) using small amounts of distilled water for rinse (<5mL). If >10 mL of absorbing solution was used, bring the absorber solution in each impinger to orginal volume with distilled H<INF>2</INF> O and pipet 10-mL portions from each impinger into a series of 25-mL volumetric flasks. If the color development steps are not to be started within 12 hours of sampling, store the solutions at 5 deg. <plus-minus> 5 deg.C. Calculate the total micrograms SO<INF>2</INF> in each solution as

follows:
[GRAPHIC] [TIFF OMITTED] TR31AU93.015

where:

C<INF>a</INF> = concentration of SO<INF>2</INF> in the standard atmosphere, <greek-m>g/m\3\ ;
O<INF>s</INF> = sampling flow rate, std L/min;
t=sampling time, min;
V<INF>a</INF> = volume of absorbing solution used for color development (10 mL); and
V<INF>b</INF> = volume of absorbing solution used for sampling, mL.

Add the remaining reagents for color development in the same manner as in Section 10.2 for static solutions. Calculate a calibration equation and a calibration factor (B<INF>g</INF>) according to Section 10.2, adhering to all the specified criteria.

10.3.2 Calibration Option 2B (24-hour samples): Generate a standard atmosphere containing approximately 1,050 <greek-m>g SO<INF>2</INF>/m\3\ and calculate the exact concentration according to equation 12. Set up a series of six absorbers according to Figure 2 and connect to a common manifold for sampling the standard atmosphere. Be sure that the total flow rate of the standard exceeds the flow demand at the sample manifold, with the excess flow vented at atmospheric pressure. The absorbers are then allowed to sample the atmosphere for varying time periods to yield solutions containing 0, 0.2, 0.6, 1.0, 1.4, 1.8, and 2.2 <greek-m>g SO<INF>2</INF>/mL solution. The sampling times required to attain these solution concentrations are calculated as follows:
[GRAPHIC] [TIFF OMITTED] TR31AU93.016

where:

t = sampling time, min;
V<INF>b</INF> = volume of absorbing solution used for sampling (50 mL);
C<INF>s</INF> = desired concentration of SO<INF>2</INF> in the absorbing solution, <greek-m>g/mL;
C<INF>a</INF> = concentration of the standard atmosphere calculated according to equation 12, <greek-m>g/m\3\ ; and
Q<INF>s</INF> = sampling flow rate, std L/min.

At the completion of sampling, bring the absorber solutions to original volume with distilled water. Pipet a 10-mL portion from each absorber into one of a series of 25-mL volumetric flasks. If the color development steps are not to be started within 12 hours of sampling, store the solutions at 5 deg. <plus-minus> 5 deg.C. Add the remaining reagents for color development in the same manner as in Section 10.2 for static solutions. Calculate the total <greek-m>g SO<INF>2</INF> in each standard as follows:
[GRAPHIC] [TIFF OMITTED] TR31AU93.017

where:

V<INF>a</INF> = volume of absorbing solution used for color development (10 mL).
All other parameters are defined in equation 14.

Calculate a calibration equation and a calibration factor

(B<INF>t</INF>) according to Section 10.2 adhering to all the specified criteria.

11.0 Sample Preparation and Analysis.

11.1 Sample Preparation. Remove the samples from the shipping container. If the shipment period exceeded 12 hours from the completion of sampling, verify that the temperature is below 10 deg.C. Also, compare the solution level to the temporary level mark on the absorber. If either the temperature is above 10 deg.C or there was significant loss (more than 10 mL) of the sample during shipping, make an appropriate notation in the record and invalidate the sample. Prepare the samples for analysis as follows:

1. For 30-minute or 1-hour samples: Quantitatively transfer the entire 10 mL amount of absorbing solution to a 25-mL volumetric flask and rinse with a small amount (<5 mL) of distilled water.

2. For 24-hour samples: If the volume of the sample is less than the original 50-mL volume (permanent mark on the absorber), adjust the volume back to the original volume with distilled water to compensate for water lost to evaporation during sampling. If the final volume is greater than the original volume, the volume must be measured using a graduated cylinder. To analyze, pipet 10 mL

of the solution into a 25-mL volumetric flask.

11.2 Sample Analysis. For each set of determinations, prepare a reagent blank by adding 10 mL TCM absorbing solution to a 25-mL volumetric flask, and two control standards containing approximately 5 and 15 <greek-m>g SO<INF>2,</INF> respectively. The control standards are prepared according to Section 10.2 or 10.3. The analysis is carried out as follows:

1. Allow the sample to stand 20 minutes after the completion of sampling to allow any ozone to decompose (if applicable).

2. To each 25-mL volumetric flask containing reagent blank, sample, or control standard, add 1 mL of 0.6% sulfamic acid (Section 8.2.1) and allow to react for 10 min.

3. Accurately pipet 2 mL of 0.2% formaldehyde solution (Section 8.2.2) and then 5 mL of pararosaniline solution (Section 8.2.13) into each flask. Start a laboratory timer set at 30 minutes.

4. Bring each flask to volume with recently boiled and cooled distilled water and mix thoroughly.

5. During the 30 minutes, the solutions must be in a temperature controlled environment in the range of 20 deg. to 30 deg.C maintained to ^{plus-minus} 1 deg.C. This temperature must also be within 1 deg.C of that used during calibration.

6. After 30 minutes and before 60 minutes, determine the corrected absorbances (equation 10) of each solution at 548 nm using 1-cm optical path length cells against a distilled water reference (Section 10.1). (Distilled water is used as a reference instead of the reagent blank because of the sensitivity of the reagent blank to temperature.)

7. Do not allow the colored solution to stand in the cells because a film may be deposited. Clean the cells with isopropyl alcohol after use.

8. The reagent blank must be within 0.03 absorbance units of the intercept of the calibration equation determined in Section 10.

11.3 Absorbance range. If the absorbance of the sample solution ranges between 1.0 and 2.0, the sample can be diluted 1:1 with a portion of the reagent blank and the absorbance redetermined within 5 minutes. Solutions with higher absorbances can be diluted up to sixfold with the

reagent blank in order to obtain scale readings of less than 1.0 absorbance unit. However, it is recommended that a smaller portion (<10 mL) of the original sample be reanalyzed (if possible) if the sample requires a dilution greater than 1:1.

11.4 Reaqent disposal. All reagents containing mercury compounds must be stored and disposed of using one of the procedures contained in Section 13. Until disposal, the discarded solutions can be stored in closed glass containers and should be left in a fume hood.

12.0 Calculations.

12.1 Calibration Slope, Intercept, and Correlation Coefficient. The method of least squares is used to calculate a calibration equation in the form of:

[GRAPHIC] [TIFF OMITTED] TC08NO91.012

where:

y = corrected absorbance,
m = slope, absorbance unit/<greek-m>g SO<INF>2,</INF>
x = micrograms of SO<INF>2,</INF>
b = y intercept (absorbance units).

The slope (m), intercept (b), and correlation coefficient (r) are calculated as follows:

[GRAPHIC] [TIFF OMITTED] TR31AU93.018

[GRAPHIC] [TIFF OMITTED] TR31AU93.019

[GRAPHIC] [TIFF OMITTED] TR31AU93.020

where n is the number of calibration points.

A data form (Figure 5) is supplied for easily organizing calibration data when the slope, intercept, and correlation coefficient are calculated by hand.

12.2 Total Sample Volume. Determine the sampling volume at standard conditions as follows:

[GRAPHIC] [TIFF OMITTED] TR31AU93.021

where:

V<INF>std</INF> = sampling volume in std L,
Q<INF>i</INF> = standard flow rate determined at the initiation of sampling in std L/min,
Q<INF>f</INF> = standard flow rate determined at the completion of sampling is std L/min, and
t = total sampling time, min.

12.3 Sulfur Dioxide Concentration. Calculate and report the concentration of each sample as follows:

[GRAPHIC] [TIFF OMITTED] TR31AU93.022

where:

A = corrected absorbance of the sample solution, from equation (10);
A<INF>o</INF> = corrected absorbance of the reagent blank, using equation (10);
B<INF>x</INF> = calibration factor equal to B<INF>s,</INF>
B<INF>g,</INF> or B<INF>t</INF> depending on the calibration procedure

used, the reciprocal of the slope of the calibration equation;
V<INF>a</INF> = volume of absorber solution analyzed, mL;
V<INF>b</INF> = total volume of solution in absorber (see 11.1-2), mL;
and
V<INF>std</INF> = standard air volume sampled, std L (from Section 12.2).

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Data Form
[For hand calculations]

Calibration point no.	Micro- grams So<INF>2</INF>	Absor- bance units		
	(x)	(y)		
	x²	xy	y²	
1				
2				
3				
4				
5				
6				

<greek-S> x=_____ <greek-S> y=_____ <greek-S> x\2\=_____
<greek-S>xy_____ <greek-S>y\2_____
n=_____ (number of pairs of coordinates.)

Figure 5. Data form for hand calculations.

12.4 Control Standards. Calculate the analyzed micrograms of SO<INF>2</INF> in each control standard as follows:
[GRAPHIC] [TIFF OMITTED] TC08NO91.070

where:

C<INF>q</INF> = analyzed <greek-m>g SO<INF>2</INF> in each control standard,
A = corrected absorbance of the control standard, and
A<INF>o</INF> = corrected absorbance of the reagent blank.

The difference between the true and analyzed values of the control standards must not be greater than 1 <greek-m>g. If the difference is greater than 1 <greek-m>g, the source of the discrepancy must be identified and corrected.

12.5 Conversion of <greek-m>g/m³ to ppm (v/v). If

desired, the concentration of sulfur dioxide at reference conditions can be converted to ppm SO<INF>2</INF> (v/v) as follows:
[GRAPHIC] [TIFF OMITTED] TR31AU93.023

13.0 The TCM absorbing solution and any reagents containing mercury compounds must be treated and disposed of by one of the methods discussed below. Both methods remove greater than 99.99 percent of the mercury.

13.1 Disposal of Mercury-Containing Solutions.

13.2 Method for Forming an Amalgam.

1. Place the waste solution in an uncapped vessel in a hood.

2. For each liter of waste solution, add approximately 10 g of sodium carbonate until neutralization has occurred (NaOH may have to be used).

3. Following neutralization, add 10 g of granular zinc or magnesium.

4. Stir the solution in a hood for 24 hours. Caution must be exercised as hydrogen gas is evolved by this treatment process.

5. After 24 hours, allow the solution to stand without stirring to allow the mercury amalgam (solid black material) to settle to the bottom of the waste receptacle.

6. Upon settling, decant and discard the supernatant liquid.

7. Quantitatively transfer the solid material to a container and allow to dry.

8. The solid material can be sent to a mercury reclaiming plant. It must not be discarded.

13.3 Method Using Aluminum Foil Strips.

1. Place the waste solution in an uncapped vessel in a hood.

2. For each liter of waste solution, add approximately 10 g of aluminum foil strips. If all the aluminum is consumed and no gas is evolved, add an additional 10 g of foil. Repeat until the foil is no longer consumed and allow the gas to evolve for 24 hours.

3. Decant the supernatant liquid and discard.

4. Transfer the elemental mercury that has settled to the bottom of the vessel to a storage container.

5. The mercury can be sent to a mercury reclaiming plant. It must not be discarded.

14.0 References for SO<INF>2</INF> Method.

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Appendix B to Part 50--Reference Method for the Determination of Suspended Particulate Matter in the Atmosphere (High-Volume Method)

1.0 Applicability.

1.1 This method provides a measurement of the mass concentration of total suspended particulate matter (TSP) in ambient air for determining compliance with the primary and secondary national ambient air quality standards for particulate matter as specified in Sec. 50.6 and Sec. 50.7 of this chapter. The measurement process is nondestructive, and the size of the sample collected is usually adequate for subsequent chemical analysis. Quality assurance procedures and guidance are provided in part 58, appendixes A and B, of this chapter and in References 1 and 2.

2.0 Principle.

2.1 An air sampler, properly located at the measurement site, draws a measured quantity of ambient air into a covered housing and through a filter during a 24-hr (nominal) sampling period. The sampler flow rate and the geometry of the shelter favor the collection of particles up to 25-50 <greek-m>m (aerodynamic diameter), depending on wind speed and direction.(3) The filters used are specified to have a minimum collection efficiency of 99 percent for 0.3 <greek-m>m (DOP) particles (see Section 7.1.4).

2.2 The filter is weighed (after moisture equilibration) before and after use to determine the net weight (mass) gain. The total volume of air sampled, corrected to EPA standard conditions (25 deg.C, 760 mm Hg [101 kPa]), is determined from the measured flow rate and the sampling time. The concentration of total suspended particulate matter in the ambient air is computed as the mass of collected particles divided by the volume of air sampled, corrected to standard conditions, and is expressed in micrograms per standard cubic meter (<greek-m>g/std m³). For samples collected at temperatures and pressures significantly different than standard conditions, these corrected concentrations may differ substantially from actual concentrations (micrograms per actual cubic meter), particularly at high elevations. The actual particulate matter concentration can be calculated from the corrected concentration using the actual temperature and pressure during the sampling period.

3.0 Range.

3.1 The approximate concentration range of the method is 2 to 750 <greek-m>g/std m^{3.} The upper limit is determined by the point at which the sampler can no longer maintain the specified

flow rate due to the increased pressure drop of the loaded filter. This point is affected by particle size distribution, moisture content of the collected particles, and variability from filter to filter, among other things. The lower limit is determined by the sensitivity of the balance (see Section 7.10) and by inherent sources of error (see Section 6).

3.2 At wind speeds between 1.3 and 4.5 m/sec (3 and 10 mph), the high-volume air sampler has been found to collect particles up to 25 to 50 <greek-m>m, depending on wind speed and direction.(3) For the filter specified in Section 7.1, there is effectively no lower limit on the particle size collected.

4.0 Precision.

4.1 Based upon collaborative testing, the relative standard deviation (coefficient of variation) for single analyst precision (repeatability) of the method is 3.0 percent. The corresponding value

for interlaboratory precision (reproducibility) is 3.7 percent.(4)

5.0 Accuracy.

5.1 The absolute accuracy of the method is undefined because of the complex nature of atmospheric particulate matter and the difficulty in determining the ``true'' particulate matter concentration. This method provides a measure of particulate matter concentration suitable for the purpose specified under Section 1.0, Applicability.

6.0 Inherent Sources of Error.

6.1 Airflow variation. The weight of material collected on the filter represents the (integrated) sum of the product of the instantaneous flow rate times the instantaneous particle concentration. Therefore, dividing this weight by the average flow rate over the sampling period yields the true particulate matter concentration only when the flow rate is constant over the period. The error resulting from a nonconstant flow rate depends on the magnitude of the instantaneous changes in the flow rate and in the particulate matter concentration. Normally, such errors are not large, but they can be greatly reduced by equipping the sampler with an automatic flow controlling mechanism that maintains constant flow during the sampling period. Use of a contant flow controller is recommended.*

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*At elevated altitudes, the effectiveness of automatic flow controllers may be reduced because of a reduction in the maximum sampler flow.

6.2 Air volume measurement. If the flow rate changes substantially or nonuniformly during the sampling period, appreciable error in the estimated air volume may result from using the average of the presampling and postsampling flow rates. Greater air volume measurement accuracy may be achieved by (1) equipping the sampler with a flow controlling mechanism that maintains constant air flow during the sampling period,* (2) using a calibrated, continuous flow rate recording device to record the actual flow rate during the samping period and integrating the flow rate over the period, or (3) any other means that will accurately measure the total air volume sampled during the sampling period. Use of a continuous flow recorder is recommended, particularly if the sampler is not equipped with a constant flow controller.

6.3 Loss of volatiles. Volatile particles collected on the filter may be lost during subsequent sampling or during shipment and/or storage of the filter prior to the postsampling weighing.(5) Although such losses are largely unavoidable, the filter should be reweighed as soon after sampling as practical.

6.4 Artifact particulate matter. Artifact particulate matter can be formed on the surface of alkaline glass fiber filters by oxidation of acid gases in the sample air, resulting in a higher than true TSP determination.(6 7) This effect usually occurs early in the sample period and is a function of the filter pH and the presence of acid gases. It is generally believed to account for only a small percentage of the filter weight gain, but the effect may become more significant where relatively small particulate weights are collected.

6.5 Humidity. Glass fiber filters are comparatively insensitive to changes in relative humidity, but collected particulate matter can be hygroscopic.(8) The moisture conditioning procedure minimizes but may not completely eliminate error due to moisture.

6.6 Filter handling. Careful handling of the filter between the

presampling and postsampling weighings is necessary to avoid errors due to loss of fibers or particles from the filter. A filter paper cartridge or cassette used to protect the filter can minimize handling errors. (See Reference 2, Section 2).

6.7 Nonsampled particulate matter. Particulate matter may be deposited on the filter by wind during periods when the sampler is inoperative. (9) It is recommended that errors from this source be minimized by an automatic mechanical device that keeps the filter covered during nonsampling periods, or by timely installation and retrieval of filters to minimize the nonsampling periods prior to and following operation.

6.8 Timing errors. Samplers are normally controlled by clock timers set to start and stop the sampler at midnight. Errors in the nominal 1,440-min sampling period may result from a power interruption during the sampling period or from a discrepancy between the start or stop time recorded on the filter information record and the actual start or stop time of the sampler. Such discrepancies may be caused by (1) poor resolution of the timer set-points, (2) timer error due to power interruption, (3) missetting of

the timer, or (4) timer malfunction. In general, digital electronic timers have much better set-point resolution than mechanical timers, but require a battery backup system to maintain continuity of operation after a power interruption. A continuous flow recorder or elapsed time meter provides an indication of the sampler run-time, as well as indication of any power interruption during the sampling period and is therefore recommended.

6.9 Recirculation of sampler exhaust. Under stagnant wind conditions, sampler exhaust air can be resampled. This effect does not appear to affect the TSP measurement substantially, but may result in increased carbon and copper in the collected sample. (10) This problem can be reduced by ducting the exhaust air well away, preferably downwind, from the sampler.

7.0 Apparatus.

(See References 1 and 2 for quality assurance information.)

Note: Samplers purchased prior to the effective date of this amendment are not subject to specifications preceded by (<dagger>).

7.1 Filter. (Filters supplied by the Environmental Protection Agency can be assumed to meet the following criteria. Additional specifications are required if the sample is to be analyzed chemically.)

7.1.1 Size: 20.3 <plus-minus> 0.2 x 25.4 <plus-minus> 0.2 cm (nominal 8 x 10 in).

7.1.2 Nominal exposed area: 406.5 cm\2\ (63 in\2\).

7.1.3. Material: Glass fiber or other relatively inert, nonhygroscopic material. (8)

7.1.4 Collection efficiency: 99 percent minimum as measured by the DOP test (ASTM-2986) for particles of 0.3 <greek-m>m diameter.

7.1.5 Recommended pressure drop range: 42-54 mm Hg (5.6-7.2 kPa) at a flow rate of 1.5 std m\3\/min through the nominal exposed area.

7.1.6 pH: 6 to 10. (11)

7.1.7 Integrity: 2.4 mg maximum weight loss. (11)

7.1.8 Pinholes: None.

7.1.9 Tear strength: 500 g minimum for 20 mm wide strip cut from filter in weakest dimension. (See ASTM Test D828-60).

7.1.10 Brittleness: No cracks or material separations after single

lengthwise crease.

7.2 Sampler. The air sampler shall provide means for drawing the air sample, via reduced pressure, through the filter at a uniform face velocity.

7.2.1 The sampler shall have suitable means to:

a. Hold and seal the filter to the sampler housing.

b. Allow the filter to be changed conveniently.

c. Preclude leaks that would cause error in the measurement of the air volume passing through the filter.

d. (<dagger>) Manually adjust the flow rate to accommodate variations in filter pressure drop and site line voltage and altitude. The adjustment may be accomplished by an automatic flow controller or by a manual flow adjustment device. Any manual adjustment device must be designed with positive detents or other means to avoid unintentional changes in the setting.

(<dagger>) See note at beginning of Section 7 of this appendix.

7.2.2 Minimum sample flow rate, heavily loaded filter: 1.1 m³/min (39 ft³/min).<dagger><dagger>

<dagger><dagger> These specifications are in actual air volume units; to convert to EPA standard air volume units, multiply the specifications by (P<INF>b</INF>/P<INF>std</INF>)(298/T) where P<INF>b</INF> and T are the barometric pressure in mm Hg (or kPa) and the temperature in K at the sampler, and P<INF>std</INF> is 760 mm Hg (or 101 kPa).

7.2.3 Maximum sample flow rate, clean filter: 1.7 m³/min (60 ft³/min).<dagger><dagger>

7.2.4 Blower Motor: The motor must be capable of continuous operation for 24-hr periods.

7.3 Sampler shelter.

7.3.1 The sampler shelter shall:

a. Maintain the filter in a horizontal position at least 1 m above the sampler supporting surface so that sample air is drawn downward through the filter.

b. Be rectangular in shape with a gabled roof, similar to the design shown in Figure 1.

c. Cover and protect the filter and sampler from precipitation and other weather.

d. Discharge exhaust air at least 40 cm from the sample air inlet.

e. Be designed to minimize the collection of dust from the supporting surface by incorporating a baffle between the exhaust outlet and the supporting surface.

7.3.2 The sampler cover or roof shall overhang the sampler housing somewhat, as shown in Figure 1, and shall be mounted so as to form an air inlet gap between the cover and the sampler housing walls. ^{<greek-p>} This sample air inlet should be approximately uniform on all sides of the sampler. ^{<greek-p>} The area of the sample air inlet must be sized to provide an effective particle capture air velocity of between 20 and 35 cm/sec at the recommended operational flow rate. The capture velocity is the sample air flow rate

divided by the inlet area measured in a horizontal plane at the lower edge of the cover. ^{<greek-p>} Ideally, the inlet area and operational flow rate should be selected to obtain a capture air velocity of 25 <plus-minus>2 cm/sec.

7.4 Flow rate measurement devices.

7.4.1 The sampler shall incorporate a flow rate measurement device capable of indicating the total sampler flow rate. Two common types of flow indicators covered in the calibration procedure are (1) an electronic mass flowmeter and (2) an orifice or orifices

located in the sample air stream together with a suitable pressure indicator such as a manometer, or aneroid pressure gauge. A pressure recorder may be used with an orifice to provide a continuous record of the flow. Other types of flow indicators (including rotameters) having comparable precision and accuracy are also acceptable.

7.4.2 <dagger> The flow rate measurement device must be capable of being calibrated and read in units corresponding to a flow rate which is readable to the nearest 0.02 std m³/min over the range 1.0 to 1.8 std m³/min.

7.5 Thermometer, to indicate the approximate air temperature at the flow rate measurement orifice, when temperature corrections are used.

7.5.1 Range: -40 deg. to +50 deg.C (223-323 K).

7.5.2 Resolution: 2 deg.C (2 K).

7.6 Barometer, to indicate barometric pressure at the flow rate measurement orifice, when pressure corrections are used.

7.6.1 Range: 500 to 800 mm Hg (66-106 kPa).

7.6.2 Resolution: <plus-minus>5 mm Hg (0.67 kPa).

7.7 Timing/control device.

7.7.1 The timing device must be capable of starting and stopping the sampler to obtain an elapsed run-time of 24 hr <plus-minus>1 hr (1,440 <plus-minus>60 min).

7.7.2 Accuracy of time setting: <plus-minus>30 min, or better. (See Section 6.8).

7.8 Flow rate transfer standard, traceable to a primary standard. (See Section 9.2.)

7.8.1 Approximate range: 1.0 to 1.8 m³/min.

7.8.2 Resolution: 0.02 m³/min.

7.8.3 Reproducibility: <plus-minus>2 percent (2 times coefficient of variation) over normal ranges of ambient temperature and pressure for the stated flow rate range. (See Reference 2, Section 2.)

7.8.4 Maximum pressure drop at 1.7 std m³/min; 50 cm H2 O (5 kPa).

7.8.5 The flow rate transfer standard must connect without leaks to the inlet of the sampler and measure the flow rate of the total air sample.

7.8.6 The flow rate transfer standard must include a means to vary the sampler flow rate over the range of 1.0 to 1.8 m³/min (35-64 ft³/min) by introducing various levels of flow resistance between the sampler and the transfer standard inlet.

7.8.7 The conventional type of flow transfer standard consists of: An orifice unit with adapter that connects to the inlet of the sampler, a manometer or other device to measure orifice pressure drop, a means to vary the flow through the sampler unit, a thermometer to measure the ambient temperature, and a barometer to measure ambient pressure. Two such devices are shown in Figures 2a and 2b. Figure 2a shows multiple

fixed resistance plates, which necessitate disassembly of the unit each time the flow resistance is changed. A preferable design, illustrated in Figure 2b, has a variable flow restriction that can be adjusted externally without disassembly of the unit. Use of a conventional, orifice-type transfer standard is assumed in the calibration procedure (Section 9). However, the use of other types of transfer standards meeting the above specifications, such as the one shown in Figure 2c, may be approved; see the note following Section 9.1.

7.9 Filter conditioning environment

7.9.1 Controlled temperature: between 15 deg. and 30 deg.C with less than ^{plus-minus}3 deg.C variation during equilibration period.

7.9.2 Controlled humidity: Less than 50 percent relative humidity, constant within ^{plus-minus}5 percent.

7.10 Analytical balance.

7.10.1 Sensitivity: 0.1 mg.

7.10.2 Weighing chamber designed to accept an unfolded 20.3 x 25.4 cm (8 x 10 in) filter.

7.11 Area light source, similar to X-ray film viewer, to backlight filters for visual inspection.

7.12 Numbering device, capable of printing identification numbers on the filters before they are placed in the filter conditioning environment, if not numbered by the supplier.

8.0 Procedure.

(See References 1 and 2 for quality assurance information.)

8.1 Number each filter, if not already numbered, near its edge with a unique identification number.

8.2 Backlight each filter and inspect for pinholes, particles, and other imperfections; filters with visible imperfections must not be used.

8.3 Equilibrate each filter in the conditioning environment for at least 24-hr.

8.4 Following equilibration, weigh each filter to the nearest milligram and record this tare weight (W<INF>i</INF>) with the filter identification number.

8.5 Do not bend or fold the filter before collection of the sample.

8.6 Open the shelter and install a numbered, preweighed filter in the sampler, following the sampler manufacturer's instructions. During inclement weather, precautions must be taken while changing filters to prevent damage to the clean filter and loss of sample from or damage to the exposed filter. Filter cassettes that can be loaded and unloaded in the laboratory may be used to minimize this problem (See Section 6.6).

8.7 Close the shelter and run the sampler for at least 5 min to establish run-temperature conditions.

8.8 Record the flow indicator reading and, if needed, the barometric pressure (P <INF>3</INF>) and the ambient temperature (T <INF>3</INF>) see NOTE following step 8.12). Stop the sampler. Determine the sampler flow rate (see Section 10.1); if it is outside the acceptable range (1.1 to 1.7 m³/min [39-60 ft³/min]), use a different filter, or adjust the sampler flow rate. Warning: Substantial flow adjustments may affect the

calibration of the orifice-type flow indicators and may necessitate recalibration.

8.9 Record the sampler identification information (filter number,

site location or identification number, sample date, and starting time).

8.10 Set the timer to start and stop the sampler such that the sampler runs 24-hrs, from midnight to midnight (local time).

8.11 As soon as practical following the sampling period, run the sampler for at least 5 min to again establish run-temperature conditions.

8.12 Record the flow indicator reading and, if needed, the barometric pressure (P <INF>3</INF>) and the ambient temperature (T <INF>3</INF>).

Note: No onsite pressure or temperature measurements are necessary if the sampler flow indicator does not require pressure or temperature corrections (e.g., a mass flowmeter) or if average barometric pressure and seasonal average temperature for the site are incorporated into the sampler calibration (see step 9.3.9). For individual pressure and temperature corrections, the ambient pressure and temperature can be obtained by onsite measurements or from a nearby weather station. Barometric pressure readings obtained from airports must be station pressure, not corrected to sea level, and may need to be corrected for differences in elevation between the sampler site and the airport. For samplers having flow recorders but not constant flow controllers, the average temperature and pressure at the site during the sampling period should be estimated from weather bureau or other available data.

8.13 Stop the sampler and carefully remove the filter, following the sampler manufacturer's instructions. Touch only the outer edges of the filter. See the precautions in step 8.6.

8.14 Fold the filter in half lengthwise so that only surfaces with collected particulate matter are in contact and place it in the filter holder (glassine envelope or manila folder).

8.15 Record the ending time or elapsed time on the filter information record, either from the stop set-point time, from an elapsed time indicator, or from a continuous flow record. The sample period must be 1,440 <plus-minus> 60 min. for a valid sample.

8.16 Record on the filter information record any other factors, such as meteorological conditions, construction activity, fires or dust storms, etc., that might be pertinent to the measurement. If the sample is known to be defective, void it at this time.

8.17 Equilibrate the exposed filter in the conditioning environment for at least 24-hrs.

8.18 Immediately after equilibration, reweigh the filter to the nearest milligram and record the gross weight with the filter identification number. See Section 10 for TSP concentration calculations.

9.0 Calibration.

9.1 Calibration of the high volume sampler's flow indicating or control device is necessary to establish traceability of the field measurement to a primary standard via a flow rate transfer standard. Figure 3a illustrates the certification of the flow rate transfer standard and Figure 3b illustrates its use in calibrating a sampler flow indicator. Determination of the corrected flow rate from the sampler flow indicator, illustrated in Figure 3c, is addressed in Section 10.1

Note: The following calibration procedure applies to a conventional orifice-type flow transfer standard and an orifice-type flow indicator in the sampler (the most common types). For samplers using a pressure recorder having a square-root scale, 3 other acceptable calibration procedures are provided in Reference 12. Other types of transfer standards may be used if the manufacturer or user provides an appropriately modified calibration procedure that has been approved by

EPA under Section 2.8 of appendix C to part 58 of this chapter.

9.2 Certification of the flow rate transfer standard.

9.2.1 Equipment required: Positive displacement standard volume meter traceable to the National Bureau of Standards (such as a Roots meter or equivalent), stop-watch, manometer, thermometer, and barometer.

9.2.2 Connect the flow rate transfer standard to the inlet of the standard volume meter. Connect the manometer to measure the pressure at the inlet of the standard volume meter. Connect the orifice manometer to the pressure tap on the transfer standard. Connect a high-volume air pump (such as a high-volume sampler blower) to the outlet side of the standard volume meter. See Figure 3a.

9.2.3 Check for leaks by temporarily clamping both manometer lines (to avoid fluid loss) and blocking the orifice with a large-diameter rubber stopper, wide cellophane tape, or other suitable means. Start the high-volume air pump and note any change in the standard volume meter reading. The reading should remain constant. If the reading changes, locate any leaks by listening for a whistling sound and/or retightening all connections, making sure that all gaskets are properly installed.

9.2.4 After satisfactorily completing the leak check as described above, unclamp both manometer lines and zero both manometers.

9.2.5 Achieve the appropriate flow rate through the system, either by means of the variable flow resistance in the transfer standard or by varying the voltage to the air pump. (Use of resistance plates as shown in Figure 1a is discouraged because the above leak check must be repeated each time a new resistance plate is installed.) At least five different but constant flow rates, evenly distributed, with at least three in the specified

flow rate interval (1.1 to 1.7 m\3\/min [39-60 ft \3\/min]), are required.

9.2.6 Measure and record the certification data on a form similar to the one illustrated in Figure 4 according to the following steps.

9.2.7 Observe the barometric pressure and record as P<INF>1</INF> (item 8 in Figure 4).

9.2.8 Read the ambient temperature in the vicinity of the standard volume meter and record it as T<INF>1</INF> (item 9 in Figure 4).

9.2.9 Start the blower motor, adjust the flow, and allow the system to run for at least 1 min for a constant motor speed to be attained.

9.2.10 Observe the standard volume meter reading and simultaneously start a stopwatch. Record the initial meter reading (V<INF>i</INF>) in column 1 of Figure 4.

9.2.11 Maintain this constant flow rate until at least 3 m³ of air have passed through the standard volume meter. Record the standard volume meter inlet pressure manometer reading as <greek-D>P (column 5 in Figure 4), and the orifice manometer reading as <greek-D>H (column 7 in Figure 4). Be sure to indicate the correct units of measurement.

9.2.12 After at least 3 m³ of air have passed through the system, observe the standard volume meter reading while simultaneously stopping the stopwatch. Record the final meter reading (V<INF>f</INF>) in column 2 and the elapsed time (t) in column 3 of Figure 4.

9.2.13 Calculate the volume measured by the standard volume meter at meter conditions of temperature and pressures as V<INF>m</INF>=V<INF>f</INF>-V<INF>i.</INF> Record in column 4 of Figure 4.

9.2.14 Correct this volume to standard volume (std m³) as follows:
[GRAPHIC] [TIFF OMITTED] TR31AU93.024

where:

V<INF>std</INF> = standard volume, std m³;
V<INF>m</INF> = actual volume measured by the standard volume meter;
P<INF>1</INF> = barometric pressure during calibration, mm Hg or kPa;
<greek-D>P = differential pressure at inlet to volume meter, mm Hg or kPa;
P<INF>std</INF> = 760 mm Hg or 101 kPa;
T<INF>std</INF> = 298 K;
T<INF>1</INF> = ambient temperature during calibration, K.
Calculate the standard flow rate (std m³/min) as follows:
[GRAPHIC] [TIFF OMITTED] TC08NO91.013

where:

Q<INF>std</INF> = standard volumetric flow rate, std m³/min
t = elapsed time, minutes.

Record Q<INF>std</INF> to the nearest 0.01 std m³/min in column 6 of Figure 4.

9.2.15 Repeat steps 9.2.9 through 9.2.14 for at least four additional constant flow rates, evenly spaced over the approximate range of 1.0 to 1.8 std m³/min (35-64 ft\3\/min).

9.2.16 For each flow, compute

<radical><greek-D><greek-D>H (P<INF>1</INF>/P<INF>std</INF>)(298/T<INF>1</INF>)

(column 7a of Figure 4) and plot these value against Q<INF>std</INF> as shown in Figure 3a. Be sure to use consistent units (mm Hg or kPa) for barometric pressure. Draw the orifice transfer standard certification curve or calculate the linear least squares slope (m) and intercept (b) of the certification curve:

<radical><greek-D><greek-D>H (P<INF>1</INF>/P<INF>std</INF>)(298/T<INF>1</INF>)

=mQ<INF>std</INF>+b. See Figures 3 and 4. A certification graph should be readable to 0.02 std m\3\/min.

9.2.17 Recalibrate the transfer standard annually or as required by applicable quality control procedures. (See Reference 2.)

9.3 Calibration of sampler flow indicator.

Note: For samplers equipped with a flow controlling device, the flow controller must be disabled to allow flow changes during calibration of the sampler's flow indicator, or the alternate calibration of the flow controller given in 9.4 may be used. For samplers using an orifice-type flow indicator downstream of the motor, do not vary the flow rate by adjusting the voltage or power supplied to the sampler.

9.3.1 A form similar to the one illustrated in Figure 5 should be used to record the calibration data.

9.3.2 Connect the transfer standard to the inlet of the sampler.

Connect the orifice manometer to the orifice pressure tap, as illustrated in Figure 3b. Make sure there are no leaks between the orifice unit and the sampler.

9.3.3 Operate the sampler for at least 5 minutes to establish thermal equilibrium prior to the calibration.

9.3.4 Measure and record the ambient temperature, T<INF>2,</INF> and the barometric pressure, P<INF>2,</INF> during calibration.

9.3.5 Adjust the variable resistance or, if applicable, insert the appropriate resistance plate (or no plate) to achieve the desired flow rate.

9.3.6 Let the sampler run for at least 2 min to re-establish the run-temperature conditions. Read and record the pressure drop across the orifice (<greek-D>H) and the sampler flow rate indication (I) in the appropriate columns of Figure 5.

9.3.7 Calculate <radical><greek-D><greek-D>H(P<INF>2</INF>/ P<INF>std</INF>)(298/T<INF>2</INF>) and determine the flow rate at standard conditions (Q<INF>std</INF>) either graphically from the certification curve or by calculating Q<INF>std</INF> from the least square slope and intercept of the transfer standard's transposed certification curve: Q<INF>std</INF>=1/m <radical><greek-D>H(P<INF>2</INF>/P<INF>std</INF>)(298/T<INF>2</INF>)-b. Record the value of Q<INF>std</INF> on Figure 5.

9.3.8 Repeat steps 9.3.5, 9.3.6, and 9.3.7 for several additional flow rates distributed over a range that includes 1.1 to 1.7 std m³/min.

9.3.9 Determine the calibration curve by plotting values of the appropriate expression involving I, selected from table 1, against Q<INF>std.</INF> The choice of expression from table 1 depends on the flow rate measurement device used (see Section 7.4.1) and also on whether the calibration curve is to incorporate geographic average barometric pressure (P<INF>a</INF>) and seasonal average temperature (T<INF>a</INF>) for the site to approximate actual pressure and temperature. Where P<INF>a</INF> and T<INF>a</INF> can be determined for a site for a seasonal period such that the actual barometric pressure and temperature at the site do not vary by more than <plus-minus>60 mm Hg (8 kPa) from P<INF>a</INF> or <plus-minus>15 deg.C from T<INF>a,</INF> respectively, then using P<INF>a</INF> and T<INF>a</INF> avoids the need for subsequent pressure and temperature calculation when the sampler is used. The geographic average barometric pressure (P<INF>a</INF>) may be estimated from an altitude-pressure table or by making an (approximate) elevation correction of -26 mm Hg (-3.46 kPa) for each 305 m (1,000 ft) above sea level (760 mm Hg or 101 kPa). The seasonal average temperature (T<INF>a</INF>) may be estimated from weather station or other records. Be sure to use consistent units (mm Hg or kPa) for barometric pressure.

9.3.10 Draw the sampler calibration curve or calculate the linear least squares slope (m), intercept (b), and correlation coefficient of the calibration curve: [Expression from table 1]= mQ<INF>std</INF>+b. See Figures 3 and 5. Calibration curves should be readable to 0.02 std m³/min.

9.3.11 For a sampler equipped with a flow controller, the flow controlling mechanism should be re-enabled and set to a flow near the lower flow limit to allow maximum control range. The sample flow rate should be verified at this time with a clean filter installed. Then add two or more filters to the sampler to see if the flow controller

maintains a constant flow; this is particularly important at high altitudes where the range of the flow controller may be reduced.

9.4 Alternate calibration of flow-controlled samplers. A flow-controlled sampler may be calibrated solely at its controlled flow rate, provided that previous operating history of the sampler demonstrates that the flow rate is stable and reliable. In this case, the flow indicator may remain uncalibrated but should be used to indicate any relative change between initial and final flows, and the sampler should be recalibrated more often to minimize potential loss of samples because of controller malfunction.

9.4.1 Set the flow controller for a flow near the lower limit of the flow range to allow maximum control range.

9.4.2 Install a clean filter in the sampler and carry out steps 9.3.2, 9.3.3, 9.3.4, 9.3.6, and 9.3.7.

9.4.3 Following calibration, add one or two additional clean filters to the sampler, reconnect the transfer standard, and operate the sampler to verify that the controller maintains the same calibrated flow rate; this is particularly important at high altitudes where the flow control range may be reduced.

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10.0 Calculations of TSP Concentration.

10.1 Determine the average sampler flow rate during the sampling period according to either 10.1.1 or 10.1.2 below.

10.1.1 For a sampler without a continuous flow recorder, determine the appropriate expression to be used from table 2 corresponding to the one from table 1 used in step 9.3.9. Using this appropriate expression, determine Q<INF>std</INF> for the initial flow rate from the sampler calibration curve, either graphically or from the transposed regression equation:

Q<INF>std</INF> =
1/m ([Appropriate expression from table 2]-b)

Similarly, determine Q<INF>std</INF> from the final flow reading, and calculate the average flow Q<INF>std</INF> as one-half the sum of the initial and final flow rates.

10.1.2 For a sampler with a continuous flow recorder, determine the average flow rate device reading, I, for the period. Determine the appropriate expression from table 2 corresponding to the one from table 1 used in step 9.3.9. Then using this expression and the average flow rate reading, determine Q<INF>std</INF> from the sampler calibration curve, either graphically or from the transposed regression equation:

Q<INF>std</INF> =

1/m ([Appropriate expression from table 2]-b)

If the trace shows substantial flow change during the sampling period, greater accuracy may be achieved by dividing the sampling period into intervals and calculating an average reading before determining Q<INF>std</INF>.

10.2 Calculate the total air volume sampled as:

V-Q<INF>std</INF> x t

where:

V = total air volume sampled, in standard volume units, std m\3\/;
Q<INF>std</INF> = average standard flow rate, std m\3\/min;
t = sampling time, min.

10.3 Calculate and report the particulate matter concentration as:
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where:

TSP = mass concentration of total suspended particulate matter, <greek-m>g/std m\3\;
W<INF>i</INF> = initial weight of clean filter, g;
W<INF>f</INF> = final weight of exposed filter, g;
V = air volume sampled, converted to standard conditions, std m\3\,
10\6\ = conversion of g to <greek-m>g.

10.4 If desired, the actual particulate matter concentration (see Section 2.2) can be calculated as follows:

(TSP)<INF>a</INF>=TSP (P<INF>3</INF>/P<INF>std</INF>)(298/T<INF>3</INF>)

where:

(TSP)<INF>a</INF> = actual concentration at field conditions, <greek-m>g/m\3\;

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TSP = concentration at standard conditions, <greek-m>g/std m\3\;
P<INF>3</INF> = average barometric pressure during sampling period, mm Hg;
P<INF>std</INF> = 760 mn Hg (or 101 kPa);
T<INF>3</INF> = average ambient temperature during sampling period, K.

11.0 References.

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[47 FR 54912, Dec. 6, 1982; 48 FR 17355, Apr. 22, 1983]

Appendix C to Part 50--Measurement Principle and Calibration Procedure for the Measurement of Carbon Monoxide in the Atmosphere (Non-Dispersive Infrared Photometry)

Measurement Principle

1. Measurements are based on the absorption of infrared radiation by carbon monoxide (CO) in a non-dispersive photometer. Infrared energy from a source is passed through a cell containing the gas sample to be analyzed, and the quantitative absorption of energy by CO in the sample cell is measured by a suitable detector. The photometer is sensitized to CO by employing CO gas in either the detector or in a filter cell in the optical path, thereby limiting the measured absorption to one or more of the characteristic wavelengths at which CO strongly absorbs. Optical filters or other means may

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also be used to limit sensitivity of the photometer to a narrow band of interest. Various schemes may be used to provide a suitable zero reference for the photometer. The measured absorption is converted to an electrical output signal, which is related to the concentration of CO in the measurement cell.

2. An analyzer based on this principle will be considered a reference method only if it has been designated as a reference method in accordance with part 53 of this chapter.

3. Sampling considerations.

The use of a particle filter on the sample inlet line of an NDIR CO analyzer is optional and left to the discretion of the user or the manufacturer. Use of filter should depend on the analyzer's susceptibility to interference, malfunction, or damage due to particles.

Calibration Procedure

1. Principle. Either of two methods may be used for dynamic multipoint calibration of CO analyzers:

(1) One method uses a single certified standard cylinder of CO, diluted as necessary with zero air, to obtain the various calibration concentrations needed.

(2) The other method uses individual certified standard cylinders of CO for each concentration needed. Additional information on calibration may be found in Section 2.0.9 of Reference 1.

2. Apparatus. The major components and typical configurations of the calibration systems for the two calibration methods are shown in Figures 1 and 2.

2.1 Flow controller(s). Device capable of adjusting and regulating flow rates. Flow rates for the dilution method (Figure 1) must be regulated to <plus-minus> 1%.

2.2 Flow meter(s). Calibrated flow meter capable of measuring and monitoring flow rates. Flow rates for the dilution method (Figure 1) must be measured with an accuracy of <plus-minus> 2% of the measured value.

2.3 Pressure regulator(s) for standard CO cylinder(s). Regulator must have nonreactive diaphragm and internal parts and a suitable delivery pressure.

2.4 Mixing chamber. A chamber designed to provide thorough mixing of CO and diluent air for the dilution method.

2.5 Output manifold. The output manifold should be of sufficient diameter to insure an insignificant pressure drop at the analyzer connection. The system must have a vent designed to insure atmospheric pressure at the manifold and to prevent ambient air from entering the manifold.

3. Reagents.

3.1 CO concentration standard(s). Cylinder(s) of CO in air containing appropriate concentrations(s) of CO suitable for the selected operating range of the analyzer under calibration; CO standards for the dilution method may be contained in a nitrogen matrix if the zero air dilution ratio is not less than 100:1. The assay of the cylinder(s) must be traceable either to a National Bureau of Standards (NBS) CO in air Standard Reference Material (SRM) or to an NBS/EPA-approved commercially available Certified Reference Material (CRM). CRM's are described in Reference 2, and a list of CRM sources is available from the address shown for Reference 2. A recommended protocol for certifying CO gas cylinders against either a CO SRM or a CRM is given in Reference 1. CO

gas cylinders should be recertified on a regular basis as determined by the local quality control program.

3.2 Dilution gas (zero air). Air, free of contaminants which will cause a detectable response on the CO analyzer. The zero air should contain <0.1 ppm CO. A procedure for generating zero air is given in Reference 1.

4. Procedure Using Dynamic Dilution Method.

4.1 Assemble a dynamic calibration system such as the one shown in Figure 1. All calibration gases including zero air must be introduced into the sample inlet of the analyzer system. For specific operating instructions refer to the manufacturer's manual.

4.2 Insure that all flowmeters are properly calibrated, under the conditions of use, if appropriate, against an authoritative standard such as a soap-bubble meter or wet-test meter. All volumetric flowrates should be corrected to 25 deg.C and 760 mm Hg (101 kPa). A discussion on calibration of flowmeters is given in Reference 1.

4.3 Select the operating range of the CO analyzer to be calibrated.

4.4 Connect the signal output of the CO analyzer to the input of the strip chart recorder or other data collection device. All adjustments to the analyzer should be based on the appropriate strip chart or data device readings. References to analyzer responses in the procedure given below refer to recorder or data device responses.

4.5 Adjust the calibration system to deliver zero air to the output manifold. The total air flow must exceed the total demand of the analyzer(s) connected to the output manifold to insure that no ambient air is pulled into the manifold vent. Allow the analyzer to sample zero air until a stable respose is obtained. After the response has stabilized, adjust the analyzer zero control. Offsetting the analyzer zero adjustments to +5 percent of scale is recommended to facilitate observing negative zero drift. Record the stable zero air response as Z<INF>CO</INF>.

4.6 Adjust the zero air flow and the CO flow from the standard CO cylinder to provide a diluted CO concentration of approximately 80 percent of the upper range limit (URL) of the operating range of the analyzer. The total air flow must exceed the total demand of the analyzer(s) connected to the output manifold to insure that no ambient air is

pulled into the manifold vent. The exact CO concentration is calculated from:

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where:

[CO]<INF>OUT</INF> = diluted CO concentration at the output manifold, ppm;
[CO]<INF>STD</INF> = concentration of the undiluted CO standard, ppm;
F<INF>CO</INF> = flow rate of the CO standard corrected to 25 deg.C and 760 mm Hg, (101 kPa), L/min; and
F<INF>D</INF> = flow rate of the dilution air corrected to 25 deg.C and 760 mm Hg, (101 kPa), L/min.

Sample this CO concentration until a stable response is obtained. Adjust the analyzer span control to obtain a recorder response as indicated below:

Recorder response (percent scale) =

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where:

URL = nominal upper range limit of the analyzer's operating range, and Z<INF>CO</INF> = analyzer response to zero air, % scale.

If substantial adjustment of the analyzer span control is required, it may be necessary to recheck the zero and span adjustments by repeating Steps 4.5 and 4.6. Record the CO concentration and the analyzer's response. 4.7 Generate several additional concentrations (at least three evenly spaced points across the remaining scale are suggested to verify linearity) by decreasing F<INF>CO</INF> or increasing F<INF>D.</INF> Be sure the total flow exceeds the analyzer's total flow demand. For each concentration generated, calculate the exact CO concentration using Equation (1). Record the concentration and the analyzer's response for each concentration. Plot the analyzer responses versus the corresponding CO concentrations and draw or calculate the calibration curve.

5. Procedure Using Multiple Cylinder Method. Use the procedure for the dynamic dilution method with the following changes:

5.1 Use a multi-cylinder system such as the typical one shown in Figure 2.

5.2 The flowmeter need not be accurately calibrated, provided the flow in the output manifold exceeds the analyzer's flow demand.

5.3 The various CO calibration concentrations required in Steps 4.6 and 4.7 are obtained without dilution by selecting the appropriate certified standard cylinder.

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[47 FR 54922, Dec. 6, 1982; 48 FR 17355, Apr. 22, 1983]

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Appendix D to Part 50--Measurement Principle and Calibration Procedure

for the Measurement of Ozone in the Atmosphere

measurement principle

1. Ambient air and ethylene are delivered simultaneously to a mixing zone where the ozone in the air reacts with the ethylene to emit light, which is detected by a photomultiplier tube. The resulting photocurrent is amplified and is either read directly or displayed on a recorder.

2. An analyzer based on this principle will be considered a reference method only if it has been designated as a reference method in accordance with part 53 of this chapter and calibrated as follows:

calibration procedure

1. Principle. The calibration procedure is based on the photometric assay of ozone (O<INF>3</INF>) concentrations in a dynamic flow system. The concentration of O<INF>3</INF> in an absorption cell is determined from a measurement of the amount of 254 nm light absorbed by the sample. This determination requires knowledge of (1) the absorption coefficient (<greek-a>) of O<INF>3</INF> at 254 nm, (2) the optical path length (l) through the sample, (3) the transmittance of the sample at a wavelength of 254 nm, and (4) the temperature (T) and pressure (P) of the sample. The transmittance is defined as the ratio I/I<INF>0,</INF> where I is the intensity of light which passes through the cell and is sensed by the detector when the cell contains an O<INF>3</INF> sample, and
I<INF>0</INF>
is the intensity of light which passes through the cell and is sensed by the detector when the cell contains zero air. It is assumed that all conditions of the system, except for the contents of the absorption cell, are identical during measurement of I and I<INF>0.</INF> The quantities defined above are related by the Beer-Lambert absorption law,
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where:

<greek-a> = absorption coefficient of O<INF>3</INF> at 254 nm=308^{plus-minus}4 atm⁻¹ cm⁻¹ at 0 deg.C and 760 torr. ^{(1,} 2,</SUP> 3,</SUP> 4,</SUP> 5,</SUP> 6,</SUP> 7)
</SUP>c = O<INF>3</INF> concentration in atmospheres
l = optical path length in cm

In practice, a stable O<INF>3</INF> generator is used to produce O<INF>3</INF> concentrations over the required range. Each O<INF>3</INF> concentration is determined from the measurement of the transmittance (I/I<INF>0</INF>) of the sample at 254 nm with a photometer of path length l and calculated from the equation,
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The calculated O<INF>3</INF> concentrations must be corrected for O<INF>3</INF> losses which may occur in the photometer and for the temperature and pressure of the sample.

2. Applicability. This procedure is applicable to the calibration of ambient air O<INF>3</INF> analyzers, either directly or by means of a transfer standard certified by this procedure. Transfer standards must meet the requirements and specifications set forth in Reference 8.

3. Apparatus. A complete UV calibration system consists of an ozone

generator, an output port or manifold, a photometer, an appropriate source of zero air, and other components as necessary. The configuration must provide a stable ozone concentration at the system output and allow the photometer to accurately assay the output concentration to the precision specified for the photometer (3.1). Figure 1 shows a commonly used configuration and serves to illustrate the calibration procedure which follows. Other configurations may require appropriate variations in the procedural steps. All connections between components in the calibration system downstream of the O<INF>3</INF> generator should be of glass, Teflon, or other relatively inert materials. Additional information regarding the assembly of a UV photometric calibration apparatus is given in Reference 9. For certification of transfer standards which provide their own source of O<INF>3,</INF> the transfer standard may replace the O<INF>3</INF> generator and possibly other components shown in Figure 1; see Reference 8 for guidance.

3.1 UV photometer. The photometer consists of a low-pressure mercury discharge lamp, (optional) collimation optics, an absorption cell, a detector, and signal-processing electronics, as illustrated in Figure 1. It must be capable of measuring the transmittance, I/I<INF>0,</INF> at a wavelength of 254 nm with sufficient precision such that the standard deviation of the concentration measurements does not exceed the greater of 0.005 ppm or 3% of the concentration. Because the low-pressure mercury lamp radiates at several wavelengths, the photometer must incorporate suitable means to assure that no O<INF>3</INF> is generated in the cell by the lamp, and that at least 99.5% of the radiation sensed by the detector is 254 nm radiation. (This can be readily achieved by prudent selection of optical filter and detector response characteristics.) The length of the light path through the absorption cell must be known with an accuracy of at least 99.5%. In addition, the cell and associated plumbing must be designed to

minimize loss of O<INF>3</INF> from contact with cell walls and gas handling components. See Reference 9 for additional information.

3.2 Air flow controllers. Devices capable of regulating air flows as necessary to meet the output stability and photometer precision requirements.

3.3 Ozone generator. Device capable of generating stable levels of O<INF>3</INF> over the required concentration range.

3.4 Output manifold. The output manifold should be constructed of glass, Teflon, or other relatively inert material, and should be of sufficient diameter to insure a negligible pressure drop at the photometer connection and other output ports. The system must have a vent designed to insure atmospheric pressure in the manifold and to prevent ambient air from entering the manifold.

3.5 Two-way valve. Manual or automatic valve, or other means to switch the photometer flow between zero air and the O<INF>3</INF> concentration.

3.6 Temperature indicator. Accurate to ^{plus-minus}1 deg.C.

3.7 Barometer or pressure indicator. Accurate to ^{plus-minus}2 torr.

4. Reagents.

4.1 Zero air. The zero air must be free of contaminants which would cause a detectable response from the O<INF>3</INF> analyzer, and it should be free of NO, C<INF>2</INF> H<INF>4,</INF> and other species

which react with O<INF>3.</INF> A procedure for generating suitable zero air is given in Reference 9. As shown in Figure 1, the zero air supplied to the photometer cell for the I<INF>0</INF> reference measurement must be derived from the same source as the zero air used for generation of the ozone concentration to be assayed (I measurement). When using the photometer to certify a transfer standard having its own source of ozone, see Reference 8 for guidance on meeting this requirement.

5. Procedure.

5.1 General operation. The calibration photometer must be dedicated exclusively to use as a calibration standard. It should always be used with clean, filtered calibration gases, and never used for ambient air sampling. Consideration should be given to locating the calibration photometer in a clean laboratory where it can be stationary, protected from physical shock, operated by a responsible analyst, and used as a common standard for all field calibrations via transfer standards.

5.2 Preparation. Proper operation of the photometer is of critical importance to the accuracy of this procedure. The following steps will help to verify proper operation. The steps are not necessarily required prior to each use of the photometer. Upon initial operation of the photometer, these steps should be carried out frequently, with all quantitative results or indications recorded in a chronological record either in tabular form or plotted on a graphical chart. As the performance and stability record of the photometer is established, the frequency of these steps may be reduced consistent with the documented stability of the photometer.

5.2.1 Instruction manual: Carry out all set up and adjustment procedures or checks as described in the operation or instruction manual associated with the photometer.

5.2.2 System check: Check the photometer system for integrity, leaks, cleanliness, proper flowrates, etc. Service or replace filters and zero air scrubbers or other consumable materials, as necessary.

5.2.3 Linearity: Verify that the photometer manufacturer has adequately established that the linearity error of the photometer is less than 3%, or test the linearity by dilution as follows: Generate and assay an O<INF>3</INF> concentration near the upper range limit of the system (0.5 or 1.0 ppm), then accurately dilute that concentration with zero air and reassay it. Repeat at several different dilution ratios. Compare the assay of the original concentration with the assay of the diluted concentration divided by the dilution ratio, as follows
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where:

E = linearity error, percent
A<INF>1</INF> = assay of the original concentration
A<INF>2</INF> = assay of the diluted concentration
R = dilution ratio = flow of original concentration divided by the total flow

The linearity error must be less than 5%. Since the accuracy of the measured flow-rates will affect the linearity error as measured this way, the test is not necessarily conclusive. Additional information on verifying linearity is contained in Reference 9.

5.2.4 Intercomparison: When possible, the photometer should be occasionally intercompared, either directly or via transfer standards, with calibration photometers used by other agencies or laboratories.

5.2.5 Ozone losses: Some portion of the O<INF>3</INF> may be lost

upon contact with the photometer cell walls and gas handling components. The magnitude of this loss must be determined and used to correct the calculated O<INF>3</INF> concentration. This loss must not exceed 5%. Some guidelines for quantitatively determining this loss are discussed in Reference 9.

5.3 Assay of O<INF>3</INF> concentrations.

5.3.1 Allow the photometer system to warm up and stabilizer.

5.3.2 Verify that the flowrate through the photometer absorption cell, F allows the cell to be flushed in a reasonably short period of time (2 liter/min is a typical flow). The precision of the measurements is inversely related to the time required for flushing, since the photometer drift error increases with time.

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5.3.3 Insure that the flowrate into the output manifold is at least 1 liter/min greater than the total flowrate required by the photometer and any other flow demand connected to the manifold.

5.3.4 Insure that the flowrate of zero air, F<INF>z,</INF> is at least 1 liter/min greater than the flowrate required by the photometer.

5.3.5 With zero air flowing in the output manifold, actuate the two-way valve to allow the photometer to sample first the manifold zero air, then F<INF>z.</INF> The two photometer readings must be equal (I=I<INF>o</INF>).

Note: In some commercially available photometers, the operation of the two-way valve and various other operations in section 5.3 may be carried out automatically by the photometer.

5.3.6 Adjust the O<INF>3</INF> generator to produce an O<INF>3</INF> concentration as needed.

5.3.7 Actuate the two-way valve to allow the photometer to sample zero air until the absorption cell is thoroughly flushed and record the stable measured value of I<INF>o</INF>.

5.3.8 Actuate the two-way valve to allow the photometer to sample the ozone concentration until the absorption cell is thoroughly flushed and record the stable measured value of I.

5.3.9 Record the temperature and pressure of the sample in the photometer absorption cell. (See Reference 9 for guidance.)

5.3.10 Calculate the O<INF>3</INF> concentration from equation 4. An average of several determinations will provide better precision.
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where:

[O<INF>3</INF>]<INF>OUT</INF> = O<INF>3</INF> concentration, ppm
<greek-a> = absorption coefficient of O<INF>3</INF> at 254 nm=308 atm⁻¹ cm⁻¹ at 0 deg.C and 760 torr
l = optical path length, cm
T = sample temperature, K
P = sample pressure, torr
L = correction factor for O<INF>3</INF> losses from 5.2.5=(1-fraction O<INF>3</INF> lost).

Note: Some commercial photometers may automatically evaluate all or part of equation 4. It is the operator's responsibility to verify that all of the information required for equation 4 is obtained, either automatically by the photometer or manually. For ``automatic'' photometers which evaluate the first term of equation 4 based on a

linear approximation, a manual correction may be required, particularly at higher O<INF>3</INF> levels. See the photometer instruction manual and Reference 9 for guidance.

5.3.11 Obtain additional O<INF>3</INF> concentration standards as necessary by repeating steps 5.3.6 to 5.3.10 or by Option 1.

5.4 Certification of transfer standards. A transfer standard is certified by relating the output of the transfer standard to one or more ozone standards as determined according to section 5.3. The exact procedure varies depending on the nature and design of the transfer standard. Consult Reference 8 for guidance.

5.5 Calibration of ozone analyzers. Ozone analyzers are calibrated as follows, using ozone standards obtained directly according to section 5.3 or by means of a certified transfer standard.

5.5.1 Allow sufficient time for the O<INF>3</INF> analyzer and the photometer or transfer standard to warmup and stabilize.

5.5.2 Allow the O<INF>3</INF> analyzer to sample zero air until a stable response is obtained and adjust the O<INF>3</INF> analyzer's zero control. Offsetting the analyzer's zero adjustment to +5% of scale is recommended to facilitate observing negative zero drift. Record the stable zero air response as ``Z''.

5.5.3 Generate an O<INF>3</INF> concentration standard of approximately 80% of the desired upper range limit (URL) of the O<INF>3</INF> analyzer. Allow the O<INF>3</INF> analyzer to sample this O<INF>3</INF> concentration standard until a stable response is obtained.

5.5.4 Adjust the O<INF>3</INF> analyzer's span control to obtain a convenient recorder response as indicated below:

recorder response (%scale) =

[GRAPHIC] [TIFF OMITTED] TR31AU93.033

where:

URL = upper range limit of the O<INF>3</INF> analyzer, ppm
Z = recorder response with zero air, % scale

Record the O<INF>3</INF> concentration and the corresponding analyzer response. If substantial adjustment of the span control is necessary, recheck the zero and span adjustments by repeating steps 5.5.2 to 5.5.4.

5.5.5 Generate several other O<INF>3</INF> concentration standards (at least 5 others are recommended) over the scale range of the O<INF>3</INF> analyzer by adjusting the O<INF>3</INF> source or by Option 1. For each O<INF>3</INF> concentration standard, record the O<INF>3</INF> and the corresponding analyzer response.

5.5.6 Plot the O<INF>3</INF> analyzer responses versus the corresponding O<INF>3</INF> concentrations and draw the O<INF>3</INF> analyzer's calibration curve or calculate the appropriate response factor.

5.5.7 Option 1: The various O<INF>3</INF> concentrations required in steps 5.3.11 and 5.5.5 may be obtained by dilution of the O<INF>3</INF> concentration generated in steps 5.3.6 and 5.5.3. With this option, accurate flow measurements are required. The dynamic calibration system may be modified as shown in Figure 2 to allow for dilution air to be metered in downstream of the O<INF>3</INF> generator. A mixing chamber between the O<INF>3</INF> generator and the output manifold is also required. The flowrate through the O<INF>3</INF> generator (F<INF>o</INF>) and the dilution air flowrate

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(F<INF>D</INF>) are measured with a reliable flow or volume standard traceable to NBS. Each O<INF>3</INF> concentration generated by dilution is calculated from:
[GRAPHIC] [TIFF OMITTED] TR31AU93.031

where:

[O<INF>3</INF>]'<INF>OUT</INF> = diluted O<INF>3</INF> concentration, ppm
F<INF>0</INF> = flowrate through the O<INF>3</INF> generator, liter/min
F<INF>D</INF> = diluent air flowrate, liter/min

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[44 FR 8224, Feb. 8, 1979, as amended at 62 FR 38895, July 18, 1997]

Appendix E to Part 50 [Reserved]

Appendix F to Part 50--Measurement Principle and Calibration Procedure for the Measurement of Nitrogen Dioxide in the Atmosphere (Gas Phase Chemiluminescence)

Principle and Applicability

1. Atmospheric concentrations of nitrogen dioxide (NO<INF>2</INF>) are measured indirectly by photometrically measuring the light intensity, at wavelengths greater than 600 nanometers, resulting from the chemiluminescent reaction of nitric oxide (NO) with ozone (O<INF>3</INF>). (1,2,3) NO<INF>2</INF> is first quantitatively reduced to NO(4,5,6) by means of a converter. NO, which commonly exists in ambient air together with NO<INF>2,</INF> passes through the converter unchanged causing a resultant total NO<INF>X</INF> concentration equal to NO+NO<INF>2.</INF> A sample of the input air is also measured without having passed through the converted. This latter NO measurement is subtracted from the former measurement (NO+NO<INF>2</INF>) to yield the final NO<INF>2</INF> measurement. The NO and NO+NO<INF>2</INF> measurements may be made concurrently with dual systems, or cyclically with the same system provided the cycle time does not exceed 1 minute.

2. Sampling considerations.

2.1 Chemiluminescence NO/NO<INF>X</INF>/NO<INF>2</INF> analyzers will respond to other nitrogen containing compounds, such as peroxyacetyl nitrate (PAN), which might be reduced to NO in the thermal converter. (7) Atmospheric concentrations of these potential interferences are generally low relative to NO<INF>2</INF> and valid NO<INF>2</INF> measurements may be obtained. In certain geographical areas, where the concentration of these potential interferences is known or suspected to be high relative to NO<INF>2,</INF> the use of an equivalent method for the measurement of NO<INF>2</INF> is recommended.

2.2 The use of integrating flasks on the sample inlet line of chemiluminescence NO/NO<INF>X</INF>/NO<INF>2</INF> analyzers is optional and left to couraged. The sample residence time between the sampling point and the analyzer should be kept to a minimum to avoid erroneous NO<INF>2</INF> measurements resulting from the reaction of ambient levels of NO and O<INF>3</INF> in the sampling system.

2.3 The use of particulate filters on the sample inlet line of chemiluminescence NO/NO<INF>X</INF>/NO<INF>2</INF> analyzers is optional and left to the discretion of the user or the manufacturer.
Use of the filter should depend on the analyzer's susceptibility to interference, malfunction, or damage due to particulates. Users are cautioned that particulate matter concentrated on a filter may cause erroneous NO<INF>2</INF> measurements and therefore filters should be changed frequently.

3. An analyzer based on this principle will be considered a reference method only if it has been designated as a reference method in accordance with part 53 of this chapter.

Calibration

1. Alternative A--Gas phase titration (GPT) of an NO standard with O<INF>3</INF>.

Major equipment required: Stable O<INF>3</INF> generator. Chemiluminescence NO/NO<INF>X</INF>/NO<INF>2</INF> analyzer with strip chart recorder(s). NO concentration standard.

1.1 Principle. This calibration technique is based upon the rapid gas phase reaction between NO and O<INF>3</INF> to produce stoichiometric quantities of NO<INF>2</INF> in accordance with the following equation: (8)
[GRAPHIC] [TIFF OMITTED] TC08NO91.075

The quantitative nature of this reaction is such that when the NO

concentration is known, the concentration of NO<INF>2</INF> can be determined. Ozone is added to excess NO in a dynamic calibration system, and the NO channel of the chemiluminescence NO/NO<INF>X</INF>/NO<INF>2</INF> analyzer is used as an indicator of changes in NO concentration. Upon the addition of O<INF>3,</INF> the decrease in NO concentration observed on the calibrated NO channel is equivalent to the concentration of NO<INF>2</INF> produced. The amount of NO<INF>2</INF> generated may be varied by adding variable amounts of O<INF>3</INF> from a stable uncalibrated O<INF>3</INF> generator. (9)

1.2 Apparatus. Figure 1, a schematic of a typical GPT apparatus, shows the suggested configuration of the components listed below. All connections between components in the calibration system downstream from the O<INF>3</INF> generator should be of glass, Teflon[□] or other non-reactive material.

1.2.1 Air flow controllers. Devices capable of maintaining constant air flows within ^{plus-minus}2% of the required flowrate.

1.2.2 NO flow controller. A device capable of maintaining constant NO flows within ^{plus-minus}2% of the required flowrate. Component parts in contact with the NO should be of a non-reactive material.

1.2.3 Air flowmeters. Calibrated flowmeters capable of measuring and monitoring air flowrates with an accuracy of ^{plus-minus}2% of the measured flowrate.

1.2.4 NO flowmeter. A calibrated flowmeter capable of measuring and monitoring NO flowrates with an accuracy of ^{plus-minus}2% of the measured flowrate. (Rotameters have been reported to operate unreliably when measuring low NO flows and are not recommended.)

1.2.5 Pressure regulator for standard NO cylinder. This regulator must have a nonreactive diaphragm and internal parts and a suitable delivery pressure.

1.2.6 Ozone generator. The generator must be capable of generating sufficient and stable levels of O<INF>3</INF> for reaction with NO to generate NO<INF>2</INF> concentrations in the range required. Ozone generators of the electric discharge type may produce NO and NO<INF>2</INF> and are not recommended.

1.2.7 Valve. A valve may be used as shown in Figure 1 to divert the NO flow when zero air is required at the manifold. The valve should be constructed of glass, Teflon[□] or other nonreactive material.

1.2.8 Reaction chamber. A chamber, constructed of glass, Teflon[□] or other nonreactive material, for the quantitative reaction of O<INF>3</INF> with excess NO. The chamber should be of sufficient volume (V<INF>RC</INF>) such that the residence time (t<INF>R</INF>) meets the requirements specified in 1.4. For practical reasons, t<INF>R</INF> should be less than 2 minutes.

1.2.9 Mixing chamber. A chamber constructed of glass, Teflon[□] or other nonreactive material and designed to provide thorough mixing of reaction products and diluent air. The residence time is not critical when the dynamic parameter specification given in 1.4 is met.

1.2.10 Output manifold. The output manifold should be constructed of glass, Teflon[□] or other non-reactive material and should be of sufficient diameter to insure an insignificant pressure drop at the analyzer connection. The system must have a vent designed to insure atmospheric pressure at the manifold and to prevent ambient air from

entering the manifold.

1.3 Reagents.

1.3.1 NO concentration standard. Gas cylinder standard containing 50 to 100 ppm NO in N<INF>2</INF> with less than 1 ppm NO<INF>2.</INF> This standard must be traceable to a National Bureau of Standards (NBS) NO in N<INF>2</INF> Standard Reference Material (SRM 1683 or SRM 1684), an NBS NO<INF>2</INF> Standard Reference Material (SRM 1629), or an NBS/EPA-approved commercially available Certified Reference Material (CRM). CRM's are described in Reference 14, and a list of CRM sources is available from the address shown for Reference 14. A recommended protocol for certifying NO gas cylinders against either an NO SRM or CRM is given in section 2.0.7 of Reference 15. Reference 13 gives procedures for certifying an NO gas cylinder against an NBS NO<INF>2</INF> SRM and for determining the amount of NO<INF>2</INF> impurity in an NO cylinder.

1.3.2 Zero air. Air, free of contaminants which will cause a detectable response on the NO/NO<INF>X</INF>/NO<INF>2</INF> analyzer or which might react with either NO, O<INF>3,</INF> or NO<INF>2</INF> in the gas phase titration. A procedure for generating zero air is given in reference 13.

1.4 Dynamic parameter specification.

1.4.1 The O<INF>3</INF> generator air flowrate (F<INF>0</INF>) and NO flowrate (F<INF>NO</INF>) (see Figure 1) must be adjusted such that the following relationship holds:

[GRAPHIC] [TIFF OMITTED] TC08NO91.076

[GRAPHIC] [TIFF OMITTED] TC08NO91.077

[GRAPHIC] [TIFF OMITTED] TC08NO91.078

where:

P<INF>R</INF> = dynamic parameter specification, determined empirically, to insure complete reaction of the available O<INF>3,</INF> ppm-minute
[NO]<INF>RC</INF> = NO concentration in the reaction chamber, ppm
<INF>R</INF> = residence time of the reactant gases in the reaction chamber, minute
[NO]<INF>STD</INF> = concentration of the undiluted NO standard, ppm
F<INF>NO</INF> = NO flowrate, scm ³/min
F<INF>O</INF> = O<INF>3</INF> generator air flowrate, scm ³/min
V<INF>RC</INF> = volume of the reaction chamber, scm <SUP>3

</SUP>1.4.2 The flow conditions to be used in the GPT system are determined by the following procedure:

(a) Determine F<INF>T,</INF> the total flow required at the output manifold (F<INF>T</INF>=analyzer demand plus 10 to 50% excess).

(b) Establish [NO]<INF>OUT</INF> as the highest NO concentration (ppm) which will be required at the output manifold. [NO]<INF>OUT</INF> should be approximately equivalent to 90% of the upper range limit (URL) of the NO<INF>2</INF> concentration range to be covered.

(c) Determine F<INF>NO</INF> as

[GRAPHIC] [TIFF OMITTED] TC08NO91.079

(d) Select a convenient or available reaction chamber volume. Initially, a trial V<INF>RC</INF> may be selected to be in the range of approximately 200 to 500 scm³.

(e) Compute FO as

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(f) Compute t<INF>R</INF> as
[GRAPHIC] [TIFF OMITTED] TC08NO91.080

Verify that t<INF>R</INF> 2 minutes. If not, select a reaction chamber with a smaller V<INF>RC</INF>.

(g) Compute the diluent air flowrate as
[GRAPHIC] [TIFF OMITTED] TC08NO91.081

where:

F<INF>D</INF> = diluent air flowrate, scm ³/min

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(h) If F<INF>O</INF> turns out to be impractical for the desired system, select a reaction chamber having a different V<INF>RC</INF> and recompute F<INF>O</INF> and F<INF>D</INF>.

Note: A dynamic parameter lower than 2.75 ppm-minutes may be used if it can be determined empirically that quantitative reaction of O<INF>3</INF> with NO occurs. A procedure for making this determination as well as a more detailed discussion of the above requirements and other related considerations is given in reference 13.

1.5 Procedure.

1.5.1 Assemble a dynamic calibration system such as the one shown in Figure 1.

1.5.2 Insure that all flowmeters are calibrated under the conditions of use against a reliable standard such as a soap-bubble meter or wet-test meter. All volumetric flowrates should be corrected to 25 deg.C and 760 mm Hg. A discussion on the calibration of flowmeters is given in reference 13.

1.5.3 Precautions must be taken to remove O<INF>2</INF> and other contaminants from the NO pressure regulator and delivery system prior to the start of calibration to avoid any conversion of the standard NO to NO<INF>2.</INF> Failure to do so can cause significant errors in calibration. This problem may be minimized by (1) carefully evacuating the regulator, when possible, after the regulator has been connected to the cylinder and before opening the cylinder valve; (2) thoroughly flushing the regulator and delivery system with NO after opening the cylinder valve; (3) not removing the regulator from the cylinder between calibrations unless absolutely necessary. Further discussion of these procedures is given in reference 13.

1.5.4 Select the operating range of the NO/NO<INF>X</INF>/NO<INF>2</INF> analyzer to be calibrated. In order to obtain maximum precision and accuracy for NO<INF>2</INF> calibration, all three channels of the analyzer should be set to the same range. If operation of the NO and NO<INF>X</INF> channels on higher ranges is desired, subsequent recalibration of the NO and NO<INF>X</INF> channels on the higher ranges is recommended.

Note: Some analyzer designs may require identical ranges for NO, NO<INF>X,</INF> and NO<INF>2</INF> during operation of the analyzer.

1.5.5 Connect the recorder output cable(s) of the NO/NO<INF>X</INF>/ NO<INF>2</INF> analyzer to the input terminals of the strip chart recorder(s). All adjustments to the analyzer should be performed based on the appropriate strip chart readings. References to analyzer responses in the procedures given below refer to recorder responses.

1.5.6 Determine the GPT flow conditions required to meet the dynamic parameter specification as indicated in 1.4.

1.5.7 Adjust the diluent air and O<INF>3</INF> generator air flows to obtain the flows determined in section 1.4.2. The total air flow must exceed the total demand of the analyzer(s) connected to the output manifold to insure that no ambient air is pulled into the manifold vent. Allow the analyzer to sample zero air until stable NO, NO<INF>X,</INF> and NO<INF>2</INF> responses are obtained. After the responses have stabilized, adjust the analyzer zero control(s).

Note: Some analyzers may have separate zero controls for NO, NO<INF>X,</INF> and NO<INF>2.</INF> Other analyzers may have separate zero controls only for NO and NO<INF>X,</INF> while still others may have only one zero control common to all three channels.

Offsetting the analyzer zero adjustments to +5 percent of scale is recommended to facilitate observing negative zero drift. Record the stable zero air responses as Z<INF>NO,</INF> Znox, and Zno2.

1.5.8 Preparation of NO and NO<INF>X</INF> calibration curves.

1.5.8.1 Adjustment of NO span control. Adjust the NO flow from the standard NO cylinder to generate an NO concentration of approximately 80 percent of the upper range limit (URL) of the NO range. This exact NO concentration is calculated from:

[GRAPHIC] [TIFF OMITTED] TR31AU93.044

where:

[NO]<INF>OUT</INF> = diluted NO concentration at the output manifold, ppm

Sample this NO concentration until the NO and NO<INF>X</INF> responses have stabilized. Adjust the NO span control to obtain a recorder response as indicated below:

recorder response (percent scale) =

[GRAPHIC] [TIFF OMITTED] TR31AU93.045

where:

URL = nominal upper range limit of the NO channel, ppm

Note: Some analyzers may have separate span controls for NO, NO<INF>X,</INF> and NO<INF>2.</INF> Other analyzers may have separate span controls only for NO and NO<INF>X,</INF> while still others may have only one span control common to all three channels. When only one span control is available, the span adjustment is made on the NO channel of the analyzer.

If substantial adjustment of the NO span control is necessary, it may be necessary to recheck the zero and span adjustments by repeating steps 1.5.7 and 1.5.8.1. Record the NO concentration and the analyzer's NO response.

1.5.8.2 Adjustment of NO<INF>X</INF> span control. When adjusting the analyzer's NO<INF>X</INF> span control, the presence of any NO<INF>2</INF>
impurity in the standard NO cylinder must be taken into account. Procedures for determining the amount of NO<INF>2</INF> impurity in the standard NO

cylinder are given in reference 13. The exact NO<INF>X</INF> concentration is calculated from:
[GRAPHIC] [TIFF OMITTED] TR31AU93.046

where:

[NO<INF>X</INF>]<INF>OUT</INF> = diluted NO<INF>X</INF> concentration at the output manifold, ppm
[NO<INF>2</INF>]<INF>IMP</INF> = concentration of NO<INF>2</INF> impurity in the standard NO cylinder, ppm

Adjust the NO<INF>X</INF> span control to obtain a recorder response as indicated below:

recorder response (% scale) =
[GRAPHIC] [TIFF OMITTED] TR31AU93.047

Note: If the analyzer has only one span control, the span adjustment is made on the NO channel and no further adjustment is made here for NO<INF>x.
</INF>If substantial adjustment of the NO<INF>X</INF> span control is necessary, it may be necessary to recheck the zero and span adjustments by repeating steps 1.5.7 and 1.5.8.2. Record the NO<INF>X</INF> concentration and the analyzer's NO<INF>X</INF> response.

1.5.8.3 Generate several additional concentrations (at least five evenly spaced points across the remaining scale are suggested to verify linearity) by decreasing F<INF>NO</INF> or increasing F<INF>D.</INF> For each concentration generated, calculate the exact NO and NO<INF>X</INF> concentrations using equations (9) and (11) respectively. Record the analyzer's NO and NO<INF>X</INF> responses for each concentration. Plot the analyzer responses versus the respective calculated NO and NO<INF>X</INF> concentrations and draw or calculate the NO and NO<INF>X</INF> calibration curves. For subsequent calibrations where linearity can be assumed, these curves may be checked with a two-point calibration consisting of a zero air point and NO and NO<INF>X</INF> concentrations of approximately 80% of the URL.

1.5.9 Preparation of NO<INF>2</INF> calibration curve.

1.5.9.1 Assuming the NO<INF>2</INF> zero has been properly adjusted while sampling zero air in step 1.5.7, adjust F<INF>O</INF> and F<INF>D</INF> as determined in section 1.4.2. Adjust F<INF>NO</INF> to generate an NO concentration near 90% of the URL of the NO range. Sample this NO concentration until the NO and NO<INF>X</INF> responses have stabilized. Using the NO calibration curve obtained in section 1.5.8, measure and record the NO concentration as [NO]<INF>orig.</INF> Using the NO<INF>X</INF> calibration curve obtained in section 1.5.8, measure and record the NO<INF>X</INF> concentration as [NO<INF>X</INF>]<INF>orig</INF>.

1.5.9.2 Adjust the O<INF>3</INF> generator to generate sufficient O<INF>3</INF> to produce a decrease in the NO concentration equivalent to approximately 80% of the URL of the NO<INF>2</INF> range. The decrease must not exceed 90% of the NO concentration determined in step 1.5.9.1. After the analyzer responses have stabilized, record the resultant NO and NO<INF>X</INF> concentrations as [NO]<INF>rem</INF> and [NO<INF>X</INF>]<INF>rem</INF>.

1.5.9.3 Calculate the resulting NO<INF>2</INF> concentration from:
[GRAPHIC] [TIFF OMITTED] TC08NO91.082

where:

[NO<INF>2</INF>]<INF>OUT</INF> = diluted NO<INF>2</INF> concentration at the output manifold, ppm
[NO]<INF>orig</INF> = original NO concentration, prior to addition of O<INF>3,</INF> ppm
[NO]<INF>rem</INF> = NO concentration remaining after addition of O<INF>3,</INF> ppm

Adjust the NO<INF>2</INF> span control to obtain a recorder response as indicated below:

recorder response (% scale) =
[GRAPHIC] [TIFF OMITTED] TR31AU93.048

Note: If the analyzer has only one or two span controls, the span adjustments are made on the NO channel or NO and NO<INF>X</INF> channels and no further adjustment is made here for NO<INF>2</INF>.
If substantial adjustment of the NO<INF>2</INF> span control is necessary, it may be necessary to recheck the zero and span adjustments by repeating steps 1.5.7 and 1.5.9.3. Record the NO<INF>2</INF> concentration and the corresponding analyzer NO<INF>2</INF> and NO<INF>X</INF>
responses.

1.5.9.4 Maintaining the same F<INF>NO,</INF> F<INF>O,</INF> and F<INF>D</INF> as in section 1.5.9.1, adjust the ozone generator to obtain several other concentrations of NO<INF>2</INF> over the NO<INF>2</INF> range (at least five evenly spaced points across the remaining scale are suggested). Calculate each NO<INF>2</INF> concentration using equation (13) and record the corresponding analyzer NO<INF>2</INF> and NO<INF>X</INF> responses. Plot the analyzer's NO<INF>2</INF> responses versus the corresponding calculated NO<INF>2</INF> concentrations and draw or calculate the NO<INF>2</INF> calibration curve.

1.5.10 Determination of converter efficiency.

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1.5.10.1 For each NO<INF>2</INF> concentration generated during the preparation of the NO<INF>2</INF> calibration curve (see section 1.5.9) calculate the concentration of NO<INF>2</INF> converted from:
[GRAPHIC] [TIFF OMITTED] TC08NO91.083

where:

[NO<INF>2</INF>]<INF>CONV</INF> = concentration of NO<INF>2</INF> converted, ppm
[NO<INF>X</INF>]<INF>orig</INF> = original NO<INF>X</INF> concentration prior to addition of O<INF>3,</INF> ppm
[NO<INF>X</INF>]<INF>rem</INF> = NO<INF>X</INF> concentration remaining after addition of O<INF>3,</INF> ppm

Note: Supplemental information on calibration and other procedures in this method are given in reference 13.
Plot [NO<INF>2</INF>]<INF>CONV</INF> (y-axis) versus [NO<INF>2</INF>]<INF>OUT</INF> (x-axis) and draw or calculate the converter efficiency curve. The slope of the curve times 100 is the average converter efficiency, E<INF>C.</INF> The average converter efficiency must be greater than 96%; if it is less than 96%, replace or

service the converter.

2. Alternative B--NO<INF>2</INF> permeation device.

Major equipment required:

Stable O<INF>3</INF> generator.

Chemiluminescence NO/NO<INF>X</INF>/NO<INF>2</INF> analyzer with strip chart recorder(s).

NO concentration standard.

NO<INF>2</INF> concentration standard.

2.1 Principle. Atmospheres containing accurately known concentrations of nitrogen dioxide are generated by means of a permeation device. (10) The permeation device emits NO<INF>2</INF> at a known constant rate provided the temperature of the device is held constant (^{plus-minus}0.1 deg.C) and the device has been accurately calibrated at the temperature of use. The NO<INF>2</INF> emitted from the device is diluted with zero air to produce NO<INF>2</INF> concentrations suitable for calibration of the NO<INF>2</INF> channel of the NO/NO<INF>X</INF>/NO<INF>2</INF> analyzer. An NO concentration standard is used for calibration of the NO and NO<INF>X</INF> channels of the analyzer.

2.2 Apparatus. A typical system suitable for generating the required NO and NO<INF>2</INF> concentrations is shown in Figure 2. All connections between components downstream from the permeation device should be of glass, Teflon[□] or other non-reactive material.

2.2.1 Air flow controllers. Devices capable of maintaining constant air flows within ^{plus-minus}2% of the required flowrate.

2.2.2 NO flow controller. A device capable of maintaining constant NO flows within ^{plus-minus}2% of the required flowrate. Component parts in contact with the NO must be of a non-reactive material.

2.2.3 Air flowmeters. Calibrated flowmeters capable of measuring and monitoring air flowrates with an accuracy of ^{plus-minus}2% of the measured flowrate.

2.2.4 NO flowmeter. A calibrated flowmeter capable of measuring and monitoring NO flowrates with an accuracy of ^{plus-minus}2% of the measured flowrate. (Rotameters have been reported to operate unreliably when measuring low NO flows and are not recommended.)

2.2.5 Pressure regulator for standard NO cylinder. This regulator must have a non-reactive diaphragm and internal parts and a suitable delivery pressure.

2.2.6 Drier. Scrubber to remove moisture from the permeation device air system. The use of the drier is optional with NO<INF>2</INF> permeation devices not sensitive to moisture. (Refer to the supplier's instructions for use of the permeation device.)

2.2.7 Constant temperature chamber. Chamber capable of housing the NO<INF>2</INF> permeation device and maintaining its temperature to within ^{plus-minus}0.1 deg.C.

2.2.8 Temperature measuring device. Device capable of measuring and monitoring the temperature of the NO<INF>2</INF> permeation device with an accuracy of ^{plus-minus}0.05 deg.C.

2.2.9 Valves. A valve may be used as shown in Figure 2 to divert the NO<INF>2</INF> from the permeation device when zero air or NO is required at the manifold. A second valve may be used to divert the NO flow when zero air or NO<INF>2</INF> is required at the manifold.

The valves should be constructed of glass, Teflon[□] or other nonreactive material.

2.2.10 Mixing chamber. A chamber constructed of glass, Teflon[□] or other nonreactive material and designed to

provide thorough mixing of pollutant gas streams and diluent air.

2.2.11 Output manifold. The output manifold should be constructed of glass, Teflon[□] or other non-reactive material and should be of sufficient diameter to insure an insignificant pressure drop at the analyzer connection. The system must have a vent designed to insure atmospheric pressure at the manifold and to prevent ambient air from entering the manifold.

2.3 Reagents.

2.3.1 Calibration standards. Calibration standards are required for both NO and NO<INF>2.</INF> The reference standard for the calibration may be either an NO or NO<INF>2</INF> standard, and must be traceable to a National Bureau of Standards (NBS) NO in N<INF>2</INF> Standard Reference Material (SRM 1683 or SRM 1684), and NBS NO<INF>2</INF> Standard Reference Material (SRM 1629), or an NBS/EPA-approved commercially

available Certified Reference Material (CRM). CRM's are described in Reference 14, and a list of CRM sources is available from the address shown for Reference 14. Reference 15 gives recommended procedures for certifying an NO gas cylinder against an NO SRM or CRM and for certifying an NO<INF>2</INF> permeation device against an NO<INF>2</INF> SRM. Reference 13 contains procedures for certifying an NO gas cylinder against an NO<INF>2</INF> SRM and for certifying an NO<INF>2</INF> permeation device against an NO SRM or CRM. A procedure for determining the amount of NO<INF>2</INF> impurity in an NO cylinder is also contained in Reference 13. The NO or NO<INF>2</INF> standard selected as the reference standard must be used to certify the other standard to ensure consistency between the two standards.

2.3.1.1 NO<INF>2</INF> Concentration standard. A permeation device suitable for generating NO<INF>2</INF> concentrations at the required flow-rates over the required concentration range. If the permeation device is used as the reference standard, it must be traceable to an SRM or CRM as specified in 2.3.1. If an NO cylinder is used as the reference standard, the NO<INF>2</INF> permeation device must be certified against the NO standard according to the procedure given in Reference 13. The use of the permeation device should be in strict accordance with the instructions supplied with the device. Additional information regarding the use of permeation devices is given by Scaringelli et al. (11) and Rook et al. (12).

2.3.1.2 NO Concentration standard. Gas cylinder containing 50 to 100 ppm NO in N<INF>2</INF> with less than 1 ppm NO<INF>2.</INF> If this cylinder is used as the reference standard, the cylinder must be traceable to an SRM or CRM as specified in 2.3.1. If an NO<INF>2</INF> permeation device is used as the reference standard, the NO cylinder must be certified against the NO<INF>2</INF> standard according to the procedure given in Reference 13. The cylinder should be recertified on a regular basis as determined by the local quality control program.

2.3.3 Zero air. Air, free of contaminants which might react with NO or NO<INF>2</INF> or cause a detectable response on the NO/ NO<INF>X</INF>/NO<INF>2</INF> analyzer. When using permeation devices that are sensitive to moisture, the zero air passing across the permeation device must be dry to avoid surface reactions on the device. (Refer to the supplier's instructions for use of the permeation device.) A procedure for generating zero air is given in reference 13.

2.4 Procedure.

2.4.1 Assemble the calibration apparatus such as the typical one shown in Figure 2.

2.4.2 Insure that all flowmeters are calibrated under the conditions of use against a reliable standard such as a soap bubble meter or wet-test meter. All volumetric flowrates should be corrected to 25 deg.C and 760 mm Hg. A discussion on the calibration of flowmeters is given in reference 13.

2.4.3 Install the permeation device in the constant temperature chamber. Provide a small fixed air flow (200-400 scm ³/min) across the device. The permeation device should always have a continuous air flow across it to prevent large buildup of NO<INF>2</INF> in the system and a consequent restabilization period. Record the flowrate as FP. Allow the device to stabilize at the calibration temperature for at least 24 hours. The temperature must be adjusted and controlled to within ^{plus-minus}0.1 deg.C or less of the calibration temperature as monitored with the temperature measuring device.

2.4.4 Precautions must be taken to remove O<INF>2</INF> and other contaminants from the NO pressure regulator and delivery system prior to the start of calibration to avoid any conversion of the standard NO to NO<INF>2.</INF> Failure to do so can cause significant errors in calibration. This problem may be minimized by

(1) Carefully evacuating the regulator, when possible, after the regulator has been connected to the cylinder and before opening the cylinder valve;

(2) Thoroughly flushing the regulator and delivery system with NO after opening the cylinder valve;

(3) Not removing the regulator from the cylinder between calibrations unless absolutely necessary. Further discussion of these procedures is given in reference 13.

2.4.5 Select the operating range of the NO/NO<INF>X</INF> NO<INF>2</INF> analyzer to be calibrated. In order to obtain maximum precision and accuracy for NO<INF>2</INF> calibration, all three channels of the analyzer should be set to the same range. If operation of the NO and NO<INF>X</INF> channels on higher ranges is desired, subsequent recalibration of the NO and NO<INF>X</INF> channels on the higher ranges is recommended.

Note: Some analyzer designs may require identical ranges for NO, NO<INF>X,</INF> and NO<INF>2</INF> during operation of the analyzer.

2.4.6 Connect the recorder output cable(s) of the NO/NO<INF>X</INF>/ NO<INF>2</INF> analyzer to the input terminals of the strip chart recorder(s). All adjustments to the analyzer should be performed based on the appropriate strip chart readings. References to analyzer responses in the procedures given below refer to recorder responses.

2.4.7 Switch the valve to vent the flow from the permeation device and adjust the diluent air flowrate, F<INF>D,</INF> to provide zero air at the output manifold. The total air flow must exceed the total demand of the analyzer(s) connected to the output manifold to insure that no ambient air is pulled into the manifold vent. Allow the analyzer to sample zero air until stable NO, NO<INF>X,</INF> and NO<INF>2</INF> responses are obtained. After the responses have stabilized, adjust the analyzer zero control(s).

Note: Some analyzers may have separate zero controls for NO, NO<INF>X,</INF> and NO<INF>2.</INF> Other analyzers may have separate zero controls only for NO and NO<INF>X,</INF> while still others may

have only one zero common control to all three channels.
Offsetting the analyzer zero adjustments to +5% of scale is recommended to facilitate observing negative zero drift. Record the stable zero air responses as Z<INF>NO,</INF> Z<INF>NOX,</INF> and Z<INF>NO2</INF>.

2.4.8 Preparation of NO and NO<INF>X</INF> calibration curves.

2.4.8.1 Adjustment of NO span control. Adjust the NO flow from the standard NO cylinder to generate an NO concentration of approximately 80% of the upper range limit (URL) of the NO range. The exact NO concentration is calculated from:
[GRAPHIC] [TIFF OMITTED] TR31AU93.049

where:

[NO]<INF>OUT</INF> = diluted NO concentration at the output manifold, ppm
F<INF>NO</INF> = NO flowrate, scm³/min
[NO]<INF>STD</INF>=concentration of the undiluted NO standard, ppm
F<INF>D</INF> = diluent air flowrate, scm ³/min

Sample this NO concentration until the NO and NO<INF>X</INF> responses have stabilized. Adjust the NO span control to obtain a recorder response as indicated below:

recorder response (% scale) =
[GRAPHIC] [TIFF OMITTED] TR31AU93.050

[GRAPHIC] [TIFF OMITTED] TR31AU93.051

where:

URL = nominal upper range limit of the NO channel, ppm

Note: Some analyzers may have separate span controls for NO, NO<INF>X,</INF> and NO<INF>2.</INF> Other analyzers may have separate span controls only for NO and NO<INF>X,</INF> while still others may have only one span control common to all three channels. When only one span control is available, the span adjustment is made on the NO channel of the analyzer.
If substantial adjustment of the NO span control is necessary, it may be necessary to recheck the zero and span adjustments by repeating steps 2.4.7 and 2.4.8.1. Record the NO concentration and the analyzer's NO response.

2.4.8.2 Adjustment of NO<INF>X</INF> span control. When adjusting the analyzer's NO<INF>X</INF> span control, the presence of any NO<INF>2</INF>
impurity in the standard NO cylinder must be taken into account. Procedures for determining the amount of NO<INF>2</INF> impurity in the standard NO cylinder are given in reference 13. The exact NO<INF>X</INF> concentration is calculated from:
[GRAPHIC] [TIFF OMITTED] TR31AU93.052

where:
[NO<INF>X</INF>]<INF>OUT</INF> = diluted NO<INF>X</INF> cencentration at the output manifold, ppm
[NO<INF>2</INF>]<INF>IMP</INF> = concentration of NO<INF>2</INF> impurity in the standard NO cylinder, ppm

Adjust the NO<INF>X</INF> span control to obtain a convenient recorder response as indicated below:

recorder response (% scale)
[GRAPHIC] [TIFF OMITTED] TR31AU93.053

Note: If the analyzer has only one span control, the span adjustment is made on the NO channel and no further adjustment is made here for NO<INF>X</INF>.
If substantial adjustment of the NO<INF>X</INF> span control is necessary, it may be necessary to recheck the zero and span adjustments by repeating steps 2.4.7 and 2.4.8.2. Record the NO<INF>X</INF> concentration and the analyzer's NO<INF>X</INF> response.

2.4.8.3 Generate several additional concentrations (at least five evenly spaced points across the remaining scale are suggested to verify linearity) by decreasing F<INF>NO</INF> or increasing F<INF>D.</INF> For each concentration generated, calculate the exact NO and NO<INF>X</INF> concentrations using equations (16) and (18) respectively. Record the analyzer's NO and NO<INF>X</INF> responses for each concentration. Plot the analyzer responses versus the respective calculated NO and NO<INF>X</INF> concentrations and draw or calculate the NO and NO<INF>X</INF> calibration curves. For subsequent calibrations where linearity can be assumed, these curves may be checked with a two-point calibration consisting of a zero point and NO and NO<INF>X</INF> concentrations of approximately 80 percent of the URL.

2.4.9 Preparation of NO<INF>2</INF> calibration curve.

2.4.9.1 Remove the NO flow. Assuming the NO<INF>2</INF> zero has been properly adjusted while sampling zero air in step 2.4.7, switch the valve to provide NO<INF>2</INF> at the output manifold.

2.4.9.2 Adjust F<INF>D</INF> to generate an NO<INF>2</INF> concentration of approximately 80 percent of the URL of the NO<INF>2</INF> range. The total air flow must exceed the demand of the analyzer(s) under calibration. The actual concentration of NO<INF>2</INF> is calculated from:
[GRAPHIC] [TIFF OMITTED] TR31AU93.054

where:

[NO<INF>2</INF>]<INF>OUT</INF> = diluted NO<INF>2</INF> concentration at the output manifold, ppm
R = permeation rate, <greek-m>g/min
K = 0.532<greek-m>l NO<INF>2</INF>/<greek-m>g NO<INF>2</INF> (at 25 deg.C and 760 mm Hg)
F<INF>p</INF> = air flowrate across permeation device, scm ³/min
F<INF>D</INF> = diluent air flowrate, scm ³/min

Sample this NO<INF>2</INF> concentration until the NO<INF>X</INF> and NO<INF>2</INF> responses have stabilized. Adjust the NO<INF>2</INF> span control to obtain a recorder response as indicated below:

recorder response (% scale)
[GRAPHIC] [TIFF OMITTED] TR31AU93.055

Note: If the analyzer has only one or two span controls, the span

adjustments are made on the NO channel or NO and NO<INF>X</INF> channels and no further adjustment is made here for NO<INF>2</INF>.

If substantial adjustment of the NO<INF>2</INF> span control is necessary it may be necessary to recheck the zero and span adjustments by repeating steps 2.4.7 and 2.4.9.2. Record the NO<INF>2</INF> concentration and the analyzer's NO<INF>2</INF> response. Using the NO<INF>X</INF> calibration curve obtained in step 2.4.8, measure and record the NO<INF>X</INF> concentration as [NO<INF>X</INF>]<INF>M</INF>.

2.4.9.3 Adjust F<INF>D</INF> to obtain several other concentrations of NO<INF>2</INF> over the NO<INF>2</INF> range (at least five evenly spaced points across the remaining scale are suggested). Calculate each NO<INF>2</INF> concentration using equation (20) and record the corresponding analyzer NO<INF>2</INF> and NO<INF>X</INF> responses. Plot the analyzer's NO<INF>2</INF> responses versus the corresponding calculated NO<INF>2</INF> concentrations and draw or calculate the NO<INF>2</INF> calibration curve.

2.4.10 Determination of converter efficiency.

2.4.10.1 Plot [NO<INF>X</INF>]<INF>M</INF> (y-axis) versus [NO<INF>2</INF>]<INF>OUT</INF> (x-axis) and draw or calculate the converter efficiency curve. The slope of the curve times 100 is the average converter efficiency, E<INF>C.</INF> The average converter efficiency must be greater than 96 percent; if it is less than 96 percent, replace or service the converter.

Note: Supplemental information on calibration and other procedures in this method are given in reference 13.

3. Frequency of calibration. The frequency of calibration, as well as the number of points necessary to establish the calibration curve and the frequency of other performance checks, will vary from one analyzer to another. The user's quality control program should provide guidelines for initial establishment of these variables and for subsequent alteration as operational experience is accumulated. Manufacturers of analyzers should include in their instruction/operation manuals information and guidance as to these variables and on other matters of operation, calibration, and quality control.

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[41 FR 52688, Dec. 1, 1976, as amended at 48 FR 2529, Jan 20, 1983]

Appendix G to Part 50--Reference Method for the Determination of Lead in Suspended Particulate Matter Collected From Ambient Air

1. Principle and applicability.

1.1 Ambient air suspended particulate matter is collected on a glass-fiber filter for 24 hours using a high volume air sampler. The analysis of the 24-hour samples may be performed for either individual samples or composites of the samples collected over a calendar month or quarter, provided that the compositing procedure has been approved in accordance with section 2.8 of appendix C to part 58 of this chapter--Modifications of methods by users. (Guidance or assistance in requesting

approval under Section 2.8 can be obtained from the address given in section 2.7 of appendix C to part 58 of this chapter.)

1.2 Lead in the particulate matter is solubilized by extraction with nitric acid (HNO<INF>3</INF>), facilitated by heat or by a mixture of HNO<INF>3</INF> and hydrochloric acid (HCl) facilitated by ultrasonication.

1.3 The lead content of the sample is analyzed by atomic absorption spectrometry using an air-acetylene flame, the 283.3 or 217.0 nm lead absorption line, and the optimum instrumental conditions recommended by the manufacturer.

1.4 The ultrasonication extraction with HNO<INF>3</INF>/HCl will extract metals other than lead from ambient particulate matter.

2. Range, sensitivity, and lower detectable limit. The values given below are typical of the methods capabilities. Absolute values will vary for individual situations depending on the type of instrument used, the lead line, and operating conditions.

2.1 Range. The typical range of the method is 0.07 to 7.5 <greek-m>g Pb/m³ assuming an upper linear range of analysis of 15 <greek-m>g/ml and an air volume of 2,400 m³.

2.2 Sensitivity. Typical sensitivities for a 1 percent change in absorption (0.0044 absorbance units) are 0.2 and 0.5 <greek-m>g Pb/ml for the 217.0 and 283.3 nm lines, respectively.

2.3 Lower detectable limit (LDL). A typical LDL is 0.07 <greek-m>g Pb/m^{3.} The above value was calculated by doubling the between-laboratory standard deviation obtained for the lowest measurable lead concentration in a collaborative test of the method.(15) An air volume of 2,400 m³ was assumed.

3. Interferences. Two types of interferences are possible: chemical and light scattering.

3.1 Chemical. Reports on the absence (1, 2, 3, 4, 5) of chemical interferences far outweigh those reporting their presence, (6) therefore, no correction for chemical interferences is given here. If the analyst suspects that the sample matrix is causing a chemical interference, the interference can be verified and corrected for by carrying out the analysis with and without the method of standard additions.(7)

3.2 Light scattering. Nonatomic absorption or light scattering, produced by high concentrations of dissolved solids in the sample, can produce a significant interference, especially at low lead concentrations. (2) The interference is greater at the 217.0 nm line than at the 283.3 nm line. No interference was observed using the 283.3 nm line with a similar method.(1)

Light scattering interferences can, however, be corrected for instrumentally. Since the dissolved solids can vary depending on the origin of the sample, the correction may be necessary, especially when using the 217.0 nm line. Dual beam instruments with a continuum source give the most accurate correction. A less accurate correction can be obtained by using a nonabsorbing lead line that is near the lead analytical line. Information on use of these correction techniques can be obtained from instrument manufacturers' manuals.

If instrumental correction is not feasible, the interference can be eliminated by use of the ammonium pyrrolidinecarbodithioate-methylisobutyl ketone, chelation-solvent extraction technique of sample preparation.(8)

4. Precision and bias.

4.1 The high-volume sampling procedure used to collect ambient air particulate matter has a between-laboratory relative standard deviation of 3.7 percent over the range 80 to 125 <greek-m>g/m³.(9) The combined extraction-analysis procedure has an average within-laboratory relative standard deviation of 5 to 6 percent over the range 1.5 to 15 <greek-m>g Pb/ml, and an average between laboratory relative standard deviation of 7 to 9 percent over the same range. These values include use of either extraction procedure.

4.2 Single laboratory experiments and collaborative testing indicate that there is no significant difference in lead recovery between the hot and ultrasonic extraction procedures.(15)

5. Apparatus.

5.1 Sampling.

5.1.1 High-Volume Sampler. Use and calibrate the sampler as described in appendix B to this part.

5.2 Analysis.

5.2.1 Atomic absorption spectrophotometer. Equipped with lead hollow cathode or electrodeless discharge lamp.

5.2.1.1 Acetylene. The grade recommended by the instrument manufacturer should be used. Change cylinder when pressure drops below 50-100 psig.

5.2.1.2 Air. Filtered to remove particulate, oil, and water.

5.2.2 Glassware. Class A borosilicate glassware should be used throughout the analysis.

5.2.2.1 Beakers. 30 and 150 ml. graduated, Pyrex.

5.2.2.2 Volumetric flasks. 100-ml.

5.2.2.3 Pipettes. To deliver 50, 30, 15, 8, 4, 2, 1 ml.

5.2.2.4 Cleaning. All glassware should be scrupulously cleaned. The following procedure is suggested. Wash with laboratory detergent, rinse, soak for 4 hours in 20 percent (w/w) HNO<INF>3,</INF> rinse 3 times with distilled-deionized water, and dry in a dust free manner.

5.2.3 Hot plate.

5.2.4. Ultrasonication water bath, unheated. Commercially available laboratory ultrasonic cleaning baths of 450 watts or higher ``cleaning power,'' i.e., actual ultrasonic power output to the bath have been found satisfactory.

5.2.5 Template. To aid in sectioning the glass-fiber filter. See figure 1 for dimensions.

5.2.6 Pizza cutter. Thin wheel. Thickness 1mm.

5.2.7 Watch glass.

5.2.8 Polyethylene bottles. For storage of samples. Linear polyethylene gives better storage stability than other polyethylenes and is preferred.

5.2.9 Parafilm ``M''.\1\ American Can Co., Marathon Products, Neenah, Wis., or equivalent.

\1\ Mention of commercial products does not imply endorsement by the U.S. Environmental Protection Agency.

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6. Reagents.

6.1 Sampling.

6.1.1 Glass fiber filters. The specifications given below are intended to aid the user in obtaining high quality filters with reproducible properties. These specifications have been met by EPA

contractors.

6.1.1.1 Lead content. The absolute lead content of filters is not critical, but low values are, of course, desirable. EPA typically obtains filters with a lead content of 75 <greek-m>g/filter.

It is important that the variation in lead content from filter to filter, within a given batch, be small.

6.1.1.2 Testing.

6.1.1.2.1 For large batches of filters (>500 filters) select at random 20 to 30 filters from a given batch. For small batches (>500 filters) a lesser number of filters may be taken. Cut one \3/4\" x 8" strip from each filter anywhere in the filter. Analyze all strips, separately, according to the directions in sections 7 and 8.

6.1.1.2.2 Calculate the total lead in each filter as

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where:

F<INF>b</INF> = Amount of lead per 72 square inches of filter, <greek-m>g.

6.1.1.2.3 Calculate the mean, F<INF>b,</INF> of the values and the relative standard deviation (standard deviation/mean x 100). If the relative standard deviation is high enough so

that, in the analysts opinion, subtraction of F<INF>b,</INF> (section 10.3) may result in a significant error in the <greek-m>g Pb/m^{3,} the batch should be rejected.

6.1.1.2.4 For acceptable batches, use the value of F<INF>b</INF> to correct all lead analyses (section 10.3) of particulate matter collected using that batch of filters. If the analyses are below the LDL (section 2.3) no correction is necessary.

6.2 Analysis.

6.2.1 Concentrated (15.6 M) HNO<INF>3.</INF> ACS reagent grade HNO<INF>3</INF> and commercially available redistilled HNO<INF>3</INF> has found to have sufficiently low lead concentrations.

6.2.2 Concentrated (11.7 M) HCl. ACS reagent grade.

6.2.3 Distilled-deionized water. (D.I. water).

6.2.4 3 M HNO<INF>3.</INF> This solution is used in the hot extraction procedure. To prepare, add 192 ml of concentrated HNO<INF>3</INF> to D.I. water in a 1 l volumetric flask. Shake well, cool, and dilute to volume with D.I. water. Caution: Nitric acid fumes are toxic. Prepare in a well ventilated fume hood.

6.2.5 0.45 M HNO<INF>3.</INF> This solution is used as the matrix for calibration standards when using the hot extraction procedure. To prepare, add 29 ml of concentrated HNO<INF>3</INF> to D.I. water in a 1 l volumetric flask. Shake well, cool, and dilute to volume with D.I. water.

6.2.6 2.6 M HNO<INF>3</INF>+0 to 0.9 M HCl. This solution is used in the ultrasonic extraction procedure. The concentration of HCl can be varied from 0 to 0.9 M. Directions are given for preparation of a 2.6 M HNO<INF>3</INF>+0.9 M HCl solution. Place 167 ml of concentrated HNO<INF>3</INF> into a 1 l volumetric flask and add 77 ml of concentrated HCl. Stir 4 to 6 hours, dilute to nearly 1 l with D.I. water, cool to room temperature, and dilute to 1 l.

6.2.7 0.40 M HNO<INF>3</INF> + X M HCl. This solution is used as the

matrix for calibration standards when using the ultrasonic extraction procedure. To prepare, add 26 ml of concentrated HNO<INF>3,</INF> plus the ml of HCl required, to a 1 l volumetric flask. Dilute to nearly 1 l with D.I. water, cool to room temperature, and dilute to 1 l. The amount of HCl required can be determined from the following equation:
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where:

y = ml of concentrated HCl required.
x = molarity of HCl in 6.2.6.
0.15 = dilution factor in 7.2.2.

6.2.8 Lead nitrate, Pb(NO<INF>3</INF>)<INF>2.</INF> ACS reagent grade, purity 99.0 percent. Heat for 4 hours at 120 deg.C and cool in a desiccator.

6.3 Calibration standards.

6.3.1 Master standard, 1000 <greek-m>g Pb/ml in HNO<INF>3.</INF> Dissolve 1.598 g of Pb(NO<INF>3</INF>)<INF>2</INF> in 0.45 M HNO<INF>3</INF> contained in a 1 l volumetric flask and dilute to volume with 0.45 M HNO<INF>3</INF>.

6.3.2 Master standard, 1000 <greek-m>g Pb/ml in HNO<INF>3</INF>/HCl. Prepare as in section 6.3.1 except use the HNO<INF>3</INF>/HCl solution in section 6.2.7.

Store standards in a polyethylene bottle. Commercially available certified lead standard solutions may also be used.

7. Procedure.

7.1 Sampling. Collect samples for 24 hours using the procedure described in reference 10 with glass-fiber filters meeting the specifications in section 6.1.1. Transport collected samples to the laboratory taking care to minimize contamination and loss of sample. (16).

7.2 Sample preparation.

7.2.1 Hot extraction procedure.

7.2.1.1 Cut a \3/4\" x 8" strip from the exposed filter using a template and a pizza cutter as described in Figures 1 and 2. Other cutting procedures may be used.

Lead in ambient particulate matter collected on glass fiber filters has been shown to be uniformly distributed across the filter.^{1,} 3,</SUP> 11</SUP> Another study ¹² has shown that when sampling near a roadway, strip position contributes significantly to the overall variability associated with lead analyses. Therefore, when sampling near a roadway, additional strips should be analyzed to minimize this variability.

7.2.1.2 Fold the strip in half twice and place in a 150-ml beaker. Add 15 ml of 3 M HNO<INF>3</INF> to cover the sample. The acid should completely cover the sample. Cover the beaker with a watch glass.

7.2.1.3 Place beaker on the hot-plate, contained in a fume hood, and boil gently for 30 min. Do not let the sample evaporate to dryness. Caution: Nitric acid fumes are toxic.

7.2.1.4 Remove beaker from hot plate and cool to near room temperature.

7.2.1.5 Quantitatively transfer the sample as follows:

7.2.1.5.1 Rinse watch glass and sides of beaker with D.I. water.

7.2.1.5.2 Decant extract and rinsings into a 100-ml volumetric flask.

7.2.1.5.3 Add D.I. water to 40 ml mark on beaker, cover with watch

glass, and set aside for a minimum of 30 minutes. This is a critical step and cannot be omitted since it allows the HNO<INF>3</INF> trapped in the filter to diffuse into the rinse water.

7.2.1.5.4 Decant the water from the filter into the volumetric flask.

7.2.1.5.5 Rinse filter and beaker twice with D.I. water and add rinsings to volumetric flask until total volume is 80 to 85 ml.

7.2.1.5.6 Stopper flask and shake vigorously. Set aside for approximately 5 minutes or until foam has dissipated.

7.2.1.5.7 Bring solution to volume with D.I. water. Mix thoroughly.

7.2.1.5.8 Allow solution to settle for one hour before proceeding with analysis.

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7.2.1.5.9 If sample is to be stored for subsequent analysis, transfer to a linear polyethylene bottle.

7.2.2 Ultrasonic extraction procedure.

7.2.2.1 Cut a \3/4\" x 8" strip from the exposed filter as described in section 7.2.1.1.

7.2.2.2 Fold the strip in half twice and place in a 30 ml beaker. Add 15 ml of the HNO<INF>3</INF>/HCl solution in section 6.2.6. The acid should completely cover the sample. Cover the beaker with parafilm.

The parafilm should be placed over the beaker such that none of the parafilm is in contact with water in the ultrasonic bath. Otherwise, rinsing of the parafilm (section 7.2.2.4.1) may contaminate the sample.

7.2.2.3 Place the beaker in the ultrasonication bath and operate for 30 minutes.

7.2.2.4 Quantitatively transfer the sample as follows:

7.2.2.4.1 Rinse parafilm and sides of beaker with D.I. water.

7.2.2.4.2 Decant extract and rinsings into a 100 ml volumetric flask.

7.2.2.4.3 Add 20 ml D.I. water to cover the filter strip, cover with parafilm, and set aside for a minimum of 30 minutes. This is a critical step and cannot be omitted. The sample is then processed as in sections 7.2.1.5.4 through 7.2.1.5.9.

Note: Samples prepared by the hot extraction procedure are now in 0.45 M HNO<INF>3.</INF> Samples prepared by the ultrasonication procedure are in 0.40 M HNO<INF>3</INF> + X M HCl.

8. Analysis.

8.1 Set the wavelength of the monochromator at 283.3 or 217.0 nm. Set or align other instrumental operating conditions as recommended by the manufacturer.

8.2 The sample can be analyzed directly from the volumetric flask, or an appropriate amount of sample decanted into a sample analysis tube. In either case, care should be taken not to disturb the settled solids.

8.3 Aspirate samples, calibration standards and blanks (section 9.2) into the flame and record the equilibrium absorbance.

8.4 Determine the lead concentration in <greek-m>g Pb/ml, from the calibration curve, section 9.3.

8.5 Samples that exceed the linear calibration range should be diluted with acid of the same concentration as the calibration standards and reanalyzed.

9. Calibration.

9.1 Working standard, 20 <greek-m>g Pb/ml. Prepared by diluting 2.0 ml of the master standard (section 6.3.1 if the hot acid extraction was used or section 6.3.2 if the ultrasonic extraction procedure was used)

to 100 ml with acid of the same concentration as used in preparing the master standard.

9.2 Calibration standards. Prepare daily by diluting the working standard, with the same acid matrix, as indicated below. Other lead concentrations may be used.

Volume of 20 <greek-m>g/ml working standard, ml	Final volume, ml	Concentration <greek-m>g Pb/ml
0	100	0
1.0	200	0.1
2.0	200	0.2
2.0	100	0.4
4.0	100	0.8
8.0	100	1.6
15.0	100	3.0
30.0	100	6.0
50.0	100	10.0
100.0	100	20.0

9.3 Preparation of calibration curve. Since the working range of analysis will vary depending on which lead line is used and the type of instrument, no one set of instructions for preparation of a calibration curve can be given. Select standards (plus the reagent blank), in the same acid concentration as the samples, to cover the linear absorption range indicated by the instrument manufacturer. Measure the absorbance of the blank and standards as in section 8.0. Repeat until good agreement is obtained between replicates. Plot absorbance (y-axis) versus concentration in <greek-m>g Pb/ml (x-axis). Draw (or compute) a straight line through the linear portion of the curve. Do not force the calibration curve through zero. Other calibration procedures may be used.

To determine stability of the calibration curve, remeasure--alternately--one of the following calibration standards for every 10th sample analyzed: Concentration <INF>ls-thn-eq</INF> 1<greek-m>g Pb/ml; concentration <INF>ls-thn-eq</INF> 10 <greek-m>g Pb/ml. If either standard deviates by more than 5 percent from the value predicted by the calibration curve, recalibrate and repeat the previous 10 analyses.

10. Calculation.

10.1 Measured air volume. Calculate the measured air volume at Standard Temperature and Pressure as described in Reference 10.

10.2 Lead concentration. Calculate lead concentration in the air sample.

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where:

C = Concentration, <greek-m>g Pb/sm³.
<greek-m>g Pb/ml = Lead concentration determined from section 8.
100 ml/strip = Total sample volume.
12 strips = Total useable filter area, 8" x 9". Exposed area of one strip, \3/4\" x 7".

Filter = Total area of one strip, \3/4\" x 8".
F<INF>b</INF> = Lead concentration of blank filter, <greek-m>g, from section 6.1.1.2.3.
V<INF>STP</INF> = Air volume from section 10.2.

11. Quality control.

\3/4\" x 8" glass fiber filter strips containing 80 to 2000 <greek-m>g Pb/strip (as lead salts) and blank strips with zero Pb content should be used to determine if the method--as being used--has any bias. Quality control charts should be established to monitor differences between measured and true values. The frequency of such checks will depend on the local quality control program.

To minimize the possibility of generating unreliable data, the user should follow practices established for assuring the quality of air pollution data, (13) and take part in EPA's semiannual audit program for lead analyses.

12. Trouble shooting.

1. During extraction of lead by the hot extraction procedure, it is important to keep the sample covered so that corrosion products--formed on fume hood surfaces which may contain lead--are not deposited in the extract.

2. The sample acid concentration should minimize corrosion of the nebulizer. However, different nebulizers may require lower acid concentrations. Lower concentrations can be used provided samples and standards have the same acid concentration.

3. Ashing of particulate samples has been found, by EPA and contractor laboratories, to be unnecessary in lead analyses by atomic absorption. Therefore, this step was omitted from the method.

4. Filtration of extracted samples, to remove particulate matter, was specifically excluded from sample preparation, because some analysts have observed losses of lead due to filtration.

5. If suspended solids should clog the nebulizer during analysis of samples, centrifuge the sample to remove the solids.

13. Authority.

(Secs. 109 and 301(a), Clean Air Act, as amended (42 U.S.C. 7409, 7601(a)))

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(Secs. 109, 301(a) of the Clean Air Act, as amended (42 U.S.C. 7409, 7601(a)); secs. 110, 301(a) and 319 of the Clean Air Act (42 U.S.C. 7410, 7601(a), 7619))

[43 FR 46258, Oct. 5, 1978; 44 FR 37915, June 29, 1979, as amended at 46 FR 44163, Sept. 3, 1981; 52 FR 24664, July 1, 1987]

Appendix H to Part 50--Interpretation of the 1-Hour Primary and Secondary National Ambient Air Quality Standards for Ozone

1. General

This appendix explains how to determine when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm (235 <greek-m>g/m³) is equal to or less than 1. An expanded discussion of these procedures and associated examples are contained in the ``Guideline for Interpretation of Ozone Air Quality Standards.'' For purposes of clarity in the following discussion, it is convenient to use the term ``exceedance'' to describe a daily maximum hourly average ozone measurement that is greater than the level of the standard. Therefore, the phrase ``expected number of days with maximum hourly average ozone concentrations above the level of the standard'' may be simply stated as the ``expected number of exceedances.''

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The basic principle in making this determination is relatively straightforward. Most of the complications that arise in determining the expected number of annual exceedances relate to accounting for incomplete sampling. In general, the average number of exceedances per calendar year must be less than or equal to 1. In its simplest form, the number of exceedances at a monitoring site would be recorded for each calendar year and then averaged over the past 3 calendar years to determine if this average is less than or equal to 1.

2. Interpretation of Expected Exceedances

The ozone standard states that the expected number of exceedances per year must be less than or equal to 1. The statistical term ``expected number'' is basically an arithmetic average. The following example explains what it would mean for an area to be in compliance with this type of standard. Suppose a monitoring station records a valid daily maximum hourly average ozone value for every day of the year during the past 3 years. At the end of each year, the number of days with maximum hourly concentrations above 0.12 ppm is determined and this number is averaged with the results of previous years. As long as this average remains ``less than or equal to 1,'' the area is in compliance.

3. Estimating the Number of Exceedances for a Year

In general, a valid daily maximum hourly average value may not be available for each day of the year, and it will be necessary to account for these missing values when estimating the number of exceedances for a particular calendar year. The purpose of these computations is to determine if the expected number of exceedances per year is less than or equal to 1. Thus, if a site has two or more observed exceedances each year, the standard is not met and it is not necessary to use the procedures of this section to account for incomplete sampling.

The term ``missing value'' is used here in the general sense to describe all days that do not have an associated ozone measurement. In some cases, a measurement might actually have been missed but in other cases no measurement may have been scheduled for that day. A daily maximum ozone value is defined to be the highest hourly ozone value recorded for the day. This daily maximum value is considered to be valid if 75 percent of the hours from 9:01 a.m. to 9:00 p.m. (LST) were measured or if the highest hour is greater than the level of the standard.

In some areas, the seasonal pattern of ozone is so pronounced that entire months need not be sampled because it is extremely unlikely that the standard would be exceeded. Any such waiver of the ozone monitoring requirement would be handled under provisions of 40 CFR, part 58. Some allowance should also be made for days for which valid daily maximum hourly values were not obtained but which would quite likely have been below the standard. Such an allowance introduces a complication in that it becomes necessary to define under what conditions a missing value may be assumed to have been less than the level of the standard. The following criterion may be used for ozone:

A missing daily maximum ozone value may be assumed to be less than the level of the standard if the valid daily maxima on both the preceding day and the following day do not exceed 75 percent of the level of the standard.

Let z denote the number of missing daily maximum values that may be assumed to be less than the standard. Then the following formula shall

be used to estimate the expected number of exceedances for the year:
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(*Indicates multiplication.)

where:

e = the estimated number of exceedances for the year,
N = the number of required monitoring days in the year,
n = the number of valid daily maxima,
v = the number of daily values above the level of the standard, and
z = the number of days assumed to be less than the standard level.

This estimated number of exceedances shall be rounded to one decimal place (fractional parts equal to 0.05 round up).

It should be noted that N will be the total number of days in the year unless the appropriate Regional Administrator has granted a waiver under the provisions of 40 CFR part 58.

The above equation may be interpreted intuitively in the following manner. The estimated number of exceedances is equal to the observed number of exceedances (v) plus an increment that accounts for incomplete sampling. There were (N-n) missing values for the year but a certain number of these, namely z, were assumed to be less than the standard. Therefore, (N-n-z) missing values are considered to include possible exceedances. The fraction of measured values that are above the level of the standard is v/n. It is assumed that this same fraction applies to the (N-n-z) missing values and that (v/n)*(N-n-z) of these values would also have exceeded the level of the standard.

[44 FR 8220, Feb. 8, 1979, as amended at 62 FR 38895, July 18, 1997]

Appendix I to Part 50--Interpretation of the 8-Hour Primary and Secondary National Ambient Air Quality Standards for Ozone

1. General.

This appendix explains the data handling conventions and computations necessary for determining whether the national 8-hour primary and secondary ambient air quality standards for ozone specified in Sec. 50.10 are met at an ambient ozone air quality monitoring site. Ozone is measured in the ambient air by a reference method based on appendix D of this part. Data reporting, data handling, and computation procedures to be used in making comparisons between reported ozone concentrations and the level of the ozone standard are specified in the following sections. Whether to exclude, retain, or make adjustments to the data affected by stratospheric ozone intrusion or other natural events is subject to the approval of the appropriate Regional Administrator.

2. Primary and Secondary Ambient Air Quality Standards for Ozone.

2.1 Data Reporting and Handling Conventions.

2.1.1 Computing 8-hour averages. Hourly average concentrations shall be reported in parts per million (ppm) to the third decimal place, with additional digits to the right being truncated. Running 8-hour averages shall be computed from the hourly ozone concentration data for each hour of the year and the result shall be stored in the first, or start, hour of the 8-hour period. An 8-hour average shall be considered valid if at

least 75% of the hourly averages for the 8-hour period are available. In the event that only 6 (or 7) hourly averages are available, the 8-hour average shall be computed on the basis of the hours available using 6 (or 7) as the divisor. (8-hour periods with three or more missing hours shall not be ignored if, after substituting one-half the minimum detectable limit for the missing hourly concentrations, the 8-hour average concentration is greater than the level of the standard.) The computed 8-hour average ozone concentrations shall be reported to three decimal places (the insignificant digits to the right of the third decimal place are truncated, consistent with the data handling procedures for the reported data.)

2.1.2 Daily maximum 8-hour average concentrations. (a) There are 24 possible running 8-hour average ozone concentrations for each calendar day during the ozone monitoring season. (Ozone monitoring seasons vary by geographic location as designated in part 58, appendix D to this chapter.) The daily maximum 8-hour concentration for a given calendar day is the highest of the 24 possible 8-hour average concentrations computed for that day. This process is repeated, yielding a daily maximum 8-hour average ozone concentration for each calendar day with ambient ozone monitoring data. Because the 8-hour averages are recorded in the start hour, the daily maximum 8-hour concentrations from two consecutive days may have some hourly concentrations in common. Generally, overlapping daily maximum 8-hour averages are not likely, except in those non-urban monitoring locations with less pronounced diurnal variation in hourly concentrations.

(b) An ozone monitoring day shall be counted as a valid day if valid 8-hour averages are available for at least 75% of possible hours in the day (i.e., at least 18 of the 24 averages). In the event that less than 75% of the 8-hour averages are available, a day shall also be counted as a valid day if the daily maximum 8-hour average concentration for that day is greater than the level of the ambient standard.

2.2 Primary and Secondary Standard-related Summary Statistic. The standard-related summary statistic is the annual fourth-highest daily maximum 8-hour ozone concentration, expressed in parts per million, averaged over three years. The 3-year average shall be computed using the three most recent, consecutive calendar years of monitoring data meeting the data completeness requirements described in this appendix. The computed 3-year average of the annual fourth-highest daily maximum 8-hour average ozone concentrations shall be expressed to three decimal places (the remaining digits to the right are truncated.)

2.3 Comparisons with the Primary and Secondary Ozone Standards. (a) The primary and secondary ozone ambient air quality standards are met at an ambient air quality monitoring site when the 3-year average of the annual fourth-highest daily maximum 8-hour average ozone concentration is less than or equal to 0.08 ppm. The number of significant figures in the level of the standard dictates the rounding convention for comparing the computed 3-year average annual fourth-highest daily maximum 8-hour average ozone concentration with the level of the standard. The third decimal place of the computed value is rounded, with values equal to or greater than 5 rounding up. Thus, a computed 3-year average ozone concentration of 0.085 ppm is the smallest value that is greater than 0.08 ppm.

(b) This comparison shall be based on three consecutive, complete calendar years of air quality monitoring data. This requirement is met for the three year period at a monitoring site if daily maximum 8-hour average concentrations are available for at least 90%, on average, of the days during the designated ozone monitoring season, with a minimum

data completeness in any one year of at least 75% of the designated sampling days. When

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computing whether the minimum data completeness requirements have been met, meteorological or ambient data may be sufficient to demonstrate that meteorological conditions on missing days were not conducive to concentrations above the level of the standard. Missing days assumed less than the level of the standard are counted for the purpose of meeting the data completeness requirement, subject to the approval of the appropriate Regional Administrator.

(c) Years with concentrations greater than the level of the standard shall not be ignored on the ground that they have less than complete data. Thus, in computing the 3-year average fourth maximum concentration, calendar years with less than 75% data completeness shall be included in the computation if the average annual fourth maximum 8-hour concentration is greater than the level of the standard.

(d) Comparisons with the primary and secondary ozone standards are demonstrated by examples 1 and 2 in paragraphs (d)(1) and (d) (2) respectively as follows:

(1) As shown in example 1, the primary and secondary standards are met at this monitoring site because the 3-year average of the annual fourth-highest daily maximum 8-hour average ozone concentrations (i.e., 0.084 ppm) is less than or equal to 0.08 ppm. The data completeness requirement is also met because the average percent of days with valid ambient monitoring data is greater than 90%, and no single year has less than 75% data completeness.

Example 1. Ambient monitoring site attaining the primary and secondary ozone standards

Year	Percent Valid Days	1st Highest Daily Max 8-hour Conc. (ppm)	2nd Highest Daily Max 8-hour Conc. (ppm)	3rd Highest Daily Max 8-hour Conc. (ppm)	4th Highest Daily Max 8-hour Conc. (ppm)	5th Highest Daily Max 8-hour Conc. (ppm)
1993	100%	0.092	0.091	0.090	0.088	0.085
1994	96%	0.090	0.089	0.086	0.084	0.080
1995	98%	0.087	0.085	0.083	0.080	0.075
Average	98%					

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(2) As shown in example 2, the primary and secondary standards are not met at this monitoring site because the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations (i.e., 0.093 ppm) is greater than 0.08 ppm. Note that the ozone concentration data for 1994 is used in these computations, even though the data capture is less than 75%, because the average fourth-highest daily maximum 8-hour average concentration is greater than 0.08 ppm.

Example 2. Ambient Monitoring Site Failing to Meet the Primary and Secondary Ozone Standards

Year	Percent Valid Days	1st Highest Daily Max 8-hour Conc. (ppm)	2nd Highest Daily Max 8-hour Conc. (ppm)	3rd Highest Daily Max 8-hour Conc. (ppm)	4th Highest Daily Max 8-hour Conc. (ppm)	5th Highest Daily Max 8-hour Conc. (ppm)
1993	96%	0.105	0.103	0.103	0.102	0.102
1994	74%	0.090	0.085	0.082	0.080	0.078
1995	98%	0.103	0.101	0.101	0.097	0.095
Average	89%					

3. Design Values for Primary and Secondary Ambient Air Quality Standards for Ozone. The air quality design value at a monitoring site is defined as that concentration that when reduced to the level of the standard ensures that the site meets the standard. For a concentration-based standard, the air quality design value is simply the standard-related test statistic. Thus, for the primary and secondary ozone standards, the 3-year average annual fourth-highest daily maximum 8-hour average ozone concentration is also the air quality design value for the site.

[62 FR 38895, July 18, 1997]

Appendix J to Part 50--Reference Method for the Determination of Particulate Matter as PM<INF>10</INF> in the Atmosphere

1.0 Applicability.

1.1 This method provides for the measurement of the mass concentration of particulate matter with an aerodynamic diameter less than or equal to a nominal 10 micrometers (PM<INF>1O</INF>) in ambient air over a 24-hour period for purposes of determining attainment and maintenance of the primary and secondary national ambient air quality standards for particulate matter specified in Sec. 50.6 of this chapter. The measurement process is nondestructive, and the PM<INF>10</INF> sample can be subjected to subsequent physical or chemical analyses. Quality assurance procedures and guidance are provided in part 58, appendices A and B, of this chapter and in References 1 and 2.

2.0 Principle.

2.1 An air sampler draws ambient air at a constant flow rate into a specially shaped inlet where the suspended particulate matter is inertially separated into one or more size fractions within the PM<INF>10</INF> size range. Each size fraction in the PM<INF>1O</INF> size range is then collected on a separate filter over the specified sampling period. The particle size discrimination characteristics (sampling effectiveness and 50 percent cutpoint) of the sampler inlet are prescribed as performance specifications in part 53 of this chapter.

2.2 Each filter is weighed (after moisture equilibration) before and after use to determine the net weight (mass) gain due to collected PM<INF>10.</INF> The total volume of air sampled, corrected to EPA reference conditions (25 C, 101.3 kPa), is determined from the measured flow rate and the sampling time. The mass concentration of PM<INF>10</INF> in the ambient air is computed as the total mass of collected particles in the PM<INF>10</INF> size range divided by the volume of air sampled, and is expressed in micrograms per standard cubic meter (<greek-m>g/std m\3\). For PM<INF>10</INF> samples collected at temperatures and pressures significantly different from EPA reference conditions, these corrected concentrations sometimes differ substantially from actual concentrations (in micrograms per actual cubic meter), particularly at high elevations. Although not required, the actual PM<INF>10</INF> concentration can be calculated from the corrected concentration, using the average ambient temperature and barometric pressure during the sampling period.

2.3 A method based on this principle will be considered a reference method only if (a) the associated sampler meets the requirements specified in this appendix and the requirements in part 53 of this chapter, and (b) the method has been designated as a reference method in accordance with part 53 of this chapter.

3.0 Range.

3.1 The lower limit of the mass concentration range is determined by the repeatability of filter tare weights, assuming the nominal air sample volume for the sampler. For samplers having an automatic filter-changing mechanism, there may be no upper limit. For samplers that do not have an automatic filter-changing mechanism, the upper limit is determined by the filter mass loading beyond which the sampler no longer maintains the operating flow rate within specified limits due to increased pressure drop across the loaded filter. This upper limit cannot be specified precisely because it is a complex function of the ambient particle size distribution and type, humidity, filter type, and perhaps other factors. Nevertheless, all samplers should be capable of measuring 24-hour PM<INF>10</INF> mass concentrations of at least 300 <greek-m>g/std m\3\ while maintaining the operating flow rate within the

specified limits.

4.0 Precision.

4.1 The precision of PM<INF>10</INF> samplers must be 5 <greek-m>g/m\3\ for PM<INF>10</INF> concentrations below 80 <greek-m>g/m\3\ and 7 percent for PM<INF>10</INF> concentrations above 80 <greek-m>g/m\3\, as required by part 53 of this chapter, which prescribes a test procedure that determines the variation in the PM<INF>10</INF> concentration measurements of identical samplers under typical sampling conditions. Continual assessment of precision via collocated samplers is required by part 58 of this chapter for PM<INF>10</INF> samplers used in certain monitoring networks.

5.0 Accuracy.

5.1 Because the size of the particles making up ambient particulate matter varies over a wide range and the concentration of particles varies with particle size, it is difficult to define the absolute accuracy of PM<INF>10</INF> samplers. Part 53 of this chapter provides a specification for the sampling effectiveness of PM<INF>10</INF> samplers. This specification requires that the expected mass concentration calculated for a candidate PM<INF>10</INF> sampler, when sampling a specified particle size distribution, be within <plus-minus>10 percent of that calculated for an ideal sampler whose sampling effectiveness is explicitly specified. Also, the particle size for 50 percent sampling effectivensss is required to be 10<plus-minus>0.5 micrometers. Other specifications related to accuracy apply to flow measurement and calibration, filter media, analytical (weighing) procedures, and artifact. The flow rate accuracy of PM<INF>10</INF> samplers used in certain monitoring networks is required by part 58 of this chapter to be assessed periodically via flow rate audits.

6.0 Potential Sources of Error.

6.1 Volatile Particles. Volatile particles collected on filters are often lost during shipment and/or storage of the filters prior to the post-sampling weighing \3\. Although shipment or storage of loaded filters is sometimes unavoidable, filters should be reweighed as soon as practical to minimize these losses.

6.2 Artifacts. Positive errors in PM<INF>10</INF> concentration measurements may result from retention of gaseous species on filters ^{4, 5.} Such errors include the retention of sulfur

dioxide and nitric acid. Retention of sulfur dioxide on filters, followed by oxidation to sulfate, is referred to as artifact sulfate formation, a phenomenon which increases with increasing filter alkalinity \6\. Little or no artifact sulfate formation should occur using filters that meet the alkalinity specification in section 7.2.4. Artifact nitrate formation, resulting primarily from retention of nitric acid, occurs to varying degrees on many filter types, including glass fiber, cellulose ester, and many quartz fiber filters ^{5, 7, 8, 9, 10.} Loss of true atmospheric particulate nitrate during or following sampling may also occur due to dissociation or chemical reaction. This phenomenon has been observed on Teflon® filters \8\ and inferred for quartz fiber filters ^{11, 12.} The magnitude of nitrate artifact errors in PM<INF>10</INF> mass concentration measurements will vary with location and ambient temperature; however, for most sampling locations, these errors are expected to be small.

6.3 Humidity. The effects of ambient humidity on the sample are unavoidable. The filter equilibration procedure in section 9.0 is designed to minimize the effects of moisture on the filter medium.

6.4 Filter Handling. Careful handling of filters between presampling and postsampling weighings is necessary to avoid errors due to damaged filters or loss of collected particles from the filters. Use of a filter cartridge or cassette may reduce the magnitude of these errors. Filters must also meet the integrity specification in section 7.2.3.

6.5 Flow Rate Variation. Variations in the sampler's operating flow rate may alter the particle size discrimination characteristics of the sampler inlet. The magnitude of this error will depend on the sensitivity of the inlet to variations in flow rate and on the particle distribution in the atmosphere during the sampling period. The use of a flow control device (section 7.1.3) is required to minimize this error.

6.6 Air Volume Determination. Errors in the air volume determination may result from errors in the flow rate and/or sampling time measurements. The flow control device serves to minimize errors in the flow rate determination, and an elapsed time meter (section 7.1.5) is required to minimize the error in the sampling time measurement.

7.0 Apparatus.

7.1 PM<INF>10</INF> Sampler.

7.1.1 The sampler shall be designed to:

a. Draw the air sample into the sampler inlet and through the particle collection filter at a uniform face velocity.

b. Hold and seal the filter in a horizontal position so that sample air is drawn downward through the filter.

c. Allow the filter to be installed and removed conveniently.

d. Protect the filter and sampler from precipitation and prevent insects and other debris from being sampled.

e. Minimize air leaks that would cause error in the measurement of the air volume passing through the filter.

f. Discharge exhaust air at a sufficient distance from the sampler inlet to minimize the sampling of exhaust air.

g. Minimize the collection of dust from the supporting surface.

7.1.2 The sampler shall have a sample air inlet system that, when operated within a specified flow rate range, provides particle size discrimination characteristics meeting all of the applicable performance specifications prescribed in part 53 of this chapter. The sampler inlet shall show no significant wind direction dependence. The latter requirement can generally be satisfied by an inlet shape that is circularly symmetrical about a vertical axis.

7.1.3 The sampler shall have a flow control device capable of maintaining the sampler's operating flow rate within the flow rate limits specified for the sampler inlet over normal variations in line voltage and filter pressure drop.

7.1.4 The sampler shall provide a means to measure the total flow rate during the sampling period. A continuous flow recorder is recommended but not required. The flow measurement device shall be accurate to <plus-minus>2 percent.

7.1.5 A timing/control device capable of starting and stopping the sampler shall be used to obtain a sample collection period of 24 <plus-minus>1 hr (1,440 <plus-minus>60 min). An elapsed time meter, accurate to within <plus-minus>15 minutes, shall be used to measure sampling time. This meter is optional for samplers with continuous flow recorders if the sampling time measurement obtained by means of the recorder meets the <plus-minus>15 minute accuracy specification.

7.1.6 The sampler shall have an associated operation or instruction

manual as required by part 53 of this chapter which includes detailed instructions on the calibration, operation, and maintenance of the sampler.

7.2 Filters.

7.2.1 Filter Medium. No commercially available filter medium is ideal in all respects for all samplers. The user's goals in sampling determine the relative importance of various filter characteristics (e.g., cost, ease of handling, physical and chemical characteristics, etc.) and, consequently, determine the choice among acceptable filters. Furthermore, certain types of filters may not be suitable for use with some samplers, particularly under heavy loading conditions (high mass concentrations), because of high or rapid increase in the filter flow resistance that would exceed the capability of the sampler's flow control device. However, samplers equipped with automatic filter-changing

mechanisms may allow use of these types of filters. The specifications given below are minimum requirements to ensure acceptability of the filter medium for measurement of PM<INF>10</INF> mass concentrations. Other filter evaluation criteria should be considered to meet individual sampling and analysis objectives.

7.2.2 Collection Efficiency. <gr-thn-eq>99 percent, as measured by the DOP test (ASTM-2986) with 0.3 <greek-m>m particles at the sampler's operating face velocity.

7.2.3 Integrity. <plus-minus>5 <greek-m>g/m\3\ (assuming sampler's nominal 24-hour air sample volume). Integrity is measured as the PM<INF>10</INF> concentration equivalent corresponding to the average difference between the initial and the final weights of a random sample of test filters that are weighed and handled under actual or simulated sampling conditions, but have no air sample passed through them (i.e., filter blanks). As a minimum, the test procedure must include initial equilibration and weighing, installation on an inoperative sampler, removal from the sampler, and final equilibration and weighing.

7.2.4 Alkalinity. <25 microequivalents/gram of filter, as measured by the procedure given in Reference 13 following at least two months storage in a clean environment (free from contamination by acidic gases) at room temperature and humidity.

7.3 Flow Rate Transfer Standard. The flow rate transfer standard must be suitable for the sampler's operating flow rate and must be calibrated against a primary flow or volume standard that is traceable to the National Bureau of Standards (NBS). The flow rate transfer standard must be capable of measuring the sampler's operating flow rate with an accuracy of <plus-minus>2 percent.

7.4 Filter Conditioning Environment.

7.4.1 Temperature range: 15 to 30 C.

7.4.2 Temperature control: <plus-minus>3 C.

7.4.3 Humidity range: 20% to 45% RH.

7.4.4 Humidity control: <plus-minus>5% RH.

7.5 Analytical Balance. The analytical balance must be suitable for weighing the type and size of filters required by the sampler. The range and sensitivity required will depend on the filter tare weights and mass loadings. Typically, an analytical balance with a sensitivity of 0.1 mg is required for high volume samplers (flow rates >0.5 m\3\/min). Lower volume samplers (flow rates <0.5 m\3\/min) will require a more sensitive balance.

8.0 Calibration.

8.1 General Requirements.

8.1.1 Calibration of the sampler's flow measurement device is required to establish traceability of subsequent flow measurements to a primary standard. A flow rate transfer standard calibrated against a primary flow or volume standard shall be used to calibrate or verify the accuracy of the sampler's flow measurement device.

8.1.2 Particle size discrimination by inertial separation requires that specific air velocities be maintained in the sampler's air inlet system. Therefore, the flow rate through the sampler's inlet must be maintained throughout the sampling period within the design flow rate range specified by the manufacturer. Design flow rates are specified as actual volumetric flow rates, measured at existing conditions of temperature and pressure (Q<INF>a</INF>). In contrast, mass concentrations of PM<INF>10</INF> are computed using flow rates corrected to EPA reference conditions of temperature and pressure (Q<INF>std</INF>).

8.2 Flow Rate Calibration Procedure.

8.2.1 PM<INF>10</INF> samplers employ various types of flow control and flow measurement devices. The specific procedure used for flow rate calibration or verification will vary depending on the type of flow controller and flow indicator employed. Calibration in terms of actual volumetric flow rates (Q<INF>a</INF>) is generally recommended, but other measures of flow rate (e.g., Q<INF>std</INF>) may be used provided the requirements of section 8.1 are met. The general procedure given here is based on actual volumetric flow units (Q<INF>a</INF>) and serves to illustrate the steps involved in the calibration of a PM<INF>10</INF> sampler. Consult the sampler manufacturer's instruction manual and Reference 2 for specific guidance on calibration. Reference 14 provides additional information on the use of the commonly used measures of flow rate and their interrelationships.

8.2.2 Calibrate the flow rate transfer standard against a primary flow or volume standard traceable to NBS. Establish a calibration relationship (e.g., an equation or family of curves) such that traceability to the primary standard is accurate to within 2 percent over the expected range of ambient conditions (i.e., temperatures and pressures) under which the transfer standard will be used. Recalibrate the transfer standard periodically.

8.2.3 Following the sampler manufacturer's instruction manual, remove the sampler inlet and connect the flow rate transfer standard to the sampler such that the transfer standard accurately measures the sampler's flow rate. Make sure there are no leaks between the transfer standard and the sampler.

8.2.4 Choose a minimum of three flow rates (actual m\3\/min), spaced over the acceptable flow rate range specified for the inlet (see 7.1.2) that can be obtained by suitable adjustment of the sampler flow rate. In accordance with the sampler manufacturer's instruction manual, obtain or verify the calibration relationship between the flow rate (actual m\3\/min) as indicated by the transfer standard and the sampler's flow indicator response. Record the ambient temperature and barometric pressure. Temperature and pressure corrections to subsequent flow indicator readings may be required for certain types of

flow measurement devices. When such corrections are necessary, correction on an individual or daily basis is preferable. However,

seasonal average temperature and average barometric pressure for the sampling site may be incorporated into the sampler calibration to avoid daily corrections. Consult the sampler manufacturer's instruction manual and Reference 2 for additional guidance.

8.2.5 Following calibration, verify that the sampler is operating at its design flow rate (actual m\3\/min) with a clean filter in place.

8.2.6 Replace the sampler inlet.

9.0 Procedure.

9.1 The sampler shall be operated in accordance with the specific guidance provided in the sampler manufacturer's instruction manual and in Reference 2. The general procedure given here assumes that the sampler's flow rate calibration is based on flow rates at ambient conditions (Q<INF>a</INF>) and serves to illustrate the steps involved in the operation of a PM<INF>10</INF> sampler.

9.2 Inspect each filter for pinholes, particles, and other imperfections. Establish a filter information record and assign an identification number to each filter.

9.3 Equilibrate each filter in the conditioning environment (see 7.4) for at least 24 hours.

9.4 Following equilibration, weigh each filter and record the presampling weight with the filter identification number.

9.5 Install a preweighed filter in the sampler following the instructions provided in the sampler manufacturer's instruction manual.

9.6 Turn on the sampler and allow it to establish run-temperature conditions. Record the flow indicator reading and, if needed, the ambient temperature and barometric pressure. Determine the sampler flow rate (actual m\3\/min) in accordance with the instructions provided in the sampler manufacturer's instruction manual. NOTE.--No onsite temperature or pressure measurements are necessary if the sampler's flow indicator does not require temperature or pressure corrections or if seasonal average temperature and average barometric pressure for the sampling site are incorporated into the sampler calibration (see step 8.2.4). If individual or daily temperature and pressure corrections are required, ambient temperature and barometric pressure can be obtained by on-site measurements or from a nearby weather station. Barometric pressure readings obtained from airports must be station pressure, not corrected to sea level, and may need to be corrected for differences in elevation between the sampling site and the airport.

9.7 If the flow rate is outside the acceptable range specified by the manufacturer, check for leaks, and if necessary, adjust the flow rate to the specified setpoint. Stop the sampler.

9.8 Set the timer to start and stop the sampler at appropriate times. Set the elapsed time meter to zero or record the initial meter reading.

9.9 Record the sample information (site location or identification number, sample date, filter identification number, and sampler model and serial number).

9.10 Sample for 24<plus-minus>1 hours.

9.11 Determine and record the average flow rate (Q<INF>a</INF>) in actual m\3\/min for the sampling period in accordance with the instructions provided in the sampler manufacturer's instruction manual. Record the elapsed time meter final reading and, if needed, the average ambient temperature and barometric pressure for the sampling period (see note following step 9.6).

9.12 Carefully remove the filter from the sampler, following the sampler manufacturer's instruction manual. Touch only the outer edges of the filter.

9.13 Place the filter in a protective holder or container (e.g., petri dish, glassine envelope, or manila folder).

9.14 Record any factors such as meteorological conditions, construction activity, fires or dust storms, etc., that might be pertinent to the measurement on the filter information record.

9.15 Transport the exposed sample filter to the filter conditioning environment as soon as possible for equilibration and subsequent weighing.

9.16 Equilibrate the exposed filter in the conditioning environment for at least 24 hours under the same temperature and humidity conditions used for presampling filter equilibration (see 9.3).

9.17 Immediately after equilibration, reweigh the filter and record the postsampling weight with the filter identification number.

10.0 Sampler Maintenance.

10.1 The PM<INF>10</INF> sampler shall be maintained in strict accordance with the maintenance procedures specified in the sampler manufacturer's instruction manual.

11.0 Calculations.

11.1 Calculate the average flow rate over the sampling period corrected to EPA reference conditions as Q<INF>std.</INF> When the sampler's flow indicator is calibrated in actual volumetric units (Q<INF>a</INF>), Q<INF>std</INF> is calculated as:

Q<INF>std</INF>=Q<INF>a</INF> x (P<INF>av</INF>/
T<INF>av</INF>)(T<INF>std</INF>/P<INF>std</INF>)

where

Q<INF>std</INF> = average flow rate at EPA reference conditions, std m\3\/min;
Q<INF>a</INF> = average flow rate at ambient conditions, m\3\/min;
P<INF>av</INF> = average barometric pressure during the sampling period or average barometric pressure for the sampling site, kPa (or mm Hg);
T<INF>av</INF> = average ambient temperature during the sampling period or seasonal average

ambient temperature for the sampling site, K;
T<INF>std</INF> = standard temperature, defined as 298 K;
P<INF>std</INF> = standard pressure, defined as 101.3 kPa (or 760 mm Hg).

11.2 Calculate the total volume of air sampled as:

V<INF>std</INF> = Q<INF>std</INF> x t

where

V<INF>std</INF> = total air sampled in standard volume units, std m\3\;
t = sampling time, min.

11.3 Calculate the PM<INF>10</INF> concentration as:

PM<INF>10</INF> = (W<INF>f</INF>-W<INF>i</INF>) x 10\6\/V<INF>std</INF>

where

PM<INF>10</INF> = mass concentration of PM<INF>10,</INF> <greek-m>g/std m\3\;
W<INF>f,</INF> W<INF>i</INF> = final and initial weights of filter collecting PM<INF>1O</INF> particles, g;
10\6\ = conversion of g to <greek-m>g.

Note: If more than one size fraction in the PM<INF>10</INF> size range is collected by the sampler, the sum of the net weight gain by each collection filter [<greek-S>(W<INF>f</INF>-W<INF>i</INF>)] is used to calculate the PM<INF>10</INF> mass concentration.

12.0 References.

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Appendix K to Part 50--Interpretation of the National Ambient Air Quality Standards for Particulate Matter

1.0 General.

(a) This appendix explains the computations necessary for analyzing particulate matter data to determine attainment of the 24-hour and annual standards specified in 40 CFR 50.6. For the primary and secondary standards, particulate matter is measured in the ambient air as PM<INF>10</INF> (particles with an aerodynamic diameter less than or equal to a nominal 10 micrometers) by a reference method based on appendix J of this part and designated in accordance with part 53 of this chapter, or by an equivalent method designated in accordance with part 53 of this chapter. The required frequency of measurements is specified in part 58 of this chapter.

(b) The terms used in this appendix are defined as follows:

Average refers to an arithmetic mean. All particulate matter standards are expressed in terms of expected annual values: Expected number of exceedances per year for the 24-hour standards and expected annual arithmetic mean for the annual standards.

Daily value for PM<INF>10</INF> refers to the 24-hour average concentration of PM<INF>10</INF> calculated or measured from midnight to midnight (local time).

Exceedance means a daily value that is above the level of the 24-hour standard after

rounding to the nearest 10 <greek-m>g/m\3\ (i.e., values ending in 5 or greater are to be rounded up).

Expected annual value is the number approached when the annual values from an increasing number of years are averaged, in the absence of long-term trends in emissions or meteorological conditions.

Year refers to a calendar year.

(c) Although the discussion in this appendix focuses on monitored data, the same principles apply to modeling data, subject to EPA modeling guidelines.

2.0 Attainment Determinations.

2.1 24-Hour Primary and Secondary Standards.

(a) Under 40 CFR 50.6(a) the 24-hour primary and secondary standards are attained when the expected number of exceedances per year at each monitoring site is less than or equal to one. In the simplest case, the number of expected exceedances at a site is determined by recording the number of exceedances in each calendar year and then averaging them over the past 3 calendar years. Situations in which 3 years of data are not available and possible adjustments for unusual events or trends are discussed in sections 2.3 and 2.4 of this appendix. Further, when data for a year are incomplete, it is necessary to compute an estimated number of exceedances for that year by adjusting the observed number of exceedances. This procedure, performed by calendar quarter, is described in section 3.0 of this appendix. The expected number of exceedances is then estimated by averaging the individual annual estimates for the past 3 years.

(b) The comparison with the allowable expected exceedance rate of one per year is made in terms of a number rounded to the nearest tenth (fractional values equal to or greater than 0.05 are to be rounded up;

e.g., an exceedance rate of 1.05 would be rounded to 1.1, which is the lowest rate for nonattainment).

2.2 Annual Primary and Secondary Standards. Under 40 CFR 50.6(b), the annual primary and secondary standards are attained when the expected annual arithmetic mean PM<INF>10 </INF>concentration is less than or equal to the level of the standard. In the simplest case, the expected annual arithmetic mean is determined by averaging the annual arithmetic mean PM<INF>10 </INF>concentrations for the past 3 calendar years. Because of the potential for incomplete data and the possible seasonality in PM<INF>10 </INF>concentrations, the annual mean shall be calculated by averaging the four quarterly means of PM<INF>10 </INF>concentrations within the calendar year. The equations for calculating the annual arithmetic mean are given in section 4.0 of this appendix. Situations in which 3 years of data are not available and possible adjustments for unusual events or trends are discussed in sections 2.3 and 2.4 of this appendix. The expected annual arithmetic mean is rounded to the nearest 1 <greek-m>g/m\3\ before comparison with the annual standards (fractional values equal to or greater than 0.5 are to be rounded up).

2.3 Data Requirements.

(a) 40 CFR 58.13 specifies the required minimum frequency of sampling for PM<INF>10</INF>. For the purposes of making comparisons with the particulate matter standards, all data produced by National Air Monitoring Stations (NAMS), State and Local Air Monitoring Stations (SLAMS) and other sites submitted to EPA in accordance with the part 58 requirements must be used, and a minimum of 75 percent of the scheduled PM<INF>10 </INF>samples per quarter are required.

(b) To demonstrate attainment of either the annual or 24-hour standards at a monitoring site, the monitor must provide sufficient data to perform the required calculations of sections 3.0 and 4.0 of this appendix. The amount of data required varies with the sampling frequency, data capture rate and the number of years of record. In all cases, 3 years of representative monitoring data that meet the 75 percent criterion of the previous paragraph should be utilized, if available, and would suffice. More than 3 years may be considered, if all additional representative years of data meeting the 75 percent criterion are utilized. Data not meeting these criteria may also suffice to show attainment; however, such exceptions will have to be approved by the appropriate Regional Administrator in accordance with EPA guidance.

(c) There are less stringent data requirements for showing that a monitor has failed an attainment test and thus has recorded a violation of the particulate matter standards. Although it is generally necessary to meet the minimum 75 percent data capture requirement per quarter to use the computational equations described in sections 3.0 and 4.0 of this appendix, this criterion does not apply when less data is sufficient to unambiguously establish nonattainment. The following examples illustrate how nonattainment can be demonstrated when a site fails to meet the completeness criteria. Nonattainment of the 24-hour primary standards can be established by the observed annual number of exceedances (e.g., four observed exceedances in a single year), or by the estimated number of exceedances derived from the observed number of exceedances and the required number of scheduled samples (e.g., two observed exceedances with every other day sampling). Nonattainment of the annual standards can be demonstrated on the basis of quarterly mean concentrations developed from observed data combined with one-half the minimum detectable concentration substituted for missing values. In both cases, expected annual values must exceed the levels allowed by the

standards.

2.4 Adjustment for Exceptional Events and Trends.

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(a) An exceptional event is an uncontrollable event caused by natural sources of particulate matter or an event that is not expected to recur at a given location. Inclusion of such a value in the computation of exceedances or averages could result in inappropriate estimates of their respective expected annual values. To reduce the effect of unusual events, more than 3 years of representative data may be used. Alternatively, other techniques, such as the use of statistical models or the use of historical data could be considered so that the event may be discounted or weighted according to the likelihood that it will recur. The use of such techniques is subject to the approval of the appropriate Regional Administrator in accordance with EPA guidance.

(b) In cases where long-term trends in emissions and air quality are evident, mathematical techniques should be applied to account for the trends to ensure that the expected annual values are not inappropriately biased by unrepresentative data. In the simplest case, if 3 years of data are available under stable emission conditions, this data should be used. In the event of a trend or shift in emission patterns, either the most recent representative year(s) could be used or statistical techniques or models could be used in conjunction with previous years of data to adjust for trends. The use of less than 3 years of data, and any adjustments are subject to the approval of the appropriate Regional Administrator in accordance with EPA guidance.

3.0 Computational Equations for the 24-hour Standards.

3.1 Estimating Exceedances for a Year.

(a) If PM<INF>10</INF> sampling is scheduled less frequently than every day, or if some scheduled samples are missed, a PM<INF>10</INF> value will not be available for each day of the year. To account for the possible effect of incomplete data, an adjustment must be made to the data collected at each monitoring location to estimate the number of exceedances in a calendar year. In this adjustment, the assumption is made that the fraction of missing values that would have exceeded the standard level is identical to the fraction of measured values above this level. This computation is to be made for all sites that are scheduled to monitor throughout the entire year and meet the minimum data requirements of section 2.3 of this appendix. Because of possible seasonal imbalance, this adjustment shall be applied on a quarterly basis. The estimate of the expected number of exceedances for the quarter is equal to the observed number of exceedances plus an increment associated with the missing data. The following equation must be used for these computations:

Equation 1

[GRAPHIC] [TIFF OMITTED] TR18JY97.180

where:

e<INF>q</INF> = the estimated number of exceedances for calendar quarter q;
v<INF>q</INF> = the observed number of exceedances for calendar quarter q;
N<INF>q</INF> = the number of days in calendar quarter q;
n<INF>q</INF> = the number of days in calendar quarter q with

PM<INF>10</INF> data; and
q = the index for calendar quarter, q=1, 2, 3 or 4.

(b) The estimated number of exceedances for a calendar quarter must be rounded to the nearest hundredth (fractional values equal to or greater than 0.005 must be rounded up).

(c) The estimated number of exceedances for the year, e, is the sum of the estimates for each calendar quarter.

Equation 2

[GRAPHIC] [TIFF OMITTED] TR18JY97.181

(d) The estimated number of exceedances for a single year must be rounded to one decimal place (fractional values equal to or greater than 0.05 are to be rounded up). The expected number of exceedances is then estimated by averaging the individual annual estimates for the most recent 3 or more representative years of data. The expected number of exceedances must be rounded to one decimal place (fractional values equal to or greater than 0.05 are to be rounded up).

(e) The adjustment for incomplete data will not be necessary for monitoring or modeling data which constitutes a complete record, i.e., 365 days per year.

(f) To reduce the potential for overestimating the number of expected exceedances, the correction for missing data will not be required for a calendar quarter in which the first observed exceedance has occurred if:

(1) There was only one exceedance in the calendar quarter;

(2) Everyday sampling is subsequently initiated and maintained for 4 calendar quarters in accordance with 40 CFR 58.13; and

(3) Data capture of 75 percent is achieved during the required period of everyday sampling. In addition, if the first exceedance is observed in a calendar quarter in which the monitor is already sampling every day, no adjustment for missing data will be made to the first exceedance if a 75 percent data capture rate was achieved in the quarter in which it was observed.

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Example 1

a. During a particular calendar quarter, 39 out of a possible 92 samples were recorded, with one observed exceedance of the 24-hour standard. Using Equation 1, the estimated number of exceedances for the quarter is:

e<INF>q</INF>=1 x 92/39=2.359 or 2.36.

b. If the estimated exceedances for the other 3 calendar quarters in the year were 2.30, 0.0 and 0.0, then, using Equation 2, the estimated number of exceedances for the year is 2.36=2.30=0.0=0.0 which equals 4.66 or 4.7. If no exceedances were observed for the 2 previous years, then the expected number of exceedances is estimated by: (1/3) x (4.7=0=0)=1.57 or 1.6. Since 1.6 exceeds the allowable number of expected exceedances, this monitoring site would fail the attainment test.

Example 2

In this example, everyday sampling was initiated following the first observed exceedance as required by 40 CFR 58.13. Accordingly, the first observed exceedance would not be adjusted for incomplete sampling. During the next three quarters, 1.2 exceedances were estimated. In this case, the estimated exceedances for the year would be 1.0=1.2=0.0=0.0 which equals 2.2. If, as before, no exceedances were observed for the two previous years, then the estimated exceedances for the 3-year period would then be (1/3) x (2.2=0.0=0.0)=0.7, and the monitoring site would not fail the attainment test.

3.2 Adjustments for Non-Scheduled Sampling Days.

(a) If a systematic sampling schedule is used and sampling is performed on days in addition to the days specified by the systematic sampling schedule, e.g., during episodes of high pollution, then an adjustment must be made in the eqution for the estimation of exceedances. Such an adjustment is needed to eliminate the bias in the estimate of the quarterly and annual number of exceedances that would occur if the chance of an exceedance is different for scheduled than for non-scheduled days, as would be the case with episode sampling.

(b) The required adjustment treats the systematic sampling schedule as a stratified sampling plan. If the period from one scheduled sample until the day preceding the next scheduled sample is defined as a sampling stratum, then there is one stratum for each scheduled sampling day. An average number of observed exceedances is computed for each of these sampling strata. With nonscheduled sampling days, the estimated number of exceedances is defined as:

Equation 3

[GRAPHIC] [TIFF OMITTED] TR18JY97.182

where:

e<INF>q</INF> = the estimated number of exceedances for the quarter;
N<INF>q</INF> = the number of days in the quarter;
m<INF>q</INF> = the number of strata with samples during the quarter;
v<INF>j</INF> = the number of observed exceedances in stratum j; and
k<INF>j</INF> = the number of actual samples in stratum j.

(c) Note that if only one sample value is recorded in each stratum, then Equation 3 reduces to Equation 1.

Example 3

A monitoring site samples according to a systematic sampling schedule of one sample every 6 days, for a total of 15 scheduled samples in a quarter out of a total of 92 possible samples. During one 6-day period, potential episode levels of PM<INF>10</INF> were suspected, so 5 additional samples were taken. One of the regular scheduled samples was missed, so a total of 19 samples in 14 sampling strata were measured. The one 6-day sampling stratum with 6 samples recorded 2 exceedances. The remainder of the quarter with one sample per stratum recorded zero exceedances. Using Equation 3, the estimated number of exceedances for the quarter is:

e<INF>q</INF>=(92/14) x (2/6=0=. . .=0)=2.19.

4.0 Computational Equations for Annual Standards.

4.1 Calculation of the Annual Arithmetic Mean. (a) An annual arithmetic mean value for PM<INF>10</INF> is determined by averaging the quarterly means for the 4 calendar quarters of the year. The following equation is to be used for calculation of the mean for a calendar quarter:

Equation 4

[GRAPHIC] [TIFF OMITTED] TR18JY97.183

where:

x<INF>q</INF> = the quarterly mean concentration for quarter q, q=1, 2, 3, or 4,
n<INF>q</INF> = the number of samples in the quarter, and
x<INF>i</INF> = the ith concentration value recorded in the quarter.

(b) The quarterly mean, expressed in <greek-m>g/m\3\, must be rounded to the nearest tenth (fractional values of 0.05 should be rounded up).

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(c) The annual mean is calculated by using the following equation:

Equation 5

[GRAPHIC] [TIFF OMITTED] TR18JY97.184

where:

x = the annual mean; and
x<INF>q</INF> = the mean for calendar quarter q.

(d) The average of quarterly means must be rounded to the nearest tenth (fractional values of 0.05 should be rounded up).

(e) The use of quarterly averages to compute the annual average will not be necessary for monitoring or modeling data which results in a complete record, i.e., 365 days per year.

(f) The expected annual mean is estimated as the average of three or more annual means. This multi-year estimate, expressed in <greek-m>g/m\3\, shall be rounded to the nearest integer for comparison with the annual standard (fractional values of 0.5 should be rounded up).

Example 4

Using Equation 4, the quarterly means are calculated for each calendar quarter. If the quarterly means are 52.4, 75.3, 82.1, and 63.2 <greek-m>g/m \3\, then the annual mean is:

x = (1/4) x (52.4=75.3=82.1=63.2) = 68.25 or 68.3.

4.2 Adjustments for Non-scheduled Sampling Days. (a) An adjustment in the calculation of the annual mean is needed if sampling is performed on days in addition to the days specified by the systematic sampling schedule. For the same reasons given in the discussion of estimated exceedances, under section 3.2 of this appendix, the quarterly averages would be calculated by using the following equation:

Equation 6

[GRAPHIC] [TIFF OMITTED] TR18JY97.185

where:

x<INF>q</INF> = the quarterly mean concentration for quarter q, q=1, 2, 3, or 4;
x<INF>ij</INF> = the ith concentration value recorded in stratum j;
k<INF>j</INF> = the number of actual samples in stratum j; and
m<INF>q</INF> = the number of strata with data in the quarter.

(b) If one sample value is recorded in each stratum, Equation 6 reduces to a simple arithmetic average of the observed values as described by Equation 4.

Example 5

a. During one calendar quarter, 9 observations were recorded. These samples were distributed among 7 sampling strata, with 3 observations in one stratum. The concentrations of the 3 observations in the single stratum were 202, 242, and 180 <greek-m>g/m\3\. The remaining 6 observed concentrations were 55, 68, 73, 92, 120, and 155 <greek-m>g/m\3\. Applying the weighting factors specified in Equation 6, the quarterly mean is:

x<INF>q</INF> = (1/7) x [(1/3) x (202 = 242 = 180) = 155 = 68 = 73 = 92 = 120 = 155] = 110.1

b. Although 24-hour measurements are rounded to the nearest 10 <greek-m>g/m\3\ for determinations of exceedances of the 24-hour standard, note that these values are rounded to the nearest 1 <greek-m>g/m\3\ for the calculation of means.

[62 FR 38712, July 18, 1997]

Appendix L to Part 50--Reference Method for the Determination of Fine Particulate Matter as PM<INF>2.5</INF> in the Atmosphere

1.0 Applicability.

1.1 This method provides for the measurement of the mass concentration of fine particulate matter having an aerodynamic diameter less than or equal to a nominal 2.5 micrometers (PM<INF>2.5</INF>) in ambient air over a 24-hour period for purposes of determining whether the primary and secondary national ambient air quality standards for fine particulate matter specified in Sec. 50.7 of this part are met. The measurement process is considered to be nondestructive, and the PM<INF>2.5</INF> sample obtained can be subjected to subsequent physical or chemical analyses. Quality assessment procedures are provided in part 58, appendix A of this chapter, and quality assurance guidance are provided in references 1, 2, and 3 in section 13.0 of this appendix.

1.2 This method will be considered a reference method for purposes of part 58 of this chapter only if:

(a) The associated sampler meets the requirements specified in this appendix and the applicable requirements in part 53 of this chapter, and

(b) The method and associated sampler have been designated as a reference method in accordance with part 53 of this chapter.

1.3 PM<INF>2.5</INF> samplers that meet nearly all specifications

set forth in this method but have minor deviations and/or modifications of the reference method sampler will be designated as ``Class I'' equivalent methods for PM<INF>2.5</INF> in accordance with part 53 of this chapter.

2.0 Principle.

2.1 An electrically powered air sampler draws ambient air at a constant volumetric flow rate into a specially shaped inlet and

through an inertial particle size separator (impactor) where the suspended particulate matter in the PM<INF>2.5</INF> size range is separated for collection on a polytetrafluoroethylene (PTFE) filter over the specified sampling period. The air sampler and other aspects of this reference method are specified either explicitly in this appendix or generally with reference to other applicable regulations or quality assurance guidance.

2.2 Each filter is weighed (after moisture and temperature conditioning) before and after sample collection to determine the net gain due to collected PM<INF>2.5</INF>. The total volume of air sampled is determined by the sampler from the measured flow rate at actual ambient temperature and pressure and the sampling time. The mass concentration of PM<INF>2.5</INF> in the ambient air is computed as the total mass of collected particles in the PM<INF>2.5</INF> size range divided by the actual volume of air sampled, and is expressed in micrograms per cubic meter of air (<greek-m>g/m³).

3.0 PM<INF>2.5</INF> Measurement Range.

3.1 Lower concentration limit. The lower detection limit of the mass concentration measurement range is estimated to be approximately 2 <greek-m>g/m³, based on noted mass changes in field blanks in conjunction with the 24 m³ nominal total air sample volume specified for the 24-hour sample.

3.2 Upper concentration limit. The upper limit of the mass concentration range is determined by the filter mass loading beyond which the sampler can no longer maintain the operating flow rate within specified limits due to increased pressure drop across the loaded filter. This upper limit cannot be specified precisely because it is a complex function of the ambient particle size distribution and type, humidity, the individual filter used, the capacity of the sampler flow rate control system, and perhaps other factors. Nevertheless, all samplers are estimated to be capable of measuring 24-hour PM<INF>2.5</INF> mass concentrations of at least 200 <greek-m>g/m³ while maintaining the operating flow rate within the specified limits.

3.3 Sample period. The required sample period for PM<INF>2.5</INF> concentration measurements by this method shall be 1,380 to 1500 minutes (23 to 25 hours). However, when a sample period is less than 1,380 minutes, the measured concentration (as determined by the collected PM<INF>2.5</INF> mass divided by the actual sampled air volume), multiplied by the actual number of minutes in the sample period and divided by 1,440, may be used as if it were a valid concentration measurement for the specific purpose of determining a violation of the NAAQS. This value assumes that the PM<INF>2.5</INF> concentration is zero for the remaining portion of the sample period and therefore represents the minimum concentration that could have been measured for the full 24-hour sample period. Accordingly, if the value thus calculated is high enough to be an exceedance, such an exceedance would

be a valid exceedance for the sample period. When reported to AIRS, this data value should receive a special code to identify it as not to be commingled with normal concentration measurements or used for other purposes.

4.0 Accuracy.

4.1 Because the size and volatility of the particles making up ambient particulate matter vary over a wide range and the mass concentration of particles varies with particle size, it is difficult to define the accuracy of PM<INF>2.5</INF> measurements in an absolute sense. The accuracy of PM<INF>2.5</INF> measurements is therefore defined in a relative sense, referenced to measurements provided by this reference method. Accordingly, accuracy shall be defined as the degree of agreement between a subject field PM<INF>2.5</INF> sampler and a collocated PM<INF>2.5</INF> reference method audit sampler operating simultaneously at the monitoring site location of the subject sampler and includes both random (precision) and systematic (bias) errors. The requirements for this field sampler audit procedure are set forth in part 58, appendix A of this chapter.

4.2 Measurement system bias. Results of collocated measurements where the duplicate sampler is a reference method sampler are used to assess a portion of the measurement system bias according to the schedule and procedure specified in part 58, appendix A of this chapter.

4.3 Audits with reference method samplers to determine system accuracy and bias. According to the schedule and procedure specified in part 58, appendix A of this chapter, a reference method sampler is required to be located at each of selected PM<INF>2.5</INF> SLAMS sites as a duplicate sampler. The results from the primary sampler and the duplicate reference method sampler are used to calculate accuracy of the primary sampler on a quarterly basis, bias of the primary sampler on an annual basis, and bias of a single reporting organization on an annual basis. Reference 2 in section 13.0 of this appendix provides additional information and guidance on these reference method audits.

4.4 Flow rate accuracy and bias. Part 58, appendix A of this chapter requires that the flow rate accuracy and bias of individual PM<INF>2.5</INF> samplers used in SLAMS monitoring networks be assessed periodically via audits of each sampler's operational flow rate. In addition, part 58, appendix A of this chapter requires that flow rate bias for each reference and equivalent method operated by each reporting organization be assessed quarterly and annually. Reference 2 in section 13.0 of this appendix provides additional information and guidance on flow rate accuracy audits and calculations for accuracy and bias.

5.0 Precision. A data quality objective of 10 percent coefficient of variation or better has

been established for the operational precision of PM<INF>2.5</INF> monitoring data.

5.1 Tests to establish initial operational precision for each reference method sampler are specified as a part of the requirements for designation as a reference method under Sec. 53.58 of this chapter.

5.2 Measurement System Precision. Collocated sampler results, where the duplicate sampler is not a reference method sampler but is a sampler of the same designated method as the primary sampler, are used to assess measurement system precision according to the schedule and procedure specified in part 58, appendix A of this chapter. Part 58, appendix A of this chapter requires that these collocated sampler measurements be used

to calculate quarterly and annual precision estimates for each primary sampler and for each designated method employed by each reporting organization. Reference 2 in section 13.0 of this appendix provides additional information and guidance on this requirement.

6.0 Filter for PM<INF>2.5</INF> Sample Collection. Any filter manufacturer or vendor who sells or offers to sell filters specifically identified for use with this PM<INF>2.5</INF> reference method shall certify that the required number of filters from each lot of filters offered for sale as such have been tested as specified in this section 6.0 and meet all of the following design and performance specifications.

6.1 Size. Circular, 46.2 mm diameter <plus-minus>0.25 mm.

6.2 Medium. Polytetrafluoroethylene (PTFE Teflon), with integral support ring.

6.3 Support ring. Polymethylpentene (PMP) or equivalent inert material, 0.38 <plus-minus>0.04 mm thick, outer diameter 46.2 mm <plus-minus>0.25 mm, and width of 3.68 mm (<plus-minus>0.00, -0.51 mm).

6.4 Pore size. 2 <greek-m>m as measured by ASTM F 316-94.

6.5 Filter thickness. 30 to 50 <greek-m>m.

6.6 Maximum pressure drop (clean filter). 30 cm H<INF>2</INF>O column @ 16.67 L/min clean air flow.

6.7 Maximum moisture pickup. Not more than 10 <greek-m>g weight increase after 24-hour exposure to air of 40 percent relative humidity, relative to weight after 24-hour exposure to air of 35 percent relative humidity.

6.8 Collection efficiency. Greater than 99.7 percent, as measured by the DOP test (ASTM D 2986-91) with 0.3 <greek-m>m particles at the sampler's operating face velocity.

6.9 Filter weight stability. Filter weight loss shall be less than 20 <greek-m>g, as measured in each of the following two tests specified in sections 6.9.1 and 6.9.2 of this appendix. The following conditions apply to both of these tests: Filter weight loss shall be the average difference between the initial and the final filter weights of a random sample of test filters selected from each lot prior to sale. The number of filters tested shall be not less than 0.1 percent of the filters of each manufacturing lot, or 10 filters, whichever is greater. The filters shall be weighed under laboratory conditions and shall have had no air sample passed through them, i.e., filter blanks. Each test procedure must include initial conditioning and weighing, the test, and final conditioning and weighing. Conditioning and weighing shall be in accordance with sections 8.0 through 8.2 of this appendix and general guidance provided in reference 2 of section 13.0 of this appendix.

6.9.1 Test for loose, surface particle contamination. After the initial weighing, install each test filter, in turn, in a filter cassette (Figures L-27, L-28, and L-29 of this appendix) and drop the cassette from a height of 25 cm to a flat hard surface, such as a particle-free wood bench. Repeat two times, for a total of three drop tests for each test filter. Remove the test filter from the cassette and weigh the filter. The average change in weight must be less than 20 <greek-m>g.

6.9.2 Test for temperature stability. After weighing each filter, place the test filters in a drying oven set at 40 deg.C <plus-minus>2 deg.C for not less than 48 hours. Remove, condition, and reweigh each test filter. The average change in weight must be less than 20 <greek-m>g.

6.10 Alkalinity. Less than 25 microequivalents/gram of filter, as measured by the guidance given in reference 2 in section 13.0 of this appendix.

6.11 Supplemental requirements. Although not required for determination of PM<INF>2.5</INF> mass concentration under this reference method, additional specifications for the filter must be developed by users who intend to subject PM<INF>2.5</INF> filter samples to subsequent chemical analysis. These supplemental specifications include background chemical contamination of the filter and any other filter parameters that may be required by the method of chemical analysis. All such supplemental filter specifications must be compatible with and secondary to the primary filter specifications given in this section 6.0 of this appendix.

7.0 PM<INF>2.5</INF> Sampler.

7.1 Configuration. The sampler shall consist of a sample air inlet, downtube, particle size separator (impactor), filter holder assembly, air pump and flow rate control system, flow rate measurement device, ambient and filter temperature monitoring system, barometric pressure measurement system, timer, outdoor environmental enclosure, and suitable mechanical, electrical, or electronic control capability to meet or exceed the design and functional performance as specified in this section 7.0 of this appendix. The performance specifications require that the sampler:

(a) Provide automatic control of sample volumetric flow rate and other operational parameters.

(b) Monitor these operational parameters as well as ambient temperature and pressure.

(c) Provide this information to the sampler operator at the end of each sample period in

digital form, as specified in table L-1 of section 7.4.19 of this appendix.

7.2 Nature of specifications. The PM<INF>2.5</INF> sampler is specified by a combination of design and performance requirements. The sample inlet, downtube, particle size discriminator, filter cassette, and the internal configuration of the filter holder assembly are specified explicitly by design figures and associated mechanical dimensions, tolerances, materials, surface finishes, assembly instructions, and other necessary specifications. All other aspects of the sampler are specified by required operational function and performance, and the design of these other aspects (including the design of the lower portion of the filter holder assembly) is optional, subject to acceptable operational performance. Test procedures to demonstrate compliance with both the design and performance requirements are set forth in subpart E of part 53 of this chapter.

7.3 Design specifications. Except as indicated in this section 7.3 of this appendix, these components must be manufactured or reproduced exactly as specified, in an ISO 9001-registered facility, with registration initially approved and subsequently maintained during the period of manufacture. See Sec. 53.1(t) of this chapter for the definition of an ISO-registered facility. Minor modifications or variances to one or more components that clearly would not affect the aerodynamic performance of the inlet, downtube, impactor, or filter cassette will be considered for specific approval. Any such proposed modifications shall be described and submitted to the EPA for specific individual acceptability either as part of a reference or equivalent method application under part 53 of this chapter or in writing in advance of such an intended application under part 53 of this chapter.

7.3.1 Sample inlet assembly. The sample inlet assembly, consisting of the inlet, downtube, and impactor shall be configured and assembled as indicated in Figure L-1 of this appendix and shall meet all associated requirements. A portion of this assembly shall also be subject to the maximum overall sampler leak rate specification under section 7.4.6 of this appendix.

7.3.2 Inlet. The sample inlet shall be fabricated as indicated in Figures L-2 through L-18 of this appendix and shall meet all associated requirements.

7.3.3 Downtube. The downtube shall be fabricated as indicated in Figure L-19 of this appendix and shall meet all associated requirements.

7.3.4 Impactor.

7.3.4.1 The impactor (particle size separator) shall be fabricated as indicated in Figures L-20 through L-24 of this appendix and shall meet all associated requirements. Following the manufacture and finishing of each upper impactor housing (Figure L-21 of this appendix), the dimension of the impaction jet must be verified by the manufacturer using Class ZZ go/no-go plug gauges that are traceable to NIST.

7.3.4.2 Impactor filter specifications:

(a) Size. Circular, 35 to 37 mm diameter.

(b) Medium. Borosilicate glass fiber, without binder.

(c) Pore size. 1 to 1.5 micrometer, as measured by ASTM F 316-80.

(d) Thickness. 300 to 500 micrometers.

7.3.4.3 Impactor oil specifications:

(a) Composition. Tetramethyltetraphenyltrisiloxane, single-compound diffusion oil.

(b) Vapor pressure. Maximum 2 x 10⁻⁸ mm Hg at 25 deg.C.

(c) Viscosity. 36 to 40 centistokes at 25 deg.C.

(d) Density. 1.06 to 1.07 g/cm³ at 25 deg.C.

(e) Quantity. 1 mL <plus-minus>0.1 mL.

7.3.5 Filter holder assembly. The sampler shall have a sample filter holder assembly to adapt and seal to the down tube and to hold and seal the specified filter, under section 6.0 of this appendix, in the sample air stream in a horizontal position below the downtube such that the sample air passes downward through the filter at a uniform face velocity. The upper portion of this assembly shall be fabricated as indicated in Figures L-25 and L-26 of this appendix and shall accept and seal with the filter cassette, which shall be fabricated as indicated in Figures L-27 through L-29 of this appendix.

(a) The lower portion of the filter holder assembly shall be of a design and construction that:

(1) Mates with the upper portion of the assembly to complete the filter holder assembly,

(2) Completes both the external air seal and the internal filter cassette seal such that all seals are reliable over repeated filter changings, and

(3) Facilitates repeated changing of the filter cassette by the sampler operator.

(b) Leak-test performance requirements for the filter holder assembly are included in section 7.4.6 of this appendix.

(c) If additional or multiple filters are stored in the sampler as part of an automatic sequential sample capability, all such filters, unless they are currently and directly installed in a sampling channel or sampling configuration (either active or inactive), shall be covered or (preferably) sealed in such a way as to:

(1) Preclude significant exposure of the filter to possible contamination or accumulation of dust, insects, or other material that

may be present in the ambient air, sampler, or sampler ventilation air during storage periods either before or after sampling; and

(2) To minimize loss of volatile or semi-volatile PM sample components during storage of the filter following the sample period.

7.3.6 Flow rate measurement adapter. A flow rate measurement adapter as specified in

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Figure L-30 of this appendix shall be furnished with each sampler.

7.3.7 Surface finish. All internal surfaces exposed to sample air prior to the filter shall be treated electrolytically in a sulfuric acid bath to produce a clear, uniform anodized surface finish of not less than 1000 mg/ft² (1.08 mg/cm²) in accordance with military standard specification (mil. spec.) 8625F, Type II, Class 1 in reference 4 of section 13.0 of this appendix. This anodic surface coating shall not be dyed or pigmented. Following anodization, the surfaces shall be sealed by immersion in boiling deionized water for not less than 15 minutes. Section 53.51(d)(2) of this chapter should also be consulted.

7.3.8 Sampling height. The sampler shall be equipped with legs, a stand, or other means to maintain the sampler in a stable, upright position and such that the center of the sample air entrance to the inlet, during sample collection, is maintained in a horizontal plane and is 2.0 <plus-minus>0.2 meters above the floor or other horizontal supporting surface. Suitable bolt holes, brackets, tie-downs, or other means should be provided to facilitate mechanically securing the sample to the supporting surface to prevent toppling of the sampler due to wind.

7.4 Performance specifications.

7.4.1 Sample flow rate. Proper operation of the impactor requires that specific air velocities be maintained through the device. Therefore, the design sample air flow rate through the inlet shall be 16.67 L/min (1.000 m³/hour) measured as actual volumetric flow rate at the temperature and pressure of the sample air entering the inlet.

7.4.2 Sample air flow rate control system. The sampler shall have a sample air flow rate control system which shall be capable of providing a sample air volumetric flow rate within the specified range, under section 7.4.1 of this appendix, for the specified filter, under section 6.0 of this appendix, at any atmospheric conditions specified, under section 7.4.7 of this appendix, at a filter pressure drop equal to that of a clean filter plus up to 75 cm water column (55 mm Hg), and over the specified range of supply line voltage, under section 7.4.15.1 of this appendix. This flow control system shall allow for operator adjustment of the operational flow rate of the sampler over a range of at least <plus-minus>15 percent of the flow rate specified in section 7.4.1 of this appendix.

7.4.3 Sample flow rate regulation. The sample flow rate shall be regulated such that for the specified filter, under section 6.0 of this appendix, at any atmospheric conditions specified, under section 7.4.7 of this appendix, at a filter pressure drop equal to that of a clean filter plus up to 75 cm water column (55 mm Hg), and over the specified range of supply line voltage, under section 7.4.15.1 of this appendix, the flow rate is regulated as follows:

7.4.3.1 The volumetric flow rate, measured or averaged over intervals of not more than 5 minutes over a 24-hour period, shall not

vary more than <plus-minus>5 percent from the specified 16.67 L/min flow rate over the entire sample period.

7.4.3.2 The coefficient of variation (sample standard deviation divided by the mean) of the flow rate, measured over a 24-hour period, shall not be greater than 2 percent.

7.4.3.3 The amplitude of short-term flow rate pulsations, such as may originate from some types of vacuum pumps, shall be attenuated such that they do not cause significant flow measurement error or affect the collection of particles on the particle collection filter.

7.4.4 Flow rate cut off. The sampler's sample air flow rate control system shall terminate sample collection and stop all sample flow for the remainder of the sample period in the event that the sample flow rate deviates by more than 10 percent from the sampler design flow rate specified in section 7.4.1 of this appendix for more than 60 seconds. However, this sampler cut-off provision shall not apply during periods when the sampler is inoperative due to a temporary power interruption, and the elapsed time of the inoperative period shall not be included in the total sample time measured and reported by the sampler, under section 7.4.13 of this appendix.

7.4.5 Flow rate measurement.

7.4.5.1 The sampler shall provide a means to measure and indicate the instantaneous sample air flow rate, which shall be measured as volumetric flow rate at the temperature and pressure of the sample air entering the inlet, with an accuracy of <plus-minus>2 percent. The measured flow rate shall be available for display to the sampler operator at any time in either sampling or standby modes, and the measurement shall be updated at least every 30 seconds. The sampler shall also provide a simple means by which the sampler operator can manually start the sample flow temporarily during non-sampling modes of operation, for the purpose of checking the sample flow rate or the flow rate measurement system.

7.4.5.2 During each sample period, the sampler's flow rate measurement system shall automatically monitor the sample volumetric flow rate, obtaining flow rate measurements at intervals of not greater than 30 seconds.

(a) Using these interval flow rate measurements, the sampler shall determine or calculate the following flow-related parameters, scaled in the specified engineering units:

(1) The instantaneous or interval-average flow rate, in L/min.

(2) The value of the average sample flow rate for the sample period, in L/min.

(3) The value of the coefficient of variation (sample standard deviation divided by the

average) of the sample flow rate for the sample period, in percent.

(4) The occurrence of any time interval during the sample period in which the measured sample flow rate exceeds a range of <plus-minus>5 percent of the average flow rate for the sample period for more than 5 minutes, in which case a warning flag indicator shall be set.

(5) The value of the integrated total sample volume for the sample period, in m³.

(b) Determination or calculation of these values shall properly exclude periods when the sampler is inoperative due to temporary interruption of electrical power, under section 7.4.13 of this appendix, or flow rate cut off, under section 7.4.4 of this appendix.

(c) These parameters shall be accessible to the sampler operator as specified in table L-1 of section 7.4.19 of this appendix. In addition, it is strongly encouraged that the flow rate for each 5-minute interval during the sample period be available to the operator following the end of the sample period.

7.4.6 Leak test capability.

7.4.6.1 External leakage. The sampler shall include an external air leak-test capability consisting of components, accessory hardware, operator interface controls, a written procedure in the associated Operation/Instruction Manual, under section 7.4.18 of this appendix, and all other necessary functional capability to permit and facilitate the sampler operator to conveniently carry out a leak test of the sampler at a field monitoring site without additional equipment. The sampler components to be subjected to this leak test include all components and their interconnections in which external air leakage would or could cause an error in the sampler's measurement of the total volume of sample air that passes through the sample filter.

(a) The suggested technique for the operator to use for this leak test is as follows:

(1) Remove the sampler inlet and installs the flow rate measurement adapter supplied with the sampler, under section 7.3.6 of this appendix.

(2) Close the valve on the flow rate measurement adapter and use the sampler air pump to draw a partial vacuum in the sampler, including (at least) the impactor, filter holder assembly (filter in place), flow measurement device, and interconnections between these devices, of at least 55 mm Hg (75 cm water column), measured at a location downstream of the filter holder assembly.

(3) Plug the flow system downstream of these components to isolate the components under vacuum from the pump, such as with a built-in valve.

(4) Stop the pump.

(5) Measure the trapped vacuum in the sampler with a built-in pressure measuring device.

(6) (i) Measure the vacuum in the sampler with the built-in pressure measuring device again at a later time at least 10 minutes after the first pressure measurement.

(ii) Caution: Following completion of the test, the adaptor valve should be opened slowly to limit the flow rate of air into the sampler. Excessive air flow rate may blow oil out of the impactor.

(7) Upon completion of the test, open the adaptor valve, remove the adaptor and plugs, and restore the sampler to the normal operating configuration.

(b) The associated leak test procedure shall require that for successful passage of this test, the difference between the two pressure measurements shall not be greater than the number of mm of Hg specified for the sampler by the manufacturer, based on the actual internal volume of the sampler, that indicates a leak of less than 80 mL/min.

(c) Variations of the suggested technique or an alternative external leak test technique may be required for samplers whose design or configuration would make the suggested technique impossible or impractical. The specific proposed external leak test procedure, or particularly an alternative leak test technique, proposed for a particular candidate sampler may be described and submitted to the EPA for specific individual acceptability either as part of a reference or equivalent method application under part 53 of this chapter or in writing in advance of such an intended application under part 53 of this chapter.

7.4.6.2 Internal, filter bypass leakage. The sampler shall include an internal, filter bypass leak-check capability consisting of components, accessory hardware, operator interface controls, a written procedure in the Operation/Instruction Manual, and all other necessary functional capability to permit and facilitate the sampler operator to conveniently carry out a test for internal filter bypass leakage in the sampler at a field monitoring site without additional equipment. The purpose of the test is to determine that any portion of the sample flow rate that leaks past the sample filter without passing through the filter is insignificant relative to the design flow rate for the sampler.

(a) The suggested technique for the operator to use for this leak test is as follows:

(1) Carry out an external leak test as provided under section 7.4.6.1 of this appendix which indicates successful passage of the prescribed external leak test.

(2) Install a flow-impervious membrane material in the filter cassette, either with or without a filter, as appropriate, which effectively prevents air flow through the filter.

(3) Use the sampler air pump to draw a partial vacuum in the sampler, downstream of the filter holder assembly, of at least 55 mm Hg (75 cm water column).

(4) Plug the flow system downstream of the filter holder to isolate the components under

vacuum from the pump, such as with a built-in valve.

(5) Stop the pump.

(6) Measure the trapped vacuum in the sampler with a built-in pressure measuring device.

(7) Measure the vacuum in the sampler with the built-in pressure measuring device again at a later time at least 10 minutes after the first pressure measurement.

(8) Remove the flow plug and membrane and restore the sampler to the normal operating configuration.

(b) The associated leak test procedure shall require that for successful passage of this test, the difference between the two pressure measurements shall not be greater than the number of mm of Hg specified for the sampler by the manufacturer, based on the actual internal volume of the portion of the sampler under vacuum, that indicates a leak of less than 80 mL/min.

(c) Variations of the suggested technique or an alternative internal, filter bypass leak test technique may be required for samplers whose design or configuration would make the suggested technique impossible or impractical. The specific proposed internal leak test procedure, or particularly an alternative internal leak test technique proposed for a particular candidate sampler may be described and submitted to the EPA for specific individual acceptability either as part of a reference or equivalent method application under part 53 of this chapter or in writing in advance of such intended application under part 53 of this chapter.

7.4.7 Range of operational conditions. The sampler is required to operate properly and meet all requirements specified in this appendix over the following operational ranges.

7.4.7.1 Ambient temperature. -30 to =45 deg.C (Note: Although for practical reasons, the temperature range over which samplers are

required to be tested under part 53 of this chapter is -20 to =40 deg.C, the sampler shall be designed to operate properly over this wider temperature range.).

7.4.7.2 Ambient relative humidity. 0 to 100 percent.

7.4.7.3 Barometric pressure range. 600 to 800 mm Hg.

7.4.8 Ambient temperature sensor. The sampler shall have capability to measure the temperature of the ambient air surrounding the sampler over the range of -30 to =45 deg.C, with a resolution of 0.1 deg.C and accuracy of <plus-minus>2.0 deg.C, referenced as described in reference 3 in section 13.0 of this appendix, with and without maximum solar insolation.

7.4.8.1 The ambient temperature sensor shall be mounted external to the sampler enclosure and shall have a passive, naturally ventilated sun shield. The sensor shall be located such that the entire sun shield is at least 5 cm above the horizontal plane of the sampler case or enclosure (disregarding the inlet and downtube) and external to the vertical plane of the nearest side or protuberance of the sampler case or enclosure. The maximum temperature measurement error of the ambient temperature measurement system shall be less than 1.6 deg.C at 1 m/s wind speed and 1000 W/m2 solar radiation intensity.

7.4.8.2 The ambient temperature sensor shall be of such a design and mounted in such a way as to facilitate its convenient dismounting and immersion in a liquid for calibration and comparison to the filter temperature sensor, under section 7.4.11 of this appendix.

7.4.8.3 This ambient temperature measurement shall be updated at least every 30 seconds during both sampling and standby (non-sampling) modes of operation. A visual indication of the current (most recent) value of the ambient temperature measurement, updated at least every 30 seconds, shall be available to the sampler operator during both sampling and standby (non-sampling) modes of operation, as specified in table L-1 of section 7.4.19 of this appendix.

7.4.8.4 This ambient temperature measurement shall be used for the purpose of monitoring filter temperature deviation from ambient temperature, as required by section 7.4.11 of this appendix, and may be used for purposes of effecting filter temperature control, under section 7.4.10 of this appendix, or computation of volumetric flow rate, under sections 7.4.1 to 7.4.5 of this appendix, if appropriate.

7.4.8.5 Following the end of each sample period, the sampler shall report the maximum, minimum, and average temperature for the sample period, as specified in table L-1 of section 7.4.19 of this appendix.

7.4.9 Ambient barometric sensor. The sampler shall have capability to measure the barometric pressure of the air surrounding the sampler over a range of 600 to 800 mm Hg referenced as described in reference 3 in section 13.0 of this appendix; also see part 53, subpart E of this chapter. This barometric pressure measurement shall have a resolution of 5 mm Hg and an accuracy of <plus-minus>10 mm Hg and shall be updated at least every 30 seconds. A visual indication of the value of the current (most recent) barometric pressure measurement, updated at least every 30 seconds, shall be available to the sampler operator during both sampling and standby (non-sampling) modes of operation, as specified in table L-1 of section 7.4.19 of this appendix. This barometric pressure measurement may be used for purposes of computation of volumetric flow rate, under sections 7.4.1 to 7.4.5 of this appendix, if appropriate. Following the end of a sample period, the sampler shall report the maximum, minimum, and mean barometric pressures for the sample period, as specified in table L-1 of section 7.4.19 of this appendix.

7.4.10 Filter temperature control (sampling and post-sampling). The sampler shall provide a means to limit the temperature rise of the sample filter (all sample filters for sequential samplers), from insolation and other sources, to no more 5 deg.C above the temperature of the ambient air surrounding the sampler, during both sampling and post-sampling periods of operation. The post-sampling period is the non-sampling period between the end of the active sampling period and the time of retrieval of the sample filter by the sampler operator.

7.4.11 Filter temperature sensor(s).

7.4.11.1 The sampler shall have the capability to monitor the temperature of the sample filter (all sample filters for sequential samplers) over the range of -30 to =45 deg.C during both sampling and non-sampling periods. While the exact location of this temperature sensor is not explicitly specified, the filter temperature measurement system must demonstrate agreement, within 1 deg.C, with a test temperature sensor located within 1 cm of the center of the filter downstream of the filter during both sampling and non-sampling modes, as specified in the filter temperature measurement test described in part 53, subpart E of this chapter. This filter temperature measurement shall have a resolution of 0.1 deg.C and accuracy of <plus-minus>1.0 deg.C, referenced as described in reference 3 in section 13.0 of this appendix. This temperature sensor shall be of such a design and mounted in such a way as to facilitate its reasonably convenient dismounting and immersion in a liquid for calibration and comparison to the ambient temperature sensor under section 7.4.8 of this appendix.

7.4.11.2 The filter temperature measurement shall be updated at least every 30 seconds during both sampling and standby (non-sampling) modes of operation. A visual indication of the current (most recent) value of the filter temperature measurement, updated at least every 30 seconds, shall be available to the sampler operator during both sampling and standby (non-sampling) modes of operation, as specified in table L-1 of section 7.4.19 of this appendix.

7.4.11.3 For sequential samplers, the temperature of each filter shall be measured individually unless it can be shown, as specified in the filter temperature measurement test described in Sec. 53.57 of this chapter, that the temperature of each filter can be represented by fewer temperature sensors.

7.4.11.4 The sampler shall also provide a warning flag indicator following any occurrence in which the filter temperature (any filter temperature for sequential samplers) exceeds the ambient temperature by more than 5 deg.C for more than 30 consecutive minutes during either the sampling or post-sampling periods of operation, as specified in table L-1 of section 7.4.19 of this appendix, under section 10.12 of this appendix, regarding sample validity when a warning flag occurs. It is further recommended (not required) that the sampler be capable of recording the maximum differential between the measured filter temperature and the ambient temperature and its time and date of occurrence during both sampling and post-sampling (non-sampling) modes of operation and providing for those data to be accessible to the sampler operator following the end of the sample period, as suggested in table L-1 of section 7.4.19 of this appendix.

7.4.12 Clock/timer system.

(a) The sampler shall have a programmable real-time clock timing/control system that:

(1) Is capable of maintaining local time and date, including year,

month, day-of-month, hour, minute, and second to an accuracy of <plus-minus>1.0 minute per month.

(2) Provides a visual indication of the current system time, including year, month, day-of-month, hour, and minute, updated at least each minute, for operator verification.

(3) Provides appropriate operator controls for setting the correct local time and date.

(4) Is capable of starting the sample collection period and sample air flow at a specific, operator-settable time and date, and stopping the sample air flow and terminating the sampler collection period 24 hours (1440 minutes) later, or at a specific, operator-settable time and date.

(b) These start and stop times shall be readily settable by the sampler operator to within <plus-minus>1.0 minute. The system shall provide a visual indication of the current start and stop time settings, readable to <plus-minus>1.0 minute, for verification by the operator, and the start and stop times shall also be available via the data output port, as specified in table L-1 of section 7.4.19 of this appendix. Upon execution of a programmed sample period start, the sampler shall automatically reset all sample period information and warning flag indications pertaining to a previous sample period. Refer also to section 7.4.15.4 of this appendix regarding retention of current date and time and programmed start and stop times during a temporary electrical power interruption.

7.4.13 Sample time determination. The sampler shall be capable of determining the elapsed sample collection time for each PM<INF>2.5</INF> sample, accurate to within <plus-minus>1.0 minute, measured as the time between the start of the sampling period, under section 7.4.12 of this appendix and the termination of the sample period, under section 7.4.12 of this appendix or section 7.4.4 of this appendix. This elapsed sample time shall not include periods when the sampler is inoperative due to a temporary interruption of electrical power, under section 7.4.15.4 of this appendix. In the event that the elapsed sample time determined for the sample period is not within the

range specified for the required sample period in section 3.3 of this appendix, the sampler shall set a warning flag indicator. The date and time of the start of the sample period, the value of the elapsed sample time for the sample period, and the flag indicator status shall be available to the sampler operator following the end of the sample period, as specified in table L-1 of section 7.4.19 of this appendix.

7.4.14 Outdoor environmental enclosure. The sampler shall have an outdoor enclosure (or enclosures) suitable to protect the filter and other non-weatherproof components of the sampler from precipitation, wind, dust, extremes of temperature and humidity; to help maintain temperature control of the filter (or filters, for sequential samplers); and to provide reasonable security for sampler components and settings.

7.4.15 Electrical power supply.

7.4.15.1 The sampler shall be operable and function as specified herein when operated on an electrical power supply voltage of 105 to 125 volts AC (RMS) at a frequency of 59 to 61 Hz. Optional operation as specified at additional power supply voltages and/or frequencies shall not be precluded by this requirement.

7.4.15.2 The design and construction of the sampler shall comply with all applicable National Electrical Code and Underwriters

Laboratories electrical safety requirements.

7.4.15.3 The design of all electrical and electronic controls shall be such as to provide reasonable resistance to interference or malfunction from ordinary or typical levels of stray electromagnetic fields (EMF) as may be found at various monitoring sites and from typical levels of electrical transients or electronic noise as may often or occasionally be present on various electrical power lines.

7.4.15.4 In the event of temporary loss of electrical supply power to the sampler, the sampler shall not be required to sample or provide other specified functions during such loss of power, except that the internal clock/timer system shall maintain its local time and date setting within <plus-minus>1 minute per week, and the sampler shall retain all other time and programmable settings and all data required to be available to the sampler operator following each sample period for at least 7 days without electrical supply power. When electrical power is absent at the operator-set time for starting a sample period or is interrupted during a sample period, the sampler shall automatically start or resume sampling when electrical power is restored, if such restoration of power occurs before the operator-set stop time for the sample period.

7.4.15.5 The sampler shall have the capability to record and retain a record of the year, month, day-of-month, hour, and minute of the start of each power interruption of more than 1 minute duration, up to 10 such power interruptions per sample period. (More than 10 such power interruptions shall invalidate the sample, except where an exceedance is measured, under section 3.3 of this appendix.) The sampler shall provide for these power interruption data to be available to the sampler operator following the end of the sample period, as specified in table L-1 of section 7.4.19 of this appendix.

7.4.16 Control devices and operator interface. The sampler shall have mechanical, electrical, or electronic controls, control devices, electrical or electronic circuits as necessary to provide the timing, flow rate measurement and control, temperature control, data storage and computation, operator interface, and other functions specified. Operator-accessible controls, data displays, and interface devices shall be designed to be simple, straightforward, reliable, and easy to learn, read, and operate under field conditions. The sampler shall have provision for operator input and storage of up to 64 characters of numeric (or alphanumeric) data for purposes of site, sampler, and sample identification. This information shall be available to the sampler operator for verification and change and for output via the data output port along with other data following the end of a sample period, as specified in table L-1 of section 7.4.19 of this appendix. All data required to be available to the operator following a sample collection period or obtained during standby mode in a post-sampling period shall be retained by the sampler until reset, either manually by the operator or automatically by the sampler upon initiation of a new sample collection period.

7.4.17 Data output port requirement. The sampler shall have a standard RS-232C data output connection through which digital data may be exported to an external data storage or transmission device. All information which is required to be available at the end of each sample period shall be accessible through this data output connection. The information that shall be accessible though this output port is summarized in table L-1 of section 7.4.19 of this appendix. Since no specific format for the output data is provided, the sampler manufacturer or vendor shall make available to sampler purchasers

appropriate computer software capable of receiving exported sampler data and correctly translating the data into a standard spreadsheet format and optionally any other formats as may be useful to sampler users. This requirement shall not preclude the sampler from offering other types of output connections in addition to the required RS-232C port.

7.4.18 Operation/instruction manual. The sampler shall include an associated comprehensive operation or instruction manual, as required by part 53 of this chapter, which includes detailed operating instructions on

the setup, operation, calibration, and maintenance of the sampler. This manual shall provide complete and detailed descriptions of the operational and calibration procedures prescribed for field use of the sampler and all instruments utilized as part of this reference method. The manual shall include adequate warning of potential safety hazards that may result from normal use or malfunction of the method and a description of necessary safety precautions. The manual shall also include a clear description of all procedures pertaining to installation, operation, periodic and corrective maintenance, and troubleshooting, and shall include parts identification diagrams.

7.4.19 Data reporting requirements. The various information that the sampler is required to provide and how it is to be provided is summarized in the following table L-1.

Table L-1--Summary of Information To Be Provided By the Sampler

Information to be provided	Appendix L section reference	Availability			Format		
		Anytime[1]	End of period[2]	Visual display[3]	Data output[4]	Digital reading[5]	Units
Flow rate, 30-second maximum	7.4.5.1	<check>	<check>	*	XX.X		L/min
Flow rate, average for the sample period.	7.4.5.2		*	<check>	XX.X		L/min
Flow rate, CV, for sample period.	7.4.5.2		*	<check>	XX.X		%
Flow rate, 5-min. average out of spec. (FLAG[6]).	7.4.5.2	<check>	<check>	<check>	<box>	On/Off	
Sample volume, total	7.4.5.2		*	<check>	XX.X		m[3]
Temperature, ambient, 30-second	7.4.8	<check>	<check>		XX.X		deg.C

interval.
Temperature, ambient, min., max., 7.4.8..... *
<check> <check> <check><box> XX.X..... deg.C
average for the sample period.
Baro pressure, ambient, 30-second 7.4.9..... <check>
..... <check> ..... XXX..... mm Hg
interval.
Baro pressure, ambient, min., 7.4.9..... *
<check> <check> <check><box> XXX..... mm Hg
max., average for the sample
period.
Filter temperature, 30-second 7.4.11..... <check>
..... <check> ..... XX.X..... deg.C
interval.
Filter temperature differential, 7.4.11..... *
<check> <check> <check><box> On/Off.....
.....
30-second interval, out of spec.
(FLAG⁶).
Filter temperature, maximum 7.4.11..... *
* * * X.X, YY/MM/DD HH:mm deg.C, Yr./Mon./
differential from ambient, date,
Day Hrs. min
time of occurrence.
Date and time..... 7.4.12..... <check>
..... <check> ..... YY/MM/DD HH:mm..... Yr./Mon./Day
Hrs.

min
Sample start and stop time 7.4.12..... <check>
<check> <check> <check> YY/MM/DD HH:mm..... Yr./Mon./Day Hrs.
settings.
min
Sample period start time..... 7.4.12..... .....
<check> <check> <check><box> YYYY/MM/DD HH:mm... Yr./Mon./Day Hrs.

min
Elapsed sample time..... 7.4.13..... *
<check> <check> <check><box> HH:mm..... Hrs. min
Elapsed sample time, out of spec. 7.4.13..... .....
<check> <check> <check><box> On/Off.....
.....
(FLAG⁶).

Power interruptions 1 min., start 7.4.15.5..... *
<check> * <check> 1HH:mm, 2HH:mm, etc Hrs. min
time of first 10.
....
User-entered information, such as 7.4.16..... <check>
<check> <check> <check><box> As entered.....
.....
sampler and site identification.

<check> Provision of this information is required.

*Provision of this information is optional. If information related to the entire sample period is optionally provided prior to the end of the sample period, the value provided should be the value calculated for the portion of the sampler period completed up to the time the information is provided. <box> Indicates that this information is also required to be provided to the AIRS data bank; see Sec. Sec. 58.26 and 58.35 of this chapter.

¹ Information is required to be available to the operator at any time the sampler is operating, whether sampling or not.
² Information relates to the entire sampler period and must be provided following the end of the sample period until reset manually by the operator or
automatically by the sampler upon the start of a new sample period.
³ Information shall be available to the operator visually.
⁴ Information is to be available as digital data at the sampler's data output port specified in section 7.4.16 of this appendix following the end of the
sample period until reset manually by the operator or automatically by the sampler upon the start of a new sample period.
⁵ Digital readings, both visual and data output, shall have not less than the number of significant digits and resolution specified.
⁶ Flag warnings may be displayed to the operator by a single-flag indicator or each flag may be displayed individually. Only a set (on) flag warning
must be indicated; an off (unset) flag may be indicated by the absence of a flag warning. Sampler users should refer to section 10.12 of this appendix regarding the validity of samples for which the sampler provided an associated flag warning.

8.0 Filter Weighing. See reference 2 in section 13.0 of this appendix, for additional, more detailed guidance.

8.1 Analytical balance. The analytical balance used to weigh filters must be suitable for weighing the type and size of filters specified, under section 6.0 of this appendix, and have a readability of <plus-minus>1 <greek-m>g. The balance shall be calibrated as specified by the manufacturer at installation and recalibrated immediately prior to each weighing session. See reference 2 in section 13.0 of this appendix for additional guidance.

8.2 Filter conditioning. All sample filters used shall be conditioned immediately before both the pre- and post-sampling weighings as specified below. See reference 2 in section 13.0 of this appendix for additional guidance.

8.2.1 Mean temperature. 20 - 23 deg.C.

8.2.2 Temperature control. <plus-minus>2 deg.C over 24 hours.

8.2.3 Mean humidity. Generally, 30-40 percent relative humidity; however, where it can be shown that the mean ambient relative humidity during sampling is less than 30 percent, conditioning is permissible at a mean relative humidity within <plus-minus>5 relative humidity percent of the mean ambient relative humidity during sampling, but not less than 20 percent.

8.2.4 Humidity control. <plus-minus>5 relative humidity percent over 24 hours.

8.2.5 Conditioning time. Not less than 24 hours.

8.3 Weighing procedure.

8.3.1 New filters should be placed in the conditioning environment immediately upon arrival and stored there until the pre-sampling weighing. See reference 2 in section 13.0 of this appendix for

additional guidance.

8.3.2 The analytical balance shall be located in the same controlled environment in which the filters are conditioned. The filters shall be weighed immediately following the conditioning period without intermediate or transient exposure to other conditions or environments.

8.3.3 Filters must be conditioned at the same conditions (humidity within <plus-minus>5 relative humidity percent) before both the pre- and post-sampling weighings.

8.3.4 Both the pre- and post-sampling weighings should be carried out on the same analytical balance, using an effective technique to neutralize static charges on the filter, under reference 2 in section 13.0 of this appendix. If possible, both weighings should be carried out by the same analyst.

8.3.5 The pre-sampling (tare) weighing shall be within 30 days of the sampling period.

8.3.6 The post-sampling conditioning and weighing shall be completed within 240 hours (10 days) after the end of the sample period, unless the filter sample is maintained at 4 deg.C or less during the entire time between retrieval from the sampler and the start of the conditioning, in which case the period shall not exceed 30 days. Reference 2 in section 13.0 of this appendix has additional guidance on transport of cooled filters.

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8.3.7 Filter blanks.

8.3.7.1 New field blank filters shall be weighed along with the pre-sampling (tare) weighing of each lot of PM<INF>2.5</INF> filters. These blank filters shall be transported to the sampling site, installed in the sampler, retrieved from the sampler without sampling, and reweighed as a quality control check.

8.3.7.2 New laboratory blank filters shall be weighed along with the pre-sampling (tare) weighing of each set of PM<INF>2.5</INF> filters. These laboratory blank filters should remain in the laboratory in protective containers during the field sampling and should be reweighed as a quality control check.

8.3.8 Additional guidance for proper filter weighing and related quality assurance activities is provided in reference 2 in section 13.0 of this appendix.

9.0 Calibration. Reference 2 in section 13.0 of this appendix contains additional guidance.

9.1 General requirements.

9.1.1 Multipoint calibration and single-point verification of the sampler's flow rate measurement device must be performed periodically to establish and maintain traceability of subsequent flow measurements to a flow rate standard.

9.1.2 An authoritative flow rate standard shall be used for calibrating or verifying the sampler's flow rate measurement device with an accuracy of <plus-minus>2 percent. The flow rate standard shall be a separate, stand-alone device designed to connect to the flow rate measurement adapter, Figure L-30 of this appendix. This flow rate standard must have its own certification and be traceable to a National Institute of Standards and Technology (NIST) primary standard for volume or flow rate. If adjustments to the sampler's flow rate measurement system calibration are to be made in conjunction with an audit of the sampler's flow measurement system, such adjustments shall be made following the audit. Reference 2 in section 13.0 of this appendix

contains additional guidance.

9.1.3 The sampler's flow rate measurement device shall be re-calibrated after electromechanical maintenance or transport of the sampler.

9.2 Flow rate calibration/verification procedure.

9.2.1 PM<INF>2.5</INF> samplers may employ various types of flow control and flow measurement devices. The specific procedure used for calibration or verification of the flow rate measurement device will vary depending on the type of flow rate controller and flow rate measurement employed. Calibration shall be in terms of actual ambient volumetric flow rates (Q^a), measured at the sampler's inlet downtube. The generic procedure given here serves to illustrate the general steps involved in the calibration of a PM<INF>2.5</INF> sampler. The sampler operation/instruction manual required under section 7.4.18 of this appendix and the Quality Assurance Handbook in reference 2 in section 13.0 of this appendix provide more specific and detailed guidance for calibration.

9.2.2 The flow rate standard used for flow rate calibration shall have its own certification and be traceable to a NIST primary standard for volume or flow rate. A calibration relationship for the flow rate standard, e.g., an equation, curve, or family of curves relating actual flow rate (Q<INF>a</INF>) to the flow rate indicator reading, shall be established that is accurate to within 2 percent over the expected range of ambient temperatures and pressures at which the flow rate standard may be used. The flow rate standard must be re-calibrated or re-verified at least annually.

9.2.3 The sampler flow rate measurement device shall be calibrated or verified by removing the sampler inlet and connecting the flow rate standard to the sampler's downtube in accordance with the operation/ instruction manual, such that the flow rate standard accurately measures the sampler's flow rate. The sampler operator shall first carry out a sampler leak check and confirm that the sampler passes the leak test and then verify that no leaks exist between the flow rate standard and the sampler.

9.2.4 The calibration relationship between the flow rate (in actual L/min) indicated by the flow rate standard and by the sampler's flow rate measurement device shall be established or verified in accordance with the sampler operation/instruction manual. Temperature and pressure corrections to the flow rate indicated by the flow rate standard may be required for certain types of flow rate standards. Calibration of the sampler's flow rate measurement device shall consist of at least three separate flow rate measurements (multipoint calibration) evenly spaced within the range of -10 percent to =10 percent of the sampler's operational flow rate, section 7.4.1 of this appendix. Verification of the sampler's flow rate shall consist of one flow rate measurement at the sampler's operational flow rate. The sampler operation/instruction manual and reference 2 in section 13.0 of this appendix provide additional guidance.

9.2.5 If during a flow rate verification the reading of the sampler's flow rate indicator or measurement device differs by <plus-minus> 4 percent or more from the flow rate measured by the flow rate standard, a new multipoint calibration shall be performed and the flow rate verification must then be repeated.

9.2.6 Following the calibration or verification, the flow rate standard shall be removed from the sampler and the sampler inlet shall be reinstalled. Then the sampler's normal operating flow rate (in L/min) shall be determined with a clean filter in place. If the flow rate

indicated by the sampler differs by <plus-minus>2 percent or more from the required sampler flow rate, the sampler flow rate must be

adjusted to the required flow rate, under section 7.4.1 of this appendix.

9.3 Periodic calibration or verification of the calibration of the sampler's ambient temperature, filter temperature, and barometric pressure measurement systems is also required. Reference 3 of section 13.0 of this appendix contains additional guidance.

10.0 PM<INF>2.5</INF> Measurement Procedure. The detailed procedure for obtaining valid PM<INF>2.5</INF> measurements with each specific sampler designated as part of a reference method for PM<INF>2.5</INF> under part 53 of this chapter shall be provided in the sampler-specific operation or instruction manual required by section 7.4.18 of this appendix. Supplemental guidance is provided in section 2.12 of the Quality Assurance Handbook listed in reference 2 in section 13.0 of this appendix. The generic procedure given here serves to illustrate the general steps involved in the PM<INF>2.5</INF> sample collection and measurement, using a PM<INF>2.5</INF> reference method sampler.

10.1 The sampler shall be set up, calibrated, and operated in accordance with the specific, detailed guidance provided in the specific sampler's operation or instruction manual and in accordance with a specific quality assurance program developed and established by the user, based on applicable supplementary guidance provided in reference 2 in section 13.0 of this appendix.

10.2 Each new sample filter shall be inspected for correct type and size and for pinholes, particles, and other imperfections. Unacceptable filters should be discarded. A unique identification number shall be assigned to each filter, and an information record shall be established for each filter. If the filter identification number is not or cannot be marked directly on the filter, alternative means, such as a number-identified storage container, must be established to maintain positive filter identification.

10.3 Each filter shall be conditioned in the conditioning environment in accordance with the requirements specified in section 8.2 of this appendix.

10.4 Following conditioning, each filter shall be weighed in accordance with the requirements specified in section 8.0 of this appendix and the presampling weight recorded with the filter identification number.

10.5 A numbered and preweighed filter shall be installed in the sampler following the instructions provided in the sampler operation or instruction manual.

10.6 The sampler shall be checked and prepared for sample collection in accordance with instructions provided in the sampler operation or instruction manual and with the specific quality assurance program established for the sampler by the user.

10.7 The sampler's timer shall be set to start the sample collection at the beginning of the desired sample period and stop the sample collection 24 hours later.

10.8 Information related to the sample collection (site location or identification number, sample date, filter identification number, and sampler model and serial number) shall be recorded and, if appropriate, entered into the sampler.

10.9 The sampler shall be allowed to collect the PM<INF>2.5</INF>

sample during the set 24-hour time period.

10.10 Within 96 hours of the end of the sample collection period, the filter, while still contained in the filter cassette, shall be carefully removed from the sampler, following the procedure provided in the sampler operation or instruction manual and the quality assurance program, and placed in a protective container. The protective container shall contain no loose material that could be transferred to the filter. The protective container shall hold the filter cassette securely such that the cover shall not come in contact with the filter's surfaces. Reference 2 in section 13.0 of this appendix contains additional information.

10.11 The total sample volume in actual m³ for the sampling period and the elapsed sample time shall be obtained from the sampler and recorded in accordance with the instructions provided in the sampler operation or instruction manual. All sampler warning flag indications and other information required by the local quality assurance program shall also be recorded.

10.12 All factors related to the validity or representativeness of the sample, such as sampler tampering or malfunctions, unusual meteorological conditions, construction activity, fires or dust storms, etc. shall be recorded as required by the local quality assurance program. The occurrence of a flag warning during a sample period shall not necessarily indicate an invalid sample but rather shall indicate the need for specific review of the QC data by a quality assurance officer to determine sample validity.

10.13 After retrieval from the sampler, the exposed filter containing the PM<INF>2.5</INF> sample should be transported to the filter conditioning environment as soon as possible ideally to arrive at the conditioning environment within 24 hours for conditioning and subsequent weighing. During the period between filter retrieval from the sampler and the start of the conditioning, the filter shall be maintained as cool as practical and continuously protected from exposure to temperatures over 25 deg.C. See section 8.3.6 of this appendix regarding time limits for completing the post-sampling weighing. See reference 2 in section 13.0 of this appendix for additional guidance on transporting filter samplers to the conditioning and weighing laboratory.

10.14. The exposed filter containing the PM<INF>2.5</INF> sample shall be re-conditioned in the conditioning environment in accordance

with the requirements specified in section 8.2 of this appendix.

10.15. The filter shall be reweighed immediately after conditioning in accordance with the requirements specified in section 8.0 of this appendix, and the postsampling weight shall be recorded with the filter identification number.

10.16 The PM<INF>2.5</INF> concentration shall be calculated as specified in section 12.0 of this appendix.

11.0 Sampler Maintenance. The sampler shall be maintained as described by the sampler's manufacturer in the sampler-specific operation or instruction manual required under section 7.4.18 of this appendix and in accordance with the specific quality assurance program developed and established by the user based on applicable supplementary guidance provided in reference 2 in section 13.0 of this appendix.

12.0 Calculations

12.1 (a) The PM<INF>2.5</INF> concentration is calculated as:

PM<INF>2.5</INF> = (W<INF>f</INF> - W<INF>i</INF>)/V<INF>a</INF>

where:

PM<INF>2.5</INF> = mass concentration of PM<INF>2.5</INF>, <greek-m>g/m³;
W<INF>f</INF>, W<INF>i</INF> = final and initial weights, respectively, of the filter used to collect the PM<INF>2.5</INF> particle sample, <greek-m>g;
V<INF>a</INF> = total air volume sampled in actual volume units, as provided by the sampler, m³.

Note: Total sample time must be between 1,380 and 1,500 minutes (23 and 25 hrs) for a fully valid PM<INF>2.5</INF> sample; however, see also section 3.3 of this appendix.

13.0 References.

1. Quality Assurance Handbook for Air Pollution Measurement Systems, Volume I, Principles. EPA/600/R-94/038a, April 1994. Available from CERI, ORD Publications, U.S. Environmental Protection Agency, 26 West Martin Luther King Drive, Cincinnati, Ohio 45268.

2. Copies of section 2.12 of the Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II, Ambient Air Specific Methods, EPA/600/R-94/038b, are available from Department E (MD-77B), U.S. EPA, Research Triangle Park, NC 27711.

3. Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements, (Revised Edition) EPA/600/R-94/038d, March, 1995. Available from CERI, ORD Publications, U.S. Environmental Protection Agency, 26 West Martin Luther King Drive, Cincinnati, Ohio 45268.

4. Military standard specification (mil. spec.) 8625F, Type II, Class 1 as listed in Department of Defense Index of Specifications and Standards (DODISS), available from DODSSP-Customer Service, Standardization Documents Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 1911-5094.

14.0 Figures L-1 through L-30 to Appendix L.

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[62 FR 38714, July 18, 1997, as amended at 64 FR 19719, Apr. 22, 1999]

Appendix M to Part 50--Reference Method for the Determination of Particulate Matter as PM<INF>10</INF> in the Atmosphere

1.0 Applicability.

1.1 This method provides for the measurement of the mass concentration of particulate matter with an aerodynamic diameter less than or equal to a nominal 10 micrometers (PM<INF>10</INF>) in ambient air over a 24-hour period for purposes of determining attainment and maintenance of the primary and secondary national ambient air quality standards for particulate matter specified in Sec. 50.6 of this chapter.

The measurement process is nondestructive, and the PM<INF>10</INF> sample can be subjected to subsequent physical or chemical analyses. Quality assurance procedures and guidance are provided in part 58, Appendices A and B of this chapter and in references 1 and 2 of section 12.0 of this appendix.

2.0 Principle.

2.1 An air sampler draws ambient air at a constant flow rate into a specially shaped inlet where the suspended particulate matter is inertially separated into one or more size fractions within the PM<INF>10</INF> size range. Each size fraction in the PM<INF>1O </INF>size range is then collected on a separate filter over the specified sampling period. The particle size discrimination characteristics (sampling effectiveness and 50 percent cutpoint) of the sampler inlet are prescribed as performance specifications in part 53 of this chapter.

2.2 Each filter is weighed (after moisture equilibration) before and after use to determine the net weight (mass) gain due to collected PM<INF>10</INF>. The total volume of air sampled, measured at the actual ambient temperature and pressure, is determined from the measured flow rate and the sampling time. The mass concentration of PM<INF>10</INF> in the ambient air is computed as the total mass of collected particles in the PM<INF>10</INF> size range divided by the volume of air sampled, and is expressed in micrograms per actual cubic meter (<greek-m>g/m³).

2.3 A method based on this principle will be considered a reference method only if the associated sampler meets the requirements specified in this appendix and the requirements in part 53 of this chapter, and the method has been designated as a reference method in accordance with part 53 of this chapter.

3.0 Range.

3.1 The lower limit of the mass concentration range is determined by the repeatability of filter tare weights, assuming the nominal air sample volume for the sampler. For samplers having an automatic filter-changing mechanism, there may be no upper limit. For samplers that do not have an automatic filter-changing mechanism, the upper limit is determined by the filter mass loading beyond which the sampler no longer maintains the operating flow rate within specified limits due to increased pressure drop across the loaded filter. This upper limit cannot be specified precisely because it is a complex function of the ambient particle size distribution and type, humidity, filter type, and perhaps other factors. Nevertheless, all samplers should be capable of measuring 24-hour PM<INF>10</INF> mass concentrations of at least 300 <greek-m>g/m\3\ while maintaining the operating flow rate within the specified limits.

4.0 Precision.

4.1 The precision of PM<INF>10</INF> samplers must be 5 <greek-m>g/m\3\ for PM<INF>10</INF> concentrations below 80 <greek-m>g/m\3\ and 7 percent for PM<INF>10</INF> concentrations above 80 <greek-m>g/m\3\, as required by part 53 of this chapter, which prescribes a test procedure that determines the variation in the PM<INF>10</INF> concentration measurements of identical samplers under typical sampling conditions. Continual assessment of precision via collocated samplers is required by part 58 of this chapter for PM<INF>10</INF> samplers used in certain monitoring networks.

5.0 Accuracy.

5.1 Because the size of the particles making up ambient particulate matter varies over a wide range and the concentration of particles

varies with particle size, it is difficult to define the absolute accuracy of PM<INF>10</INF> samplers. Part 53 of this chapter provides a specification for the sampling effectiveness of PM<INF>10</INF> samplers. This specification requires that the expected mass concentration calculated for a candidate PM<INF>10</INF> sampler, when sampling a specified particle size distribution, be within <plus-minus>10 percent of that calculated for an ideal sampler whose sampling effectiveness is explicitly specified. Also, the particle size for 50 percent sampling effectiveness is required to be 10<plus-minus>0.5 micrometers. Other specifications related to accuracy apply to flow measurement and calibration, filter media, analytical (weighing) procedures, and artifact. The flow rate accuracy of PM<INF>10</INF> samplers used in certain monitoring networks is required by part 58 of this chapter to be assessed periodically via flow rate audits.

6.0 Potential Sources of Error.

6.1 Volatile Particles. Volatile particles collected on filters are often lost during shipment and/or storage of the filters prior to the post-sampling weighing \3\. Although shipment or storage of loaded filters is sometimes unavoidable, filters should be reweighed as soon as practical to minimize these losses.

6.2 Artifacts. Positive errors in PM<INF>10</INF> concentration measurements may result from retention of gaseous species on filters ^{4, 5}. Such errors include the retention of sulfur dioxide and nitric acid. Retention of sulfur

dioxide on filters, followed by oxidation to sulfate, is referred to as artifact sulfate formation, a phenomenon which increases with increasing filter alkalinity \6\. Little or no artifact sulfate formation should occur using filters that meet the alkalinity specification in section 7.2.4 of this appendix, Artifact nitrate formation, resulting primarily from retention of nitric acid, occurs to varying degrees on many filter types, including glass fiber, cellulose ester, and many quartz fiber filters ^{5, 7, 8, 9, 10}. Loss of true atmospheric particulate nitrate during or following sampling may also occur due to dissociation or chemical reaction. This phenomenon has been observed on Teflon®filters \8\ and inferred for quartz fiber filters ^{11, 12}. The magnitude of nitrate artifact errors in PM<INF>10</INF> mass concentration measurements will vary with location and ambient temperature; however, for most sampling locations, these errors are expected to be small.

6.3 Humidity. The effects of ambient humidity on the sample are unavoidable. The filter equilibration procedure in section 9.0 of this appendix is designed to minimize the effects of moisture on the filter medium.

6.4 Filter Handling. Careful handling of filters between presampling and postsampling weighings is necessary to avoid errors due to damaged filters or loss of collected particles from the filters. Use of a filter cartridge or cassette may reduce the magnitude of these errors. Filters must also meet the integrity specification in section 7.2.3 of this appendix.

6.5 Flow Rate Variation. Variations in the sampler's operating flow rate may alter the particle size discrimination characteristics of the sampler inlet. The magnitude of this error will depend on the sensitivity of the inlet to variations in flow rate and on the particle

distribution in the atmosphere during the sampling period. The use of a flow control device, under section 7.1.3 of this appendix, is required to minimize this error.

6.6 Air Volume Determination. Errors in the air volume determination may result from errors in the flow rate and/or sampling time measurements. The flow control device serves to minimize errors in the flow rate determination, and an elapsed time meter, under section 7.1.5 of this appendix, is required to minimize the error in the sampling time measurement.

7.0 Apparatus.

7.1 PM<INF>10</INF> Sampler.

7.1.1 The sampler shall be designed to:

(a) Draw the air sample into the sampler inlet and through the particle collection filter at a uniform face velocity.

(b) Hold and seal the filter in a horizontal position so that sample air is drawn downward through the filter.

(c) Allow the filter to be installed and removed conveniently.

(d) Protect the filter and sampler from precipitation and prevent insects and other debris from being sampled.

(e) Minimize air leaks that would cause error in the measurement of the air volume passing through the filter.

(f) Discharge exhaust air at a sufficient distance from the sampler inlet to minimize the sampling of exhaust air.

(g) Minimize the collection of dust from the supporting surface.

7.1.2 The sampler shall have a sample air inlet system that, when operated within a specified flow rate range, provides particle size discrimination characteristics meeting all of the applicable performance specifications prescribed in part 53 of this chapter. The sampler inlet shall show no significant wind direction dependence. The latter requirement can generally be satisfied by an inlet shape that is circularly symmetrical about a vertical axis.

7.1.3 The sampler shall have a flow control device capable of maintaining the sampler's operating flow rate within the flow rate limits specified for the sampler inlet over normal variations in line voltage and filter pressure drop.

7.1.4 The sampler shall provide a means to measure the total flow rate during the sampling period. A continuous flow recorder is recommended but not required. The flow measurement device shall be accurate to <plus-minus>2 percent.

7.1.5 A timing/control device capable of starting and stopping the sampler shall be used to obtain a sample collection period of 24 <plus-minus>1 hr (1,440 <plus-minus>60 min). An elapsed time meter, accurate to within <plus-minus>15 minutes, shall be used to measure sampling time. This meter is optional for samplers with continuous flow recorders if the sampling time measurement obtained by means of the recorder meets the <plus-minus>15 minute accuracy specification.

7.1.6 The sampler shall have an associated operation or instruction manual as required by part 53 of this chapter which includes detailed instructions on the calibration, operation, and maintenance of the sampler.

7.2 Filters.

7.2.1 Filter Medium. No commercially available filter medium is ideal in all respects for all samplers. The user's goals in sampling determine the relative importance of various filter characteristics, e.g., cost, ease of handling, physical and chemical characteristics, etc., and, consequently, determine the choice among acceptable filters. Furthermore, certain types of filters may not be suitable for use with

some samplers, particularly under heavy loading conditions (high mass concentrations), because of high or rapid increase in the filter flow resistance that would exceed the capability of the sampler's flow control device. However, samplers equipped with automatic filter-changing

mechanisms may allow use of these types of filters. The specifications given below are minimum requirements to ensure acceptability of the filter medium for measurement of PM<INF>10</INF> mass concentrations. Other filter evaluation criteria should be considered to meet individual sampling and analysis objectives.

7.2.2 Collection Efficiency. <ls-thn-eq>99 percent, as measured by the DOP test (ASTM-2986) with 0.3 <greek-m>m particles at the sampler's operating face velocity.

7.2.3 Integrity. <plus-minus>5 <greek-m>g/m\3\ (assuming sampler's nominal 24-hour air sample volume). Integrity is measured as the PM<INF>10</INF> concentration equivalent corresponding to the average difference between the initial and the final weights of a random sample of test filters that are weighed and handled under actual or simulated sampling conditions, but have no air sample passed through them, i.e., filter blanks. As a minimum, the test procedure must include initial equilibration and weighing, installation on an inoperative sampler, removal from the sampler, and final equilibration and weighing.

7.2.4 Alkalinity. 25 microequivalents/gram of filter, as measured by the procedure given in reference 13 of section 12.0 of this appendix following at least two months storage in a clean environment (free from contamination by acidic gases) at room temperature and humidity.

7.3 Flow Rate Transfer Standard. The flow rate transfer standard must be suitable for the sampler's operating flow rate and must be calibrated against a primary flow or volume standard that is traceable to the National Institute of Standard and Technology (NIST). The flow rate transfer standard must be capable of measuring the sampler's operating flow rate with an accuracy of <plus-minus>2 percent.

7.4 Filter Conditioning Environment.

7.4.1 Temperature range. 15 to 30 C.

7.4.2 Temperature control. <plus-minus>3 C.

7.4.3 Humidity range. 20% to 45% RH.

7.4.4 Humidity control. <plus-minus>5% RH.

7.5 Analytical Balance. The analytical balance must be suitable for weighing the type and size of filters required by the sampler. The range and sensitivity required will depend on the filter tare weights and mass loadings. Typically, an analytical balance with a sensitivity of 0.1 mg is required for high volume samplers (flow rates >0.5 m\3\/min). Lower volume samplers (flow rates 0.5 m\3\/min) will require a more sensitive balance.

8.0 Calibration.

8.1 General Requirements.

8.1.1 Calibration of the sampler's flow measurement device is required to establish traceability of subsequent flow measurements to a primary standard. A flow rate transfer standard calibrated against a primary flow or volume standard shall be used to calibrate or verify the accuracy of the sampler's flow measurement device.

8.1.2 Particle size discrimination by inertial separation requires that specific air velocities be maintained in the sampler's air inlet system. Therefore, the flow rate through the sampler's inlet must be

maintained throughout the sampling period within the design flow rate range specified by the manufacturer. Design flow rates are specified as actual volumetric flow rates, measured at existing conditions of temperature and pressure (Q<INF>a</INF>).

8.2 Flow Rate Calibration Procedure.

8.2.1 PM<INF>10</INF> samplers employ various types of flow control and flow measurement devices. The specific procedure used for flow rate calibration or verification will vary depending on the type of flow controller and flow rate indicator employed. Calibration is in terms of actual volumetric flow rates (Q<INF>a</INF>) to meet the requirements of section 8.1 of this appendix. The general procedure given here serves to illustrate the steps involved in the calibration. Consult the sampler manufacturer's instruction manual and reference 2 of section 12.0 of this appendix for specific guidance on calibration. Reference 14 of section 12.0 of this appendix provides additional information on various other measures of flow rate and their interrelationships.

8.2.2 Calibrate the flow rate transfer standard against a primary flow or volume standard traceable to NIST. Establish a calibration relationship, e.g., an equation or family of curves, such that traceability to the primary standard is accurate to within 2 percent over the expected range of ambient conditions, i.e., temperatures and pressures, under which the transfer standard will be used. Recalibrate the transfer standard periodically.

8.2.3 Following the sampler manufacturer's instruction manual, remove the sampler inlet and connect the flow rate transfer standard to the sampler such that the transfer standard accurately measures the sampler's flow rate. Make sure there are no leaks between the transfer standard and the sampler.

8.2.4 Choose a minimum of three flow rates (actual m\3\/min), spaced over the acceptable flow rate range specified for the inlet, under section 7.1.2 of the appendix, that can be obtained by suitable adjustment of the sampler flow rate. In accordance with the sampler manufacturer's instruction manual, obtain or verify the calibration relationship between the flow rate (actual m\3\/min) as indicated by the transfer standard and the sampler's flow indicator response. Record the ambient temperature and barometric pressure. Temperature and pressure corrections to subsequent flow indicator readings may be required for certain types of flow measurement devices. When such corrections are necessary, correction on an individual or

daily basis is preferable. However, seasonal average temperature and average barometric pressure for the sampling site may be incorporated into the sampler calibration to avoid daily corrections. Consult the sampler manufacturer's instruction manual and reference 2 in section 12.0 of this appendix for additional guidance.

8.2.5 Following calibration, verify that the sampler is operating at its design flow rate (actual m\3\/min) with a clean filter in place.

8.2.6 Replace the sampler inlet.

9.0 Procedure.

9.1 The sampler shall be operated in accordance with the specific guidance provided in the sampler manufacturer's instruction manual and in reference 2 in section 12.0 of this appendix. The general procedure given here assumes that the sampler's flow rate calibration is based on flow rates at ambient conditions (Q<INF>a</INF>) and serves to illustrate the steps involved in the operation of a PM<INF>10</INF>

sampler.

9.2 Inspect each filter for pinholes, particles, and other imperfections. Establish a filter information record and assign an identification number to each filter.

9.3 Equilibrate each filter in the conditioning environment (see 7.4) for at least 24 hours.

9.4 Following equilibration, weigh each filter and record the presampling weight with the filter identification number.

9.5 Install a preweighed filter in the sampler following the instructions provided in the sampler manufacturer's instruction manual.

9.6 (a) Turn on the sampler and allow it to establish run-temperature conditions. Record the flow indicator reading and, if needed, the ambient temperature and barometric pressure. Determine the sampler flow rate (actual m\3\/min) in accordance with the instructions provided in the sampler manufacturer's instruction manual.

(b) Note: No onsite temperature or pressure measurements are necessary if the sampler's flow indicator does not require temperature or pressure corrections or if seasonal average temperature and average barometric pressure for the sampling site are incorporated into the sampler calibration, under section 8.2.4 of this appendix. If individual or daily temperature and pressure corrections are required, ambient temperature and barometric pressure can be obtained by on-site measurements or from a nearby weather station. Barometric pressure readings obtained from airports must be station pressure, not corrected to sea level, and may need to be corrected for differences in elevation between the sampling site and the airport.

9.7 If the flow rate is outside the acceptable range specified by the manufacturer, check for leaks, and if necessary, adjust the flow rate to the specified setpoint. Stop the sampler.

9.8 Set the timer to start and stop the sampler at appropriate times. Set the elapsed time meter to zero or record the initial meter reading.

9.9 Record the sample information (site location or identification number, sample date, filter identification number, and sampler model and serial number).

9.10 Sample for 24<plus-minus>1 hours.

9.11 Determine and record the average flow rate (Q<INF>a</INF>) in actual m\3\/min for the sampling period in accordance with the instructions provided in the sampler manufacturer's instruction manual. Record the elapsed time meter final reading and, if needed, the average ambient temperature and barometric pressure for the sampling period, in note following section 9.6 of this appendix.

9.12 Carefully remove the filter from the sampler, following the sampler manufacturer's instruction manual. Touch only the outer edges of the filter.

9.13 Place the filter in a protective holder or container, e.g., petri dish, glassine envelope, or manila folder.

9.14 Record any factors such as meteorological conditions, construction activity, fires or dust storms, etc., that might be pertinent to the measurement on the filter information record.

9.15 Transport the exposed sample filter to the filter conditioning environment as soon as possible for equilibration and subsequent weighing.

9.16 Equilibrate the exposed filter in the conditioning environment for at least 24 hours under the same temperature and humidity conditions used for presampling filter equilibration (see section 9.3 of this appendix).

9.17 Immediately after equilibration, reweigh the filter and record the postsampling weight with the filter identification number.

10.0 Sampler Maintenance.

10.1 The PM<INF>10</INF> sampler shall be maintained in strict accordance with the maintenance procedures specified in the sampler manufacturer's instruction manual.

11.0 Calculations.

11.1 Calculate the total volume of air sampled as:

V = Q<INF>a</INF>t

where:

V = total air sampled, at ambient temperature and pressure,m³;
Q<INF>a</INF> = average sample flow rate at ambient temperature and pressure, m³/min; and
t = sampling time, min.

11.2 (a) Calculate the PM<INF>10</INF> concentration as:

PM<INF>10</INF> = (W<INF>f</INF>-W<INF>i</INF>) x 10\6\/V

where:

PM<INF>10</INF> = mass concentration of PM<INF>10</INF>, <greek-m>g/m\3\;
W<INF>f</INF>, W<INF>i</INF> = final and initial weights of filter collecting PM<INF>1O </INF>particles, g; and
10\6\ = conversion of g to <greek-m>g.

(b) Note: If more than one size fraction in the PM<INF>10</INF> size range is collected by the sampler, the sum of the net weight gain by each collection filter [<greek-S>(W<INF>f</INF>-W<INF>i</INF>)] is used to calculate the PM<INF>10</INF> mass concentration.

12.0 References.

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[62 FR 38753, July 18, 1997]

Appendix N to Part 50--Interpretation of the National Ambient Air Quality Standards for Particulate Matter

1.0 General.

(a) This appendix explains the data handling conventions and computations necessary for determining when the annual and 24-hour primary and secondary national ambient air quality standards for PM specified in Sec. 50.7 of this chapter are met. Particulate matter is measured in the ambient air as PM<INF>10</INF> and PM<INF>2.5</INF> (particles with an aerodynamic diameter less than or equal to a nominal 10 and 2.5 micrometers, respectively) by a reference method based on appendix M of this part for PM<INF>10</INF> and on appendix L of this part for PM<INF>2.5</INF>, as applicable, and designated in accordance with part 53 of this chapter, or by an equivalent method designated in accordance with part 53 of this chapter. Data handling and computation procedures to be used in making comparisons between reported PM<INF>10</INF> and PM<INF>2.5</INF> concentrations and the levels of the PM standards are specified in the following sections.

(b) Data resulting from uncontrollable or natural events, for example structural fires or high winds, may require special consideration. In some cases, it may be appropriate to exclude these data because they could result in inappropriate values to compare with the levels of the PM standards. In other cases, it may be more appropriate to retain the data for comparison with the level of the PM standards and then allow the EPA to formulate the appropriate regulatory response. Whether to exclude, retain, or make adjustments to the data affected by uncontrollable or natural events is subject to the approval of the appropriate Regional Administrator.

(c) The terms used in this appendix are defined as follows:

Average and mean refer to an arithmetic mean.

Daily value for PM refers to the 24-hour average concentration of PM calculated or measured from midnight to midnight (local time) for PM<INF>10</INF> or PM<INF>2.5</INF>.

Designated monitors are those monitoring sites designated in a State PM Monitoring Network Description for spatial averaging in areas opting for spatial averaging in accordance with part 58 of this chapter.

98th percentile (used for PM<INF>2.5</INF>) means the daily value out of a year of monitoring data below which 98 percent of all values in the group fall.

99th percentile (used for PM<INF>10</INF>) means the daily value out of a year of monitoring data below which 99 percent of all values in the group fall.

Year refers to a calendar year.

(d) Sections 2.1 and 2.5 of this appendix contain data handling instructions for the option of using a spatially averaged network of monitors for the annual standard. If spatial averaging is not considered for an area, then the spatial average is equivalent to the annual average of a single site and is treated accordingly in subsequent calculations. For example, paragraph (a)(3) of section 2.1 of this appendix could be eliminated since the spatial average would be equivalent to the annual average.

2.0 Comparisons with the PM<INF>2.5</INF> Standards.

2.1 Annual PM<INF>2.5</INF> Standard.

(a) The annual PM<INF>2.5</INF> standard is met when the 3-year average of the spatially averaged annual means is less than or equal to 15.0 <greek-m>g/m³. The 3-year average of the spatially averaged annual means is determined by averaging quarterly means at each monitor to obtain the annual mean PM<INF>2.5</INF> concentrations at each monitor, then averaging across all designated monitors, and finally averaging for 3 consecutive years. The steps can be summarized as follows:

(1) Average 24-hour measurements to obtain quarterly means at each monitor.

(2) Average quarterly means to obtain annual means at each monitor.

(3) Average across designated monitoring sites to obtain an annual spatial mean for an area (this can be one site in which case the spatial mean is equal to the annual mean).

(4) Average 3 years of annual spatial means to obtain a 3-year average of spatially averaged annual means.

(b) In the case of spatial averaging, 3 years of spatial averages are required to demonstrate that the standard has been met. Designated sites with less than 3 years of data shall be included in spatial averages for those years that data completeness requirements are met. For the annual PM<INF>2.5</INF> standard, a year meets data completeness requirements when at least 75 percent of the scheduled sampling days for each quarter have valid data. However, years with high concentrations and more than a minimal amount of data (at least 11 samples in each quarter) shall not be ignored just because they are comprised of quarters with less than complete data. Thus, in computing annual spatially averaged means, years containing quarters with at least 11 samples but less than 75 percent data completeness shall be included in the computation if the resulting spatially averaged annual mean concentration (rounded according to the conventions of section 2.3 of this appendix) is greater than the level of the standard.

(c) Situations may arise in which there are compelling reasons to retain years containing quarters which do not meet the data completeness requirement of 75 percent or the minimum number of 11 samples. The use of less than complete data is subject to the approval of the appropriate Regional Administrator.

(d) The equations for calculating the 3-year average annual mean of the PM<INF>2.5</INF> standard are given in section 2.5 of this appendix.

2.2 24-Hour PM<INF>2.5</INF> Standard.

(a) The 24-hour PM<INF>2.5</INF> standard is met when the 3-year average of the 98th percentile values at each monitoring site is less than or equal to 65 <greek-m>g/m³. This comparison shall be based on 3 consecutive, complete years of air quality data. A year meets data completeness requirements when at least 75 percent of the scheduled sampling days for each quarter have valid data. However, years with high concentrations shall not be ignored just because they are comprised of quarters with less than complete data. Thus, in computing the 3-year average 98th percentile value, years containing quarters with less than 75 percent data completeness shall be included in the computation if the annual 98th percentile value (rounded according to the conventions of section 2.3 of this appendix) is greater than the level of the standard.

(b) Situations may arise in which there are compelling reasons to retain years containing quarters which do not meet the data completeness requirement. The use of less than complete data is subject to the approval of the appropriate Regional Administrator.

(c) The equations for calculating the 3-year average of the annual 98th percentile values is given in section 2.6 of this appendix.

2.3 Rounding Conventions. For the purposes of comparing calculated values to the applicable level of the standard, it is necessary to round the final results of the calculations described in sections 2.5 and 2.6 of this appendix. For the annual PM<INF>2.5</INF> standard, the 3-year average of the spatially averaged annual means shall be rounded to the nearest 0.1 <greek-m>g/m³ (decimals 0.05 and greater are rounded up to the next 0.1, and any decimal lower than 0.05 is rounded down to the nearest 0.1). For the 24-hour PM<INF>2.5</INF> standard, the 3-year average of the annual 98th percentile values shall be rounded to the nearest 1 <greek-m>g/m³ (decimals 0.5 and greater are rounded up to nearest whole number, and any decimal lower than 0.5 is rounded down to the nearest whole number).

2.4 Monitoring Considerations.

(a) Section 58.13 of this chapter specifies the required minimum frequency of sampling

for PM<INF>2.5</INF>. Exceptions to the specified sampling frequencies, such as a reduced frequency during a season of expected low concentrations, are subject to the approval of the appropriate Regional Administrator. Section 58.14 of 40 CFR part 58 and section 2.8 of appendix D of 40 CFR part 58, specify which monitors are eligible for making comparisons with the PM standards. In determining a spatial mean using two or more monitoring sites operating in a given year, the annual mean for an individual site may be included in the spatial mean if and only if the mean for that site meets the criterion specified in Sec. 2.8 of appendix D of 40 CFR part 58. In the event data from an otherwise eligible site is excluded from being averaged with data from other sites

on the basis of this criterion, then the 3-year mean from that site shall be compared directly to the annual standard.

(b) For the annual PM<INF>2.5</INF> standard, when designated monitors are located at the same site and are reporting PM<INF>2.5</INF> values for the same time periods, and when spatial averaging has been chosen, their concentrations shall be averaged before an area-wide spatial average is calculated. Such monitors will then be considered as one monitor.

2.5 Equations for the Annual PM<INF>2.5</INF> Standard.

(a) An annual mean value for PM<INF>2.5</INF> is determined by first averaging the daily values of a calendar quarter:

Equation 1

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where:

x<INF>q,y,s</INF> = the mean for quarter q of year y for site s;
n<INF>q</INF> = the number of monitored values in the quarter; and
x<INF>i,q,y,s</INF> = the ith value in quarter q for year y for site s.

(b) The following equation is then to be used for calculation of the annual mean:

Equation 2

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where:

x<INF>y,s</INF> = the annual mean concentration for year y (y = 1, 2, or 3) and for site s; and
x<INF>q,y,s</INF> = the mean for quarter q of year y for site s.

(c)(1) The spatially averaged annual mean for year y is computed by first calculating the annual mean for each site designated to be included in a spatial average, x<INF>y,s</INF>, and then computing the average of these values across sites:

Equation 3

[GRAPHIC] [TIFF OMITTED] TR18JY97.002

where:

x<INF>y</INF> = the spatially averaged mean for year y;
x<INF>y,s</INF> = the annual mean for year y and site s; and
n<INF>s</INF> = the number of sites designated to be averaged.

(2) In the event that an area designated for spatial averaging has two or more sites at the same location producing data for the same time periods, the sites are averaged together before using Equation 3 by:

Equation 4

[GRAPHIC] [TIFF OMITTED] TR18JY97.003

where:

x<INF>y,s*</INF> = the annual mean for year y for the sites at the same location (which will now be considered one site);
n<INF>c</INF> = the number of sites at the same location designated to be included in the spatial average; and
x<INF>y,s</INF> = the annual mean for year y and site s.

(d) The 3-year average of the spatially averaged annual means is calculated by using the following equation:

Equation 5

[GRAPHIC] [TIFF OMITTED] TR18JY97.004

where:

x = the 3-year average of the spatially averaged annual means; and
x<INF>y</INF> = the spatially averaged annual mean for year y.

Example 1--Area Designated for Spatial Averaging That Meets the Primary Annual PM<INF>2.5</INF> Standard.

a. In an area designated for spatial averaging, four designated monitors recorded data in at least 1 year of a particular 3-year period. Using Equations 1 and 2, the annual means for PM<INF>2.5</INF> at each site are calculated for each year. The following table can be created from the results. Data completeness percentages for the quarter with the fewest number of samples are also shown.

[[Page 125]]

Table 1--Results from Equations 1 and 2

	Site 1	Site 2	Site 3	Site 4	
Spatial mean					
Year 1	Annual mean (<greek-m>g/m\3\)	12.7	.....	.....	..... 12.7
% data completeness		80	0	0	0 .....
Year 2	Annual mean (<greek-m>g/m\3\)	12.6	17.5	15.2	..... 15.05
% data completeness		90	63	38	0 .....
Year 3	Annual mean (<greek-m>g/m\3\)	12.5	18.5	14.1	16.9 15.50
% data completeness		90	80	85	50 .....

3-year mean.....
....
..... 14.42

b. The data from these sites are averaged in the order described in section 2.1 of this appendix. Note that the annual mean from site □3 in year 2 and the annual mean from site □4 in year 3 do not meet the 75 percent data completeness criteria. Assuming the 38 percent data completeness represents a quarter with fewer than 11 samples, site □3 in year 2 does not meet the minimum data completeness requirement of 11 samples in each quarter. The site is therefore excluded from the calculation of the spatial mean for year 2. However, since the spatial mean for year 3 is above the level of the standard and the minimum data requirement of 11 samples in each quarter has been met, the annual mean from site □4 in year 3 is included in the calculation of the spatial mean for year 3 and in the calculation of the 3-year average. The 3-year average is rounded to 14.4 <greek-m>g/m³, indicating that this area meets the annual PM<INF>2.5</INF> standard.

Example 2--Area With Two Monitors at the Same Location That Meets the Primary Annual PM<INF>2.5</INF> Standard.

a. In an area designated for spatial averaging, six designated monitors, with two monitors at the same location (□5 and □6), recorded data in a particular 3-year period. Using Equations 1 and 2, the annual means for PM<INF>2.5</INF> are calculated for each year. The following table can be created from the results.

Table 2--Results From Equations 1 and 2

Average of 5 Annual mean (<greek-m>g/m\3\)	Site 3	Site 4	Site 5	Site 6	Site 1 and 6	Site 2 and 6	Spatial mean
Year 1.....					12.9	9.9	
	12.6	11.1	14.5	14.6	14.55	12.21	
Year 2.....					14.5	13.3	
	12.2	10.9	16.1	16.0	16.05	13.39	
Year 3.....					14.4	12.4	
	11.5	9.7	12.3	12.1	12.20	12.04	
3-Year mean.....							
.....	.....	.....	.....	.....	.....		
							12.55

b. The annual means for sites □5 and □6 are averaged together using Equation 4 before the spatial average is calculated using Equation 3

since they are in the same location. The 3-year mean is rounded to 12.6 <greek-m>g/m³, indicating that this area meets the annual PM<INF>2.5</INF> standard.

Example 3--Area With a Single Monitor That Meets the Primary Annual PM<INF>2.5</INF> Standard.

a. Given data from a single monitor in an area, the calculations are as follows. Using Equations 1 and 2, the annual means for PM<INF>2.5</INF> are calculated for each year. If the annual means are 10.28, 17.38, and 12.25 <greek-m>g/m³, then the 3-year mean is:
[GRAPHIC] [TIFF OMITTED] TR18JY97.005

b. This value is rounded to 13.3, indicating that this area meets the annual PM<INF>2.5</INF> standard.

2.6 Equations for the 24-Hour PM<INF>2.5</INF> Standard.

(a) When the data for a particular site and year meet the data completeness requirements in section 2.2 of this appendix, calculation of the 98th percentile is accomplished by the following steps. All the daily values from a particular site and year comprise a series of values (x<INF>1</INF>, x<INF>2</INF>, x<INF>3</INF>, ..., x<INF>n</INF>), that can be sorted into a series where each number is equal to or larger than the preceding number (x<INF>[1]</INF>, x<INF>[2]</INF>, x<INF>[3]</INF>, ..., x<INF>[n]</INF>). In this case, x<INF>[1]</INF> is the smallest number and x<INF>[n]</INF> is the largest value. The 98th percentile is found from the

sorted series of daily values which is ordered from the lowest to the highest number. Compute (0.98) x (n) as the number ``i.d'', where ``i'' is the integer part of the result and ``d'' is the decimal part of the result. The 98th percentile value for year y, P<INF>0.98, y</INF>, is given by Equation 6:

Equation 6
[GRAPHIC] [TIFF OMITTED] TR18JY97.006

where:

P<INF>0.98,y</INF> = 98th percentile for year y;
x<INF>[i=1]</INF> = the (i=1)th number in the ordered series of numbers; and
i = the integer part of the product of 0.98 and n.

(b) The 3-year average 98th percentile is then calculated by averaging the annual 98th percentiles:

Equation 7
[GRAPHIC] [TIFF OMITTED] TR18JY97.007

(c) The 3-year average 98th percentile is rounded according to the conventions in section 2.3 of this appendix before a comparison with the standard is made.

Example 4--Ambient Monitoring Site With Every-Day Sampling That Meets

the Primary 24-Hour PM<INF>2.5</INF> Standard.

a. In each year of a particular 3 year period, varying numbers of daily PM<INF>2.5</INF> values (e.g., 281, 304, and 296) out of a possible 365 values were recorded at a particular site with the following ranked values (in <greek-m>g/m³):

Table 3--Ordered Monitoring Data For 3 Years

Year 1		Year 2		Year 3	
j rank	X<INF>j</INF> value	j rank	X<INF>j</INF> value	j rank	X<INF>j</INF> value
275	57.9	296	54.3	290	66.0
276	59.0	297	57.1	291	68.4
277	62.2	298	63.0	292	69.8

b. Using Equation 6, the 98th percentile values for each year are calculated as follows:
[GRAPHIC] [TIFF OMITTED] TR18JY97.008

[GRAPHIC] [TIFF OMITTED] TR18JY97.009

[GRAPHIC] [TIFF OMITTED] TR18JY97.010

c.1. Using Equation 7, the 3-year average 98th percentile is calculated as follows:
[GRAPHIC] [TIFF OMITTED] TR18JY97.011

2. Therefore, this site meets the 24-hour PM<INF>2.5</INF> standard.

3.0 Comparisons with the PM<INF>10</INF> Standards.

3.1 Annual PM<INF>10</INF> Standard.

(a) The annual PM<INF>10</INF> standard is met when the 3-year average of the annual mean PM<INF>10</INF> concentrations at each monitoring site is less than or equal to 50 <greek-m>g/m³. The 3-year average of the annual means is determined by averaging quarterly means to obtain annual mean PM<INF>10</INF> concentrations for 3 consecutive, complete years at each monitoring site. The steps can be summarized as follows:

(1) Average 24-hour measurements to obtain a quarterly mean.

(2) Average quarterly means to obtain an annual mean.

(3) Average annual means to obtain a 3-year mean.

(b) For the annual PM<INF>10</INF> standard, a year meets data

completeness requirements when at least 75 percent of the scheduled sampling days for each quarter have valid data. However, years with high concentrations and more than a minimal amount of data (at least 11 samples in each quarter) shall not be ignored just because they are comprised of quarters with less than complete data. Thus, in computing the 3-year average annual mean concentration, years containing quarters with at least 11 samples but less than 75 percent data completeness shall be included in the computation if the annual mean concentration (rounded according to the conventions of section 2.3 of this appendix) is greater than the level of the standard.

(c) Situations may arise in which there are compelling reasons to retain years containing quarters which do not meet the data completeness requirement of 75 percent or the minimum number of 11 samples. The use of less than complete data is subject to the approval of the appropriate Regional Administrator.

(d) The equations for calculating the 3-year average annual mean of the PM<INF>10</INF> standard are given in section 3.5 of this appendix.

3.2 24-Hour PM<INF>10</INF> Standard.

(a) The 24-hour PM<INF>10</INF> standard is met when the 3-year average of the annual 99th percentile values at each monitoring site is less than or equal to 150 <greek-m>g/m³. This comparison shall be based on 3 consecutive, complete years of air quality data. A year meets data completeness requirements when at least 75 percent of the scheduled sampling days for each quarter have valid data. However, years with high concentrations shall not be ignored just because they are comprised of quarters with less than complete data. Thus, in computing the 3-year average of the annual 99th percentile values, years containing quarters with less than 75 percent data completeness shall be included in the computation if the annual 99th percentile value (rounded according to the conventions of section 2.3 of this appendix) is greater than the level of the standard.

(b) Situations may arise in which there are compelling reasons to retain years containing quarters which do not meet the data completeness requirement. The use of less than complete data is subject to the approval of the appropriate Regional Administrator.

(c) The equation for calculating the 3-year average of the annual 99th percentile values is given in section 2.6 of this appendix.

3.3 Rounding Conventions. For the annual PM<INF>10</INF> standard, the 3-year average of the annual PM<INF>10</INF> means shall be rounded to the nearest 1 <greek-m>g/m³ (decimals 0.5 and greater are rounded up to the next whole number, and any decimal less than 0.5 is rounded down to the nearest whole number). For the 24-hour PM<INF>10</INF> standard, the 3-year average of the annual 99th percentile values of PM<INF>10</INF> shall be rounded to the nearest 10 <greek-m>g/m³ (155 <greek-m>g/m³ and greater would be rounded to 160 <greek-m>g/m³ and 154 <greek-m>g/m³ and less would be rounded to 150 <greek-m>g/m³).

3.4 Monitoring Considerations. Section 58.13 of this chapter specifies the required minimum frequency of sampling for PM<INF>10</INF>. Exceptions to the specified sampling frequencies, such as a reduced frequency during a season of expected low concentrations, are subject to the approval of the appropriate Regional Administrator. For making comparisons with the PM<INF>10</INF> NAAQS, all sites meeting applicable requirements in part 58 of this chapter would be used.

3.5 Equations for the Annual PM<INF>10</INF> Standard.

(a) An annual arithmetic mean value for PM<INF>10</INF> is determined by first averaging the 24-hour values of a calendar quarter using the following equation:

Equation 8

[GRAPHIC] [TIFF OMITTED] TR18JY97.012

where:

x<INF>q,y</INF> = the mean for quarter q of year y;
n<INF>q</INF> = the number of monitored values in the quarter; and
x<INF>i,q,y</INF> = the ith value in quarter q for year y.

(b) The following equation is then to be used for calculation of the annual mean:

Equation 9

[GRAPHIC] [TIFF OMITTED] TR18JY97.013

where:

x<INF>y</INF> = the annual mean concentration for year y, (y=1, 2, or 3); and
x<INF>q,y</INF> = the mean for a quarter q of year y.

(c) The 3-year average of the annual means is calculated by using the following equation:

Equation 10

[GRAPHIC] [TIFF OMITTED] TR18JY97.014

where:

x = the 3-year average of the annual means; and

x<INF>y</INF> = the annual mean for calendar year y.

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Example 5--Ambient Monitoring Site That Does Not Meet the Annual PM<INF>10</INF> Standard.

a. Given data from a PM<INF>10</INF> monitor and using Equations 8 and 9, the annual means for PM<INF>10</INF> are calculated for each year. If the annual means are 52.42, 82.17, and 63.23 <greek-m>g/m³, then the 3-year average annual mean is:
[GRAPHIC] [TIFF OMITTED] TR18JY97.015

b. Therefore, this site does not meet the annual PM<INF>10</INF> standard.

3.6 Equation for the 24-Hour PM<INF>10</INF> Standard.

(a) When the data for a particular site and year meet the data completeness requirements in section 3.2 of this appendix, calculation of the 99th percentile is accomplished by the following steps. All the daily values from a particular site and year comprise a series of values (x<INF>1</INF>, x<INF>2</INF>, x<INF>3</INF>, ...,

x<INF>n</INF>) that can be sorted into a series where each number is equal to or larger than the preceding number (x<INF>[1]</INF>, x<INF>[2]</INF>, x<INF>[3]</INF>, ..., x<INF>[n]</INF>). In this case, x<INF>[1]</INF> is the smallest number and x[n] is the largest value. The 99th percentile is found from the sorted series of daily values which is ordered from the lowest to the highest number. Compute (0.99) x (n) as the number ``i.d'', where ``i'' is the integer part of the result and ``d'' is the decimal part of the result. The 99th percentile value for year y, P<INF>0.99,y</INF>, is given by Equation 11:

Equation 11

[GRAPHIC] [TIFF OMITTED] TR18JY97.016

where:

P<INF>0.99,y</INF> = the 99th percentile for year y;

x<INF>[i=1]</INF> = the (i=1)th number in the ordered series of numbers; and

i = the integer part of the product of 0.99 and n.

(b) The 3-year average 99th percentile value is then calculated by averaging the annual 99th percentiles:

Equation 12

[GRAPHIC] [TIFF OMITTED] TR18JY97.017

(c) The 3-year average 99th percentile is rounded according to the conventions in section 3.3 of this appendix before a comparison with the standard is made.

Example 6--Ambient Monitoring Site With Sampling Every Sixth Day That Meets the Primary 24-Hour PM<INF>10</INF> Standard.

a. In each year of a particular 3 year period, varying numbers of PM<INF>10</INF> daily values (e.g., 110, 98, and 100) out of a possible 121 daily values were recorded at a particular site with the following ranked values (in <greek-m>g/m³):

Table 4--Ordered Monitoring Data For 3 Years

Year 1		Year 2		Year 3	
j rank	X<INF>j</INF> value	j rank	X<INF>j</INF> value	j rank	X<INF>j</INF> value
108	120	96	143	98	140
109	128	97	148	99	144

110	130	98	150	100	147

b. Using Equation 11, the 99th percentile values for each year are calculated as follows:
[GRAPHIC] [TIFF OMITTED] TR18JY97.018

[GRAPHIC] [TIFF OMITTED] TR18JY97.019

[GRAPHIC] [TIFF OMITTED] TR18JY97.020

c. 1. Using Equation 12, the 3-year average 99th percentile is calculated as follows:
[GRAPHIC] [TIFF OMITTED] TR18JY97.021

2. Therefore, this site meets the 24-hour PM<INF>10</INF> standard.

[62 FR 38755, July 18, 1997]

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PART 50—NATIONAL PRIMARY AND SECONDARY AMBIENT AIR QUALITY STANDARDS

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Appendix G to Part 50—Reference Method for the Determination of Lead in Suspended Particulate Matter Collected From Ambient Air

1. *Principle and applicability.*

1.1 Ambient air suspended particulate matter is collected on a glass-fiber filter for 24 hours using a high volume air sampler. The analysis of the 24-hour samples may be performed for either individual samples or composites of the samples collected over a calendar month or quarter, provided that the compositing procedure has been approved in accordance with section 2.8 of appendix C to part 58 of this chapter— *Modifications of methods by users.* (Guidance or assistance in requesting approval under Section 2.8 can be obtained from the address given in section 2.7 of appendix C to part 58 of this chapter.)

1.2 Lead in the particulate matter is solubilized by extraction with nitric acid (HNO_3), facilitated by heat or by a mixture of $HNO_3$and hydrochloric acid (HCl) facilitated by ultrasonication.

1.3 The lead content of the sample is analyzed by atomic absorption spectrometry using an air-acetylene flame, the 283.3 or 217.0 nm lead absorption line, and the optimum instrumental conditions recommended by the manufacturer.

1.4 The ultrasonication extraction with HNO_3/HCl will extract metals other than lead from ambient particulate matter.

2. *Range, sensitivity, and lower detectable limit.* The values given below are typical of the methods capabilities. Absolute values will vary for individual situations depending on the type of instrument used, the lead line, and operating conditions.

2.1 *Range.* The typical range of the method is 0.07 to 7.5 µg Pb/m^3 assuming an upper linear range of analysis of 15 µg/ml and an air volume of 2,400 m^3 .

2.2 *Sensitivity.* Typical sensitivities for a 1 percent change in absorption (0.0044 absorbance units) are 0.2 and 0.5 µg Pb/ml for the 217.0 and 283.3 nm lines, respectively.

2.3 *Lower detectable limit (LDL).* A typical LDL is 0.07 µg Pb/m^3 . The above value was calculated by doubling the between-laboratory standard deviation obtained for the lowest measurable lead concentration in a collaborative test of the method.(*15*) An air volume of 2,400 m^3 was assumed.

3. *Interferences.* Two types of interferences are possible: chemical and light scattering.

3.1 *Chemical.* Reports on the absence (*1, 2, 3, 4, 5*) of chemical interferences far outweigh those reporting their presence, (*6*) therefore, no correction for chemical interferences is given here. If the analyst suspects that the sample matrix is causing a chemical interference, the interference can be verified and corrected for by carrying out the analysis with and without the method of standard additions.(*7*)

3.2 *Light scattering.* Nonatomic absorption or light scattering, produced by high concentrations of dissolved solids in the sample, can produce a significant interference, especially at low lead concentrations. (*2*) The interference is greater at the 217.0 nm line than at the 283.3 nm line. No interference was observed using the 283.3 nm line with a similar method.(*1*)

Light scattering interferences can, however, be corrected for instrumentally. Since the dissolved solids can vary depending on the origin of the sample, the correction may be necessary, especially when using the 217.0 nm line. Dual beam instruments with a continuum source give the most accurate correction. A less accurate correction can be obtained by using a nonabsorbing lead line that is near the lead analytical line. Information on use of these correction techniques can be obtained from instrument manufacturers' manuals.

If instrumental correction is not feasible, the interference can be eliminated by use of the ammonium pyrrolidinecarbodithioate-methylisobutyl ketone, chelation-solvent extraction technique of sample preparation.(*8*)

4. *Precision and bias.*

4.1 The high-volume sampling procedure used to collect ambient air particulate matter has a between-laboratory relative standard deviation of 3.7 percent over the range 80 to 125 µg/m^3 .(*9*) The combined extraction-analysis procedure has an average within-laboratory relative standard deviation of 5 to 6 percent over the range 1.5 to 15 µg Pb/ml, and an average between laboratory relative standard deviation of 7 to 9 percent over the same range. These values include use of either extraction procedure.

4.2 Single laboratory experiments and collaborative testing indicate that there is no significant difference in lead recovery between the hot and ultrasonic extraction procedures.(*15*)

5. *Apparatus.*

5.1 *Sampling.*

5.1.1 *High-Volume Sampler.* Use and calibrate the sampler as described in appendix B to

this part.

5.2 *Analysis.*

5.2.1 *Atomic absorption spectrophotometer.* Equipped with lead hollow cathode or electrodeless discharge lamp.

5.2.1.1 *Acetylene.* The grade recommended by the instrument manufacturer should be used. Change cylinder when pressure drops below 50–100 psig.

5.2.1.2 *Air.* Filtered to remove particulate, oil, and water.

5.2.2 *Glassware.* Class A borosilicate glassware should be used throughout the analysis.

5.2.2.1 *Beakers.* 30 and 150 ml. graduated, Pyrex.

5.2.2.2 *Volumetric flasks.* 100-ml.

5.2.2.3 *Pipettes.* To deliver 50, 30, 15, 8, 4, 2, 1 ml.

5.2.2.4 *Cleaning.* All glassware should be scrupulously cleaned. The following procedure is suggested. Wash with laboratory detergent, rinse, soak for 4 hours in 20 percent (w/w) HNO_3, rinse 3 times with distilled-deionized water, and dry in a dust free manner.

5.2.3 *Hot plate.*

5.2.4. *Ultrasonication water bath, unheated.* Commercially available laboratory ultrasonic cleaning baths of 450 watts or higher "cleaning power," i.e., actual ultrasonic power output to the bath have been found satisfactory.

5.2.5 *Template.* To aid in sectioning the glass-fiber filter. See figure 1 for dimensions.

5.2.6 *Pizza cutter.* Thin wheel. Thickness 1mm.

5.2.7 *Watch glass.*

5.2.8 *Polyethylene bottles.* For storage of samples. Linear polyethylene gives better storage stability than other polyethylenes and is preferred.

5.2.9 Parafilm "M".[1] American Can Co., Marathon Products, Neenah, Wis., or equivalent.

[1] Mention of commercial products does not imply endorsement by the U.S. Environmental Protection Agency.

6. *Reagents.*

6.1 *Sampling.*

6.1.1 *Glass fiber filters.* The specifications given below are intended to aid the user in obtaining high quality filters with reproducible properties. These specifications have been met by EPA contractors.

6.1.1.1 *Lead content.* The absolute lead content of filters is not critical, but low values are,

of course, desirable. EPA typically obtains filters with a lead content of 75 µg/filter.

It is important that the variation in lead content from filter to filter, within a given batch, be small.

6.1.1.2 *Testing.*

6.1.1.2.1 For large batches of filters (>500 filters) select at random 20 to 30 filters from a given batch. For small batches (>500 filters) a lesser number of filters may be taken. Cut one3/4&inch;×8&inch; strip from each filter anywhere in the filter. Analyze all strips, separately, according to the directions in sections 7 and 8.

6.1.1.2.2 Calculate the total lead in each filter as

$$F_b = \mu g\ Pb/ml \times \frac{100\ \text{ml}}{\text{strip}} \times \frac{12\ \text{strips}}{\text{filter}}$$

where:

F_b= Amount of lead per 72 square inches of filter, µg.

6.1.1.2.3 Calculate the mean, F_b, of the values and the relative standard deviation (standard deviation/mean × 100). If the relative standard deviation is high enough so that, in the analysts opinion, subtraction of F_b, (section 10.3) may result in a significant error in the µg Pb/m^3 , the batch should be rejected.

6.1.1.2.4 For acceptable batches, use the value of $F_b$to correct all lead analyses (section 10.3) of particulate matter collected using that batch of filters. If the analyses are below the LDL (section 2.3) no correction is necessary.

6.2 *Analysis.*

6.2.1 Concentrated (15.6 *M)* HNO_3. ACS reagent grade $HNO_3$and commercially available redistilled HNO_3has found to have sufficiently low lead concentrations.

6.2.2 Concentrated (11.7 *M*) HCl. ACS reagent grade.

6.2.3 *Distilled-deionized water.* (D.I. water).

6.2.4 3 *M* HNO_3. This solution is used in the hot extraction procedure. To prepare, add 192 ml of concentrated $HNO_3$to D.I. water in a 1 *l* volumetric flask. Shake well, cool, and dilute to volume with D.I. water. *Caution:* Nitric acid fumes are toxic. Prepare in a well ventilated fume hood.

6.2.5 0.45 *M* HNO_3. This solution is used as the matrix for calibration standards when using the hot extraction procedure. To prepare, add 29 ml of concentrated $HNO_3$to D.I. water in a 1 *l* volumetric flask. Shake well, cool, and dilute to volume with D.I. water.

6.2.6 2.6 *M* HNO_3+0 to 0.9 *M* HCl. This solution is used in the ultrasonic extraction procedure. The concentration of HCl can be varied from 0 to 0.9 *M.* Directions are given for preparation of a 2.6 *M* HNO_3+0.9 *M* HCl solution. Place 167 ml of concentrated HNO_3into a 1 *l* volumetric flask and add 77 ml of concentrated HCl. Stir 4 to 6 hours, dilute to nearly 1 *l* with D.I. water, cool to room temperature, and dilute to 1 *l* .

6.2.7 0.40 *M* HNO_3+ X *M* HCl. This solution is used as the matrix for calibration standards when using the ultrasonic extraction procedure. To prepare, add 26 ml of concentrated HNO_3, plus the ml of HCl required, to a 1 *l* volumetric flask. Dilute to nearly 1 *l* with D.I. water, cool to room temperature, and dilute to 1 *l.* The amount of HCl required can be determined from the following equation:

$$y = \frac{77\ \text{ml} \times 0.15 \times}{0.9\ \text{M}}$$

where:

y = ml of concentrated HCl required.

x = molarity of HCl in 6.2.6.

0.15 = dilution factor in 7.2.2.

6.2.8 Lead nitrate, $Pb(NO_3)_2$. ACS reagent grade, purity 99.0 percent. Heat for 4 hours at 120 °C and cool in a desiccator.

6.3 *Calibration standards.*

6.3.1 Master standard, 1000 µg Pb/ml in HNO_3. Dissolve 1.598 g of $Pb(NO_3)_2$in 0.45 *M* HNO_3contained in a 1 *l* volumetric flask and dilute to volume with 0.45 *M* HNO_3.

6.3.2 Master standard, 1000 µg Pb/ml in HNO_3/HCl. Prepare as in section 6.3.1 except use the HNO_3/HCl solution in section 6.2.7.

Store standards in a polyethylene bottle. Commercially available certified lead standard solutions may also be used.

7. *Procedure.*

7.1 *Sampling.* Collect samples for 24 hours using the procedure described in reference *10* with glass-fiber filters meeting the specifications in section 6.1.1. Transport collected samples to the laboratory taking care to minimize contamination and loss of sample.(*16).*

7.2 *Sample preparation.*

7.2.1 *Hot extraction procedure.*

7.2.1.1 Cut a3/4&inch;×8&inch; strip from the exposed filter using a template and a pizza cutter as described in Figures 1 and 2. Other cutting procedures may be used.

Lead in ambient particulate matter collected on glass fiber filters has been shown to be uniformly distributed across the filter.[1,3,11] Another study[12] has shown that when sampling near a roadway, strip position contributes significantly to the overall variability associated with lead analyses. Therefore, when sampling near a roadway, additional strips should be analyzed to minimize this variability.

7.2.1.2 Fold the strip in half twice and place in a 150-ml beaker. Add 15 ml of 3 *M* $HNO_3$to cover the sample. The acid should completely cover the sample. Cover the beaker with a watch glass.

7.2.1.3 Place beaker on the hot-plate, contained in a fume hood, and boil gently for 30 min. Do not let the sample evaporate to dryness. *Caution:* Nitric acid fumes are toxic.

7.2.1.4 Remove beaker from hot plate and cool to near room temperature.

7.2.1.5 Quantitatively transfer the sample as follows:

7.2.1.5.1 Rinse watch glass and sides of beaker with D.I. water.

7.2.1.5.2 Decant extract and rinsings into a 100-ml volumetric flask.

7.2.1.5.3 Add D.I. water to 40 ml mark on beaker, cover with watch glass, and set aside for a minimum of 30 minutes. This is a critical step and cannot be omitted since it allows the HNO_3trapped in the filter to diffuse into the rinse water.

7.2.1.5.4 Decant the water from the filter into the volumetric flask.

7.2.1.5.5 Rinse filter and beaker twice with D.I. water and add rinsings to volumetric flask until total volume is 80 to 85 ml.

7.2.1.5.6 Stopper flask and shake vigorously. Set aside for approximately 5 minutes or until foam has dissipated.

7.2.1.5.7 Bring solution to volume with D.I. water. Mix thoroughly.

7.2.1.5.8 Allow solution to settle for one hour before proceeding with analysis.

7.2.1.5.9 If sample is to be stored for subsequent analysis, transfer to a linear polyethylene bottle.

7.2.2 *Ultrasonic extraction procedure.*

7.2.2.1 Cut a3/4&inch;×8&inch; strip from the exposed filter as described in section 7.2.1.1.

7.2.2.2 Fold the strip in half twice and place in a 30 ml beaker. Add 15 ml of the HNO_3/HCl solution in section 6.2.6. The acid should completely cover the sample. Cover the beaker with parafilm.

The parafilm should be placed over the beaker such that none of the parafilm is in contact with water in the ultrasonic bath. Otherwise, rinsing of the parafilm (section 7.2.2.4.1) may contaminate the sample.

7.2.2.3 Place the beaker in the ultrasonication bath and operate for 30 minutes.

7.2.2.4 Quantitatively transfer the sample as follows:

7.2.2.4.1 Rinse parafilm and sides of beaker with D.I. water.

7.2.2.4.2 Decant extract and rinsings into a 100 ml volumetric flask.

7.2.2.4.3 Add 20 ml D.I. water to cover the filter strip, cover with parafilm, and set aside for a minimum of 30 minutes. This is a critical step and cannot be omitted. The sample is then processed as in sections 7.2.1.5.4 through 7.2.1.5.9.

Note: Samples prepared by the hot extraction procedure are now in 0.45 *M* HNO_3. Samples prepared by the ultrasonication procedure are in 0.40 *M* HNO_3+X *M* HCl.

8. *Analysis.*

8.1 Set the wavelength of the monochromator at 283.3 or 217.0 nm. Set or align other instrumental operating conditions as recommended by the manufacturer.

8.2 The sample can be analyzed directly from the volumetric flask, or an appropriate amount of sample decanted into a sample analysis tube. In either case, care should be taken not to disturb the settled solids.

8.3 Aspirate samples, calibration standards and blanks (section 9.2) into the flame and record the equilibrium absorbance.

8.4 Determine the lead concentration in µg Pb/ml, from the calibration curve, section 9.3.

8.5 Samples that exceed the linear calibration range should be diluted with acid of the same concentration as the calibration standards and reanalyzed.

9. *Calibration.*

9.1 *Working standard,* 20 µg Pb/ml. Prepared by diluting 2.0 ml of the master standard (section 6.3.1 if the hot acid extraction was used or section 6.3.2 if the ultrasonic extraction procedure was used) to 100 ml with acid of the same concentration as used in preparing the master standard.

9.2 *Calibration standards.* Prepare daily by diluting the working standard, with the same acid matrix, as indicated below. Other lead concentrations may be used.

Volume of 20 µg/ml working standard, ml	Final volume, ml	Concentration µg Pb/ml
0	100	0
1.0	200	0.1
2.0	200	0.2
2.0	100	0.4
4.0	100	0.8
8.0	100	1.6
15.0	100	3.0
30.0	100	6.0
50.0	100	10.0
100.0	100	20.0

9.3 *Preparation of calibration curve.* Since the working range of analysis will vary

depending on which lead line is used and the type of instrument, no one set of instructions for preparation of a calibration curve can be given. Select standards (plus the reagent blank), in the same acid concentration as the samples, to cover the linear absorption range indicated by the instrument manufacturer. Measure the absorbance of the blank and standards as in section 8.0. Repeat until good agreement is obtained between replicates. Plot absorbance (y-axis) versus concentration in µg Pb/ml (x-axis). Draw (or compute) a straight line through the linear portion of the curve. Do not force the calibration curve through zero. Other calibration procedures may be used.

To determine stability of the calibration curve, remeasure—alternately—one of the following calibration standards for every 10th sample analyzed: Concentration ≤1 µg Pb/ml; concentration ≤10 µg Pb/ml. If either standard deviates by more than 5 percent from the value predicted by the calibration curve, recalibrate and repeat the previous 10 analyses.

10. *Calculation.*

10.1 *Measured air volume.* Calculate the measured air volume at Standard Temperature and Pressure as described in Reference 10.

10.2 *Lead concentration.* Calculate lead concentration in the air sample.

$$C = \frac{(\mu g\ Pb/ml \times 100\ ml/strip \times 12\ strips/filter) - F_b}{V_{STP}}$$

where:

C = Concentration, µg Pb/sm^3 .

µg Pb/ml = Lead concentration determined from section 8.

100 ml/strip = Total sample volume.

12 strips = Total useable filter area, 8&inch;×9&inch;. Exposed area of one strip,3/4&inch;×7&inch;.

Filter = Total area of one strip,3/4&inch;×8&inch;.

F_b= Lead concentration of blank filter, µg, from section 6.1.1.2.3.

V_{STP}= Air volume from section 10.1.

11. *Quality control.*

3/4&inch;×8&inch; glass fiber filter strips containing 80 to 2000 µg Pb/strip (as lead salts) and blank strips with zero Pb content should be used to determine if the method—as being used—has any bias. Quality control charts should be established to monitor differences between measured and true values. The frequency of such checks will depend on the local quality control program.

To minimize the possibility of generating unreliable data, the user should follow practices established for assuring the quality of air pollution data, (*13*) and take part in EPA's semiannual audit program for lead analyses.

12. *Trouble shooting.*

1. During extraction of lead by the hot extraction procedure, it is important to keep the sample covered so that corrosion products—formed on fume hood surfaces which may contain lead—are not deposited in the extract.

2. The sample acid concentration should minimize corrosion of the nebulizer. However, different nebulizers may require lower acid concentrations. Lower concentrations can be used provided samples and standards have the same acid concentration.

3. Ashing of particulate samples has been found, by EPA and contractor laboratories, to be unnecessary in lead analyses by atomic absorption. Therefore, this step was omitted from the method.

4. Filtration of extracted samples, to remove particulate matter, was specifically excluded from sample preparation, because some analysts have observed losses of lead due to filtration.

5. If suspended solids should clog the nebulizer during analysis of samples, centrifuge the sample to remove the solids.

13. *Authority.*

(Secs. 109 and 301(a), Clean Air Act, as amended (42 U.S.C. 7409, 7601(a)))

14. *References.*

1. Scott, D. R. et al. “Atomic Absorption and Optical Emission Analysis of NASN Atmospheric Particulate Samples for Lead.” *Envir. Sci. and Tech., 10,* 877–880 (1976).

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11. Dubois, L., et al., “The Metal Content of Urban Air.” JAPCA, *16,* 77–78 (1966).

12. EPA Report No. 600/4–77–034, June 1977, “Los Angeles Catalyst Study Symposium.” Page 223.

13. *Quality Assurance Handbook for Air Pollution Measurement System. Volume 1—Principles.* EPA–600/9–76–005, March 1976.

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15. Sharon J. Long, et al., “Lead Analysis of Ambient Air Particulates: Interlaboratory Evaluation of EPA Lead Reference Method” APCA Journal, 29, 28–31 (1979).

16. *Quality Assurance Handbook for Air Pollution Measurement Systems. Volume II—Ambient Air Specific Methods.* EPA–600/4–77/027a, May 1977.

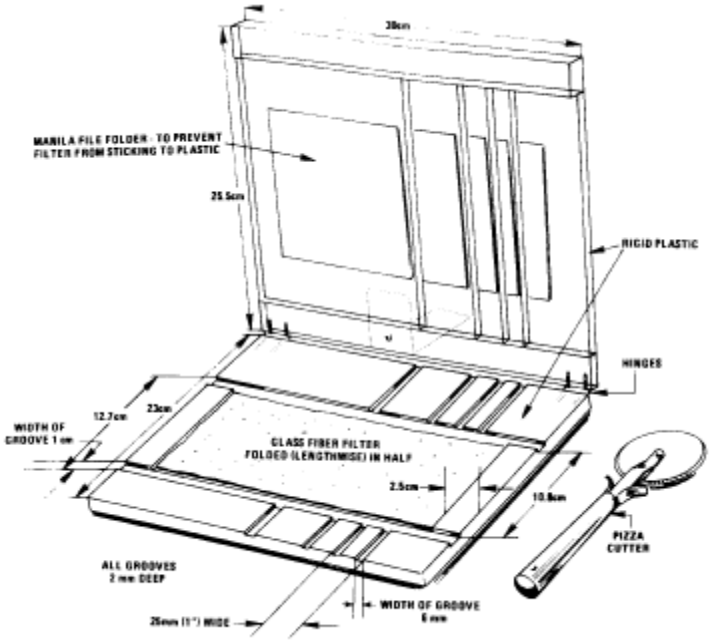


Figure 1

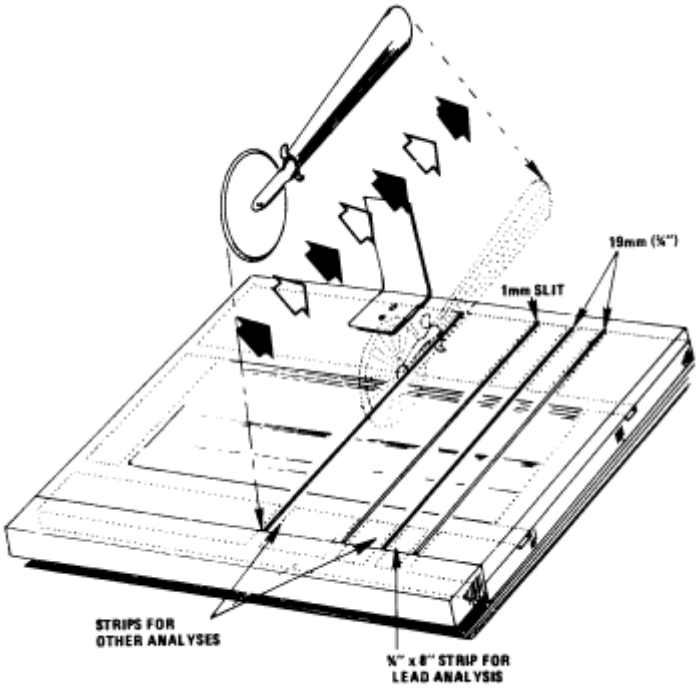


Figure 2

(Secs. 109, 301(a) of the Clean Air Act, as amended (42 U.S.C. 7409, 7601(a)); secs. 110, 301(a) and 319 of the Clean Air Act (42 U.S.C. 7410, 7601(a), 7619))

[43 FR 46258, Oct. 5, 1978; 44 FR 37915, June 29, 1979, as amended at 46 FR 44163, Sept. 3, 1981; 52 FR 24664, July 1, 1987; 73 FR 67052, Nov. 12, 2008]

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DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR FORCE CIVIL ENGINEER SUPPORT AGENCY

19 APR 2011

FROM: HQ AFCESA/CEO
139 Barnes Drive, Suite 1
Tyndall AFB, FL 32403-5319

SUBJECT: **Engineering Technical Letter (ETL) 11-18: Small Arms Range Design and Construction**

1. Purpose.

1.1. This ETL provides criteria for the design and construction of Air Force small arms ranges and applies to both new construction and major renovations. Additionally, this ETL should be used as a guide for any ranges purchased as equipment items. The intent of this ETL is to provide the minimum design criteria necessary for achieving a safe range design. This ETL assumes users have a formal engineering education and background or access to local engineering expertise. This ETL does not establish the number of firing points, target distance, targetry, or type of range. A planning team composed of major command (MAJCOM) and installation-level combat arms (CA), civil engineering (CE), bioenvironmental engineer (BEE) and safety (SE) personnel will jointly establish the number of firing points, the target distance, and the type of range based on mission, training requirements, and available real estate.

1.2. This ETL is directive in accordance with Air Force instruction (AFI) 32-1023, *Designing and Constructing Military Construction Projects*, and AFI 36-2226, *Combat Arms Program*, and must be used by the range designer when designing a new range or renovating an existing range. The range designer has the responsibility to ensure the minimum criteria presented in this ETL are used to provide a safe range design. This ETL may not cover all site-specific concerns and it is the designer's responsibility to adapt the intent of the ETL criteria to ensure the range is operationally safe. This ETL is not a specification or a prescriptive checklist and is not intended to replace professional judgment by a competent licensed professional engineer, after coordination with the end-user or installation CA section. Additionally, nothing in this ETL should preclude consideration and use of emerging technologies and commercially available products if these can be proven to result in a safe and satisfactory range design.

1.3. This ETL supersedes ETL 08-11, *Small Arms Range Design and Construction*.

Note: The use of the name or mark of any specific manufacturer, commercial product, commodity, or service in this ETL does not imply endorsement by the Air Force.

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2. Summary of Revisions. This ETL is revised as a result of a 2010 air ventilation survey. The primary change to this ETL eliminates the design of new, fully contained outdoor ranges. The reason for eliminating this option is because controlling air flow within the range is virtually impossible with an open roof over the baffles. With this new ETL only two options remain: fully contained indoor range or non-contained range, for design and major renovation of small arms ranges. Range ventilation performance will also need to be validated prior to final inspection to ensure that proper ventilation is provided within the range. This ETL also allows for expanded use of noise-reduction material to improve occupational exposure to high noise levels.

3. Application: All Air Force installations.

- The criteria in this ETL shall apply to all small arms ranges where the design phase is 35 percent complete or less on the effective date of this ETL.
- New partially contained ranges or fully contained outdoor ranges will not be designed or constructed. If planned major range or component repairs of an existing range will cost more than 50 percent of the estimated range replacement cost (plant replacement value), the entire facility must be upgraded to comply with this ETL.
- The salient safety, health, and environmental features of permanent ranges shall apply to expeditionary or portable ranges; therefore, these ETL standards shall apply to portable ranges purchased as equipment.
- The requirements in this ETL are applicable in OCONUS locations. When conflicts exist between this ETL and host nation requirements, the strictest requirement shall apply.
- After MAJCOM approval, HQ AFSFC/SFXW may approve deviations from the criteria in this ETL. MAJCOMs will submit requests for deviation to HQ AFSFC/SFXW, who will coordinate with HQ AFCESA and AFMSA for review.

3.1. Authority: Air Force policy directive (AFPD) 32-10, *Installations and Facilities*.

3.2. Effective date: Immediately.

3.3. Intended Users: MAJCOM functional managers; CE; BEE; CA, and range designers for the Air Force.

3.4. Coordination: MAJCOM functional managers and HQ AFSFC/SFXW.

4. Referenced Publications. In some instances, the references listed in paragraphs 4.1 through 4.7 may advocate procedures that seem to contradict those in this ETL. In these cases, the information in this ETL supersedes any other design and construction source. Likewise, policy guidance on range operation and maintenance contained in AFI 36-2226 takes precedence over other sources.

4.1. Public Law:

- Title 29 Code of Federal Regulations (CFR) 1910.1000, *Air contaminants*, http://www.access.gpo.gov/nara/cfr/waisidx_10/29cfr1910a_10.html
- 29 CFR 1910.1025, *Lead*, http://www.access.gpo.gov/nara/cfr/waisidx_10/29cfr1910a_10.html

4.2. Department of Defense (DOD):

- DOD Directive (DODD) 5100.76-M, *Physical Security of Sensitive Conventional Arms, Ammunition, and Explosives*, http://www.dtic.mil/whs/directives/corres/pdf/510076m.pdf
- DOD Instruction (DODI) 6055.12, *Hearing Conservation Program (HCP)*, http://www.dtic.mil/whs/directives/corres/pdf/605512p.pdf
- Unified Facilities Criteria (UFC) 1-200-01, *General Building Requirements*, http://www.wbdg.org/ccb/browse_cat.php?o=29&c=4
- UFC 3-120-01, *Air Force Sign Standard*, http://www.wbdg.org/ccb/browse_cat.php?o=29&c=4
- UFC 4-010-01, *DoD Minimum Antiterrorism Standards for Buildings,* http://www.wbdg.org/ccb/browse_cat.php?o=29&c=4
- UFC 4-020-01, *DoD Security Engineering Facilities Planning Manual*, http://www.wbdg.org/ccb/browse_cat.php?o=29&c=4

4.3. Air Force (available at http://www.e-publishing.af.mil):

- AFI 31-101, *Integrated Defense* (FOUO)
- AFPD 32-10, *Installations and Facilities*
- AFI 32-1023, *Designing and Constructing Military Construction Projects*
- AFI 36-2226, *Combat Arms Program*
- AFI 90-901, *Operational Risk Management*
- Air Force pamphlet (AFPAM) 90-902, *Operational Risk Management (ORM) Guidelines and Tools*
- Air Force Occupational Safety and Health (AFOSH) Standard 48-20, *Occupational Noise and Hearing Conservation Program*
- Air Force manual (AFMAN) 48-155, *Occupational and Environmental Health Exposure Controls*

4.4. Navy:

- Navy and Marine Corps Public Health Center Technical Manual (NMCPHC-TM) IH 6290.10, *Indoor Firing Ranges Industrial Hygiene Technical Guide*, http://www-nehc.med.navy.mil/Publications_Reports/techmanuals.aspx
- Navy Environmental Health Center, Technical Manual (NEHC-TM) 6290.99-10 Rev. 1, *Indoor Firing Ranges Industrial Hygiene Technical Guide*, http://www-nehc.med.navy.mil/downloads/ih/indoor_firing_range.pdf

4.5. Army:

- Army Pamphlet (PAM) 385-63, *Range Safety*, http://www.apd.army.mil/jw2/xmldemo/p385_63/cover.asp

- Training Circular (TC) 25-8, *Training Ranges*, http://armypubs.army.mil/doctrine/tc_1.html
- National Guard Bureau Regulation (NGR) 385-15, *Policy and Responsibilities for Inspection, Evaluation and Operation of Army National Guard Indoor Firing Ranges*, http://www.ngbpdc.ngb.army.mil/pubs/ARNG%20Series/arngseries.htm

4.6. Environmental Protection Agency (EPA):

- *Best Management Practices for Lead at Outdoor Shooting Ranges*, http://www.epa.gov/region02/waste/leadshot/

4.7. Industry:

- American Welding Society (AWS) D1.1, *Structural Welding Code – Steel*, https://www.awspubs.com
- ASTM A514/A514M, *Standard Specification for High-Yield-Strength, Quenched and Tempered Alloy Steel Plate, Suitable for Welding*, http://www.astm.org
- ASTM C76, *Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe*, http://www.astm.org
- ASTM C136, *Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates*, http://www.astm.org
- Illuminating Engineering Society of North America (IESNA) Lighting Handbook, http://www.iesna.org/
- American Conference of Governmental Industrial Hygienists (ACGIH), *Industrial Ventilation: A Manual of Recommended Practice*, 27th Edition, http://www.acgih.org/store/ProductDetail.cfm?id=1913

5. Acronyms and Symbols.

AFCESA	- Air Force Civil Engineer Support Agency
AFMAN	- Air Force manual
AFH	- Air Force handbook
AFI	- Air Force instruction
AFMSA/SG3PB	– Air Force Medical Support Agency, Bioenvironmental Engineering Division
AFOSH	- Air Force Occupational Safety & Health
AFPAM	- Air Force pamphlet
AFPD	- Air Force policy directive
AR	- abrasion resistant (e.g., AR500 plate)
AWS	- American Welding Society
BCE	- base civil engineer
BE	- bioenvironmental engineering (office)
BEE	- bioenvironmental engineer
BHN	- Brinnell Hardness Number
BMP	- best management practices
CA	- combat arms

cal.	- caliber
CE	- civil engineering
CFR	- Code of Federal Regulations
CMU	- concrete masonry unit
dBA	- decibels (“A” scale)
DOD	- Department of Defense
DODD	- Department of Defense Directive
DODI	- Department of Defense Instruction
EOD	- explosive ordnance disposal
EPA	- Environmental Protection Agency
ETL	- Engineering Technical Letter
FOUO	- For Official Use Only
fpm	- feet per minute
FRT	- fire resistant treated
ft	- foot
HEPA	- high-efficiency particulate air (filter)
HMMWV	- high-mobility multi-purpose wheeled vehicle
HQ AFCESA/CEOA	- Headquarters Air Force Civil Engineer Support Agency, Engineer and Programs Support Division, Engineer Support Branch
HQ AFSFC/SFXW	- Headquarters, Air Force Security Forces Center, Combat Arms
HVAC	- heating, ventilation, and air conditioning
IESNA	- Illuminating Engineering Society of North America
in.	- inch
LAW	- light anti-tank weapon
LR	- long rifle
m	- meter
MAJCOM	- major command
MIL-HDBK	- military handbook
mm	- millimeter
mpm	- meters per minute
NCOIC	- noncommissioned officer in charge
NEHC	- Navy Environmental Health Center
NMCPHC	- Navy and Marine Corps Public Health Center
OCONUS	- outside continental United States
ORM	- operational risk management
PEL	- permissible exposure limit
pH	- symbol for logarithm of reciprocal of hydrogen ion concentration in gram atoms per liter
PPBE	- planning, programming, budgeting, and execution
psi	- pound per square inch
RH	- relative humidity
RKT HEAT	- rocket high-explosive anti-tank
SDZ	- surface danger zone
SE	- safety

TACOM-ARDEC	- U.S. Army Tank-Automotive and Armaments Command – Armament Research Development and Engineering Center
TBD	- to be determined
TC	- Training Circular
UFC	- Unified Facilities Criteria
VDZ	- vertical danger zone

6. Definitions.

6.1. *Small arms range*: A live-fire training facility for training and certifying personnel in the use of handguns, shotguns, rifles up to 7.62mm, rifles or machine guns up to .50 caliber, and the MK-19 40mm machine gun. A small arms range may include special ranges for 40mm grenade launchers, light anti-tank weapons (LAW), and 81mm mortars. Equipment items such as fully (self-) contained portable or expeditionary ranges fall into this category.

6.2. *Surface danger zone (SDZ)*: The portions of the range in the horizontal plane that are endangered by firing a particular weapon. The SDZ includes the area between the firing line and the target line, an impact area, a ricochet trajectory area, and a secondary danger area. The SDZ may also include a weapon back-blast area. The SDZ must be located completely within the boundaries of U.S. government-owned or -leased properties. A fully contained range which is incapable of allowing a fired projectile to escape its limits does not have an exterior SDZ.

6.3. *Vertical danger zone (VDZ)*: For non-contained and partially contained ranges, the VDZ is the volume of airspace above the SDZ between the ground surface and the maximum ordinate of a direct-fired or ricochet round. The height of the VDZ varies with the weapon and ammunition fired (see Attachment 1). For fully contained ranges, the VDZ is the area between the SDZ and the upper limits of containment.

6.4. *Non-contained range (impact range)*: A non-contained range is an outdoor/open range. The firing line may be covered or uncovered. Direct-fire rounds and ricochets are unimpeded and may fall anywhere within the SDZ. The non-contained range requires an SDZ equal to 100 percent of the maximum range of the most powerful round to be used on the range. This type of range requires the largest amount of real estate to satisfy the SDZ requirements.

6.5. *Partially contained range*: This range has a covered firing line, side containment, overhead baffles, and a bullet backstop. Direct fire is totally contained by the firing line canopy, side containment, baffles, and bullet trap (no “blue sky” observed from firing positions). Ricochets are not totally contained, but reduced by the baffles and side containment. A partially contained range requires an SDZ length equal to 50 percent of the maximum range of the most powerful round to be used on the range. A partially contained range will not permit lateral movement along the firing line or movement toward the target line unless the range has the additional baffles required to stop direct fire at the downrange firing lines.

6.6. *Fully contained range*: Range in which direct fire and ricochets are totally contained within the limits of the range. There is no SDZ requirement outside the limits of the containment.

7. Design Criteria. Range design is based on providing facilities that meet the needs of the training courses of fire specified by HQ AFSFC/SFXW and MAJCOMs based on mission needs. Future range designs must consider courses of fire that may differ from traditional "line-up-and-shoot" courses of fire: certain courses of fire may require the shooter to advance downrange toward the target; other scenarios may include driving a vehicle (HMMWV ["Hummvee"] without pedestal-mounted weapon) into the range to practice vehicle dismount, cover techniques, and target engagement. It is imperative that a range designer fully understand what types of training and courses of fire will take place on the range and design the range accordingly. The designer should also consider design flexibility that allows for changing courses of fire in the future. Facility design and construction must comply with UFC 1-200-01, *General Building Requirements*.

Air Force ranges will not be designed or constructed to only accommodate frangible ammunition. To ensure operational range safety is not compromised, existing ranges that do not have the required SDZ may restrict the range to frangible ammunition only. However, this must be a temporary work-around and the owning organization must program corrective action to permit firing of ball ammunition.

The goal of the new Air Force small arms training philosophy is to increase the current 25-meter standard target distance and expand the diversity of training that can be accomplished on the range. Ranges should be designed to allow the greatest target distance possible within the available land at the site (e.g., 50 meters, 100 meters, 300 meters, 1000 meters). The desired target distance is at or as close as possible to the sight zero distance for the weapon.

Base and MAJCOM CA, CE, BE, and SE offices will jointly develop site-specific designs using the minimum criteria outlined in this ETL. MAJCOMs may submit designs that deviate from the requirements of this ETL to HQ AFSFC/SFXW for review. HQ AFSFC/SFXW will coordinate with HQ AFCESA/CEOA, Engineer Support Branch, and AFMSA/SG3PB, Bioenvironmental Engineering Division, for review. Submit designs to HQ AFSFC only after MAJCOM approval. Individual MAJCOMs may establish design criteria exceeding the minimums specified in this ETL.

7.1. Range Types, Combination Ranges, Range Configuration, Site Selection, and Range Geometric Design.

7.1.1. Range Types.

7.1.1.1. Non-contained Range (Impact Range). The non-contained range accommodates the controlled and supervised discharge of weapons and has

sufficient land area to ensure the discharged projectile does not exit the SDZ. The trajectory of the projectile is along the line of fire (orientation of the range) and the impact of the projectile is designed to be within the limits of the impact area. The firing line may be covered or uncovered. Typically, there are no overhead baffles, but surface barriers or sidewalls may be provided to partially limit projectile trajectory. A non-contained range must have the land area to accommodate both the full SDZ and the full VDZ. Ammunition used on the range will establish the required length of the SDZ and the required height of the VDZ. SDZ length must be equal to the longest distance equal to 100 percent of the extreme range for the types of ammunition used on the range. The required SDZ must equal or exceed the minimum SDZ lengths listed in Table 1. For minimum VDZ height requirements, see Attachment 1.

Table 1. Minimum SDZ Distance Requirements for Small Arms Ammunition — Non-contained Range

Weapon/Caliber	Ammunition	Minimum SDZ Length Meters (Feet)
Handgun, 9mm pistol Submachine gun, 9mm	M882	1840 (6036)
Handgun, 9mm pistol	Frangible, lead-free, Winchester AA16	1584 (5196)
Handgun, .44 magnum	Commercial local purchase	2290 (7513)
Shotgun, 12 gauge	00 buckshot	600 (1968)
Rifle, 5.56mm	Ball M193; tracer M196	3100 (10,170)
Rifle, 5.56mm	Ball M855; tracer M856	3600 (11,811)
Rifle, 5.56mm	M862 (plastic)	250 (820)
Rifle, 5.56mm	Frangible, lead-free, Federal Cartridge BC556NT1, PSPCL and Winchester AA40	2750 (9022)
Rifle/machine gun, 7.62mm	Ball M80; tracer M81	4300 (14,107)
Rifle/machine gun, 7.62mm	Match M118	4800 (15,748)
Machine gun, .50 caliber	Ball M2 and M33/tracer M17/M8 API/M20 APIT	6700 (21,981)
M79, M203, 40mm low-velocity	M781/M407A1/M406/ M433/M381/M386/M441	500 (1640) 100* (328*)
MK-19, 40mm high-velocity	M918/M383/M430	2650 (8694) 350* (1148*)
M72 LAW, 35mm sub-caliber	M73	1300 (4265) 100* (328*)

Weapon/Caliber	Ammunition	Minimum SDZ Length Meters (Feet)
M72 LAW, 66mm RKT HEAT	M72	1250 (4101) 250* (820*)
AT-4, 84mm RKT HEAT	M136	2600 (8530) 200* (656*)

*Additional standoff distance that must be added to minimum SDZ length to allow for explosive ordnance disposal (EOD) make-safe procedure.

7.1.1.2. Fully Contained Range. A fully contained range is designed to prevent 100 percent of the direct-fired rounds and 100 percent of the ricochets from leaving the limits of the range. This type of range is used when the required minimum SDZ or VDZ requirements are not available because of lack of land area or compatible land use. These ranges have an overhead containment structure (ballistic safety baffles) and sidewalls. The building envelope is typically not designed to prevent projectile penetration unless it is part of the containment. The structure elements and materials used for the building roof may vary depending upon the type and configuration of interior overhead containment, type of backstop, and method used to trap bullets. The fully contained range design must preclude the escape of both direct-fired projectiles and ricochets. Construct the overhead baffles with a minimum of 150 millimeters (6 inches) of horizontal overlap between the trailing edge of any baffle and the leading edge of the next baffle downrange (see Figure 8). The range design must include engineering controls to mitigate hazardous noise and other occupational and environmental hazards resulting from the use of both lead and non-lead frangible ammunition. For example, ammunition residue may contain unburned propellant. Excess build-up of this residue has caused flammable hazards within ranges. This flammability hazard may be controlled using a combination of facility and operational procedures to eliminate the risk of fire. Range personnel must work with local agencies to determine the required frequencies and procedures for removing unburned propellant from the range.

7.1.1.2.1. Fully Contained Indoor Range. A fully contained indoor range has a firing platform, bullet trap, and baffle system (or other ballistic containment system) enclosed within a complete building envelope. The complete building envelope is required to prevent influences from the exterior environment and to allow a slight negative pressure to be maintained within the range.

7.1.1.2.2. Fully Contained Outdoor Range. A fully contained outdoor range has baffle systems exposed to the environment and does not have a complete building envelope enclosing the entire range. Fully contained outdoor ranges are not permitted for new construction unless specifically approved by HQ AFSFC, HQ AFCESA, and AFMSA. All existing fully contained outdoor ranges designed in accordance with previously

published criteria may continue to operate if range safety can be verified. If an existing fully contained outdoor range does not meet the mechanical air flow requirement of paragraph 7.2.8.1, at the firing platform only, the installation shall program a project to provide the required airflow.

7.1.1.3. Partially Contained Range.

7.1.1.3.1. Partially contained ranges are not permitted for new construction unless specifically approved by HQ AFSFC, HQ AFCESA, and AFMSA**.** There are many existing partially contained ranges in the Air Force inventory.

7.1.1.3.2. All existing partially contained ranges that do not have the required SDZ must be programmed for upgrade or replacement to meet either full-distance, non-contained range criteria, fully contained range criteria, or the footprint of the existing deficient SDZ must be increased to meet the 50 percent SDZ requirement for a partially contained range. Existing partially contained ranges and other facilities designed in accordance with previously published criteria may continue to operate if range safety can be verified. Existing partially contained ranges that have an enclosed firing platform with sidewalls and back wall shall remove the sidewalls and back wall to improve natural ventilation.

- Verify range safety using the operational risk management (ORM) analysis in accordance with AFI 90-901, *Operational Risk Management*. See Attachment 2 for an ORM example.
- Range computer modeling and simulation is a proven technique for analyzing range safety and identifying necessary improvements.

Range safety violations and unsafe operating conditions must be addressed and corrected as soon as they are identified.

7.1.2. Combination Ranges. Range designs may be configured to accommodate a variety of weapons and courses of fire. The appropriate configuration must be determined by the types and sequence of weapons used.

7.1.2.1. Multi-purpose Ranges. The multi-purpose range provides for simultaneously firing more than one type of weapon. The complex consists of adjacent baffled and/or impact bays. A sidewall separates the two range types to prevent bullets from one range from entering the adjacent range.

7.1.2.2. Superimposed Ranges. A superimposed range accommodates different types of weapons and may be either a non-contained (impact) range or a fully contained (baffled) range; however, only one type of weapon may be fired at one time. The superimposed range allows for the maximum use of

land area and is usually the least expensive since there are no sidewalls between firing positions.

7.1.2.3. Special Ranges. Typically, special ranges are non-contained ranges designed to accommodate multiple target lines or arrays and set up for special types of weapons or unique courses of fire. Certain special ranges may exceed the scope of this ETL. Contact HQ AFSFC and HQ AFCESA for additional guidance.

7.1.3. Range Configuration. The range type, size, and configuration are based upon the installation mission, land availability, Air Force and MAJCOM policy, installation population, annual training requirements, and weapon-specific training requirements. Base CA personnel will submit their requirements for ranges through their chain of command to the MAJCOM functional manager. After the MAJCOM has validated the need, the BCE will begin a feasibility study for the proposed range. Programming and budgeting for range construction must occur within the framework of the normal planning, programming, budgeting and execution (PPBE) process.

7.1.4. Site Selection.

7.1.4.1. BCE. The BCE will identify the available real estate for the site of a small arms range facility that is consistent with the installation's master plan. The installation master plan will indicate the range location, orientation, SDZ, and VDZ.

7.1.4.2. Planning. A project team composed of the CA non-commissioned officer in charge (NCOIC), a land use planner, CE, SE, and BE representatives should collectively review the proposed range usage and location for land use compatibility. Safety is the primary concern when determining the site for a small arms range. Orient the SDZ and VDZ to minimize the effect of range operations on populated areas, aircraft ground and air operations, and land uses within the travel distance of the ammunition. Where full-containment enclosures have not been provided, the project team should assume that ricochets would land in all portions of the SDZ. The BCE is responsible for plotting the SDZ and the VDZ on the base master plan. Mitigate any conflicts of land use or airspace operations with the SDZ or the VDZ as part of the PPBE process.

7.1.4.3. Real Estate Acquisition. When government-owned property suitable for a small arms range is not available, and where land acquisition is feasible, the BCE will prepare the documents required for purchase or lease.

7.1.4.4. Geographical, Environmental, and Climatic Effects.

7.1.4.4.1. If possible, the outdoor non-contained range should be oriented north-to-south to minimize glare. To minimize residue being blown back towards the shooter, site the non-contained range with the prevailing wind blowing from the shooter's back toward the target line. For existing outdoor non-contained and outdoor partially contained ranges, supplemental ventilation may be required if natural air flow is not adequate to remove contaminated air from the firing line area. Seek assistance from the local BEE when assessing the air quality at existing firing platform areas. Avoid locating the range upwind of residential or populated areas. Site non-contained ranges and their impact areas to minimize projectiles and projectile residue falling in wetlands or waterways.

7.1.4.4.2. Regions subject to snow accumulation and extended periods of continuous sub-freezing temperatures should have fully contained indoor ranges. When this is not possible, the non-contained range should be sited to minimize drifting snow, ice buildup, and excess water, and to facilitate snow removal inside the range periphery.

7.1.4.4.3. Range sites must consider environmental concerns such as storm water management, protection of wetlands, ground and surface waters, historical or archaeological features, previously contaminated sites, and other concerns as may be determined by federal, state, and local environmental laws.

7.1.5. Range Geometric Design. The layout and dimensions of the facility must satisfy safety requirements and user needs. The following criteria are minimums:

7.1.5.1. SDZ Geometry. The range danger zone includes the projectile impact area, the SDZ, and the VDZ. Refer to Figures 1 through 6 for the typical geometry of the SDZ. The VDZ reflects the geometry of the SDZ extended to the VDZ height.

7.1.5.2. Limits of Fire. The limits of fire are imaginary lines drawn from the outermost edges of the endmost firing positions, extended downrange through the target line and terminating at the SDZ limit. The limits of fire may be perpendicular to the firing line or they may depart the firing line at a designated angle. The range's configuration and use determines the departure angle of the limits of fire.

7.1.5.3. Projectile Impact Area or Direct Fire Zone. The projectile impact area is bounded by the left and right limits of fire, the firing line, and extends to the minimum SDZ arc length for the ammunition and range type (Table 1). When the target line and the firing line are the same width, the impact area forms a rectangle (Figure 1). When the target line is wider than the firing line, the impact area becomes a pie-shaped area formed by the limits of fire and the arc of the minimum SDZ length (Figure 2).

7.1.5.4. Ricochet Danger Area. The ricochet danger area is the area between the impact area and the secondary danger area. The ricochet area is typically determined by extending a line drawn at a 10 degree angle off the left and right limits of fire, beginning at the firing line and extending to the minimum SDZ arc (Figures 1, 2, and 3). For a LAW range (Figure 4), the ricochet area is drawn at a 13 degree angle.

7.1.5.5. Secondary Danger Areas. Secondary danger areas are provided to catch fragments from exploding ammunition or ricochets from rounds that impact at the outer edge of the ricochet danger area. A line beginning at the intersection of the firing line and the firing limits is drawn departing from the line of fire at an angle of 40 degrees, extending outward for 1,000 meters (3,280 feet). From the 1,000-meter point, a second line extends to a point on the minimum SDZ arc 100 meters (328 feet) outside the ricochet area limits.

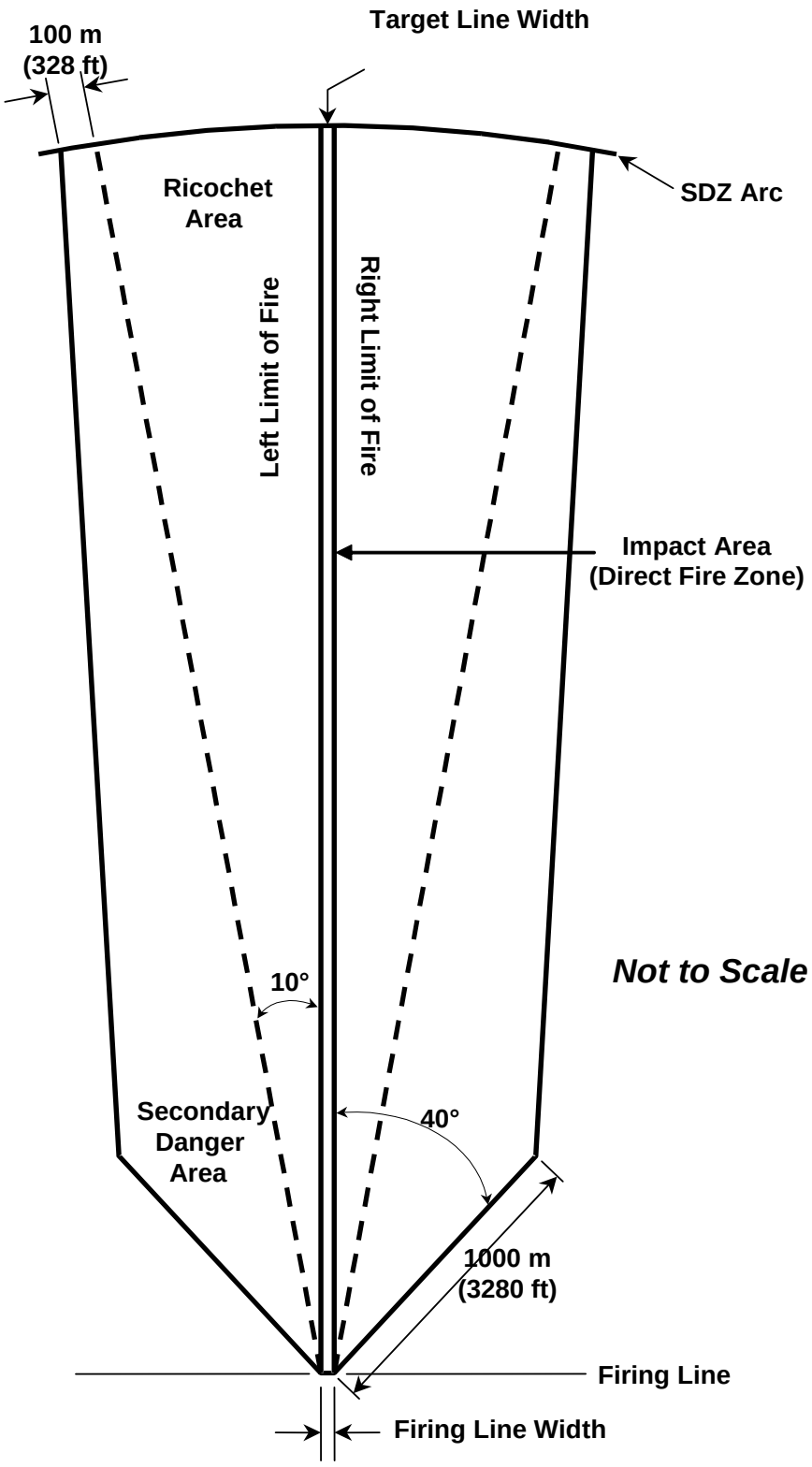


Figure 1. SDZ Configuration — Firing Line Width Equal to Target Line Width

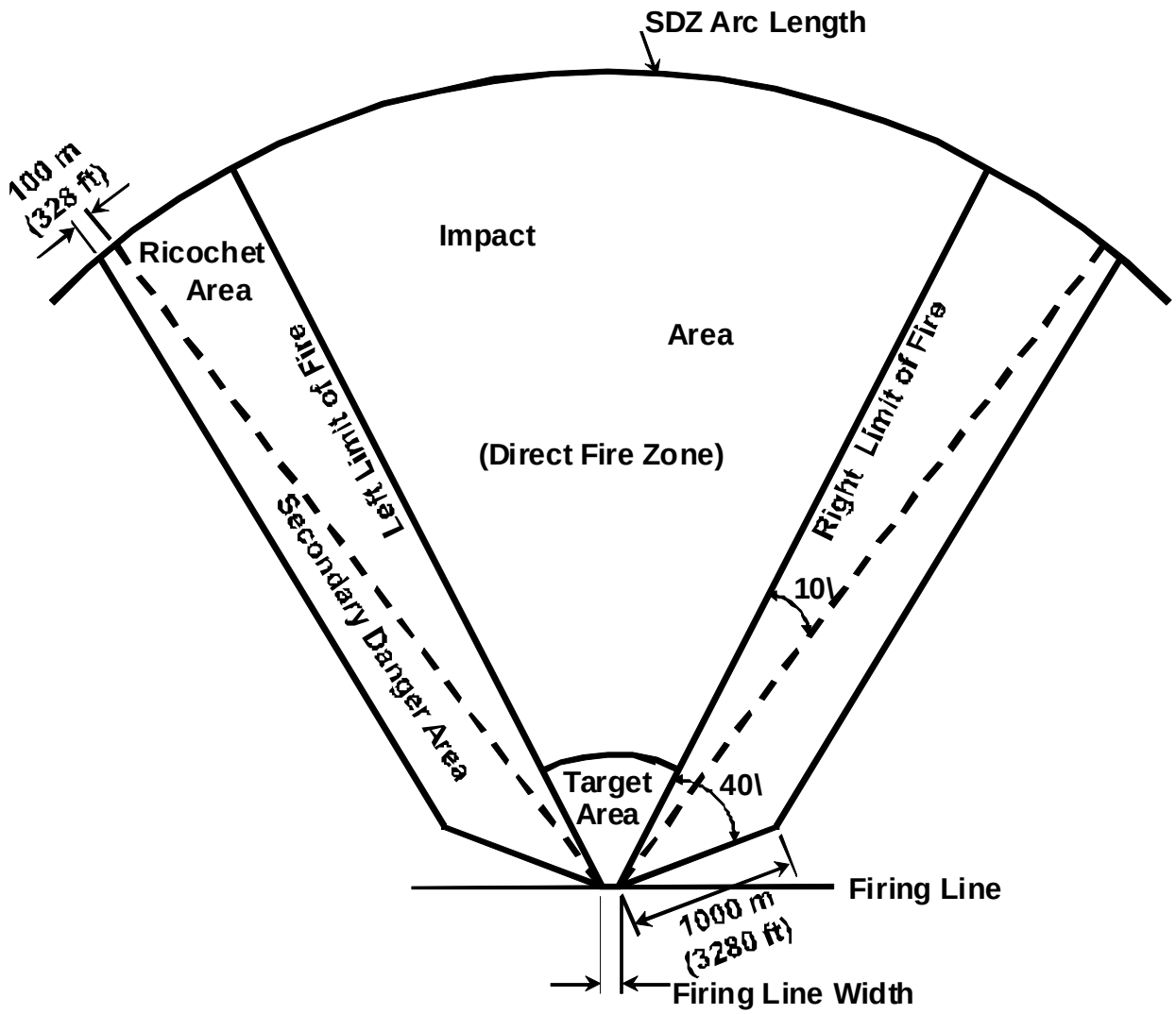
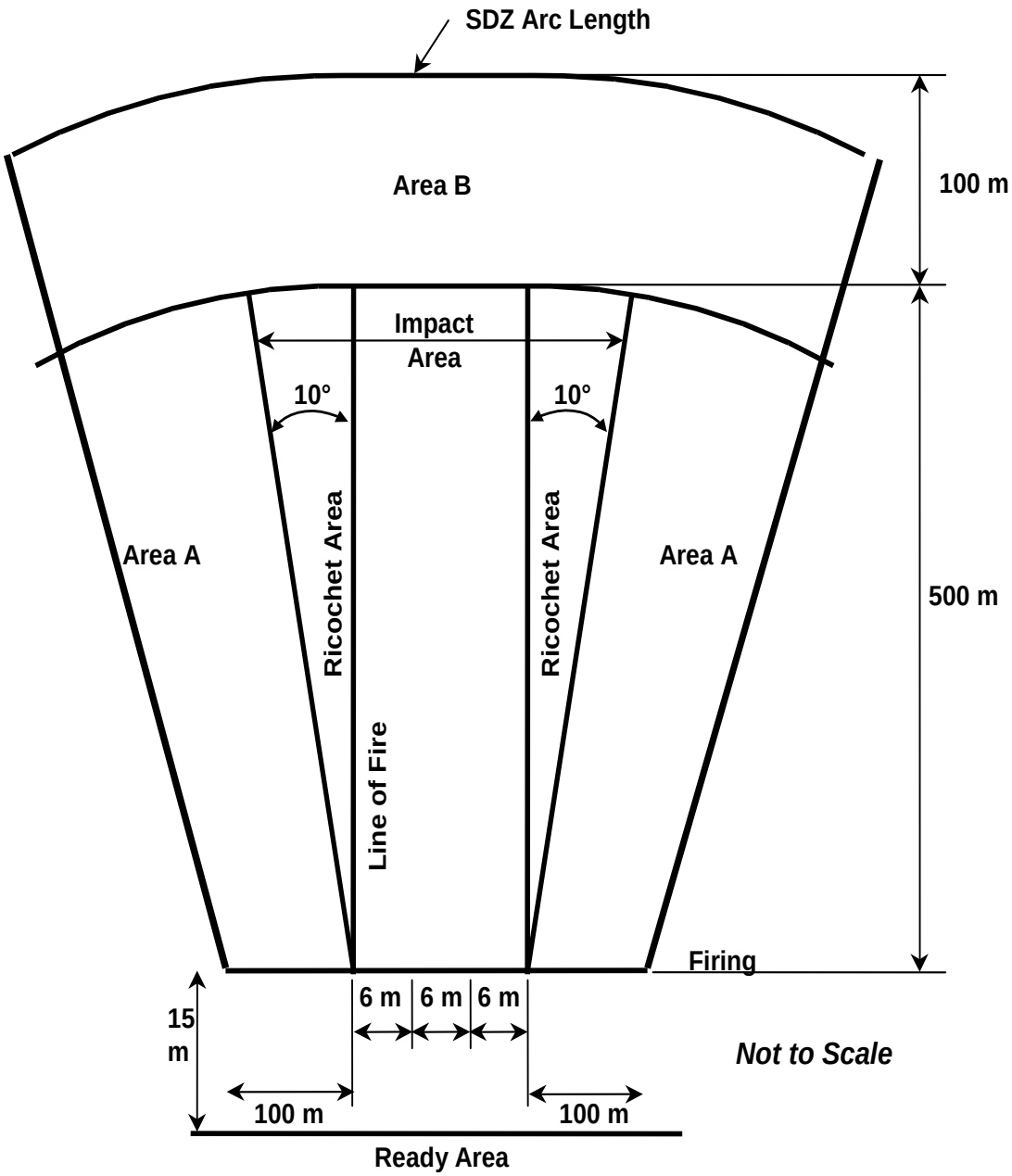


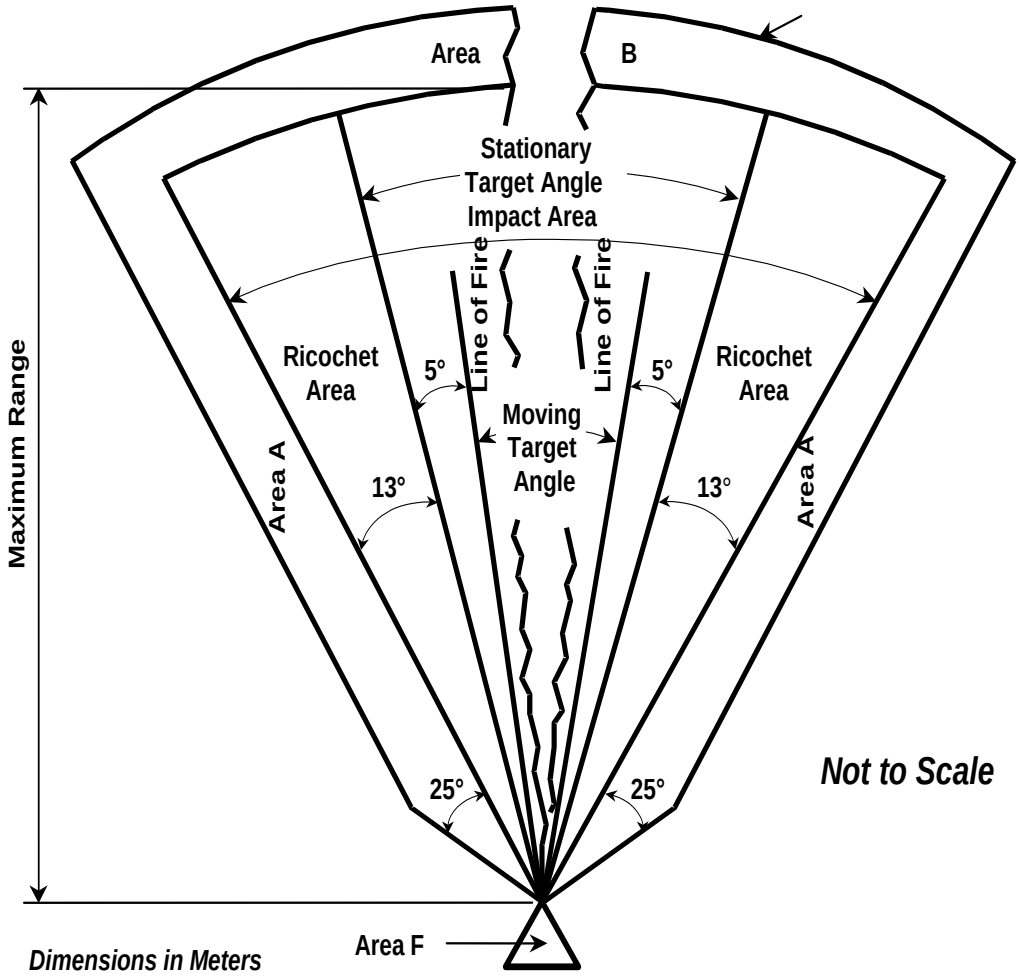
Figure 2. SDZ Configuration — Target Line Wider Than Firing Line



NOTES

1. Additional firing positions may be added provided minimum of 6 m (19 ft) is maintained.
2. Provide a 100-m (328-ft) clear zone (Areas A and B) around the perimeter of the range for EOD disposal of dud rounds with explosive type projectiles.
3. Ranges only certified for use of M781 or other inert projectile rounds are not required to include the 100-m (328-ft) space (Area A) to the left and right of the firing positions.

Figure 3. SDZ Configuration — M79 and M203 Grenade Launcher Range



	Area		Minimum Range to Impact	Maximum Range	Area F	
	A	B			Depth	Base
66mm HEAT Rocket, M72	250	250	75	1250	40	25
35mm Subcaliber, M73	100	100	50	1300	40	25
84mm HEAT Rocket , M136	227	200	50	2600	95	190

Figure 4. SDZ Configuration — Light Anti-Tank Weapon (LAW) Range

7.1.5.6. SDZ for Frangible Ammunition. On existing ranges that do not have the required SDZ, the use of frangible ammunition may mitigate the lack of SDZ and allow the ranges to continue to operate safely. This may only be used as a temporary measure and the owning unit must program for corrective action to allow firing of full-power ball ammunition. The SDZs depicted in Figures 5 and 6 are based on firing from the firing line only; down-range firing training operations shall not be used unless a projectile trajectory analysis is performed.

7.1.5.6.1. For an existing 25-meter (82-foot) partially contained range with earth side berms and an earth backstop, the required SDZ when using frangible ammunition is 300 yards (274 meters). See Figure 5.

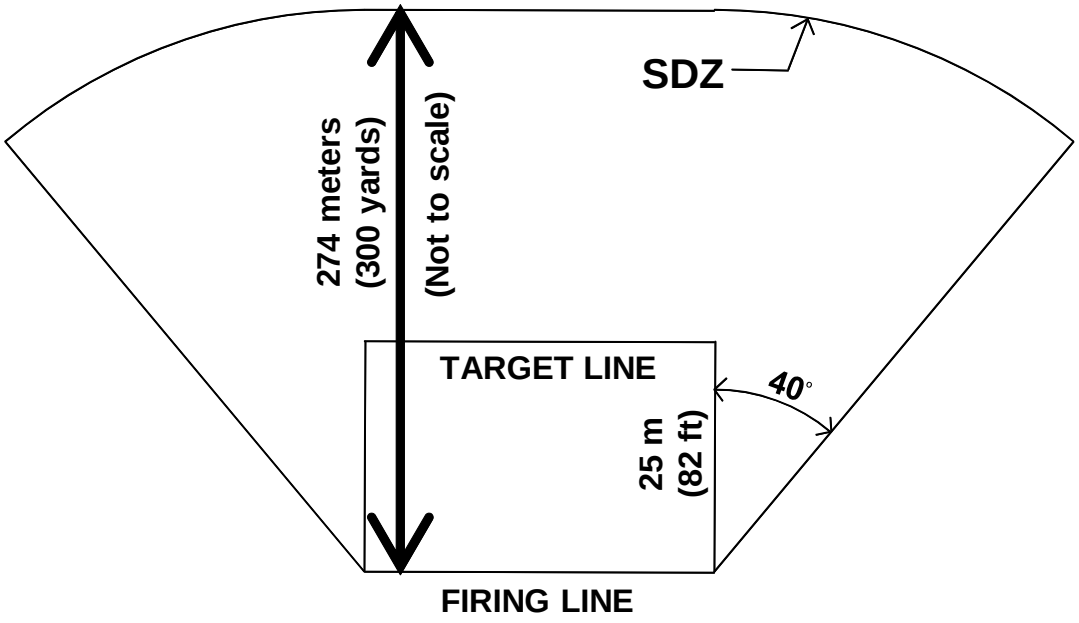


Figure 5. SDZ Requirement for Frangible Ammunition on a 25-Meter (82-Foot) Partially Contained Range with Earth Side Berms and Earth Backstop

7.1.5.6.2. For an existing 25-meter (82-foot) partially contained range with sidewalls of concrete or concrete block, overhead ballistic baffles (angled or vertical), and a bullet trap, the required SDZ when using frangible ammunition is 100 meters (328 feet). See Figure 6.

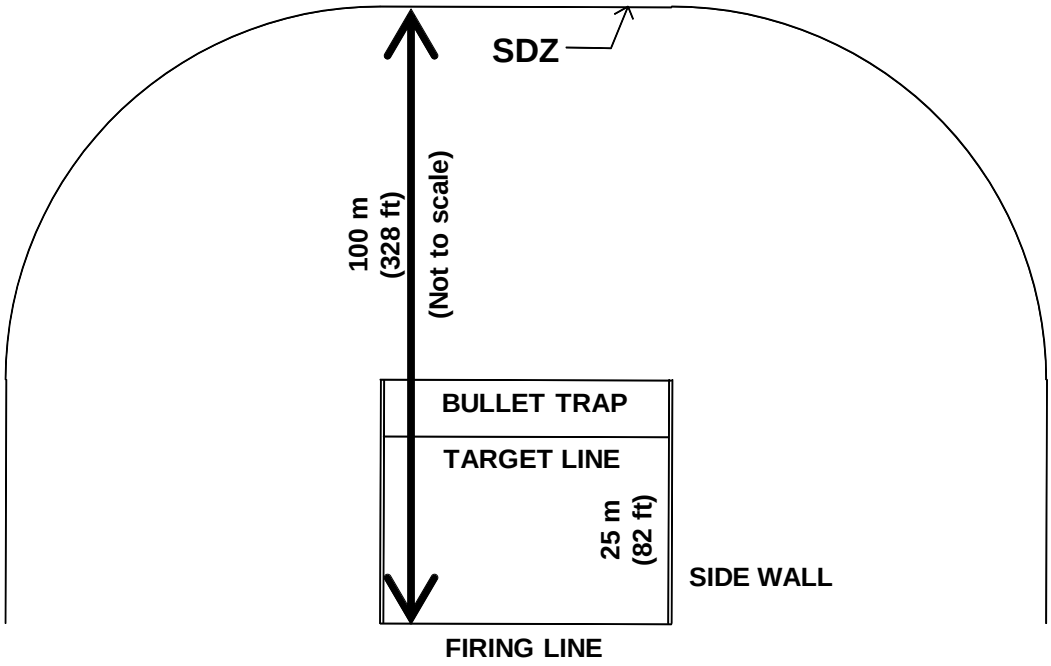


Figure 6. SDZ Requirements for Frangible Ammunition on a 25-Meter (82-Foot) Partially Contained Range with Sidewalls and Bullet Trap

7.1.5.7. Firing Line Positions/Platforms. The number of firing positions establishes the width of the firing line. All small arms (rifle, pistol, and shotgun) ranges must have a minimum of fourteen positions on the firing line. Add additional positions in increments of seven firing positions. The width of the firing positions must be at least 1.52 meters (5 feet) center-to-center. The firing line must be located on a stable horizontal surface that is at least 4.3 meters (14 feet) wide, clear distance, for the length of the firing line. For most ranges, the firing platform is a concrete slab on grade. For non-contained ranges that have fighting positions dug in the ground, sandbags, or other definite structures to identify the firing line, the firing platform can be an earth surface. For special weapons, CA personnel will specify the number of firing positions and the widths of each position based upon training requirements.

7.1.5.7.1. Position Numbering. Each firing position will be numbered beginning from the left when facing the target line. The numbers must be at least 200 millimeters (8 inches) tall and displayed on rectangular backgrounds attached to the position barricade or other location that is clearly visible to all shooters and range officials. Odd-numbered positions will be marked with white numbers on a black background; even-numbered positions will be marked with black numbers on a white background.

7.1.5.7.2. Position Barricades. A wooden barricade in the form of a cross (+) must be installed at the left edge of each firing position. The minimum nominal dimensions of the wood must be 50 millimeters (2 inches) by 150 millimeters (6 inches). The top surface of the horizontal member must be 1220 millimeters (48 inches) above the platform.

7.1.5.7.3. Firing Line. Paint a red line a minimum of 100 millimeters (4 inches) wide on the leading edge of the firing platform on the target side. For non-contained ranges without concrete firing line platforms, a firing line will be marked definitively in red on the downrange side of the firing positions; examples include treated timber embedded along the firing line and painted red, or a line of safety cones. This is the stationary firing line and must be continuous for the full length of all the firing positions. For move-and-shoot courses of fire, the firing line is relocated down range as appropriate for the training scenario.

7.1.5.8. Ready Line. Paint a yellow line 100 millimeters (4 inches) wide on the firing line platform at least 2.4 meters (8 feet) behind the firing line (towards the rear of the firing platform). The line must be continuous for the length of the firing platform.

7.1.5.9. Target Line. Targets are placed along the target line, which runs parallel to the firing line. Targets are placed opposite and aligned with each firing position.

7.1.5.10. Target Line Configuration.

7.1.5.10.1. The distance from the firing line to the target line must be the same for all firing positions. Targets may be placed on turning, pop-up, or stationary mechanisms, or target-retrieval systems along the target line. Ensure that the line of sight from the firing line to the target line is clear and structural members, baffles, walls, or improper lighting do not obstruct the shooter’s sight picture from any firing position the shooters will use (e.g., prone, kneeling, left barricade, right barricade). Number each target location the same as its corresponding firing position. On non-contained ranges, the target line may be fixed and several firing lines constructed to permit firing at reduced distances. When this option is used, only the rear-most firing line will incorporate a firing platform. If the range has an earthen backstop, ensure there is sufficient distance between the closest firing line and the earthen backstop to eliminate the possibility of backspatter and ricochets affecting the shooter. For manufactured bullet traps, ensure there is 15 meters (49 feet) between the closest firing line and the bullet trap.

7.1.5.10.2. The center of the target must be located between the upper limit of fire (standing position), which is 1500 millimeters (60 inches) above

the firing line, and the lower limit of fire (prone position), which is 150 millimeters (6 inches) above the firing platform. The entire target face must be fully displayed to the firing position when exposed to the shooter for engagement.

7.2. Criteria Applicable to All Ranges. Design all range components (including ballistic safety structures and deflector plates) to satisfy the requirements for the weapon and ball ammunition used on the range. Except for non-contained ranges, ballistic safety structures are required for firing ranges. Ballistic safety structures include baffles, side containment, and backstops. Baffles are safety structures classified as canopy baffles or overhead baffles. Side containment is provided by sidewalls, berms, or discontinuous side baffles. A backstop is an impact berm or bullet trap designed to stop direct-fired rounds. See paragraph 7.5 for more detailed descriptions of ballistic safety structures.

7.2.1. Construction Materials. The materials selected for range construction must achieve the longest life-cycle possible, considering frequency of use, budget constraints, or other concerns. The desired life expectancy of permanent small arms range construction is 20 years. Permanent construction does not include protective construction, baffles, or sacrificial materials intended to capture projectiles. Evaluate alternative range design options using a life-cycle cost composed of the initial costs plus all operation and maintenance (O&M) costs for the first five years of range operation. Using the proper materials for sidewalls, baffles, overhead containment, bullet traps, and other areas where a projectile could impact will ensure that the bullet is deflected downrange and not towards the firing line. Ricochet control must be considered when positioning brackets used for baffles, locating bolt heads, and selecting protective construction.

7.2.2. Horizontal and Vertical Control. Establish vertical control by assuming the firing platform surface is equal to elevation 0.0 meter. The firing line is the baseline for horizontal control.

7.2.3. Drains. On outdoor ranges, use positive grading to direct water away from the firing line and toward the target line. When the length of the slope or the natural terrain requires using drains between the target and the firing line, a trench drain should be located at the forward edge of the bullet trap. If a trench drain is installed, the bullet trap should extend into the trench drain to eliminate any exposed edges that may cause unpredictable ricochets. Use grade breaks to prevent exposing vertical surfaces to the firing line. Do not route storm water runoff from any range floor to a stream, pond, or other body of surface water. In some circumstances, if the range is located near a surface water body, it may be necessary to incorporate detention basins or flow-through sand or peat filters to prevent particulate heavy metals that may be present in storm water runoff from reaching surface water bodies. Indoor ranges will not have floor drains downrange of the firing line. See the EPA's *Best Management Practices for Lead at Outdoor Shooting Ranges* for additional guidance.

7.2.4. Range Occupational Health Standards. Design the range to control contaminants produced at the muzzle and ejection port of the weapon, bullet trap, and from the ventilation exhaust to ensure compliance with local, state, and federal regulations. Review NMCPHC-TM IH 6290.10, *Indoor Firing Ranges Industrial Hygiene Technical Guide*, and the EPA's *Best Management Practices for Lead at Outdoor Shooting Ranges*. Additionally, the designer must coordinate with SE and BEE for additional requirements to ensure compliance with current policy.

7.2.5. Floor Surfaces. Fully contained indoor ranges must have a smooth, steel-trowel-finished concrete floor extending from the firing line to the bullet trap. Concrete used in floor construction shall have a minimum compressive strength of 3500 pounds per square inch (psi). The concrete floor should not be painted and must be protected with a waterproof sealant. In special circumstances, hardened steel plate of a thickness sufficient to prevent penetration of the projectile may be used for the range floor if the designer provides design criteria, supporting data, and supporting calculations for approval. No protrusions from the floor that could be struck by bullets are permissible. Fully contained range floors should be cleaned using approved methods, such as HEPA-filtered vacuuming or damp mopping. Water wash-down or dry sweeping is not permitted. Design the range floor as a pavement to support anticipated vehicular loads (training or service vehicles). Design and locate floor slab joints to minimize the potential for unpredictable ricochets. Sawed control joints no more than 6 millimeters (0.25 inch) wide are permitted. Locate longitudinal floor joints between firing lanes. Traditional chamfered construction joints are not permitted.

7.2.6. Wall Surfaces. Construct wall surfaces for fully contained ranges of reinforced concrete, fully grouted reinforced masonry, or hardened steel plate of a thickness sufficient to prevent penetration by any projectiles fired on the range. If hardened steel plate walls are used, submit data and supporting calculations to the MAJCOM for approval. Steel plate wall designs must address noise abatement and must not have exposed bolts or anchors. If concrete or masonry walls are used, they must remain unpainted to preserve their inherent sound-absorbing properties. Walls should have a continuous smooth surface, with no projections above the wall surface from bolt or rivet heads or the leading edge of deflector plates. Wall expansion/contraction joints should be designed with care to ensure a smooth wall surface is maintained. The typical 19-millimeter (0.75-inch) chamfered wall joint detail is not permitted unless baffle/deflector plates are incorporated in the joint design to span the chamfer. To eliminate erratic ricochets, install baffle/deflector plates to protect any range features attached to the wall. The deflector plates should be recessed into the wall surface to eliminate exposed edges.

7.2.7. Openings. If an existing building is converted for use as a range, all openings downrange of the firing line must be filled in with ballistic safety

structures. All heating, ventilation, and air conditioning (HVAC) equipment downrange of the firing line must be located behind baffles or the backstop. In new buildings, conceal pipes and conduits in the walls, above the ceiling baffles, or behind protective baffles. In converted buildings, relocate exposed pipes or provide protective construction. When doors are required downrange, they must be constructed of ballistic-resistant materials and equipped with hardware to allow opening only from the range side. Protect downrange doors with baffles and provide them with a visual and audible alarm.

7.2.8. Ventilation. The ventilation system must control exposure to lead in accordance with 29 CFR 1910.1025, *Lead*. The supply and exhaust air system is critical to the safe operation of fully contained ranges and for the health of range users.

7.2.8.1. Airflow. The ventilation system should provide laminar airflow across the range toward the bullet trap. At the firing line, the air velocity must be 23 meters per minute (mpm) (75 feet per minute [fpm]), ±4.6 mpm (15 fpm). Airflow should be evenly distributed across the firing line ±4.6 mpm (15 fpm). Noise from the ventilation system will not exceed 85 decibels (dBA) behind the firing line.

7.2.8.2. Air Distribution. To ensure contaminants are removed from the firing line, install a perforated air distribution plenum, radial plenum, or other distribution fixture along the rear wall to provide unidirectional airflow across the firing line and continuing downrange. The air-distribution fixture should be installed to ensure prescribed air velocities at every shooter location. The distance from the firing line to the perforated rear wall, radial plenum, or other distribution fixture will be a minimum of 5 meters (16.4 feet). The air distribution plenum openings must be sized to provide no more than 610 mpm (2000 fpm) velocity through the openings, with a recommended velocity between 122 mpm to 183 mpm (400 fpm to 600 fpm).

7.2.8.3. For a fully contained indoor range, the ventilation design must include a positive exhaust system for effectively capturing and removing airborne contaminants. Maintain slightly negative air pressure on the range, achieved by exhausting 3 to 7 percent more air than is supplied. Supply and exhaust fan systems must have control interlocks to ensure simultaneous operation. All doors into the negative-pressure area must have air locks. Re-circulation of range air is not permitted.

7.2.8.4. Exhaust Intakes. To ensure proper airflow, locate exhaust intakes at or behind the bullet trap.

7.2.8.5. Exhaust Air Discharge. Exhaust air discharged from the range and bullet traps must meet local, state, and federal requirements and be separated from the supply air intake to prevent cross-contamination of heavy-

metal-laden air. If the range is part of a larger building, do not discharge exhaust air at locations which could cause cross-contamination of overall building air.

7.2.8.6. Supply Air. Because re-circulated air within a range is prohibited, range supply air should not be heated or cooled. Therefore, the range shall be designed as an unconditioned environment. Fully contained ranges in colder climates may require radiant heat on the firing line.

7.2.8.7. Personnel should not be exposed to airborne contaminants above permissible limits at firing ranges. The Occupational Safety and Health Administration (OSHA) has established the permissible exposure limit (PEL) for airborne lead as 50 micrograms per cubic meter (8-hour time-weighted average). The PEL for other heavy metals can be found at 29 CFR 1910.1000, *Air contaminants*, Table Z-1, “Limits for Air Contaminants,” and Table Z-2, “Toxic and Hazardous Substances.” Fully contained ranges (indoor and outdoor) must have ventilation systems designed to control exposure to airborne contaminants. BE will evaluate potential exposure to airborne contaminants to determine if the ventilation system is adequately controlling the hazard. Lead-free ammunition (LFA) may be used to eliminate the lead contamination concern with older existing ventilation systems.

7.2.9. Noise Reduction. Engineering controls to reduce noise levels and dampen reverberation shall be implemented. Noise reduction in the range and noise transmission out of the range are different design considerations. Mass and limpness are two desirable attributes for sound absorption. Unpainted heavy masonry walls provide mass. Absorptive acoustical surfacing will reduce the noise level in the range but have little effect on transmission outside the range. Ambient noise levels at the firing line shall not exceed 85 dBA. Short-duration noise such as gunfire will exceed the 85 dBA level and may be as high as 160 dBA. Reflective surfaces in a range will reverberate noise during firing, extending the decay rate of the noise. Long decay rates (>1 second) will require the engineer to treat the noise not only as impulse (peak pressure considerations) but also as continuous noise. Therefore, sound-absorbing materials should be used to reduce the reverberation rate to below 1.5 seconds.

7.2.9.1. Use acoustical treatment on surfaces behind the firing line and on the wall and baffle surfaces of the up-range half of the range. Acoustical material shall be nonflammable and will not impede heavy metal dust removal using a vacuum process. Floor areas behind the firing line may be covered with acoustic material (rubber mats) if it will not impede heavy metal dust removal.

7.2.9.2. Do not paint downrange walls or acoustic tile, since paint significantly degrades the sound-absorbing qualities of the materials. Existing ranges may continue using painted surfaces. Special sound-absorbing concrete blocks are available that reduce noise in the range.

7.2.9.3. Acoustic panels no larger than 1200 millimeters (47 inches) wide may be installed on walls, ceilings, and baffles. Blown-on acoustic material and carpeting are not permitted due to the difficulty of cleaning accumulated heavy metal dust.

7.2.9.4. Operational controls. Appropriately identified and properly fitted hearing protection will help reduce noise exposure for personnel below 85 dBA. BE will evaluate noise exposures and make recommendations for proper hearing protection to reduce noise levels for shooters and range personnel.

7.2.10. Fire Protection. Burnt propellant, muzzle flash, freezing temperatures, and bullet damage all conflict with the operation of standard fire protection design. To resolve these conflicts, the Air Force only requires sprinklers when the range is constructed integral with range support facilities like training rooms and cleaning rooms. Sprinklers are required in the range support facilities and on the firing platform area, but are not needed in the downrange area or at the target area. Smoke and infrared detectors are also problematic and impractical in the downrange area or at the target area because of the amount of smoke and periodic muzzle flashes from the weapons. No detection is required in the downrange area and none in the range support facilities or firing platform area since these areas are protected by sprinklers. Assume metal bullet traps—rubber, foam, and other materials used for bullet traps may require dedicated additional fire protection features per the manufacturer's recommendation. Egress paths shall not require travel downrange from the primary firing line. Downrange space shall not be included in calculating minimum egress capacity requirements. Egress marking, emergency lighting, and egress door hardware shall not be required downrange of the primary firing line.

7.2.11. Infrastructure.

7.2.11.1. Range Control Booth. The control booth is a control center from where the chief range officer can observe and control the entire range. All range types should have a control booth. The following criteria apply to the design and construction of control booths.

7.2.11.1.1. Locate the control booth behind the ready line. Place the booth to permit an unrestricted view of all firing positions. The booth location and design must not impede ventilation airflow.

7.2.11.1.2. The minimum size for the control booth platform is 1.5 meters by 3 meters (5 feet by 10 feet). Align the long side parallel to the firing line.

7.2.11.1.3. The booth must be high enough (0.6 meter [2 feet] minimum above the floor) to permit the range official an unrestricted view of the

entire firing line and the projectile impact area, including all range entry points. Also, windows and doors within the booth must not restrict or distort the range official's view. Closed-circuit television monitors may be used to enhance, but will not replace, this requirement.

7.2.11.1.4. Provide a work table or counter at least 0.8 meter by 1.2 meters (2.5 feet by 4 feet) to accommodate reference materials, and provide at least one duplex electrical outlet in the worktable/counter area. Provide lighting for night/limited-visibility operations.

7.2.11.1.5. The range control booth should have positive pressure relative to the rest of the range or be sealed/isolated so that fumes and dust from firing do not enter and contaminate the booth.

7.2.11.2. Communication System. The range communication system must support communications between the control booth, the firing line, range control, range support buildings, and emergency response personnel. A permanent, hard-wired public address system is required. On a multiple-range complex, the system must also support communications between individual ranges. If it is not practical to install landlines, or if a break in landline service occurs, radio or cellular communications may be used. The control booth should be wired with connections to the base local area computer network.

7.2.11.3. Lighting. Design downrange lighting in accordance with the IESNA *Lighting Handbook* to provide for safety and housekeeping operations as well as general range illumination. Light intensity at the target face should be 914 to 1076 lux (85 to 100 foot-candles) measured 1200 millimeters (47 inches) above the range surface at the target face. Provide approximately 322 lux (30 foot-candles) for white light general range illumination. An optional 107 lux (10 foot-candles) for red general lighting may be installed if night training scenarios are required. Provide controls to vary lighting intensity throughout the range to accommodate subdued-light training requirements. Controls for all lighting will be operated from the control booth. Optional flashing red and blue lights may be installed at the firing line and downrange to simulate emergency situations.

7.2.12. Barriers, Fences, and Signs. Secure the range and SDZ areas to prevent unauthorized entry. Use barriers to block roads, walkways, or paths.

7.2.12.1. Fully contained ranges require barriers in the form of key-operated, locked doors or electrically locked doors to prevent entry while firing is in progress.

7.2.12.2. Non-contained (impact) ranges require a number of barriers and signs to make the range safe. The number of barriers required depends on

the number of roads, walkways, and paths that lead into the SDZ. Attach reflective warning signs to barriers.

7.2.12.3. Use fencing to prevent people, animals, and vehicles from entering range SDZs. A chain-link fence around the complete range complex, including the SDZ, is preferred. Use barriers or gates to block access paths. On existing partially contained baffled ranges with earth side berms and an earth/metal backstop, as a minimum, install a 1.82-meter (6-foot) chain-link fence along the sides of the SDZ and on the downrange side of the impact area, incorporating the berms. Install the fence no closer than 5 meters (16 feet) from the toe of the berms and backstop. For fully contained ranges with concrete containment walls and an earth/metal backstop, as a minimum, install the fence from one wall, around the backstop, to the opposite wall when range components are exposed. For example, if the back side of the bullet trap and spent round-retrieval system is exposed, erect a fence to restrict access by unauthorized personnel. Provide a locked access gate for maintenance equipment.

7.2.12.4. Typical range signs are shown in Figure 7. Warning signs, and flashing red warning lights for night operations, should be positioned on the approaches to the range and along the perimeter of the SDZ if access is not otherwise restricted. Place red flags and/or rotating/flashing red lights at appropriate locations to signal when the range is in use. Place signs along the normal boundaries of the range. Post the signs no more than 100 meters (328 feet) apart along the range perimeter, parallel to roads or paths. Based on local topography, place signs close enough to give reasonable warning along other areas of the SDZ. Refer to Table 2 for proper location of warning signs. Signs must be bilingual where English is not the national language or multilingual where needed. Post bilingual signs on continental United States (CONUS) ranges located near foreign borders. Consult the installation legal office for local policy on bilingual signs. Construct warning signs in compliance with UFC 3-120-01, *Air Force Sign Standard*. The warning signs should have standard red letters on a white background.

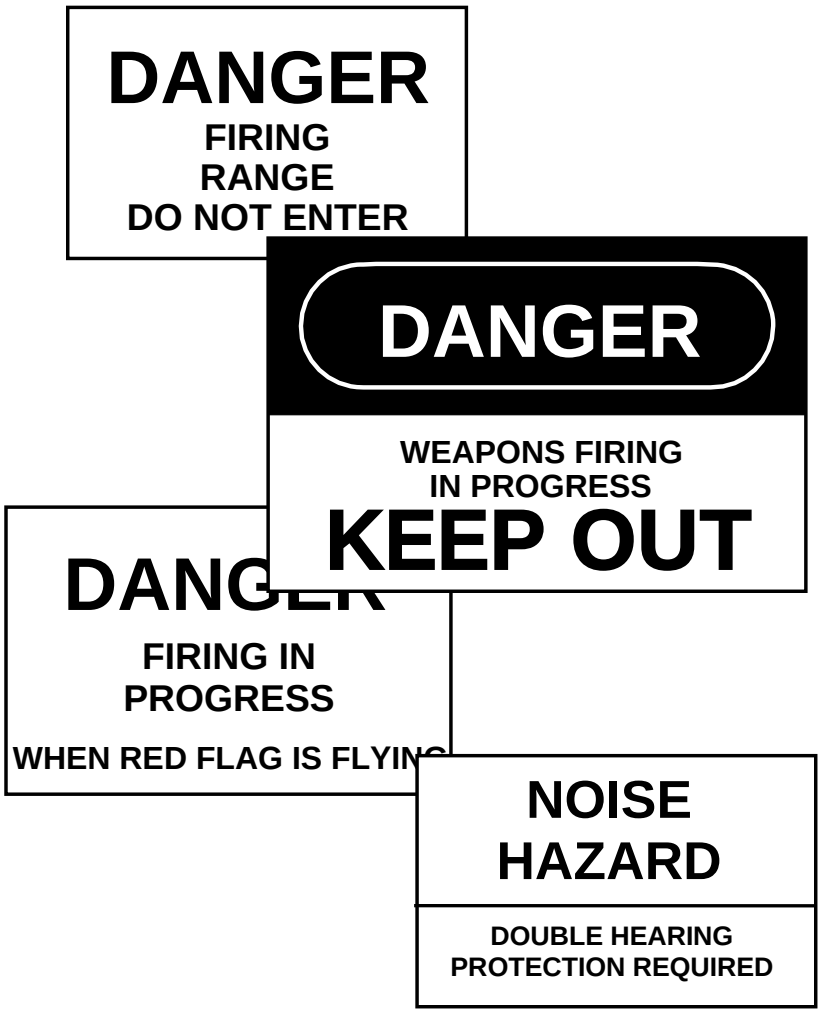


Figure 7. Typical Range Signs

Table 2. Locations of Warning Signs

Warning Sign	Location
Danger Firing in Progress When Red Flag is Flying	Approach roads
Danger Firing Range Do Not Enter	Fencing and barriers every 100m (328 ft)
Danger Weapons Firing in Progress Keep Out	Entry road
Noise Hazard Double Hearing Protection Required	Firing line

7.2.13. Utilities. Install utilities to prevent damage from normal firing range operations. Do not place any aboveground utilities in the impact zone or the ricochet zone. When utilities are directly behind backstops or berms, provide access for a maintenance vehicle. Underground utilities with proper cover may be placed anywhere on the range complex if maintenance and repair easements are provided.

7.2.13.1. Water and Sanitation. Water must be available for drinking, sanitation, hand-washing stations, and safety equipment. Drinking water and a latrine may be provided by adjacent range support facilities. The required latrine size will be determined using conventional planning criteria and based on the number of people (instructors and trainees) supported.

7.2.13.2. Electrical Power. Provide electrical power for lighting, maintenance equipment, public address systems, ventilation, bullet trap dust collection system, and target-turning mechanisms.

7.2.14. Roads and Parking. Design roads and parking for access by passenger vehicles and light or medium trucks. Provide surfaced all-weather roads for connector roads from public roads to the range complex. Parking and roadway standoff must comply with UFC 4-010-01, *DoD Minimum Antiterrorism Standards for Buildings*.

7.2.14.1. Range access roads must approach the range complex from behind the firing line and outside the SDZ footprint.

7.2.14.2. Locate parking areas to the rear of the firing platform. On fully contained ranges, the parking area may be beside the range-side containment walls. Typically, one parking space per firing position, plus an allowance for range personnel, is sufficient. Ranges with heavy training loads occasionally require two spaces per firing position. When feasible, surface parking lots for all-weather operation.

7.2.15. Storm Water Runoff and Drainage. Design storm water control structures to prevent storm water erosion of impact berms. Divert surface water runoff within the range (including the SDZ) using best management practices (BMP) for heavy metal management that may include filtration, vegetated detention or retention basin, or other engineered structure to prevent direct discharge to a surface water body. Discharge of effluent to water bodies must meet all requirements of federal, state, and local laws.

7.2.16. Environmental Contaminant Monitoring. An environmental contaminant monitoring program may provide early indications of contaminant movement within and/or between environmental matrices, e.g., soil, groundwater. A comprehensive monitoring program includes sampling soil, surface water, and ground water. The frequency of sampling is dependent on many factors including, but not limited to, how often the range is used and unique site conditions. Consult with the installation CE and BE personnel to determine if a contaminant-monitoring program is required.

7.3. Additional Criteria for Non-contained Ranges.

7.3.1. Siting Considerations. Take advantage of natural geologic formations for use as backstops. Trees are allowed downrange of the impact berm, but not between the firing line and the target line. Take advantage of natural drainage. Where terrain permits, slope the range floor toward the backstop. Flowing watercourses (streams, ditches) in the impact area or near a berm should be avoided. Avoid establishing range impact areas in wetlands or in locations subject to frequent flooding. The non-contained range line of fire should not be in the direction of residential areas or upwind of residential areas.

7.3.2. Provide maintenance vehicle access to all range areas, including the backstop, side earth berm areas, and impact areas.

7.3.3. Soils. Do not use pea gravel to surface or edge the impact area of the range or the area between the firing line and the target line. Naturally occurring soils that are not excessively rocky may be used between the firing line and the target line. Typically these will be clays, clayey sands, sands, silts, and silty

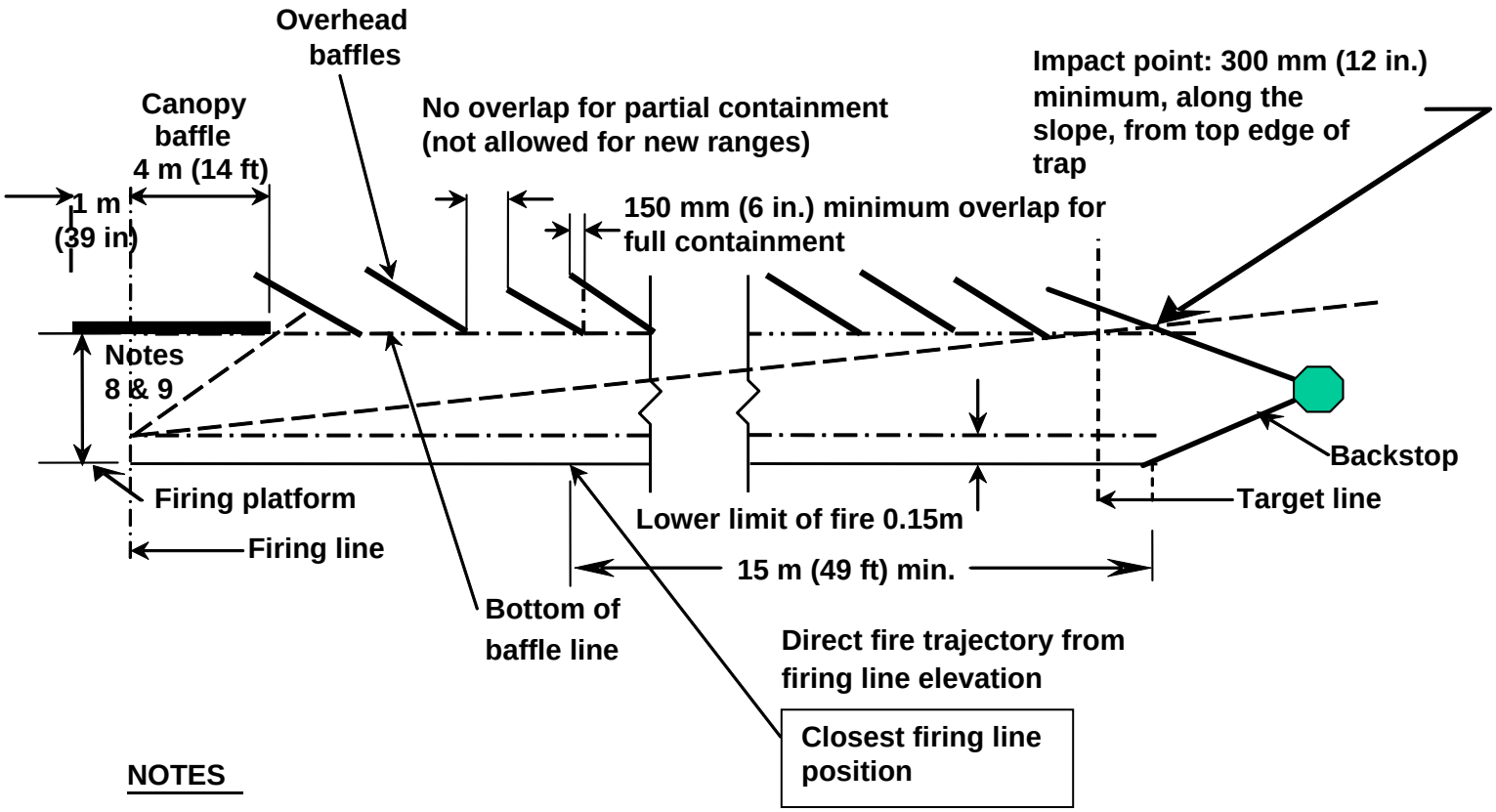
sands that are mostly free of rocks and debris, with no more than 15 percent of the material gradation retained on a 24-millimeter (1-inch) sieve.

7.3.3.1. Soil Amendments. BCE environmental management must test soils within the impact areas for pH levels every two years. The desired pH ranges from 7 to 8. Test soil additives to ensure that they will not cause cementing or hardening of the soil surface. Do not use lime as an additive or soil conditioner when the natural soil gradation includes more than 30 percent passing the #200 sieve, ASTM C136, *Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates*, and/or the natural soil Plasticity Index is higher than 12.

7.3.3.2. Vegetation. Maintain vegetation on berms and drainage-ways when possible. Plant grass on impact areas. Turf grasses do an especially good job of retaining water and sediment onsite. Choose a grass variety that is native to the area and will require minimal water and fertilizer.

7.3.3.3. Reclamation and Recycling. Remove lead from the impact face of earth berm backstops when there is evidence of lead mass buildup. This will typically require that soil be excavated to a depth of 0.6 to 0.9 meter (2 to 3 feet) and screened using a 4-millimeter (#5) wire screen. Personnel certified in lead reclamation and wearing proper personal protection may sift the lead from the soil by screening onsite after consulting with BE personnel and satisfying all environmental requirements. Reclaimed lead must be disposed of or recycled in accordance with federal, state, and local laws and regulations. Consult CE environmental management, BE, and the Defense Reutilization Management Office (DRMO) about reclaiming, recycling, or disposing of lead. Lead removed from bullet traps and earth berms is not considered a hazardous waste if recycled for metal recovery.

7.4. Additional Criteria for Fully Contained Ranges. Construct fully contained ranges to preclude any bullets from leaving the containment limits. This requires additional attention to detail so no gaps, openings, or other paths for bullet escape are present. Use ballistic safety structures to provide the containment. For fully contained ranges, construct overhead baffles with a minimum of 150 millimeters (6 inches) of horizontal overlap between the trailing edge of any baffle and the leading edge of the next baffle downrange. Figure 8 shows a baffle arrangement for full containment.



NOTES

1. This profile is based on a level range and a fixed firing line.
2. The target distance is established by CA to satisfy the intended training or courses of fire.
3. A tactical, fully contained range will allow shooters to move laterally along the firing line and downrange.
4. Overhead baffles must be angled from 12° to 32° from the horizontal.
5. Fully contained ranges require a 150-mm (6-in.) minimum baffle overlap.
6. For existing partially contained ranges, baffles are spaced as required to bring the bullet into the baffle at a point not less than 300 mm (12 in.) below the top of the following baffle as measured along its slope.
7. The bullet impact point on the bullet trap is not less than 300 mm (12 in.) below the top edge of the trap as measured along the slope.
8. If vehicle access is not required, locate the bottom of the baffles at least 2.45 m (8 ft) above the firing platform.
9. If vehicle access (without machine gun pedestal) is required, locate the bottom of the baffles at least 3.68 m (12 ft) above the platform.
10. The canopy baffle may be sloped up to 30 degrees from the horizontal. If sloped, the high point of the canopy is closest to the target line.

Figure 8. Typical Overhead Baffle Configuration

7.5. Ballistic Safety Structures.

7.5.1. Canopy Baffles. A canopy baffle is an angled or horizontal baffle attached to and directly above the firing platform, extending downrange from the firing line. It prevents direct-fired rounds from escaping the range between the firing line and the first overhead baffle. The bottom of the canopy baffle must be at least 2.45 meters (8 feet) above the level of the firing platform if vehicle access is not required. The canopy will begin at least 1 meter (3.2 feet) behind the firing line and extend at least 4 meters (14 feet) forward of the firing line toward the target line. A canopy baffle may be used to provide a covered firing line position on a non-contained range without either overhead baffles or side containment. Face the portion of the canopy baffle directly over the firing positions with plywood, lumber or other approved material (par. 8.2) of sufficient thickness to capture the ricochet from a round fired directly over the shooters.

7.5.2. Overhead Baffles. An overhead baffle is an angled baffle (vertical baffles are not authorized for new range projects) installed downrange to deflect and contain direct-fired rounds. Install overhead baffles downrange between the overhead canopy and the backstop. A shallow angle deflects bullets more easily and there is less metal fatigue and denting in the surface of the plate. A fully contained range requires a 150-millimeter (6-inch) minimum overlap of baffles. The overlapping baffles will allow shooter movement throughout the range and will prevent projectiles from leaving the range even if the weapon is accidentally fired straight up. Line-of-sight analysis shall consider rounds fired from any angle and any training position forward of the firing line. Angled overhead baffles redirect projectiles downrange. Install angled overhead baffles with the bottom edge further downrange than the top edge. Install overhead baffles parallel to the firing line. Refer to Figure 8 for a typical configuration. Install angled overhead baffles for new ranges and baffle replacement projects.

7.5.3. Additional Criteria for Vehicle Access. New training scenarios will use vehicles for practicing vehicle dismount, cover, and engaging targets from the vehicle. The design vehicle for range design purposes is a HMMWV (“Humvee”) without a pedestal-mounted weapon. Vehicle access requires consideration of higher clearance from range floor to baffles and vehicle paths into the range. See Figure 8, note 9.

7.5.4. Ground Baffles. Ground baffles are not permitted on Air Force ranges.

7.5.5. Baffle Construction.

7.5.5.1. Construct ballistic safety structures for fully contained ranges with attention to the quality of the fabricated parts. Baffle plates with butt joints must fit together closely to prevent any gaps more than 1.6 millimeters (0.0625 inch) wide. Modern plate-cutting techniques can provide precise dimensions, but particular care must be taken in erecting the baffles to ensure

a precision fit of parts. The development of construction/erection details that use overlapping joints and joint-closure plates may provide a better, more economical solution than precise fabrication and also may simplify the erection procedures.

7.5.5.2. As a minimum, use materials specified in Table 3. These materials may also be used for protective construction. For angled-steel plate baffles, install plywood facing to prevent "splash-back" ricochets on baffles located within 5 meters (16.4 feet) of the expected position of the shooter. If shooters move downrange and fire, splash-back protection will be required for baffles at the downrange locations as well. Plywood shall be fire resistant treated (FRT) plywood in accordance with International Building Code (IBC) section 803 class A flames spread 0-25 and smoke development 0-450. **Note:** The Brinnell Hardness Number (BHN) measures steel hardness. The higher the BHN, the harder the steel.

Table 3. Construction Materials for Canopy and Overhead Baffles

Weapons	Ammunition	Construction*
Handguns	.22 LR, .38 cal., .45 cal., .357 cal., 9mm, .44 cal.	6 mm (0.25 in) steel plate with a nominal 440 BHN or higher, covered with one sheet of 19 mm (0.75 in) and one sheet of 11 mm (0.4375 in) plywood
Rifle, carbine, machine gun	5.56mm, 7.62mm, .30 cal.	10 mm (0.375 in) steel plate with a nominal 500 BHN, covered with one sheet of 19 mm (0.75 in) and one sheet of 11 mm (0.4375 in) plywood

***Notes:**

1. On steel plate baffles, install FRT plywood facing on overhead baffles located within 5 meters (16.4 feet) of the shooter to mitigate the risk of "splash-back" ricochets. Attach the 19-millimeter (0.75-inch) sheathing to the steel using flathead countersunk screws. Attach the 11-millimeter (0.4375-inch) FRT plywood to the 19-millimeter (0.75-inch) sheathing using #8 flathead screws at 300-millimeter (11.8-inch) spacing.

2. Nominal AR500 ballistic plate manufactured to BHN 500 may have BHN values ranging from 480 to 530.

7.5.6. Side Containment or Sidewalls. Sidewalls are required to prevent direct fire from exiting the range. Finished elevation of a sidewall must be above the top edge of the highest overhead baffles. Each sidewall must be at least 1.52 meters (5 feet) from the outside edge of the firing position limits of fire and extend at least 1 meter (3.2 feet) to the rear of the firing line. Sidewalls may be made of earth, fully grouted reinforced masonry block (CMU), reinforced concrete, or hardened steel.

7.5.6.1. Continuous Walls. Vertical smooth-faced walls constructed of reinforced concrete, CMU with fully filled cores, or hardened steel may be used for sidewalls. Table 4 lists minimum wall thicknesses. Design these walls for all dead and live loads, including lateral forces. See paragraph 7.2.9 for noise-reduction requirements. Walls will extend 1 meter (3.2 feet) behind the firing line to prevent a bullet fired parallel to the firing line from leaving the range.

Table 4. Sidewall Minimum Thickness

Material	Caliber			
	.45/9mm	5.56mm	7.62mm	.50
3500 psi concrete	150 mm (6 in.)	150 mm (6 in.)	200 mm (8 in.)	300 mm (12 in.)
Grout-filled CMU	200 mm (8 in.)	300 mm (12 in.)	300 mm (12 in.)	600 mm (24 in)

7.5.6.2. Discontinuous Sidewall Baffles. Side baffles are similar to overhead baffles, except they provide discontinuous protection to each side of the range outside the entire length of the line of fire. They are set between 15 and 45 degrees relative to the line of fire and provide an advantage over continuous walls whenever cross-range ventilation is needed.

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7.5.6.3. Earth Berms. The slope of earth berms must not exceed a 2:3 vertical-to-horizontal ratio unless materials are stabilized. If native soil characteristics will not produce a stable slope at this angle, use fabric reinforcement in the fill. The soil may require conditioning to achieve satisfactory soil pH levels to prevent lead decomposition. Typical angles of repose for natural soils in loose or least-dense state are shown in Table 5. Use Table 5 only as a guide, since mechanical stabilization may increase the angle of repose. The width of the top of the berm must be at least 3 meters (9.8 feet). Construct the outer layer (2 meters [6.5 feet] thick) of the impact face with sands, silty sands, or clayey sands, free of rocks, and with 100 percent passing the #4 sieve, ASTM C136. Soil with more than 40 percent clay-size particles passing the #200 sieve is not acceptable for the outer 2-meter (6.5-foot) layer of the impact face. Clay may be used for the core. For erosion control, plant a vegetative cover on the faces and tops of berms. Irrigation devices may be used on the faces and tops of berms not subject to direct fire. Ensure access for maintenance vehicles.

Table 5. Natural Angles of Repose (Internal Friction) for Naturally Occurring Soils

Soil Types	Angle of Repose/ (Internal Friction)
Silty sand/fine sand/clayey sand	30
Coarse sand	35
Silts	25
Gravel/sandy gravel/gravelly sand	34

7.5.7. Backstops. A backstop is used behind the target line. It must stop a direct-fire bullet by media capture or deflect the bullet into a trap.

7.5.7.1. Earth Backstops. Earth backstops are the most common backstop for non-contained ranges. As an example, for a 25-meter (82-foot) non-contained range, locate the backstop so the longitudinal centerline of the berm (backstop) is at least 50 meters (164 feet) from the firing line. The toe of the slope must be located at least 9 meters (29.5 feet) from the target line nearest the backstop. The top of the backstop must be high enough so that a line drawn from the firing line and under the last overhead baffle will intersect the backstop at least 2 meters (6.5 feet) below its top. The impact face of the earth backstop must be soil with 100 percent passing the #4 sieve, ASTM C136, for a depth of 2 meters (6.5 feet). The slopes should be stabilized with grass vegetation and access provided for maintenance and repair equipment. Incorporate a steel deflector plate (eyebrow) into the backstop if a higher degree of confidence is required to prevent direct-fired rounds from leaving the impact area of the backstop. Soil with more than 40 percent clay-size particles passing the #200 sieve is not acceptable for use in the impact area face of the backstop. If required, soil should be conditioned to achieve suitable pH levels as indicated in paragraph 7.3.3.1.

7.5.7.2. Metal Backstops. Metal backstops are large plates installed behind the target line to stop direct fire and ricochets. Metal backstops are not approved for new construction. They are typically found on older existing partially contained or fully contained ranges but may be found on non-contained ranges. A metal backstop is not a bullet trap. See paragraph 7.5.7.4 for bullet trap requirements. The metal backstop should be located a minimum of 15 meters (49 feet) beyond the target line to allow target and backstop maintenance and to minimize the possibility of splashback ricochets or lead exposure to the shooters executing a downrange course of fire. Additionally, provide sufficient vehicle access to maintain the backstop. The required direct fire and ricochet containment must not be compromised when providing vehicle access. On outdoor ranges, provide corrosion protection for

a metal backstop. Painting does not provide adequate protection. Consider adding an overhead cover to provide protection.

CAUTION

Do not use armor-piercing or incendiary rounds with metal backstops or bullet traps unless the backstops or traps have been designed to accommodate these rounds. If commercially designed range components are used, ensure that the products satisfy the design requirements for the ammunition used on the range.

7.5.7.3. Backstop Deflector Plates (Eyebrows). A deflector plate is not a bullet trap. See paragraph 7.5.7.4 for bullet trap requirements. A backstop deflector is typically installed on top of an earth backstop to provided added containment safety. Install the backstop deflector plate at an angle between 30 and 42 degrees from horizontal (see Figure 11). Angles other than these are permissible if test data and calculations support the design. Set the highest edge of the deflector plate nearest the firing line. The shallow angle deflects bullets more easily and there is less metal fatigue and denting in the surface of the plate. Anchor steel plates supported by concrete or masonry with flush countersunk heads. Eliminate exposed edges which may produce erratic ricochets. Ensure edges of steel plates are milled at all joints and joints are butted flush and smooth. Plates must be free from buckle or wave. Exposed edges must be chamfered to a 45-degree angle to a fillet approximately 4 millimeters (0.16 inch) wide. Exposed structural members supporting deflector plates are not permitted. Welding must conform to AWS D1.1, *Structural Welding Code – Steel*, latest edition. Position steel plates so welds are no closer than 450 millimeters (17.7 inches) from the center of a target position. Steel plate jointed at and supported on structural steel supports must be spot-welded.

7.5.7.4. Bullet Traps. Only commercially designed and constructed bullet traps are permitted. Sand, media, or water traps (recycled lubricating water excepted) are not permitted in new construction. Bullet traps are typically used on contained ranges and placed in front of the backstop or rear wall of the range. They are total systems that deflect, stop, trap, and contain direct-fired rounds, and may incorporate vacuum or other dust-management systems to capture projectile particles. Bullet traps installed at indoor ranges must have a dust-management system installed to provide heavy metal particle removal from the range environment. The bullet trap must be designed to accommodate the ammunition/weapon to be fired as well as the expected quantity of ammunition fired (annual rate of fire). The bullet trap should extend the entire width of the firing line. The trap shall not present any blunt surface exposure that would create a ricochet hazard internal to the equipment or at the connection to the sidewalls and floor. All future purchases

of bullet traps must incorporate trap designs with a continuous, non-partitioned, and unbroken slot or bullet path into the deceleration chamber. In the past, typical design fabrication details have had vertical bulkhead plates in the deceleration chambers. These plates create vertical blunt edges that cause back-splash-type ricochets of the steel penetrator tips of the M855 5.56mm round. There have been documented cases of the steel penetrator tips ricocheting back to the firing line and endangering the shooters. The trap must have the capability to be cleaned of accumulated deposits of bullets and fragments while minimizing lead exposure to the maintainer.

Note: Only trained personnel wearing proper personal protection will remove lead, and only after consulting with BE personnel and following the trap manufacturer's recommended procedures.

The space directly behind the bullet trap must be easily accessible for maintenance and repair of the bullet trap and backstop. The bullet trap's metal thickness and hardness must meet the minimums listed in Table 6 for each type of ammunition to be fired on the range. If lesser thicknesses are proposed, the range component designer must provide test data and calculations supporting a lesser thickness. Angles of the metal plates must conform to those directed by the manufacturer to handle the munitions fired from varying shooter positions, target distances, and target positions. Design all traps for tracer rounds if a tracer round can be used in the weapon operated on the range.

7.5.7.4.1. Qualifications for Commercial Trap Manufacturers. Commercial bullet trap and range component manufacturers must demonstrate at least five years of continuous component manufacturing and submit a minimum of five examples, with customer references, of similar range components installed by the manufacturer.

Table 6. Minimum Steel Plate Thickness for Metal Backstops, Deflector Plates, and Bullet Traps

Max Angle	Ammunition	Armor Plate/ 300 BHN	440 BHN	500 BHN
42	.22 LR rim fire	6 mm	6 mm	6 mm
42	.38 cal. ball	10 mm	6 mm	6 mm
42	.45 cal./.357 cal.	10 mm	6 mm	6 mm
42	9mm pistol	10 mm	6 mm	6 mm
42	.44 cal. magnum	12 mm	10 mm	10 mm
30	5.56mm, 7.62mm	12 mm	Not recommended	10 mm
30	.30 cal. carbine	12 mm	Not recommended	10 mm

Note: 0.25-inch and 0.375-inch plate may be substituted for 6-mm and 10-mm plate, respectively.

7.5.8. Metal Backstop, Deflector Plates, and Bullet Trap Material.

7.5.8.1. Construct metal backstops, deflector plates, and bullet traps with the minimum metal thickness and hardness listed in Table 6. Small variations of BHN (less than 5 percent lower than the nominal number) are acceptable.

The design/specification must reference the applicable ASTM standard (ASTM A514/A514M) or military specification, the grade of steel required, and the hardness. To ensure that the correct grade of steel is installed (all steel plate looks the same), require a certificate of compliance. Plate thickness tests were conducted for the plate angles listed; however, a flatter plate angle is desired (the flatter the angle of the plate, the better). A shallow angle deflects bullets more easily, and there is less metal fatigue and denting on the surface of the plate.

7.5.8.2. Do not use mild structural steel, carbon steel plate, or low-alloy steel conforming to ASTM A36/A36M, *Standard Specification for Carbon Structural Steel*, ASTM A242/A242M, *Standard Specification for High-Strength, Low-Alloy Structural Steel*, or ASTM A572/A572M, *Standard Specification for High-Strength, Low-Alloy Columbium-Vanadium Structural Steel*; they lack adequate pitting resistance and deteriorate rapidly on small arms ranges.

7.6. Range Support Facilities. Range support facilities include the CA building and munitions storage room/building (Category Code 171-476), a building for storing range supplies and equipment (Category Code 171-472), and a building for target storage and repair (Category Code 171-473).

7.6.1. CA Building. The CA building provides a temperature-controlled environment for the CA section. The building houses classrooms, administrative

offices, weapons maintenance areas, space for cleaning and degreasing weapons, an alarmed weapons and munitions storage room, sanitary facilities, a student weapons cleaning room, and miscellaneous storage. Figure 9 presents an example of a typical floor plan. A small arms range with more than 21 firing points or an installation with more than one range or type of range requires proportionately larger facilities. Give consideration for space to accommodate weapons simulator training as mission needs dictate.

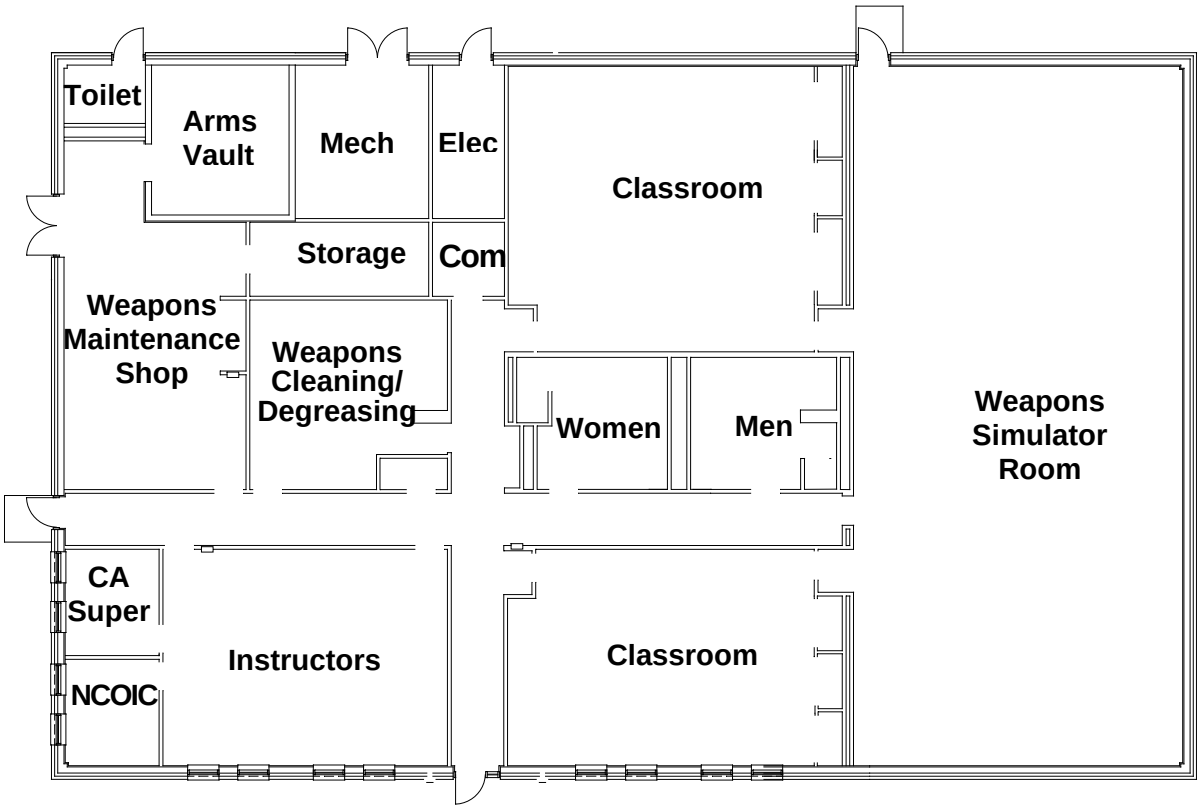


Figure 9. A Typical CA Building Configuration

7.6.1.1. Classrooms. Classrooms must be large enough to provide each student receiving handgun, rifle, shotgun, or submachine gun training a chair and a table work surface of at least 610 by 915 millimeters (24 by 36 inches). Provide space for each student receiving machine gun or LAW training to accommodate a work surface of at least 865 by 1145 millimeters (34 by 45 inches). The classroom will include a raised instructor's platform, aisle space for instructor access to individual tables, and sufficient space and connections for audio-visual equipment and computers.

7.6.1.2. Administrative Space. This area (typically about 13 square meters [140 square feet]) contains offices for program administrators and CA personnel such as the NCOIC and several instructors.

7.6.1.3. Weapons Simulator Room. This room is specifically designed for commercially purchased projection-based weapons simulators. A five-lane system requires a room approximately 10.7 meters by 5.3 meters (35 feet by 17.5 feet). A ten-lane system requires approximately 10.7 meters by 10.7 meters (35 feet by 35 feet). The room should have at least a 2.7-meter (9-foot) ceiling height and no windows. The room must have dimmable lighting, HVAC, and a minimum of four 110-volt and/or 220-volt dedicated power outlets to operate air compressors, projectors, and computers. Two dedicated telephone lines are required for operating the system and for remote diagnostic support.

7.6.1.4. Weapons Maintenance Shop. The weapons maintenance shop must have space for workbenches, hand tools, power tools, equipment, and spare parts storage. A range that supports less than 5,000 weapons requires a 28-square-meter (300-square-foot) shop. An installation that supports over 5,000 weapons will require 37 square meters (400 square feet). Provide a lavatory with potable water in the immediate area. An emergency eyewash station is also required. Provide additional ventilation as required. Maintain relative humidity (RH) below 65 percent.

7.6.1.5. Weapons Cleaning/Degreasing Room. This room accommodates workbenches, degreasing tanks, and spray hoods. Special design requirements include exhaust ventilation, vapor-proof electrical fixtures, compressed air service, and solvent-resistant wall and ceiling finishes. The minimum space requirement is typically about 12 square meters (130 square feet). A lavatory with potable water should be in the immediate area. An emergency eyewash station is also required. The installation SE office and BE may have additional design requirements. Exhaust make-up air can be transferred from the administrative and classroom areas as long as sufficient ventilation air is provided in those areas to prevent negative air pressure in relation to the outside.

7.6.1.6. Weapons and Ammunition Storage. The arms vault provides secure storage for all weapons for which the CA section is responsible, and a less-than-30-day supply of each type of ammunition used on the range. A gross floor area of 14 square meters (151 square feet) is usually adequate. Room construction must satisfy the requirements of AFI 31-101, *Integrated Defense*, and UFC 4-020-01, *DoD Security Engineering Facilities Planning Manual*, for construction materials and specifications. Additionally, requirements of DOD 5100.76-M, *Physical Security of Sensitive Conventional Arms, Ammunition, and Explosives*, must be satisfied. In general, vault construction must provide a minimum ten minutes of forced entry delay. Typical vault construction features walls, floors, and roof of 200-millimeter (7.9-inch) concrete reinforced with two layers of number 4 rebar on 225-millimeter (9-inch) centers, fitted with a class V door. Maintain RH below 65 percent.

7.6.1.7. Latrines (Sanitary Facilities). Provide facilities for both men and women. Provide additional cold-water hand-washing stations at the entrance to the CA building and at the firing range. The size of sanitary facilities depends upon the class size at that particular installation. Typically, the women's latrine need only accommodate about one-fourth the number of people as the men's latrine. Because instructors have daily contact with lead/heavy metals and may transfer these contaminants by casual contact, hand-washing stations, warm-water showers, changing areas, laundry facilities, and lockers should be provided for instructors to remove lead contamination. Use of these facilities at the end of each shift will prevent recurring casual contamination and potential health concerns, and prevent accidental inhalation or ingestion from residual lead.

7.6.1.8. Student Weapons-Cleaning Area/Room. Students must clean their weapons after completing firing. The cleaning area may be outside as long as it is covered; in cold climates, provide a room large enough to accommodate cleaning tables/benches and cleaning materials. Ensure the room is well ventilated and contains an emergency eye wash station.

7.6.1.9. Miscellaneous Storage. A storage area is required for administrative supplies, training aids, tools, and miscellaneous items. The size of this area is directly related to the type and quantity of training provided by the CA section.

7.6.2. Range Supplies and Equipment Storage. This building provides secure storage for miscellaneous range supplies, tools, and equipment. Use prefabricated metal, reinforced concrete, reinforced masonry, or wooden construction. Depending on location, type, and value of items stored, this facility may be combined with the target storage and repair building.

7.6.3. Range Target Storage and Repair Building. This facility provides space for repairing and storing targets and related equipment items, including target mechanisms and construction and repair material. Use prefabricated metal, reinforced concrete, masonry, or wooden construction. The repair space contains tables and workbenches. An electrical power source for operating power tools is required.

7.7. Specialty Weapons Ranges.

7.7.1. 40mm Grenade Launcher Range (Figure 3). The range supports firing of 40mm low-velocity grenades from M79 and M203 grenade launchers. The entire surface of the impact area must be cleared of vegetation or clipped extremely close during mowing so grenades will readily detonate on impact and EOD personnel can easily locate dud high-explosive rounds for disposal. Construct targets using lumber, steel, or concrete. Terrain features, course of fire, and weather conditions determine if a spotting tower may be needed for observing the impact area (to note point of impact for adjustment of fire and for safety).

Range personnel must be able to spot and mark dud rounds as they occur. A central tower high enough to permit observation of the entire range may be required. The range must have electrical power and lighting for the night-fire course.

7.7.2. LAW Range (Figure 4). The LAW range is set up for firing the M72 66mm rocket, the M73 35mm sub-caliber training device, and the 84mm AT-4. The danger zone to the rear of the launcher (Area F) must be clear of personnel, material, and vegetation. Arrange firing points so individual back-blast areas do not overlap.

7.7.3. Ten-Meter Machine Gun Range. If a non-contained machine gun range is not available, the machine gun must be fired on either a 10-meter tube range or on a fully contained range designed to accommodate the firing of the automatic weapon. Ten-meter tube machine gun ranges must incorporate range tubes as described in paragraphs 7.7.3.1 through 7.7.3.3. Range tubes function as baffles, thereby reducing the SDZ requirements. When the machine gun tube range is constructed in accordance with Figures 10 and 11, the SDZ length requirement is 700 meters measured downrange from the firing line. Range tubes are not required on a fully contained range designed for firing automatic weapons which has ballistic safety structures (baffles, traps, berms) designed to prevent penetration of the containment based on the ammunition being fired. Range tubes are also not required for a non-contained range with sufficient real estate to accommodate the full SDZ. The machine gun tube range is acceptable for M60/M240B/M249 machine guns.

7.7.3.1. Machine Gun Tubes.

7.7.3.1.1. If a non-contained machine gun range is not available, the 10-meter machine gun range tubes must measure at least 1.52 meters (5 feet) inside diameter by 7.3 meters (24 feet) in length. The tubes may be constructed of sectional pieces if the spigot end of the bell-spigot joint is pointed downrange. Tubes may be made of reinforced concrete pipe and must meet ASTM C76, *Standard Specification for Reinforced Concrete Culvert, Storm Drain and Sewer Pipe*, Class V reinforced concrete pipe (RCP) requirements, or may be steel pipe of suitable thickness fabricated from rolled plates. The interior of the tubes must have a smooth continuous surface. Repair any lifting lugs or holes so the tube interior is smooth and does not produce erratic ricochets.

7.7.3.1.2. For drainage, slope the tubes approximately 150 millimeters (6 inches) toward the target line. Firing positions must be at least 3.7 meters (12 feet) apart, measured center-to-center. The end of the tube toward the shooter should touch the firing line. When firing, the muzzle of the machine gun will be at least 150 millimeters (6 inches) inside the tube (see Figures 10 and 11).

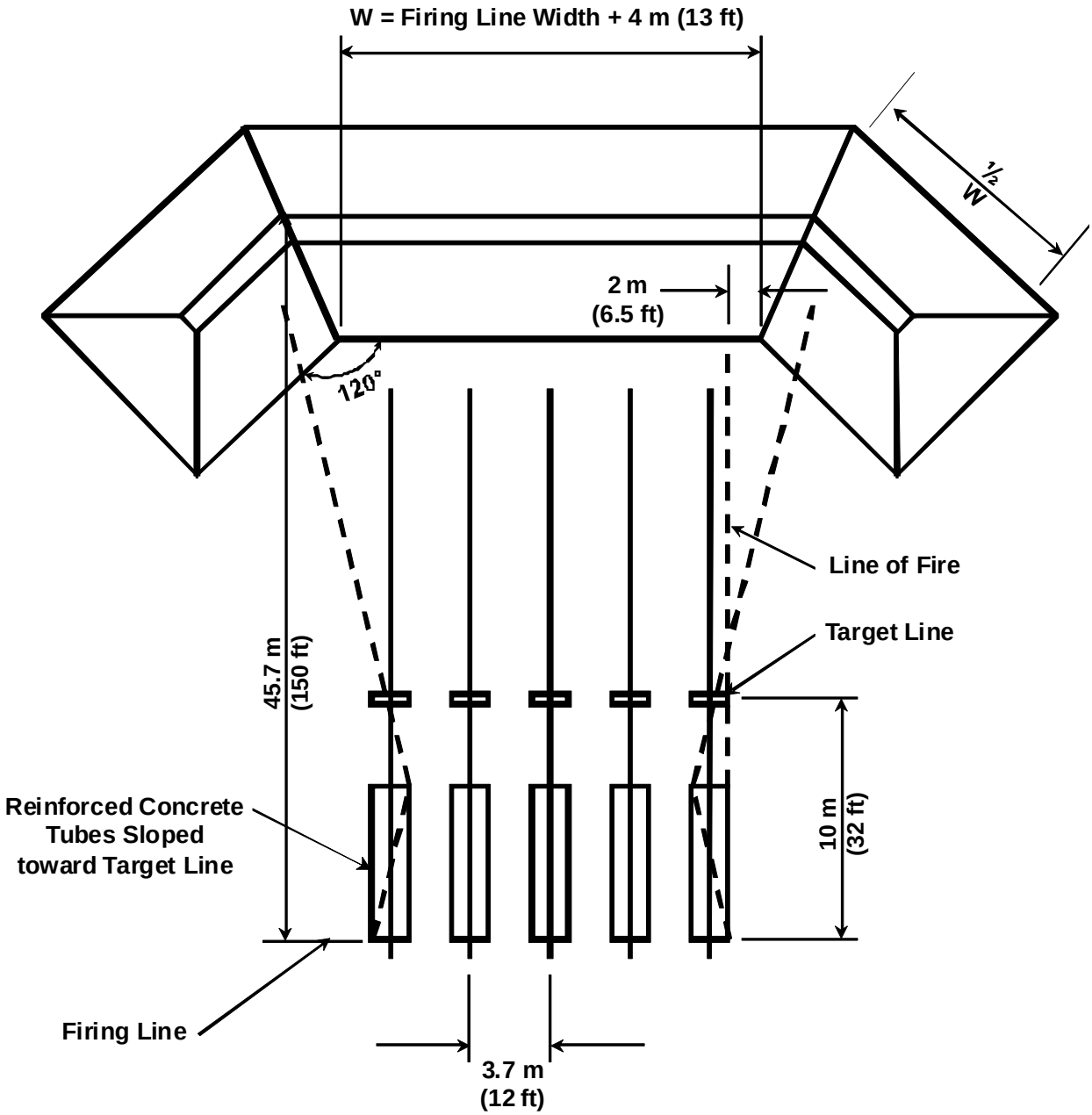


Figure 10. Machine Gun, 10-Meter Tube Range Typical Range Configuration

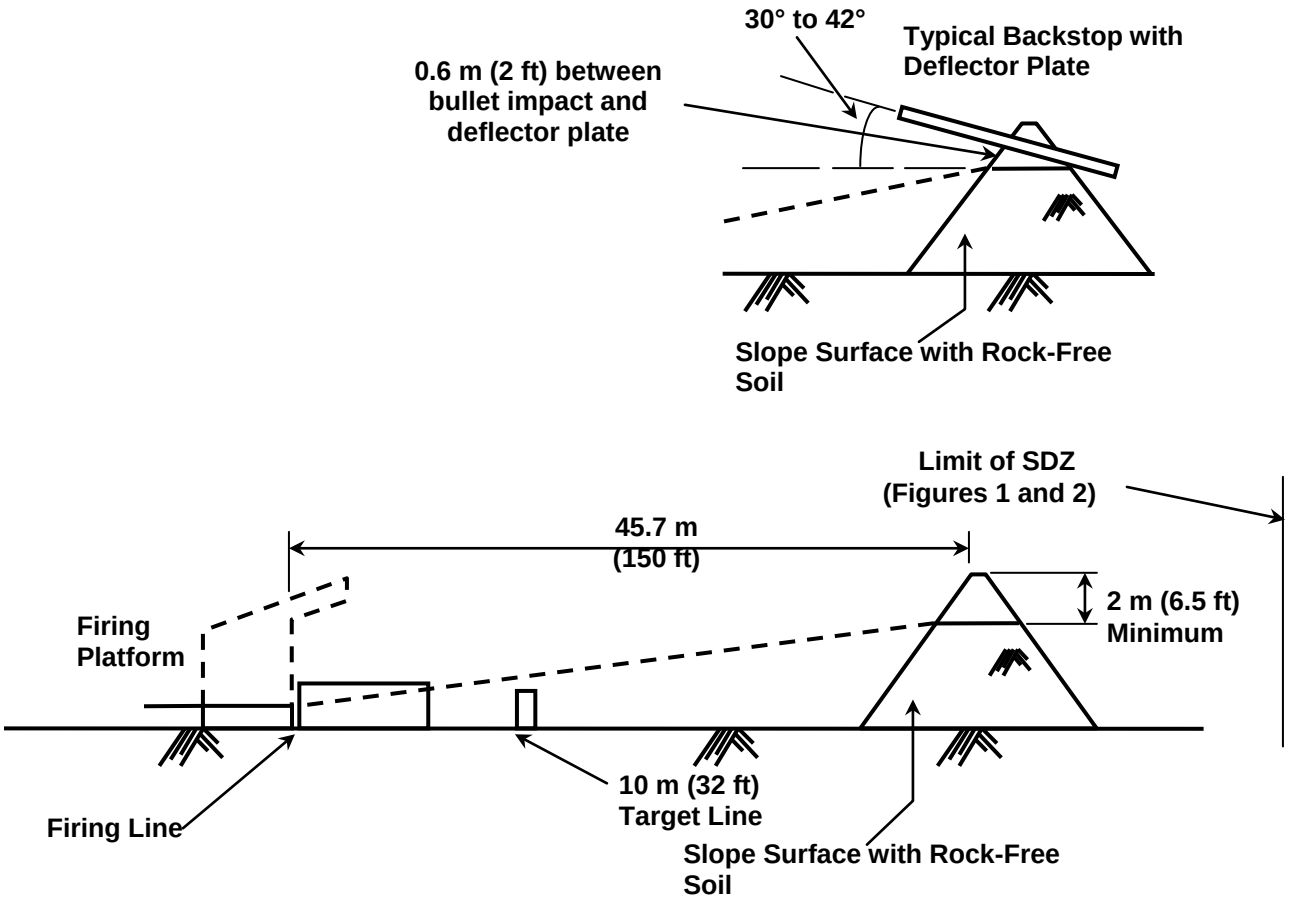


Figure 11. Machine Gun, 10-Meter Tube Range Typical Cross-Section

7.7.3.2. Firing Platform. Ensure that the firing tube placement and the firing platform height will place the muzzle of the machine gun at the approximate center of the tube diameter and at least 150 millimeters (6 inches) inside the tube. A recess in the platform may be needed, about 76 millimeters (3 inches) deep and large enough to accept a tripod.

7.7.3.3. Backstop/Deflector Plate/Bullet Trap. For berm backstops, locate the berm no more than 45.7 meters (150 feet) from the firing line to the centerline of the berm. The minimum height of the backstop is established by determining where a line drawn from the firing line to the backstop, and intersecting the highest point that a bullet could exit the target end of the tube, intersects the berm. This line must intersect the berm not less than 2 meters (6.5 feet) from the top. When a deflector plate is used, locate the deflector plate at least 0.6 meter (2 feet) above the bullet impact point on the berm. For metal trap backstops, locate the trap at least 25 meters (82 feet) away from the firing point. The line drawn from the firing point to trap shall intersect the top plate of the trap not less than 300 millimeters (12 inches) from the top, measured along the slope of the trap.

7.7.3.4. Engineering solutions to reduce noise levels from tube ranges are limited and may consist only of sand bags along the bottom of the tube.

Appropriately operational mitigation must be established to reduce noise exposure in accordance with paragraph 7.2.9. The impact of hazardous noise levels for tube ranges must be evaluated by local SE and BE. BE will evaluate noise exposures and make recommendations for proper hearing protection to reduce noise levels for shooters and range personnel.

8. Design Review, Construction Inspection, Test Firing, and Trial Operation.

8.1. Design Approval.

8.1.1. The design agent will submit a set of prefinal drawings and project specifications to the respective MAJCOM representatives of CA, CE, SE, and BE for review to ensure compliance with this ETL.

8.1.2. After MAJCOM approval is complete, HQ AFSFC/SFXW must approve all new range designs, major renovations, and changes to the type or function of the range. This approval also applies to portable or trailer type ranges. HQ AFSFC/SFXW is the approval authority for deviations or waivers from design criteria and will coordinate requests with HQ AFCESA/CEOA and AFMSA/SG3PB.

8.2. Baffle Test Before Construction. For baffles which differ from the weapons and construction mandated in Table 3**,** construct baffle test blocks/cells using the baffle materials and construction details specified in the design documents. Completion of this test is required before construction and installation of the overhead baffles. From a protected position, a shooter will engage the test block/cell with direct fire from the most powerful round authorized for the range. The baffle test should have secondary containment to stop the round if it penetrates the test baffle. Do not test the baffle blocks/cells using tracers. Do not test baffles after they are installed in their overhead position. Conducting direct-fire tests following construction could be very unsafe and costly if the baffles fail to stop the round. Machine gun range tubes do not have to be tested if they meet the material requirements listed in paragraph 7.7.3.1.1.

8.3. Construction Inspection. The BCE will validate that the proper materials have been used and construction complies with the specifications and drawings. The range and its support facilities, when completed, must satisfy or exceed the requirements of this ETL. The materials, distances, and angles are critical to safety. Distances from the firing lines to target lines are critical and must be measured during construction and on completion of the range. On fully contained ranges, visually check baffles to make sure they overlap the required 150 millimeters (6 inches), validate lighting levels, range supply, and exhaust system testing and commissioning.

8.3.1. The contractor shall provide, prior to final inspection, a full testing and balancing report for all supply and exhaust equipment. From the results of those

tests, determination will be made on airflow compliance set forth in the contract specification and this ETL. The balancing and testing shall be performed by a qualified testing agent in accordance with design criteria. Design criteria may include ACGIH *Industrial Ventilation: A Manual of Recommended Practice*, and NEHC-TM) 6290.99-10 Rev. 1, *Indoor Firing Ranges Industrial Hygiene Technical Guide*.

8.3.2. When the project includes additions and/or modifications to the sound-absorbing materials within the range, the contractor shall accomplish a hazardous noise survey. The initial hazardous-noise survey shall be conducted within five days of final acceptance of the range. The contractor shall coordinate with the government in advance to ensure personnel are scheduled and present to perform necessary weapons firing while the hazardous noise survey is being accomplished. Alternatively, the initial hazardous noise survey may be conducted in conjunction with the trial operations test. The initial hazardous noise survey shall be performed in accordance with requirements of DODI 6055.12, *Hearing Conservation Program (HCP)*, Air Force manual (AFMAN) 48-155, *Occupational and Environmental Health Exposure Controls* and AFOSH Standard 48-20, *Occupational Noise and Hearing Conservation Program*.

8.4. Test Fire Requirements. After construction or rehabilitation, and before conducting training and qualification operations, CA personnel must accomplish controlled test-firing using tracer ammunition. If tracer ammunition cannot be safely fired on the range, CA personnel will fire ball ammunition with witness screens to conduct the test fire. Representatives of SE and CE will act as observers. The CA instructor will use the most powerful ammunition authorized for use on the range for the test. Remove all fire hazards from the range and areas surrounding the range. Make sure firefighting equipment is immediately available when conducting range tests using tracer ammunition. Provide sandbags or other protection for the shooter during test firing. Hang witness screens of paper when firing non-tracer rounds to see if splash-back ricochets are occurring at the bullet trap when using the M855 round.

8.4.1. Non-contained Ranges. A test-fire is not required for a non-contained range. After the construction inspection confirms that the full SDZ land area is available and all barriers, fences, and signs are erected, proceed to trial operations.

8.4.2. Fully Contained Ranges. Do not test baffles with direct fire. Test baffles for direct-fired round containment before construction, as described in paragraph 8.2. To test for ricochet containment, the shooter must first fire service ammunition (non-tracer) from the prone position into the backstop and then at the floor. A test screen (witness) may be used to test the ricochet potential of the range floor. A test screen may be constructed from Celotex (National Stock Number [NSN] 5640-00-073-2803) or cardboard material, fashioned into a 1.2-meter by 1.2-meter (3.9-foot by 3.9-foot) four-sided cube. Place the test

screen at different locations on the range floor. Fire into the range floor in front of the test screen at various angles from the firing line. To determine if ricochets would have left the range, sight along a small-diameter dowel placed through ricochet holes in the screen material. Take corrective measures if the angle of departure and the sighting verifies that the bullet left the range. To determine ricochet patterns, conduct tracer tests using the same caliber of ammunition to be used on the range. Using tracer ammunition is the fastest and most efficient method of determining ricochet patterns and hazard potential.

8.5. Trial Operations. Trial operation of a new or rehabilitated range is mandatory. The CA NCOIC and installation SE representative will be present during trial operations. Document the results of the trial operations in a range trial operation report. One copy of the trial operations report must be included in the construction acceptance documentation. The CA section will retain an additional copy on file for the life of the range. Include the following items in the report:

- Date of construction completion
- Date of trial operation
- Course of fire
- Type of weapon, caliber, and ammunition used for the trial (This must be the most powerful ammunition intended for use on the range.)
- Target system functioning (may be mechanical or fixed)
- Number of shooters who fired
- Firing points used
- Damage incurred or improperly functioning items
- Initial hazardous noise survey report

9. Point of Contact. Recommendations for improvements to this ETL are encouraged and should be furnished to the Small Arms Range Program Manager, HQ AFCESA/CEOA, DSN 523-6119, commercial (850) 283-6119, e-mail AFCESAReachbackCenter@tyndall.af.mil

CLIFFORD C. FETTER, GS-15, P.E., DAF
Acting Chief, Operations & Programs Supt Div

3 Atchs
1. Minimum VDZ Height Requirements for Small Arms Ammunition at Non-contained Ranges
2. Operational Risk Management (ORM) Evaluation of Existing Range Facilities
3. Distribution List

MINIMUM VDZ HEIGHT REQUIREMENTS FOR SMALL ARMS AMMUNITION AT NON-CONTAINED RANGES

Weapon/Caliber	Ammunition	Maximum Ordinate of Ammunition at 30° VDZ Meters (Feet)	Safety Factor Meters (Feet)	VDZ Height in Meters (Feet)
.22 long rifle		500 (1640)	175 (575)	675 (2215)
Handgun, .38 cal.	Ball M41, PGU-12/B	500 (1640)	175 (575)	675 (2215)
Handgun, .45 cal. pistol Submachine gun, .45 cal.		400 (1312)	160 (525)	560 (1837)
Handgun, 9mm pistol Submachine gun, 9mm		500 (1640)	175 (575)	675 (2215)
Handgun, .44 magnum		TBD	TBD	TBD
Shotgun, 12 gauge	00 buckshot	200 (656)	130 (427)	330 (1083)
Rifle, 5.56mm	Ball M193; tracer M196	800 (2625)	220 (722)	1020 (3347)
Rifle, 5.56mm	Ball M855; tracer M856	900 (2953)	220 (722)	1120 (3345)
Rifle, 5.56mm	M862 (plastic)	TBD	TBD	TBD
Rifle/machine gun, 7.62mm	Ball, M80; tracer M81	1100 (3609)	265 (869)	1365 (4478P
Rifle/machine gun, 7.62mm	Match M118	1200 (3937)	280 (919)	1480 (4856)

Weapon/Caliber	Ammunition	Maximum Ordinate of Ammunition at 30° VDZ Meters (Feet)	Safety Factor Meters (Feet)	VDZ Height in Meters (Feet)
Machine gun, .50 cal.	Ball M2 and M33/Tracer M17/M8 API/M20 APIT	1600 (5248)	340 (1115)	1940 (6365)
M79 and M203, 40mm low-velocity	M781/M407A1/M406/ M433/M381/M386/ M441	100 (328)	115 (377)	215 (705)
MK-19, 40mm high-velocity	M918/M383/M430	500 (1640)	175 (575)	675 (2215)
M72 LAW, 35mm subcaliber	M73	300 (984)	145 (475)	445 (1460)
M72 Law, 66mm RKT HEAT	M72	200 (656)	280 (919)	480 (1575)
AT-4, 84mm RKT HEAT	M136	TBD	TBD	TBD

Notes:

1. VDZ in excess of 61 meters (200 feet) in height requires coordination with the local airfield manager.
2. Use a VDZ of 500 meters (1640 feet) for partially contained (baffled) ranges.

OPERATIONAL RISK MANAGEMENT (ORM) EVALUATION OF EXISTING RANGE FACILITIES

A2.1. Overview. Operational Risk Management (ORM) is a tool used to assess the risks associated with continued use of existing firing ranges that do not satisfy the minimum criteria outlined in this ETL. For further information on ORM, refer to AFI 90-901, *Operational Risk Management*, and AFPAM 90-902, *Operational Risk Management (ORM) Guidelines and Tools*. This attachment gives an example of how the ORM process can be applied to a safety evaluation of an existing range. Briefly, the ORM process can be considered to be a six-step process:

1. Identify the hazard
2. Assess the risk
3. Analyze risk-control measures
4. Make control decisions
5. Implement risk controls
6. Supervise and review

A2.2. Action Items. The six steps of the process can be broken down into several sub-steps called "actions." A discussion of each action follows.

A2.2.1. Identify the Hazard. This step has three actions:

- Mission/task analysis (e.g., training personnel to fire weapons)
- Listing the hazards (e.g., fired rounds leaving the range)
- Listing the causes (e.g., baffles are of insufficient thickness)

Listing the causes of the hazards is the action where deficiencies or discrepancies are items found to not satisfy the ETL criteria. A tabular method for recording these actions and steps is presented in the following paragraphs.

A2.2.2. Assess the Risk. This step has three actions:

A2.2.2.1. Assess hazard severity category:

- I Catastrophic (i.e., mission failure, death, system loss)
- II Critical (i.e., major mission impact, severe injury, or major system loss)
- III Moderate (i.e., minor mission impact, injury, or system damage)
- IV Negligible (i.e., little mission impact, injury, or system damage)

A2.2.2.2. Assess the mishap probability:

- A – Frequent, daily, often, 10^{-1} to 10^{-4}
- B – Likely, three weeks, occurs several times, 10^{-2} to 10^{-4}
- C – Occasional, six months, will occur, 10^{-3} to 10^{-5}
- D – Seldom, five years, could occur, 10^{-4} to 10^{-6}
- E – Unlikely, past five years has not occurred, rarely, 10^{-5} to 10^{-7}

A2.2.2.3. Assign a numerical rating based on the combination of steps A2.2.2.1 and A2.2.2.2. See Table A2.1 for the numerical value to assign to the risk.

Table A2.1. Mishap Probability

Severity		Frequent A	Likely B	Occasional C	Seldom D	Unlikely E
Catastrophic	I	1	2	6	8	12
Critical	II	3	4	7	11	15
Moderate	III	5	9	10	14	16
Negligible	IV	13	17	18	19	20

Note: Lower numbers indicate higher risk.

A2.2.3. Analyze Risk-Control Measures. This step has three actions:

A2.2.3.1. Identify risk control options: Measures taken to mitigate the risk.

A2.2.3.2. Determine control effects: Select the control options desired for consideration.

A2.2.3.3. Determine the residual risk: Prioritize the control measures and re-score the risk based on the implemented control measures using the same procedures in paragraph A2.2.2.3.

A2.2.4. Make Control Decisions. This step has two actions:

A2.2.4.1. Select the risk control measures to implement.

A2.2.4.2. Decide whether the residual risk level is acceptable or not.

A2.2.5. Implement Risk Controls. This step has three actions:

A2.2.5.1. Make the implementation clear to all parties.

A2.2.5.2. Establish accountability and responsibility for implementing risk-control measures.

A2.2.5.3. Provide support to those tasked to implement the control measures.

A2.2.6. Supervise and Review. There are two actions in this step:

A2.2.6.1. Supervise the implementation of the control measures.

A2.2.6.2. Review the effectiveness of the control measures.

A2.3. Example. The following example shows a tabular method for performing the operational risk assessment for existing firing ranges. The example shows discrepancies taken from a real-world assessment at an Air Force base.

BASE "X" FIRING RANGE
OPERATIONAL RISK EVALUATION

Discrepancy	ORM STEP 1	ORM STEP 2			ORM STEP 3		ORM STEP 4	ORM STEP 5	ORM STEP 6
	Hazard	Severity	Probability	Risk	Control Options	Residual Risk	Decision	Implementation	Results
Baffle materials do not meet ETL guidelines	Shoot through the baffle and bullets leave the range containment	I	C	6	Add additional thickness to baffles, or replace with correct material	Repair or replace will yield I,E=12	12	Make repairs	Compare as-built repairs with ETL guidelines
Baffle materials or slopes do not meet ETL guidelines	Ricochet	II	C	7	Install plywood facing on two baffles nearest the shooter, frangible ammunition	Install plywood facing is II,D=11. Frangible ammunition is III,E=16	16	Buy frangible ammunition	Verify ammunition performs as advertised
Baffle materials or slopes do not meet ETL guidelines	Lead pollution, outside of containment	II	C	7	Lead-free ammunition, frangible ammunition	Lead Free is IV,E=20. Frangible ammo is III, D= 14	20	Buy lead-free ammunition	Verify that lead ammunition is no longer being used
Side wall berm has an opening that is visible to some firing positions	Bullets leave the range containment	I	A	1	Fill in the opening or establish a procedure to not use those firing positions	Fill opening is IV,D=19. Procedure is II,E=15	19	Fill in opening	Re-inspect to verify opening has been closed
Side wall berm has an opening that is visible to some firing positions	Lead pollution, outside of containment	II	A	3	Fill in the opening or establish a procedure to not use those firing positions; lead monitoring program; lead-free ammunition	Fill opening is IV,D=19. Procedure is II,E=15. Lead Monitoring is II,E=15, Lead Free Ammo is IV,E=20	19	Fill in opening	Re-inspect to verify opening has been closed
Surface water runoff can leave the range	Lead pollution, outside of containment	II	C	7	Water monitoring program, including surface water samples and groundwater monitoring wells	Monitoring program is II,E=15	15	Install monitoring wells and hire environmental testing firm	Regular reports documenting monitoring results

DISTRIBUTION LIST

SPECIAL INTEREST ORGANIZATIONS

Information Handling Services (1)
15 Inverness Way East
Englewood, CO 80150

Construction Criteria Base (1)
National Institute of Bldg Sciences
Washington, DC 20005

UNIFIED FACILITIES CRITERIA (UFC)

DRAFT

DESIGN AND MAINTENANCE: SMALL ARMS RANGE FACILITIES



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DESIGN AND MAINTENANCE: SMALL ARMS RANGE FACILITIES

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U.S. ARMY CORPS OF ENGINEERS

NAVAL FACILITIES ENGINEERING COMMAND (Preparing Activity)

AIR FORCE CIVIL ENGINEER SUPPORT AGENCY

Record of Changes (changes are indicated by **1**\ ... /**1**/)

Change No.	Date	Location

This UFC supersedes Military Handbook 1027/3B, Range Facilities and Miscellaneous Training Facilities Other Than Buildings, dated 31 January 1989, and Notice 1, dated 31 December 1989 and REV 1 dated 30 June 199..

FOREWORD

The Unified Facilities Criteria (UFC) system is prescribed by MIL-STD 3007, provides planning, design, construction, operations, and maintenance criteria, and applies to all service commands having military construction responsibilities. UFC will be used for all service projects and work for other customers where appropriate.

UFC are living documents and will be periodically reviewed, updated, and made available to users as part of the Services' responsibility for providing technical criteria for military construction. Headquarters, U.S. Army Corps of Engineers (HQUSACE), Naval Facilities Engineering Command (NAVFAC), and Air Force Civil Engineer Support Agency (AFCESA) are responsible for administration of the UFC system. Technical content of UFC is the responsibility of the cognizant DoD working group. Recommended changes with supporting rationale should be sent to the respective service proponent office, as noted below. Defense agencies should contact the preparing service for document interpretation and improvements.

- HQUSACE, ATTN: CECW-E, 441 G Street, NW, Washington, DC 20314-1000, by electronic Criteria Change Request (CCR) form on the TECHINFO site listed below.
- Commander, Atlantic Division, Naval Facilities Engineering Command, 1510 Gilbert Street (ATTN: NAVFAC Engineering Innovation and Criteria Office), Norfolk, Virginia 23511-2699, or ufc@efdlant.navfac.navy.mil, by commercial telephone (757) 322-4200 or DSN 262-4200, or by facsimile machine to (757) 322-4416
- Air Force Civil Engineer Support Agency, 139 Barnes Drive, Tyndall Air Force Base, Florida 32403-5319, or larry.spangler@Tyndall.af.mil.

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- USACE TECHINFO Internet site http://www.hnd.usace.army.mil/techinfo/index.htm.
- NAVFAC Engineering Innovation and Criteria Office Internet site http://criteria.navfac.navy.mil/criteria.
- Construction Criteria Base (CCB) system maintained by the National Institute of Building Sciences at Internet site http://www.nibs.org/ccb.

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CHAPTER 1

INTRODUCTION

1-1 **SCOPE**. UFC 4-160-01 provides guidance for the design of small arms ranges (SAR). "Range" is used throughout this UFC to identify areas for weapons firing for personnel training and weapons testing (*not* ordnance test ranges). “Small arms” are defined as handguns, riotguns (12 gauge shotguns), rifles up to 7.62 mm, and machine guns to 50 cal.

1-2 **CANCELLATION**. This UFC cancels and supersedes MIL-HDBK-1027/3B, Rev 1, Range Facilities and Miscellaneous Training Facilities Other than Buildings, of 31 January 1989, and Notice 1, of 31 December 1989, and REV 1, 30 June 1995.

1-3 **APPLICATION**. These criteria apply to all planning, design, and construction of new ranges, and repairs to existing ranges. Existing ranges need not necessarily conform to all of the requirements of this UFC. However, existing ranges should attempt to meet the safety requirements of this UFC. Activities should program projects to address these concerns as soon as possible. Contact NAVFACENGCOM Code EICO for specific guidance.

Rehabilitated or newly constructed ranges must meet all the requirements of this UFC.

1-4 **DESIGN OBJECTIVES**. The available activity land area determines whether a range is outdoor, baffled or indoor. Most Naval activities require “indoor” ranges due to lack of land area. The range design must promote safe, efficient operation and yet be affordable to construct and maintain. When considering range size and selecting materials, consider that a small arms range should be capable of providing training or testing for all appropriate small arms assigned to Host and Tenant commands.

1-4.1 **Planning Phase**. Convene a team to review the range requirements and develop the project. The team will consist of the weapons officer, range safety officer, industrial hygienist, activity planner, public works engineer, cognizant Engineering Field Division (EFD) personnel, NAVFAC Code EICO and others who may have interest. Plot the proposed Surface Danger Zone (SDZ) on the activity General Development Map (GDM) to confirm the lack of conflicts. Check aircraft operations. Note that the Federal Aviation Administration (FAA) must be contacted if there is a vertical weapon component that exceeds 500 meters.

Consult NAVFAC publication P-80 for guidance on the number of personnel to be supported and the size of the range.

Note that rifles, pistols, and shotguns produce greatly varying amounts of projectile energy to be controlled by range structures. Design range and components to accommodate the maximum energy anticipated.

Under normal conditions, request site approval through the cognizant Engineering Field Division (EFD) or Engineering Field Activity (EFA.) Refer to NAVFAC Instruction 11010.44E, *Shore Facilities Planning Manual: A System for the Planning of Shore Facilities*.

1-5 **CENTER OF EXPERTISE**. NAVFAC INSTR 11014.53A of April 1996, established a Center of Expertise whose participation is mandatory in all range construction. The Point of Contact is:

Commander
Naval Facilities Engineering Command
Attn: Engineering Innovation and Criteria Office
1510 Gilbert Street
Norfolk, VA 23511-2699
Telephone: Commercial (757) 322-4200 DSN 262-4200 Fax: (757) 322-4416
Email : Ord@efdlant.navfac.navy.mil

1-5.1 **Contracts**. POC maintains 3 ID/IQ limited source contracts:

1-5.1.1 A/E design

1-5.1.2 Ventilation and Range composition design-build contractor

1-5.1.3 Ventilation and maintenance contracts

1-5.2 **Technical Support**. The POC also provides technical support throughout construction and operation.

1-6 **RECORD OF COMPLIANCE**. After construction is complete, a Record of Compliance is required from NAVFACENGCOM Code EICO before the range is authorized to operate. Coordinate through the cognizant EFD or EFA.

CHAPTER 2

INDOOR SMALL ARMS RANGES

2.1 INDOOR SMALL ARMS RANGES:

2-1.1 **General**. Provide indoor ranges when land is not available for the required surface danger zone (SDZ).

2-1.2 **Controlling Factors**. The most important items to be addressed are ventilation (air velocities at the firing line) and projectile containment within the facility space. The outer lane on each side is not for use.

2-1.3 **Ventilation**. Make the system 100% purge with either a two-stage (for granular rubber traps) or three-stage (for steel traps) filter bank on the exhaust. The final filter will be a high-efficiency particulate arrestor (HEPA) filter. Isolate the supply intake from the exhaust outlet. Design for air-flow velocity at the firing line to be an average 0.38 m/sec (75 fpm) +/- 10 % per stall averaging 75 fpm for the whole range, and not be less than 0.25 m/sec (50 fpm) at any reading point. Velocity is measured at three points (on centerline of the lane and 1foot to the right and left) at heights of 300 mm (1 ft), 900 mm (3 ft), and 1500 mm (5 ft) of the firing line floor. Maintain a negative inches of water pressure in the operating range area of .04 +/- .02 relative to the surrounding atmosphere. This requires seals on all wall and roof joints and penetrations. Design for laminar airflow to “go smartly down range”. Use a radial plenum for the supply air and a continuous slot to capture the exhaust air. Make all ductwork absolutely symmetrical. Provide a vortex damper to regulate the airflow through the exhaust fan and filters.

Provide telephone/modem communication to the computer that controls the ventilation system. Install such equipment in the Range Master Control Booth.

2-1.4 **Range Type and Size**. Design indoor ranges to accommodate pistols only or pistols and rifles. Shotguns may be fired on either range. Make the decision of “type” at the beginning of planning. If there is any doubt as to usage, construct for rifles. The size, and therefore ventilation, will be the same for either use. The bullet trap and overhead baffle materials will vary due to the differences in pistol vs. rifle power. Strongly suggest design range for rifle use; Pistols can be shot on a rifle range but not vice-versa.

2-1.4.1 **Range Size.** Lanes should be 41.5 m (136 ft) in length by 1.2 m (4 ft) in width.

The 41.5 m (136 ft) total length is assembled from adding – range masters office: 3.05 m (10 ft); get ready area: 4.6 m (15 ft); target distance: 25.6 m (84 ft); bullet trap: 5.2 m (17 ft); trap cleanup area: 3.05 m (10 ft) = 136 ft. The width of a 10 lane range would measure: 10 x 1.22 m (4 ft) = 12.2 m (40 ft); plus

outer lanes 2 x 1.2 m (4 ft) = 2.4 m, (8 ft); plus wall thickness =0.6 m (2 ft); for a total of 15.2 m (50 ft) out to out. See figure 2.1 at the end of this chapter.

2-1.5 **Building Construction**. Meet all service criteria for structural design and construction materials. Floor will be concrete. The walls may be grout-filled concrete masonry units, tilt-up concrete panels, or continuous reinforced concrete walls. The roof will be membrane, supported by metal joist, flat built up roofing, or reinforced concrete. Surface seal all walls and floor surfaces to facilitate cleaning. Existing buildings may be used in some instances. Avoid interior columns.

2-1.6 **Range Masters Office**. Provide a 1.2 m (4 ft) high window, side-wall to side-wall, for range visibility. Provide a 0.6 m (2 ft) wide full-length work counter at the base of the window. Install all range controls and utility panels in this area.

2-1.7 **Entry**. Construct at least one, two-door air lock entry vestibule located at one end of the range masters area. A large range with high volume usage may require two vestibules – one for entry and one for exit. The trap cleanup area requires a sealed single door with an “open door” alarm. A side, sealed double-door for maintenance in the get-ready area is optional. There will be no openings in the building structure between the firing line and the bullet trap.

2-1.8 **Safety Ceiling**. Provide a 9.5 mm (3/8-in) thick AR500 steel plate from 0.9 m (3 ft) behind to 3.6 m (12 ft) in front of the firing line. An air gap of 38.1 mm (1 ½ in) thickness created by 9.5 mm (3/8 in) thick rubber conveyor belting or 19 mm (3/4 inch) fire-retardant plywood, for splatter protection is required. Coordinate the ceiling with the radial plenum for efficient airflow. See figure 2-1 at the end of this chapter.

2-1.9 **Booths**. Provide commercial shooting booths with necessary target controls for each lane. The booths will support user requested barrier equipment. The booths may be removable.

2-1.10 **Target Retrieval Systems**. Provide a commercial retrieval system to meet user needs. Support rails, cables, controls, and target hangers are user options. Place target rails or cables 2.44 m (8 ft) above the floor.

2-1.11 **Overhead Baffles**. Provide sloped commercial ballistic baffling to contain/deflect the weapons anticipated. Splatter protection is required 15.25 m (50 ft) from firing line. Locate to prevent direct fire from striking bottom of roof.

2-1.12 **Bullet Trap**. Provide a commercial trap that is either a steel escalator type or a sloped granular rubber type. Choice of trap will be by agreement between user and NAVFAC Center of Expertise (paragraph 1-5). Choose a trap that will support the most powerful weapon anticipated.

2-1.13 **Lighting**. Provide general illumination throughout the range. Spot or floodlights are required at all target locations. The preferred lighting method is a continuous bank of fluorescent lights with supplemental metal halide fixtures or a combination of lighting fixtures running the full width of the range. Provide light intensity at target face between 914.9 to 1076.4 lux (85 to 100 foot-candles), measured 1.22 m (4 ft) above the floor at the target. Provide range with dimming control and multilevel switching of lighting fixtures to satisfy various training requirements of using activities.

2-1.14 **Communication System**. Provide one-way or two-way paging system as requested by user.

2-1.14.1 **Local Operating Procedures**. Safety of personnel and property cannot depend upon design features alone; proper operating procedures and discipline must be established and enforced at all times. Provide as part of range certification.

2.1.15 **Equipment**

2-1.15.1 High Efficiency Particulate Arrestor (HEPA) Vacuum for floor clean up and two-stage vacuum for granular rubber trap.

2-1.15.2 **Additional Building Facilities**. The following should be considered:

- Toilet and wash facilities.
- Drinking fountain.
- Emergency eyewash, if weapons cleaning capability is included.
- Storage closet for equipment and HEPA vacuum.

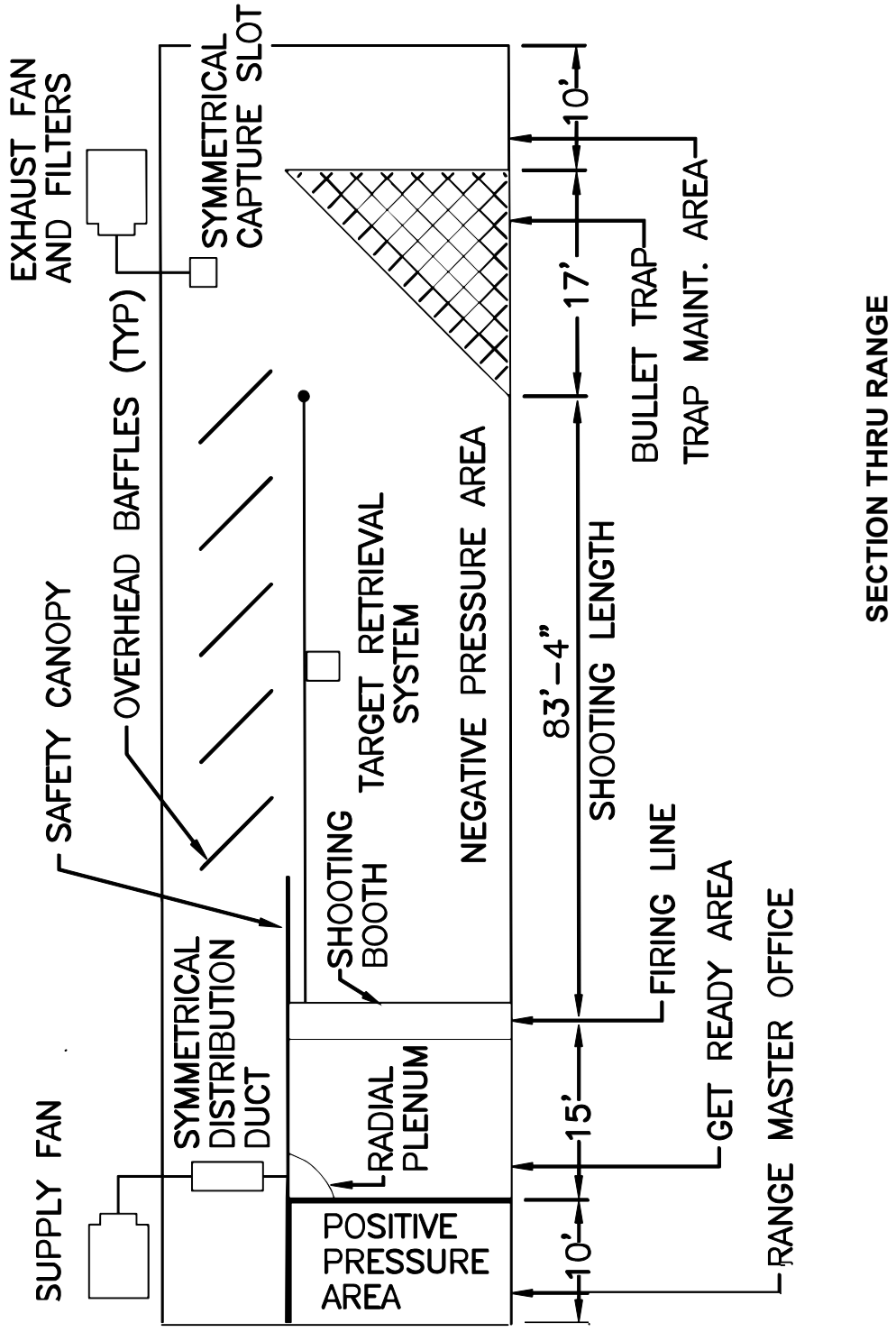
2-1.16 **Range Design Review**. Weapons to be fired and distances of firing line to targets must be determined during the planning phase. (No .50 cal allowed indoors)

Other design considerations include: number of firing points; lighting possibilities; manual and automatic target carrier/turning mechanisms; offices; shooting benches; clocks and timers; ventilation; ease of lead dust cleanup; spectator safety; acoustics; lead removal from bullet traps.

2-2 **ON-GOING MAINTENANCE**. Successful performance of small arms ranges is greatly dependent on regular, on-going maintenance by qualified personnel. The activity should plan for a monthly monitoring, quarterly preventive maintenance contract executed by the ventilation contractor who constructed the facility. An ID/IQ ventilation maintenance contract is currently in

place and available for use to achieve these objectives. An active maintenance contract is required for continued re-certification.

FIGURE 2-1 INDOOR RANGE VENTILATION



CHAPTER 3

OUTDOOR SMALL ARMS RANGES

3-1 **DESIGN POLICY**. Design the range such that the surface danger zone (SDZ) is unoccupied by any personnel, livestock, vehicles, facilities, etc., which may be damaged.

The SDZ is any area that may reasonably expect projectile impact resulting from direct fire (DF), including misdirected and accidental discharges (MAD), and ricochets (RC). The SDZ is only in force when weapons are being fired. The Range Safety Officer (RSO) maintains complete control over the SDZ. The entire SDZ must be either U.S. Government owned or legally authorized for Government use as a small arms range (SAR). Use the maximum range of the most powerful cartridge to be fired when calculating the limits of the SDZ. Select the longer distance if potential weapons are close in maximum range (for example. For a 45 caliber, select 9 mm distance). Maximum ranges for various small arms ammunition are shown in Table 3-1. Required SDZ footprints (based on soil type and range improvements) are shown in Figures 3-1 through 3-4. When two or more ranges are located contiguous and parallel, use the longest maximum distance to plot one composite symmetrical SDZ. If land area for a full SDZ is unavailable then construct various improvements (baffles) to contain the projectiles.

Alternative designs producing smaller SDZ's are presented starting in par 3-3. Note that the land available for the SDZ directs the design effort.

Table 3-1 Maximum Range of Small Arms Ammunition

Caliber	Cartridge	Max. Range in Meters
.22 long rifle		1400
.38 revolver	Ball, M41	1600
.38 revolver	Ball, PGU-12/8	1900
.45 pistol		1500
.45 submachinegun		1600
.357 magnum		2160
9mm pistol		1740
9mm submachinegun		1840
.44 magnum		2290
Shotgun, 12 ga	00 buckshot	600
.30 rifle/machinegun	Ball, M-33	3100
.30 rifle/machinegun	AP, M2	4400
.30 carbine		2300
5.56mm rifle (M-16)	Ball, M855	3400
7.62mm rifle/machinegun	Ball, M80	4100
7.62 rifle/machinegun	Match, M118	4800
.50 machinegun	Ball, M33	6500
.50 machinegun	AP, M2	6100

3-1.1 **Other Publications**. The joint Army Regulation and Marine Corps Order AR-385-63 /MCO-P3570.1A, *Policies and Procedures for Firing Ammunition for Training, Target Practice, and Combat* are coordinated with this UFC and should be consulted for weapons not covered here.

3-2 **ENVIRONMENTAL CONCERNS**. Consider that environmental regulations will become more stringent. Design and site the range to accommodate future cleanup efforts in the intended impact areas and other areas where MAD and RC may land.

3-2.1 **Best Management Practices**

3-2.1.1 **Lead**. Lead (and other associated projectile components) is a hazardous heavy metal that may adversely affect humans when finely divided dust is taken into the body or lead particulate is transported into a drinking water supply. The following procedures will keep the lead on the range, treat it to be chemically harmless, and recycle it when safety requires its removal.

The procedures involve soil amendments, vegetation management, engineering controls, contaminant monitoring, reclaiming, and recycling.

3-2.1.2 **Soil Amendments**. Test impact structure soils for pH levels every 2 years. Consult local agricultural extension agents for assistance. The desired pH levels are in the neutral range of 6 to 8. The pH level can be raised if necessary by adding hydrated, crushed, or pulverized limestone.

3-2.1.3 **Vegetation**. Maintain vegetation on berms and drainage-ways. Turf grasses do an especially good job of retaining water and sediment on site.

Choose a grass with minimal watering and fertilizing needs. Rework the projectile pocket in the berm by adding soil and grass often. Use non-nitrate based fertilizer. Minimal amounts of nitrate-based fertilizer may be used during the initial grow-in period. Remove any decaying wood or other plant life on the range, particularly on the berm face and in the SDZ in near proximity to the berm back.

3-2.1.4 **Engineering Controls**. Prevent storm water runoff from impact berms from flowing directly into surface water environments. Divert surface water runoff within the range (including the SDZ) to a vegetated detention basin or infiltration area. Provide straw bales, geotextile fabrics or other erosion controls in drainage areas. Slow the runoff and provide sediment traps.

3-2.1.5 **Contaminant Monitoring**. The monitoring program establishes early indications of lead movement. Sample the surface soil, surface water, and the ground water for soluble lead, dissolved lead, total lead, and nitrates. The

sampling cycle should be based on range usage and site geohydrological conditions.

3-2.1.6 **Reclamation and Recycling**. Remove lead in the berm face when there is a noticeable lead mass that is causing RC – normally 20,000 rounds per lane. Sift the lead from the soil on site. Place the soil immediately back on the berm face. Send the sifted lead in containers to the local recycling contractor or smelter.

3-2.1.6.1 **Health and Safety Plan**. Develop a site specific Health and Safety Plan in cooperation with the local industrial hygienist before working in an area where lead is present. Conform to OSHA regulations 29 CFR 1910.1025 and 29 CFR 1926.62.

3-3 **SURFACE DANGER ZONES OVER WATER**. If the SDZ is to be oriented over navigable water, obtain prior approval of the plan from the Chief of Naval Operations (Code N-411E).

3-3.1 **Approval**. The following SDZ controls are required to obtain approval. Include the SDZ's in construction drawings and write into the range standard operating procedures (SOP):

3-3.1.1 **Limits.** Draft limits (by latitudinal and longitudinal coordinates) of the water impact area so the limits can be transferred onto local navigation charts as a SDZ in the U.S. Army Corps of Engineers (USACE) application. Refer to par. 3-3.2.

3-3.1.2 At least two poles will display "holiday"-size red flags when the range is "live." Flags must be visible from all points of entry into the SDZ. Provide either a red or white strobe light to call attention to the flag at night. Place flags in conspicuous locations. Oceanside requirements are different from swamp- and canal-side requirements.

3-3.1.3 Provide marking buoys at the outer limits of the SDZ.

Abnormal depths or extensive ship traffic may require other procedures.

Submit alternate proposals for marking limits to NAVFACENGCOM Code EICO if buoys are impractical (see paragraph 1-5).

3-3.1.4 Maintain a lookout with direct communication to the firing line (to stop the firing if the SDZ is entered). Provide a high observation tower or beach guards for this lookout. High-speed vessels may be required to police the SDZ if there is significant water traffic.

3-3.2 **Application for SDZ.** After receiving Chief of Naval Operations approval, file an application for a SDZ with the USACE District Engineer having

jurisdiction in accordance with 33 CFR Part 344. Verify that the USACE has communicated with the U.S. Coast Guard to routinely publish announcements in the "Notice To Mariners" to warn mariners to "stand clear" when the range is in operation.

3-4 **LOCAL OPERATING PROCEDURES**. Safety of personnel and property is paramount. Proper range operation procedures and discipline will be required for safe usage. Include in the general notes, on the construction drawings, the pertinent design parameters such as: weapons, ammunition, target types, SDZ's, property lines, and aircraft flight paths to assist the RSO in writing the SOP manual.

3-5 **WARNINGS**. Provide warning signs on the approaches to the range and the perimeter of the SDZ, if access is not otherwise restricted. Provide red flags and/or rotating, flashing red lights at appropriate locations to signal when the range is in use.

Refer to the information listed in Table 3-2 and AR 385-30, *Safety Color Code Markings and Signs* for guidance. Require fencing when there are no other entry restrictions.

Table 3-2 Warning Sign Placement

WARNINGS	LOCATIONS
Danger – Firing in Progress When Red Flag is Flying	Approach Roads
Danger – Firing Ranges Do Not Enter	Fencing and Barriers

3-6 **WIND DIRECTION**. On rifle ranges, provide flags on poles at each end of the impact berm or target line and at each firing line to indicate wind direction to the shooters. This could be the same flag called for in par. 3-3.1.3.

3-7 **SITE REQUIREMENTS**. Address location, characteristics and vertical clearance when selecting the site.

3-7.1 **Location**. Sites should be remote from residential communities to avoid interaction with residents and allow for future development of the range. Record the SDZ on activity General Development Maps. Address the following items when selecting a location:

- Site must be accessible by road.

- Site must have natural drainage, but no flowing water-courses near the range floor or impact berm.

- Take advantage of any natural barriers or base restricted areas to prevent access by personnel and animals to the SDZ. Most activities have boundary conditions such as runways, magazine areas, and perimeter fences.

- Take advantage of any natural backstops that may exist for both cost savings on berm construction and noise abatement.

- Avoid areas that are subject to flooding. Cleanup costs for berms that have been washed away by floods are prohibitive.

- Avoid locating the range upwind (prevailing) of residential areas, if possible.

- Direct the line of fire away from residential areas, if possible.

3-7.2 **Characteristics**. Consider the following criteria when locating a range on a site:

3-7.2.1 Range floor requires minimal grading to produce a smooth surface of homogeneous material. A rocky surface will increase RC and enlarge the SDZ (see Figure 3-2).

3-7.2.2 Trees are allowed downrange of the impact berm in the SDZ, on exterior faces of the impact berm and side berms, and in the side SDZ's.

3-7.2.3 Vehicle access inside the range is required to ease maintenance operations and grass mowing.

3-7.2.4 If possible (safety and site considerations holding priority), the range should be oriented to eliminate firing into the sun. Backlighting the target line may cause aiming problems. In the northern hemisphere, north to northeast direction is preferable. Overhead baffling may provide sufficient shading on the targets to remove the backlighting.

3-7.2.5 The following utilities should be provided in the area:

- Electricity: Size service to accommodate power requirements for lighting, communication systems, target manipulation and control, etc. Locate wiring aboveground in conduit on any available structure or berm not exposed to DF. Many ranges are experiencing trouble with groundwater when new connections are made to upgrade systems.

- Telephone or radio communication: Needed for communication if there is a range emergency or accident. User can supply handheld units.

- Water: If available, provides service for fire protection, drinking, and sanitary uses. If not available, comment in design parameters so operators will provide required portable fire extinguishers and drinking and hand washing water. Hand washing water is required on the range.

3-7.2.6 There should be sufficient parking of appropriate surface to accommodate the anticipated vehicles.

3-7.2.7 Consider providing toilets and a storehouse to be used for ready ammunition storage, target storage and repair, first aid area, etc. Portable toilets can be used. On rifle ranges, consider placing target storage and some toilets at the ends of the target butts.

3-7.2.8 Consider a built-in communication system so the RSO can communicate with all parts of the range. The user may prefer to furnish portable radios and battery operated loud hailers.

3-7.2.9 Provide a weapon-clearing barrel at the exit from the firing line. See Figure 3-17 for details.

3-7.3 **Vertical Clearance**. On most weapons, DF could reach 1500 m (4921 ft) vertically. RC could reach 300 m (984 ft). Normal range clearance for planning (assuming proper range control) would be 500 m (1640.5 ft).

3-8 **TYPES OF RANGES**. There are two basic types of outdoor SAR's.

3-8.1 **Open (O)**. An open (0) range has uncovered firing line(s) and, highly recommended, but not required at this time, an impact structure to concentrate cleanup efforts. SDZ distance of 100 percent of the maximum range of the most powerful cartridge to be used; see Figure 3-1, 3-2, or 3-3. Note that "0" SAR's have wider fans and increased transverse lane spacing as opposed to baffled ranges. No effort is made to contain DF or RC. "0" SAR's are generally required for moving target systems; see Figure 3-3. There must be sufficient land available for a full-sized SDZ. .50 cal is restricted to Type (0) ranges.

3-8.2 **Partially Baffled (PB)**. A partially baffled (PB) range has covered firing line(s), side containment, overhead baffles (OB), and impact structure. SDZ distance of 50 percent of the maximum range of the most powerful round to be used; see Figure 3-4 From whatever location a weapon may be expected to be discharged, "the weapon can see no blue sky." Available land area will not support a full-sized SDZ and additional components are provided to prevent escape of DF.

Attempting to place a moving target system in a “PB” SAR creates numerous technical problems (SDZ fan and OB columns).

3-9 **GEOMETRY**. Vertical control is based on the firing line floor surface (FLFS) equals 0.00 meter, (refer to par. 3-10.1). Horizontal control is based on measurements taken from the rearmost firing line (FL).

The various range components (par 3-10) are located as follows:

- Locate the center of the target at an elevation between the upper limit of fire (ULF) (standing: plus 1.85 m (6.07 ft) above FLFS) and the lower limit of fire (LLF) (prone: plus 0.15 m (6 in) above FLFS). Fully display the entire target face to the shooter.

- Locate range floor (RF) (par 3-10.5) a minimum of minus 0.03 m (1 ft) below FLFS.

- Design transverse spacing for firing lanes for rifles of 2.75 m (9 ft) center to center; see Figure 3-5. Design firing lanes for pistols and shotguns of 1.50 m (4.9 ft) center to center; see Figure 3-6.

- Design the length of the range (distance between the farthest spaced firing and target lines) as appropriate to the weapon being used and the desired training; from 3 m (9.8 ft) to 550 m (1804.5 ft). Normally there will be several different firing lines to target distances on the same range. Training requirements will dictate the distances.

- Ranges may be located parallel to one another in compliance with Figure 3-7 for separation.

3-10 **RANGE COMPONENTS**. Depending on the restrictions of the SDZ, selected items of the following component list will be combined to form the operating range.

3-10.1 **Firing Line Items**. Provide the following components:

3-10.1.1 **Floor Surface**. The firing line floor surface (FLFS) elevation is the range controlling elevation. Design the surface to be smooth, firm, and graded to drain away from the targets. Side to side grading should be minimal. Transverse firing line grading should match target line transverse grading. Design sufficient fore and aft distance to support the type of training conducted. Clearly mark firing lanes on the surface to match the targets. Depending on the number of personnel to be supported (and their comfort) and the funds available, the following surfaces should be considered:

- Ground, firmly compacted with mown grasses. Railroad ties could be used for lane marking.

- Sand or fine gravel (prone firing could be uncomfortable).
- Wood decking of sufficient thickness and supporting members to avoid deck movement.
- Concrete topped with appropriate cushioning material.

3-10.1.2 **Overhead Containment**. For Type "PB" ranges, provide a ballistic canopy over all locations where a weapon may be expected to discharge (firing line by definition). Begin this canopy at least 1.0 m (3.3 ft) behind the firing line. General structural requirements may dictate more distance. Extend the canopy forward a distance (4 m (13 ft) minimum) that will work geometrically with the first OB in preventing a weapon from firing directly out of the range. See Figure 3-8. Note the prone firing location (LLF). Construct the canopy of ballistic material with sacrificial cladding as defined in par 3-10.7.

Consider sound reduction ceiling waffles. The minimum elevation of the lowest point is to be 0.60 m (1.9 ft) above UFL (plus 2.45 m (8 ft) FLFS).

Weather roofing is required above the ballistic material. Slope roof to drain. Include gutters and downspouts.

3-10.1.3 **Benches**. Continuous benches or individual trays may be provided to hold ammunition and weapons. Do not place trays in a position to encourage unsafe weapon handling.

3-10.1.4 **Partitions**. Partitions may be provided between shooting positions.

3-10.1.5 **Shed Roof**. On Type "0" ranges, any structurally sound roof for weather protection may be provided.

3-10.1.6 **Visual Area**. Provide the RSO with unrestricted view of the entire firing line from his control position.

3-10.2 **Side Containment**. For range type "PB" (Figures 2.2-4 and 2.2-5), design the top elevation of the side containment to geometrically mate with the overhead baffles to be high enough to prevent any direct fire from exiting the range. Full height side containment will extend 1.0 m (3.3 ft) to the rear of the FL. Locate the side containment at least 3 m (9.8 ft) outboard of the centerline of the outermost firing lane. Construction may be in the following forms:

3-10.2.1 **Earth Berm**. Construct the earth berm to an inside slope of 1.0v to 1.5h. If native soil characteristics will not produce a stable slope at this angle, provide geotechnical fabric reinforcement in the fill. Design for top width of berm to be 3 meters (9.9 feet). No rocks are permitted in the top 1 m (3.3 ft) of the inside surface. Slopes on the outside may be whatever is consistent with native soils. Vegetate appropriately for erosion control and maintenance.

3-10.2.2 **Continuous Walls**. Construct continuous walls of ballistic material (par 3-10.5) and make structurally capable of withstanding local weather and seismic conditions. Provide sacrificial cladding (par3-10.7) to 4 m (13 ft) forward of the FL and 1 meter (3.3 ft) behind the FL.

3-10.2.3 **Wing Walls**. Wing walls (side baffles) are discontinuous side protection set at 45 degrees to the line of fire. Locate the wing walls such that they are overlapped by 0.15 m (6 in) based on any line of fire that may strike the wing walls. Construct of ballistic material. Provide sacrificial cladding on wing walls closer than 10 m (32.8 ft) to the FL. Wing walls assist cross range ventilation.

3-10.2.4 **End Walls**. End walls may be constructed at the firing lane edge on the FL in lieu of side containment extending 1.0 m (3.3 ft) behind the FL. Construct walls long enough to close off any line of sight between the end of the side containment and the rear 1 m (3.3 ft) mark. Construct end walls of ballistic material with sacrificial cladding extending from the canopy to the FLFS.

3-10.3 **Overhead Baffles (OB).** Construct the lowest elevation of the bottom of an OB to be 0.15 m (6 in) above the ULF (plus 2.0 m (6.6 ft), FLFS). Locate the OB such that no direct fire can exit the range from any firing position (LLF usually is the controlling position). Geometrically coordinate the first OB with the firing line ballistic canopy (par 3-10.1.2). Construct the top elevation of each following baffle to be 0.15 m (6 in) higher than a line of fire that just clears beneath each preceding baffle. OB should be the same height; space them apart down range to achieve the required geometry. Place the last baffle such that the line of fire will strike the impact structure no higher than 1.5 m (6 in) below the top elevation of the structure.

3-10.3.1 Extend the OB laterally to within 0.3 m (1 ft) of the side containment (par 3-10.2).

3-10.3.2 The vertical dimension of an OB when it is vertical varies with the number and spacing of the baffles. Normally the height is between 1.25 and 2.5 m (4 to 8 ft) when considering structural support size and costs.

3-10.3.3 Construct the baffles of ballistic material (par. 3-10.6). Cover baffles within 5 m (16.4 ft) of the FL with sacrificial cladding. See Figure 3-9 for possible configurations.

3-10.3.4 Space the structural columns as far apart laterally as possible to open firing lanes. If possible do not construct any columns within the range.

Design columns or beams to withstand local wind and seismic loads. Provide protective steel plate on the faces of the columns exposed to the FL in accordance with Figure 3-9. Provide sacrificial cladding if the column is within 15 m (50 ft) of the FL.

3-10.4 **Impact Structure**. The impact structure varies depending on the type of range. Acceptable structures by range type are listed below. Alternative methods may be presented to NAVFACENGCOM Code EICO (paragraph 1-5) for prior approval.

3-10.4.1 **Type "O" Ranges**. The top elevation of the impact structure should be plus 8.0 m (26.25 ft) FLFS for ranges 92 m (300 ft) or greater in length and plus 5.0 m (16.4 ft) above FLFS for ranges 50 m (1800 ft) or less in length. Extend the impact structure 45 m (148 ft) beyond the target line ends for 92 m (300 ft) ranges and 15 m (50 ft) for 50 m (165 ft) ranges, or until joining with the side containment, if provided. Locate the beginning of the structure as close to the last target line as possible.

3-10.4.1.1 **Earth Berm**. Elevation may be met by designing a combination of earth berm and vertical baffle (Figure 3-11).

The earth berm should have a top elevation of plus 5.0 meters above FLFS. Construct the vertical baffle of ballistic material (par 3-10.6) and design to withstand local seismic and wind loads. This combination arrangement would reduce the footprint and the amount of material in the earth berm. The slope of the impact face should be no lower than 1.0v to 1.5h. The top should be 3 m (10 ft) wide. Construct the impact slope with a 1m (3.3 ft) layer of easily filtered soil (to reclaim the lead rounds) with no rocks, sticks, etc. The impact face of the berm will be periodically (every 20,000 rounds per lane) mined for spent lead, so consider maintenance when designing.

The rear slope should be appropriate to the native soil and maintenance requirements. Vegetate appropriately to prevent erosion.

3-10.4.2 **Type "PB" Ranges**. The top elevation will vary depending upon the OB and impact structure arrangement. Use a standard berm impact structure for Type "PB." The impact structure will connect to the side containment.

3-10.4.2.1 Construct the standard earth berm with slopes and width in accordance with par. 3-10.4.1.1. Provide geotextiles as necessary to achieve the slope. Construct the top of the berm to be at an elevation that is 1.5 m (5 ft) above the point where the highest line of direct fire can strike the berm.

3-10.4.2.2 Hybrids may be possible. Any means of providing slope stability, round and ricochet control, and surface screening may be presented to NAVFACENGCOM Code EICO (paragraph 1-5) at an early design stage for approval and comments.

3-10.5 **Range Floor**. Grade the surface smooth and sloped for storm drainage. Grade the floor side to side at between 1 and 2 percent. Use very shallow swales in the surface area. Place culverts and pipes in protected locations with collection points where runoff can be monitored and controlled for

lead contamination, if required. Consider subdrains. Provide erosion control vegetation that can be maintained at a low height. Refer to par. 3-2.1.3.

- Types “0” and “PB” ranges may use a 100 mm (4 in) thick pea gravel surface.

- Concrete walks with edges exposed to the FL are discouraged.

3-10.6 **Ballistic Material**. The purpose of ballistic material is to absorb, deflect, or fragment the rounds. Material for baffles on Type “PB” ranges will be 6.5 mm (1/4 in) thick AR-500 (BHN) steel plate for pistol ranges and 9.5 mm (3/8 in) thick AR-500 (BHN) steel for rifle ranges. Avoid exposed connectors if possible.

Alternative commercial products may be used; contact NAVFACENGCOM Code EICO (paragraph 1-5).

Refer to Table 3-1 for thickness of various materials.

3-10.7 **Sacrificial Cladding**. Provide 9.5 mm (3/8 inch) thick conveyor belting in front of a 38 mm (1 ½ in) air gap on any surfaces (baffles, wing walls, metal connectors, etc.) that are within 15 meters (50 feet) of the FL to control backsplatter. Size panels for easy replacement of damaged areas.

- Cover canopies with sacrificial cladding from 1 meter (3.3 ft) behind the FL to 4 meters (13 feet) forward of the FL.

- Various reprocessed rubber products for sacrificial cladding use are commercially available.

3-10.8 **Target Line and Mechanisms**. Components will be as follows:

3-10.8.1 Match target line bases grading with the FL. Protect mechanical target support bases from direct line of fire. Bury flush with the ground or place behind a protective wall. Note that a small raised earth berm at this location generates significant RC. The complexity of the mechanism will dictate the protection requirement. See Figure 3-12 for wall or trench protection of high cost target line mechanisms.

3-10.8.2 Target supports can be made of steel angles and channels, PVC pipe or wood. Do not use metal parts within 5 m (16.4 ft) of the FL where DF strikes are anticipated. Discharging weapons close to metal surfaces is extremely dangerous. Present the smallest surface area that is structurally sound to the line of fire to minimize RC. Design the target holders for easy and inexpensive replacement. Skidable, self-supporting 2 by 4 wood frames or 2 by 2’s placed into buried PVC pipe work well on simple ranges. Note: the full face of the target must be visible to the shooter. The target components are at the user’s discretion, based on training requirements. Consult with the RSO.

3-10.8.3 Turning targets and the display time are at the discretion of the user. Consider commercially available, electrically motorized target carrier and electronic scoring systems when the requirements and economics of training warrant.

3-10.8.4 See Figures 3-13, 3-14, 3-15, and 3-16 for rifle butts and targets. Use rifle target frames 1.2 by 1.8 m (4 by 6 ft) high for use to 274 m (900 ft) and 1.8 m (6 ft) square at greater distances.

3-10.9 **Multiple Firing Lines Versus Target Lines**. On Type "PB" ranges, a single FL with multiple target lines will produce the most cost effective range because of the FL canopy. An extremely advanced target mechanism may be sufficiently more expensive than multiple canopies to shift the advantage. On Type "O" ranges the single target line with multiple FL's is preferred, especially on rifle ranges where butts are required.

3-10.10 **Combat Ranges**. Forward moving (run and shoot) courses can be constructed with the above criteria. On a Type "PB" range, provide any location where a weapon is discharged with a ballistic canopy and the required geometry of baffles. It is possible that lateral personnel movement with targets at varying distances on adjoining firing lanes will provide a cost effective alternative. The required firing-position barricades will be provided by the user.

3-10.11 **Shooting Houses**. Without overhead containment, the SDZ is 360 degrees at the maximum range of the weapon being used. If DF and RC are contained by a ballistic canopy, the SDZ would be 3 m (9.9 ft) at 360 degrees.

Contact NAVFACENGCOM Code EICO for guidance.

3-10.12 **Skeet and Trap Ranges**. Refer to MIL-HDBK-1037/3, Outdoor Sports and Recreational Facilities. SDZ distance is 275 m (902 ft).

3-10.13 **Existing Fully Baffled Ranges With Ground Baffles**. These ranges can continue to operate as is, but the ground baffles should be removed, as they require maintenance. Ground baffles are a major contributor of RC. Provide a concrete range floor. Note that fully baffled (Type "FB") ranges should be phased out due to OSHA concerns.

3-10.14 **Machine Gun Ranges**. The standard distance between the FL and the target is 25 m (82 ft). The range is Type"0" with the SDZ shaped as Figure 3-1, 3-2, or 3-3. Targets are chosen and placed to satisfy local conditions and training requirements by the user. An earth berm 8 m (26 ft) high is required. Plan for extensive maintenance.

3-11 **COMPOSITE RANGES**. Where site conditions permit, locate shotgun, pistol, rifle, and machine gun ranges close to each other to better utilize supporting facilities. The SDZ's should be a common area.

3-12 **COMBAT VILLAGES**. Design combat villages using the individual paragraphs that apply to the particular course of fire or training. The SDZ is based on the most powerful round and direction of fire.

Figure 3-2 Surface Danger Zone for Small Arms Weapons Firing at Fixed Ground Targets – Open Range (Type "O") with Rocky Soil or Target causing Ricochet

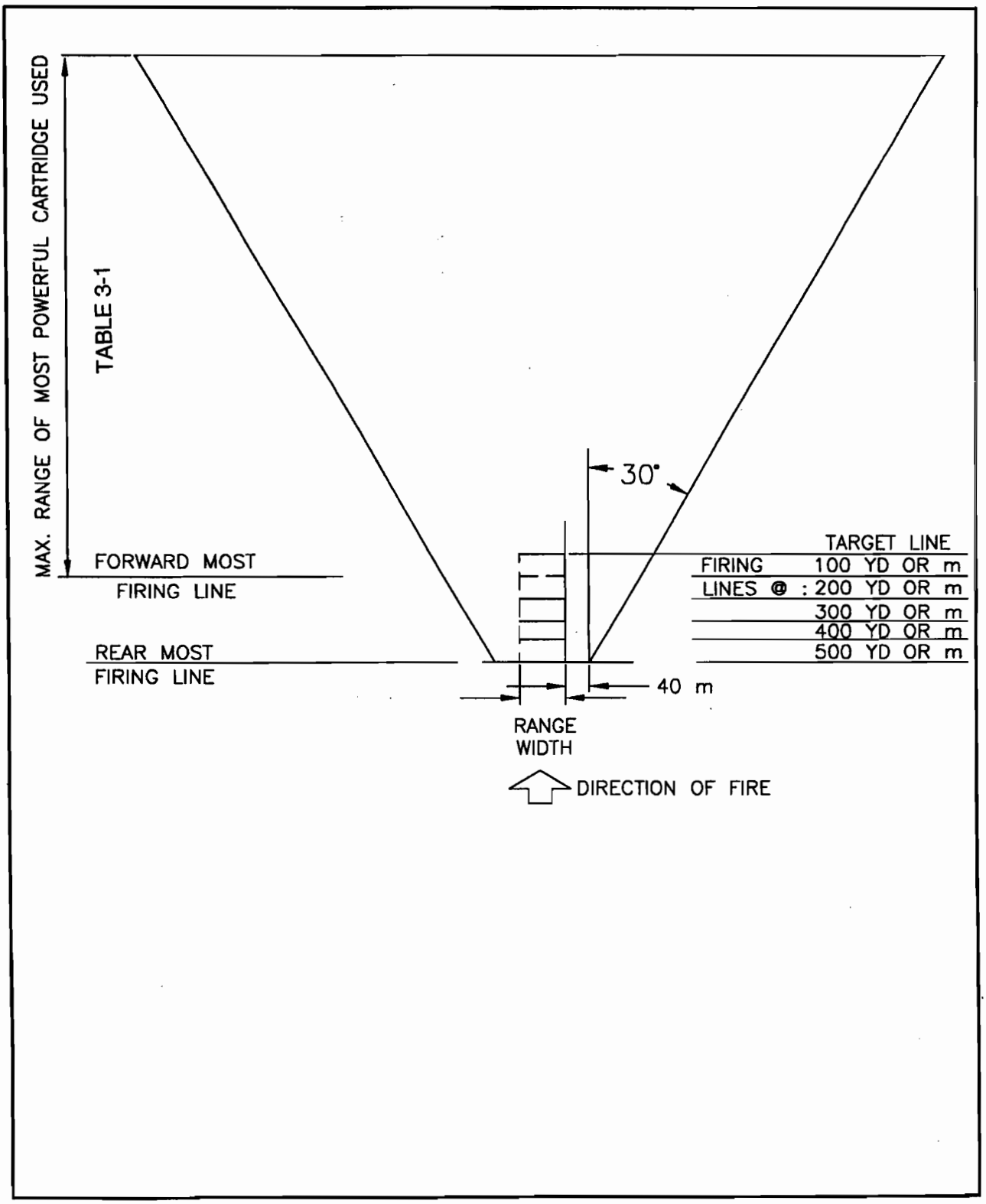


Figure 3-3 Surface Danger Zone for Small Arms Weapons Firing at Fixed Ground Targets – Partially Baffled Range (Type "PB")

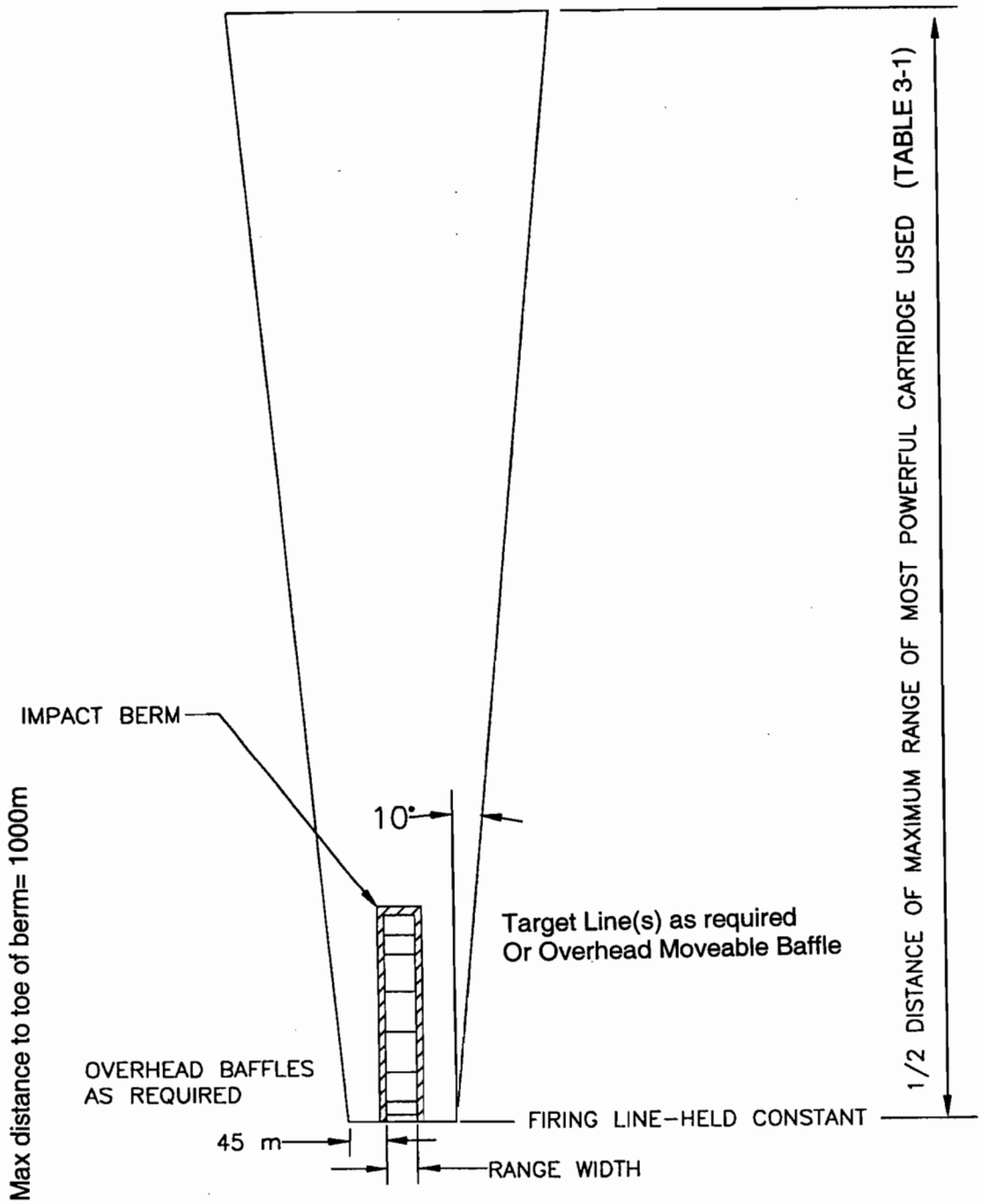


Figure 3-4 Outdoor Rifle Range Layout

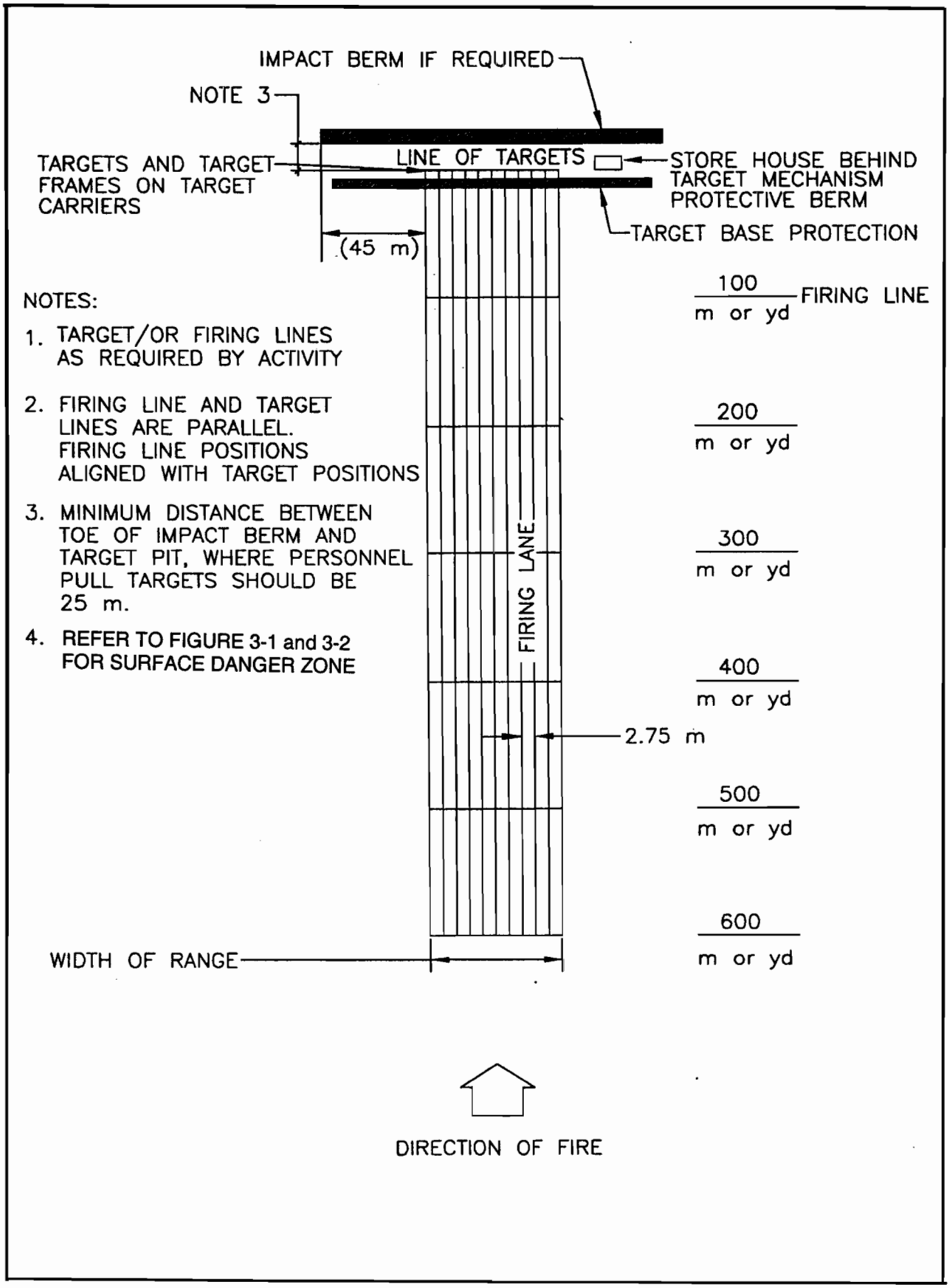


Figure 3-5 Outdoor Pistol Range Layout

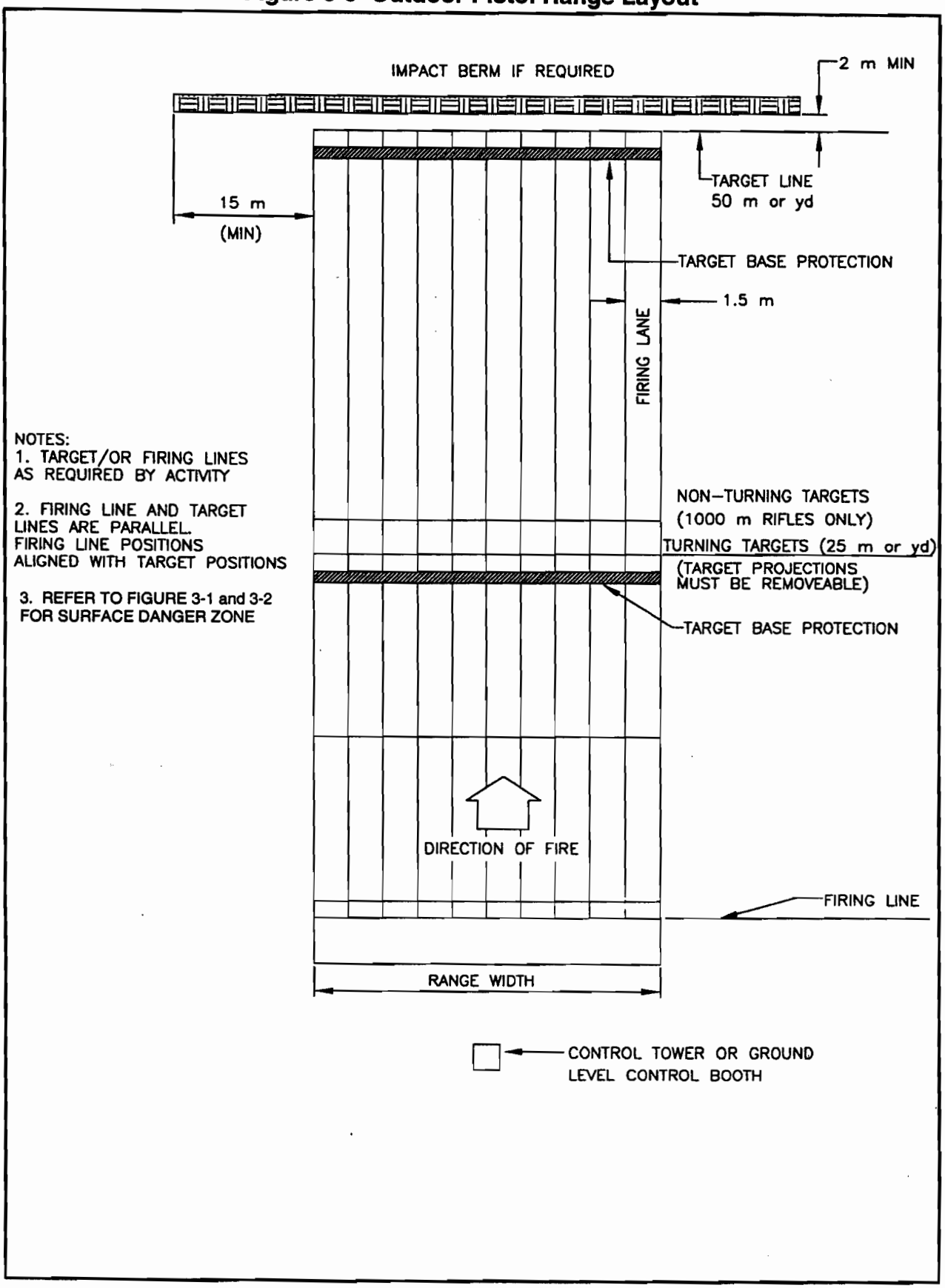
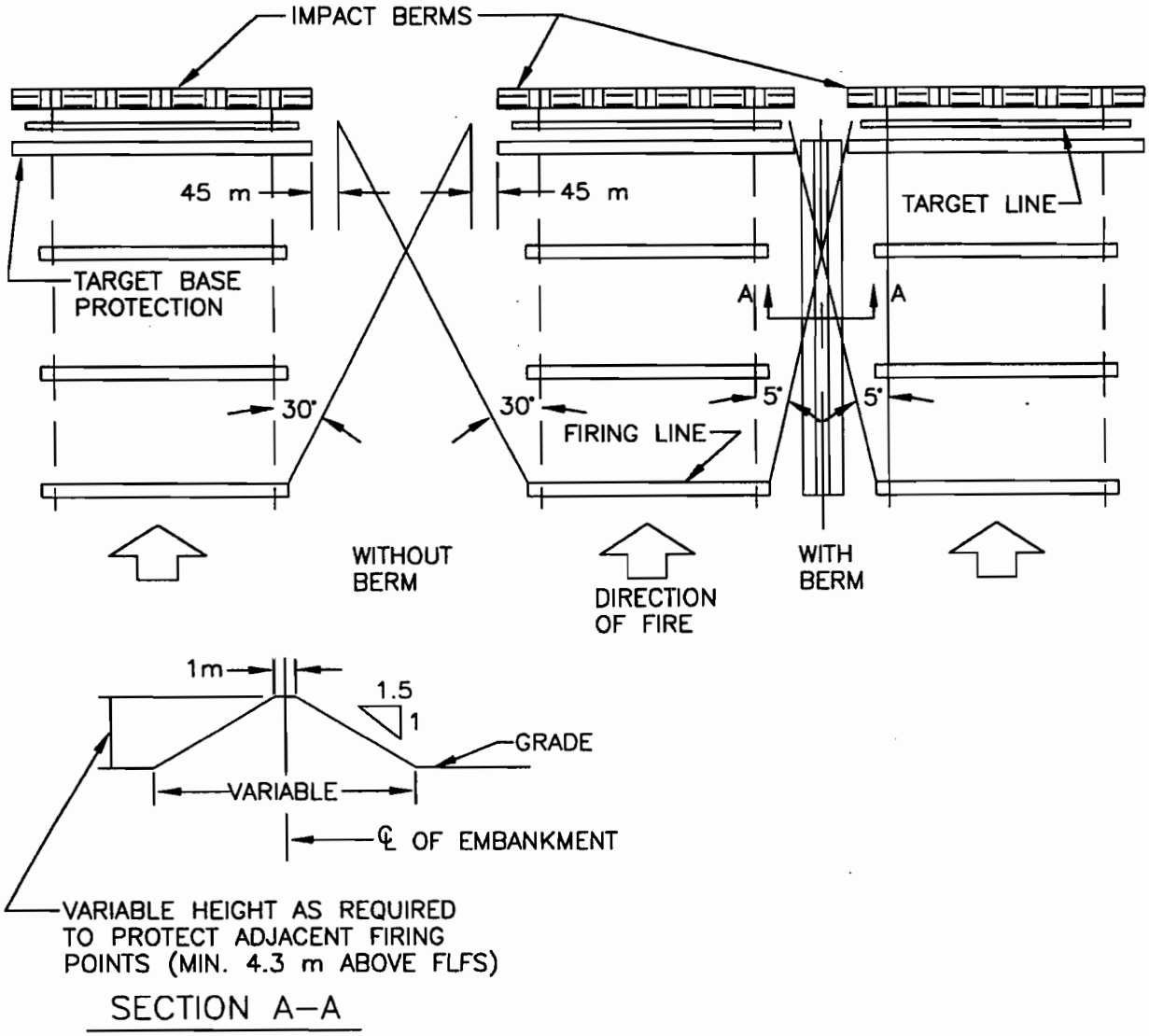


Figure 3-6 Parallel Ranges



NOTE: SAFETY ARCS FOR PARALLEL UNBERMED RANGES MAY OVERLAP AS, SHOWN, BUT NOT CLOSER THAN 45 m TO THE ENTRY POINT FOR THE TARGET PITS ON THE ADJACENT RANGE ANOTHER SPACE. WHEN THIS IS NOT POSSIBLE AND THE REQUIREMENT EXISTS FOR SIMULTANEOUS OPERATION OF ADJACENT RANGES, A SEPARATING WALL OR EMBANKMENT WILL BE REQUIRED. THE LENGTH OF THE WALL OR EMBANKMENT SHALL BE FROM THE MOST DISTANT FIRING LINE TO THE TARGET PITS. THE WALL MAY BE 200 mm THICK CONCRETE, 300 mm THICK CONCRETE MASONRY-GROUT FILLED OR EQUIVALENT.

Figure 3-7 Baffled Range Profile

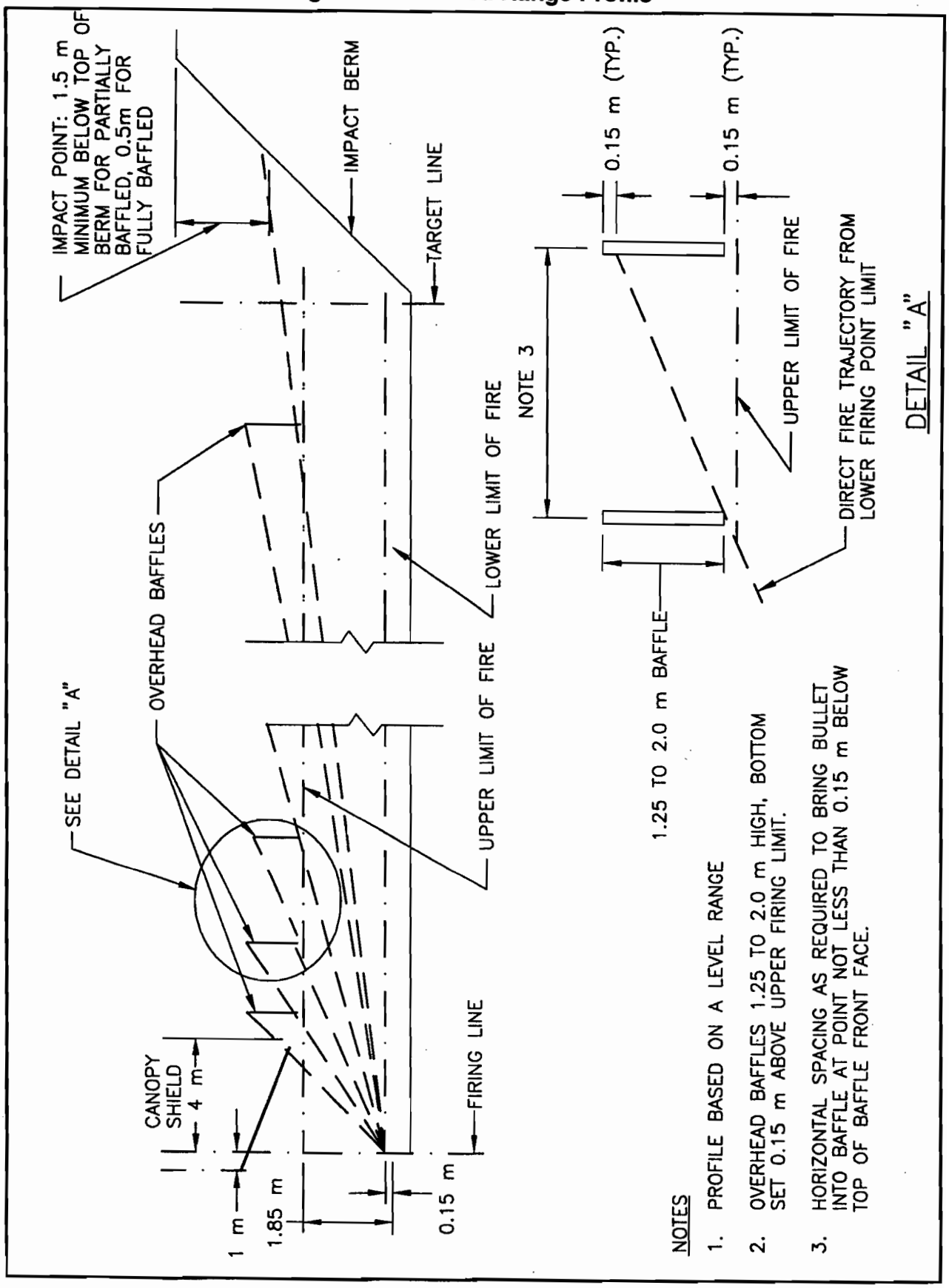
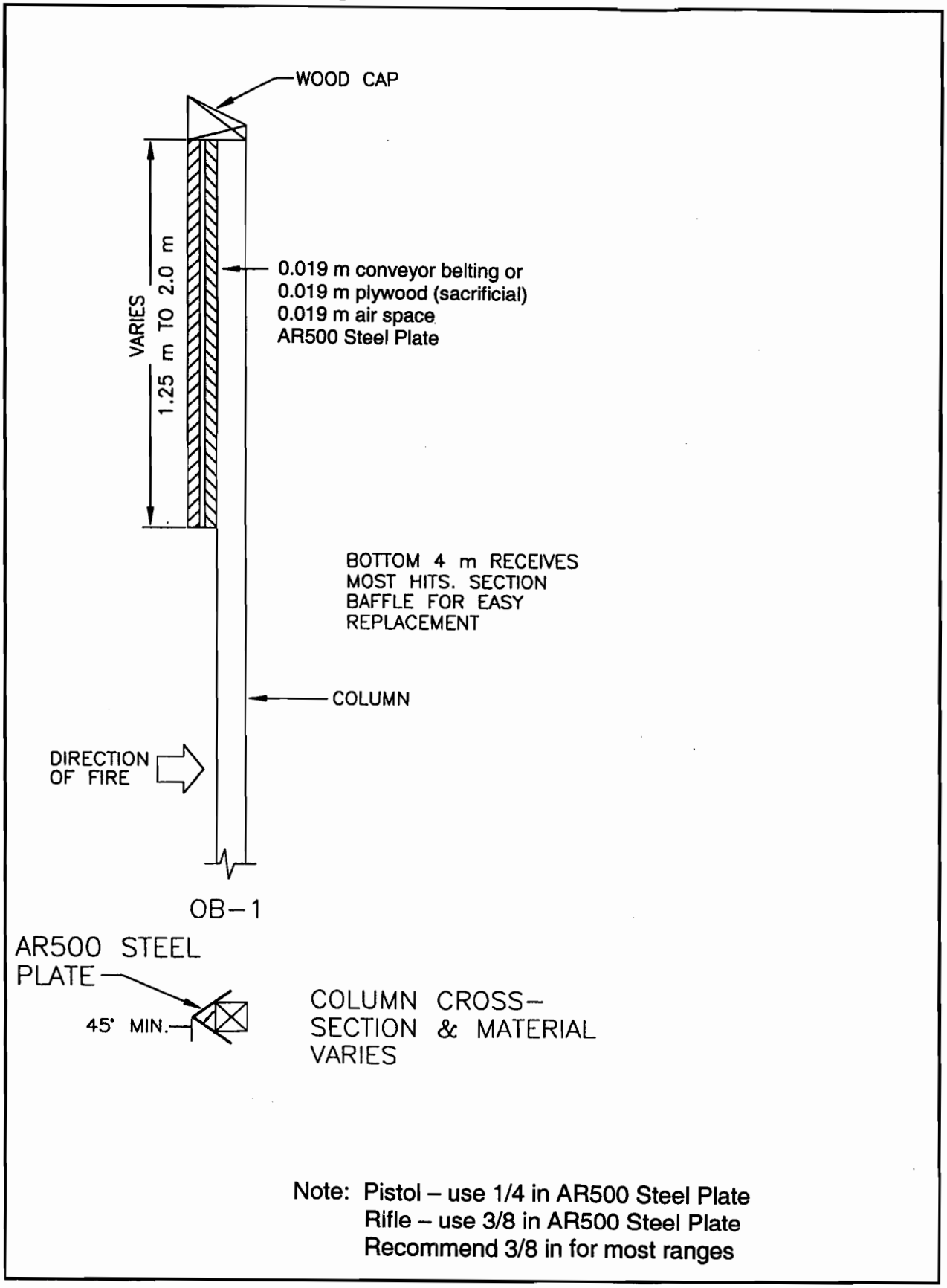
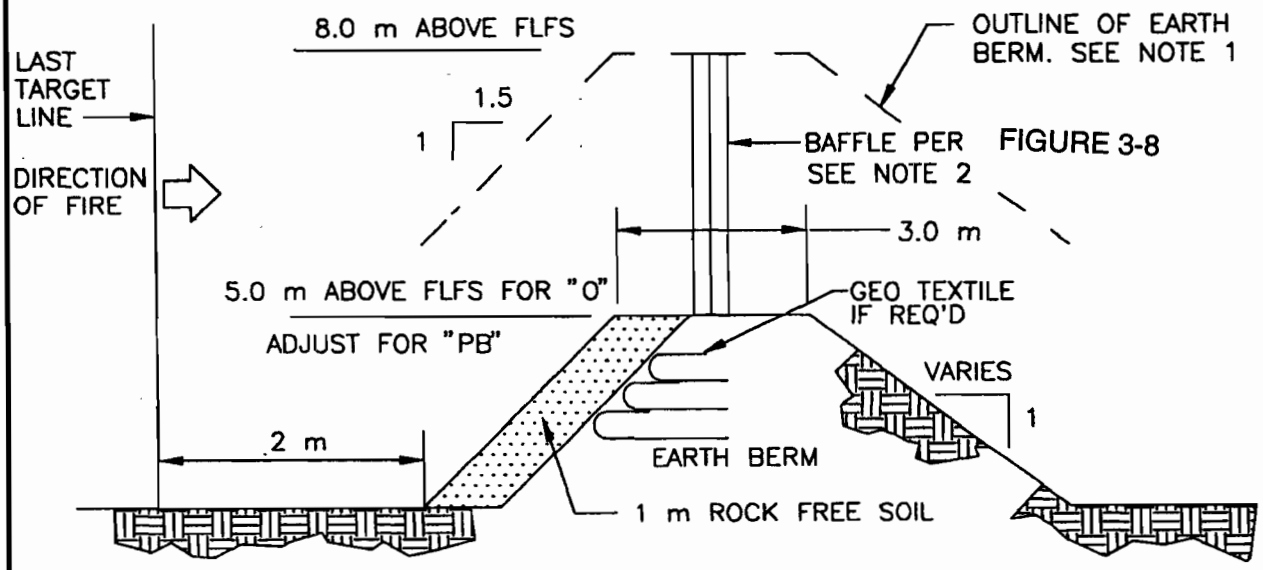


Figure 3-8 Overhead Baffle



Note: Pistol – use 1/4 in AR500 Steel Plate
Rifle – use 3/8 in AR500 Steel Plate
Recommend 3/8 in for most ranges

Figure 3-9 Impact Berm for Types "O" and "PB" Ranges



NOTE
1. OUTLINE OF IMPACT BERM IF ALL EARTH BERM IS USED IN LIEU OF COMBINATION EARTH BERM/BAFFLE.
2. BALLISTIC MATERIAL TO SPAN FULL HEIGHT.

Figure 3-10 Ballistic Protection of Target Mechanism

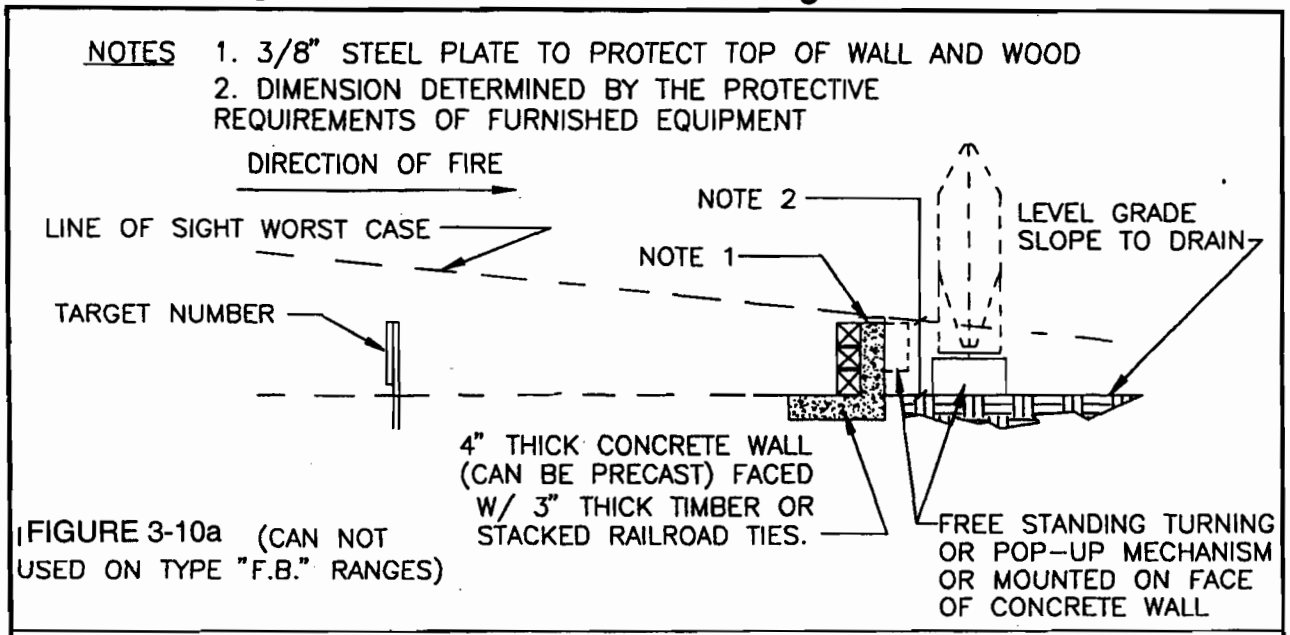


FIGURE 3-10a (CAN NOT USED ON TYPE "F.B." RANGES)

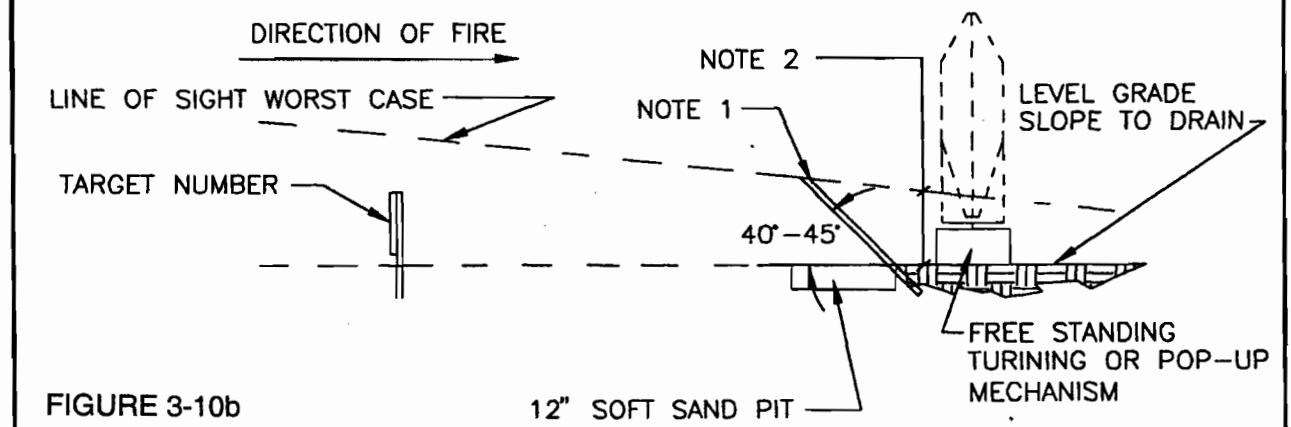


FIGURE 3-10b

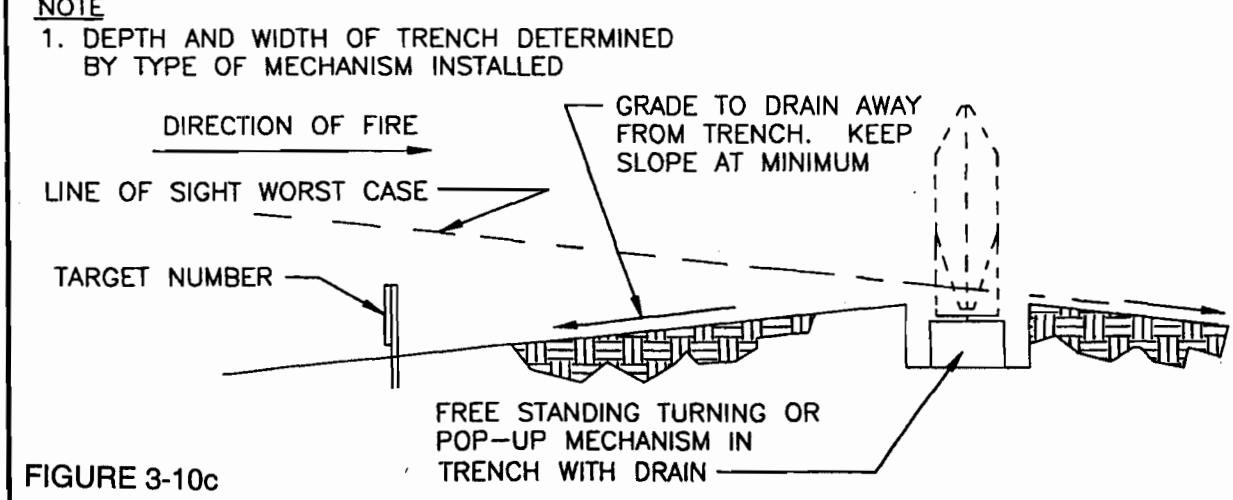


FIGURE 3-10c

Figure 3-11 Target Butts Detail

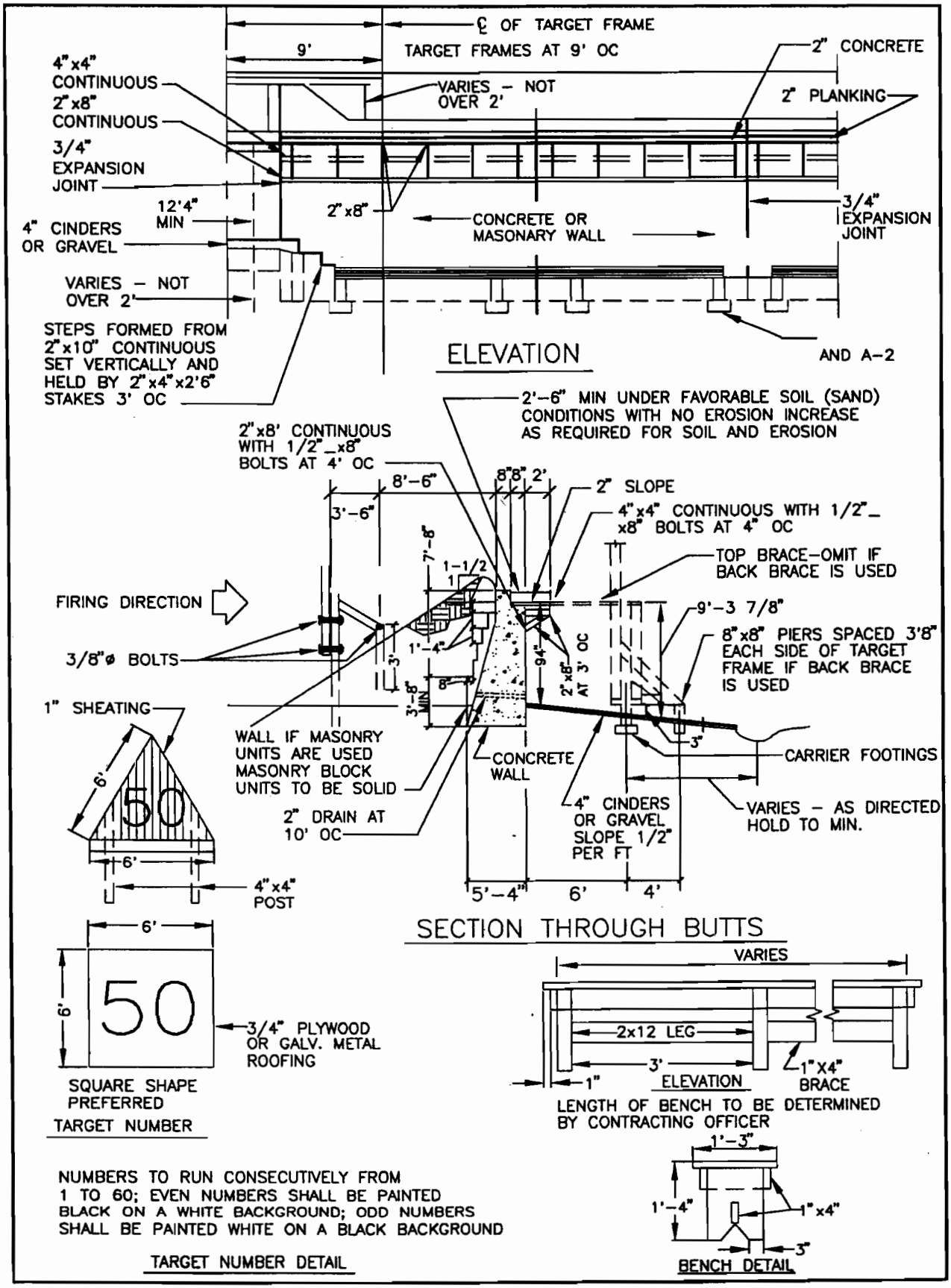


Figure 3-12 Alternate Target Butts

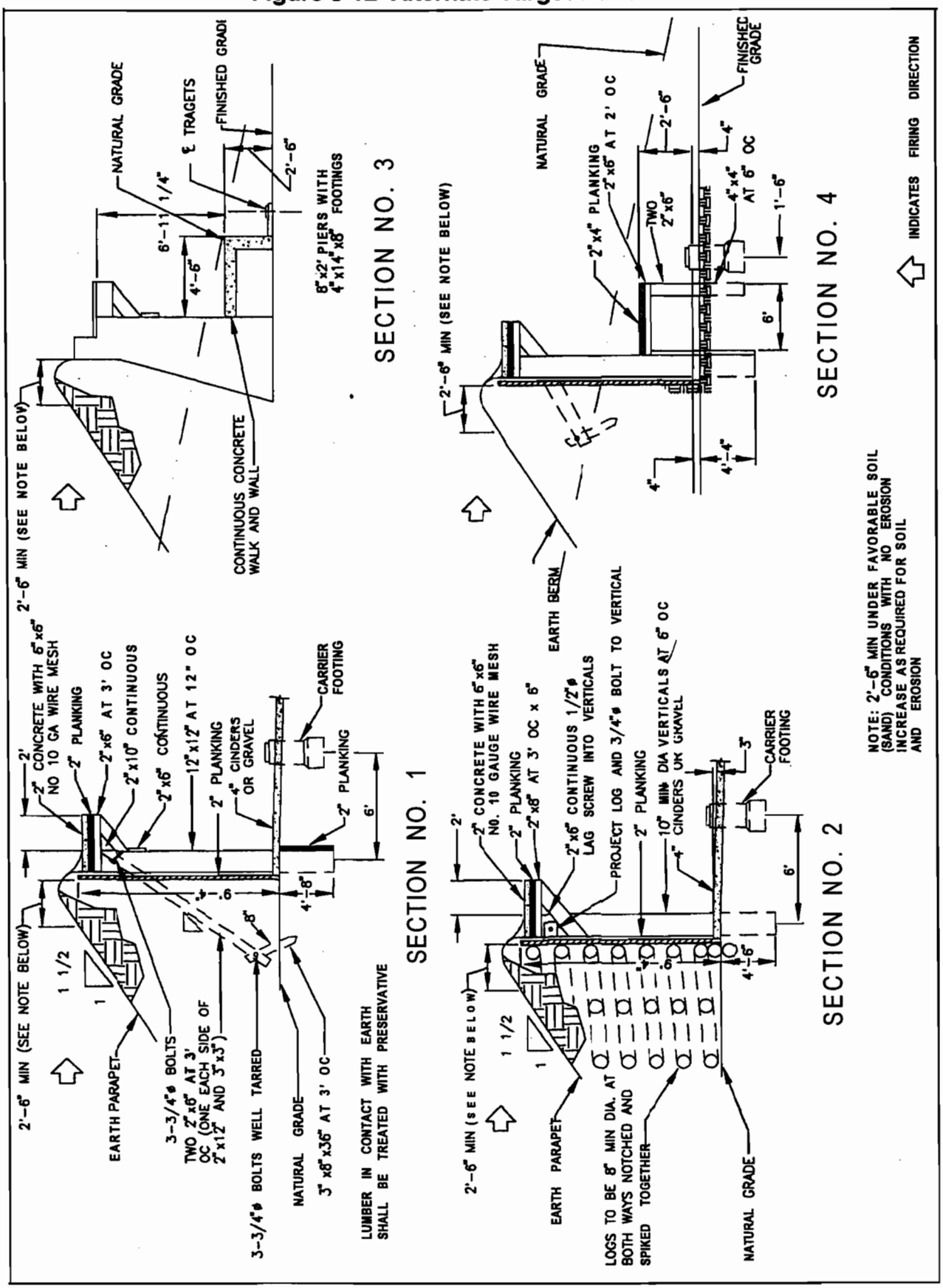
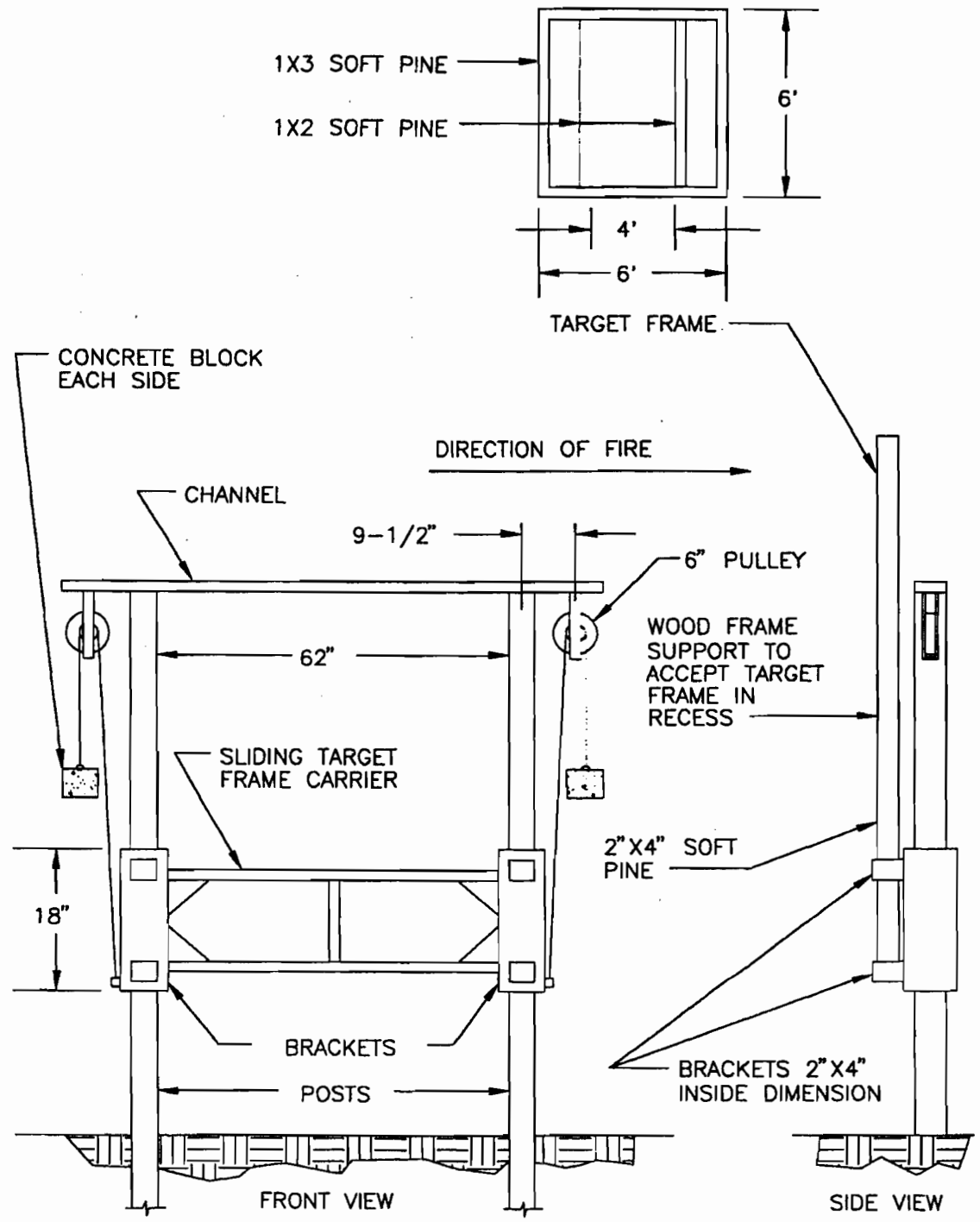
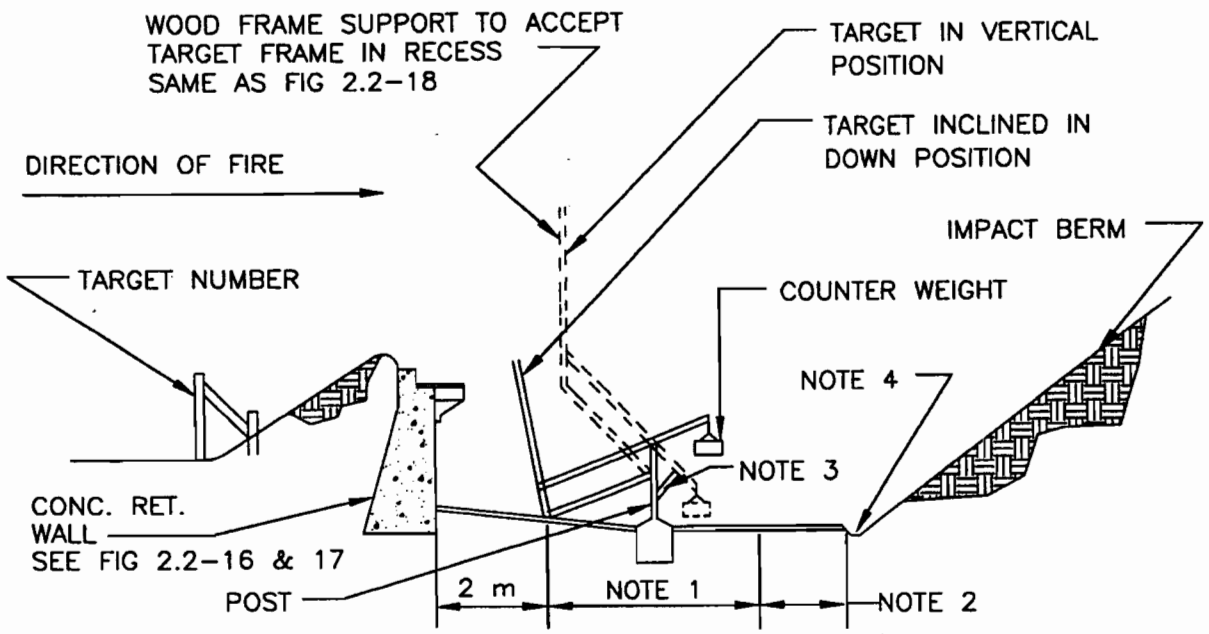


Figure 3-13 Rifle Range Target Carrier



NOTE: ENTIRE TARGET IN RAISED POSITION MUST BE VISIBLE FROM EVERY SHOOTING POINT AND EVERY FIRING POSITION

Figure 3-14 Paraleg Target Carrier



SECTION

NOTES:

1. DISTANCE AS REQUIRED BY CARRIER MECHANISM HOLD TO MINIMUM.
2. DISTANCE TO ALLOW EQUIPMENT ACCESS FOR MAINTENANCE OF CARRIER AND SLOPE
3. MECHANISM STOP TO ALIGN ALL TARGETS AT CORRECT HEIGHT
4. MAKE PROVISIONS FOR DRAINAGE
5. ENTIRE TARGET MUST BE VISIBLE FROM EVERY SHOOTING POINT AT EVERY FIRING POSITION

Figure 3-15 Weapons Clearing Barrel Parts List

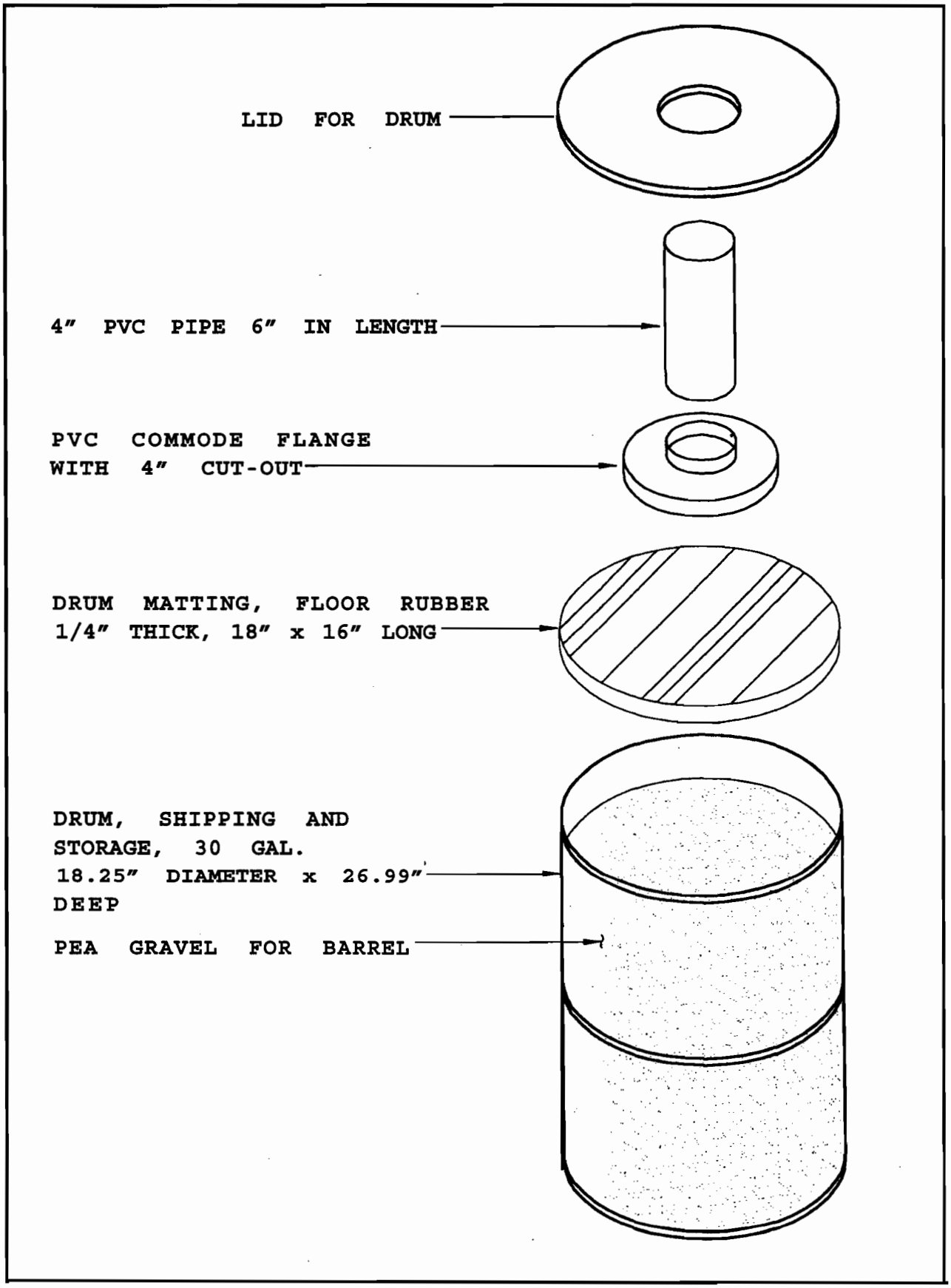
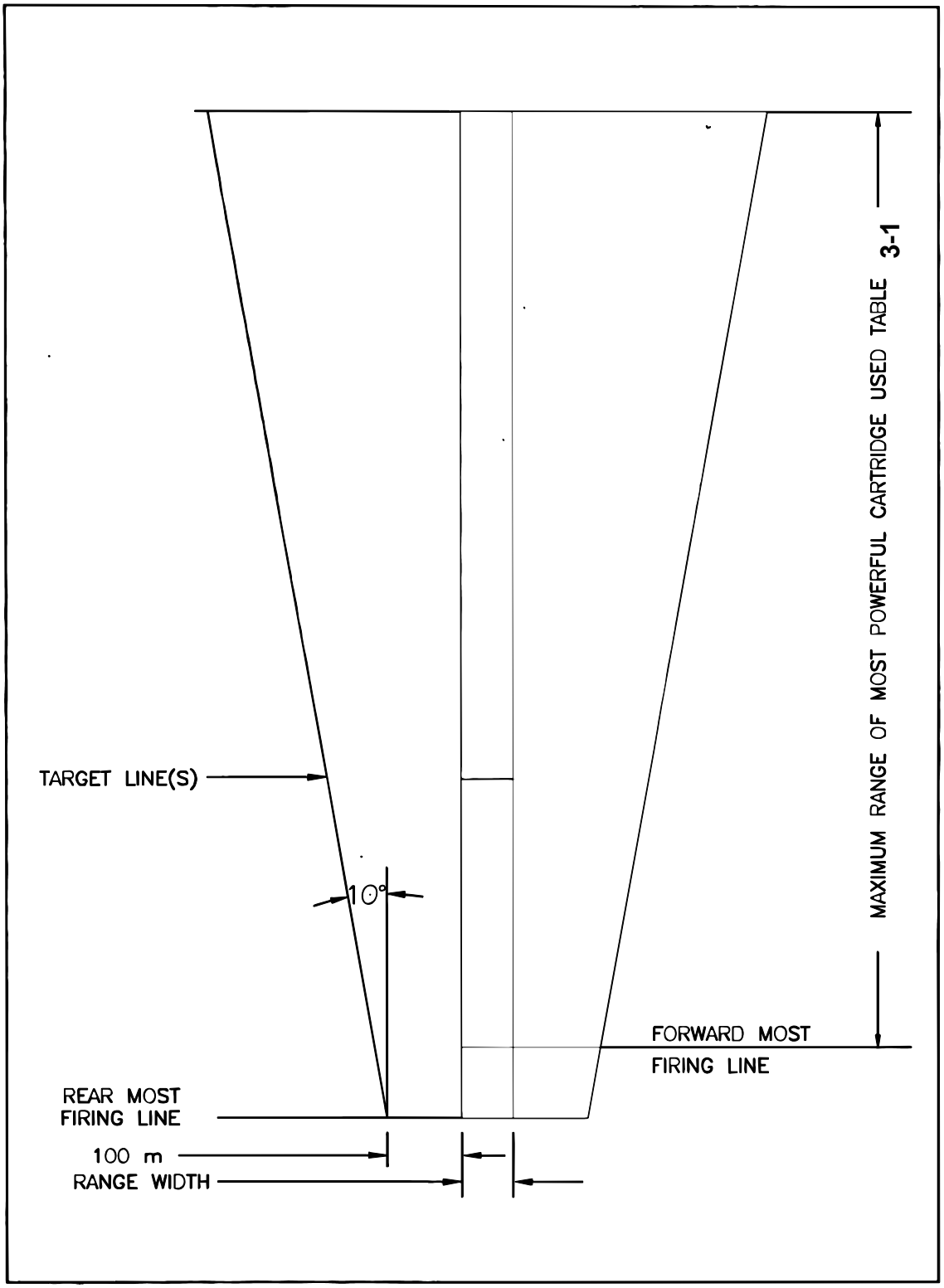


FIGURE 3-1 Surface Danger Zone



CHAPTER 4

MOBILE FIREARMS RANGES

4-1 **GENERAL.** Mobile firearms training facilities are built within an over-the-road capable semi-trailer. Design facilities capable of containing rounds fired 360 degrees within the interior without penetrating the confines of the shooting area, using a bullet trap and ballistic materials.

4-1.1 **Maintaining.** Mobile Firearms Ranges (MFRs) are very difficult to maintain. Commands must ensure adequate financial support is made available.

4-2 **EXTERIOR SPECIFICATIONS.**

4-2.1 **General Design.** Design trailers to be loadable, liftable, over-the-road capable units meeting all U.S. Department of Transportation requirements. Do not exceed trailer width of 2.6 m (102 in), trailer height of 4.1 m (162 in), overall length of 14.6 m (576 in).

4-2.2 **Entrances.** Locate primary entrance at the rear of the trailer, with initial entry being into the range master control booth. Construct entrance door no more than 740 mm (29 in) wide and 2032 mm (80 in) long. Provide prefabricated metal steps with handrails on both sides for entrance into the facility. Include removable handrails for storage during movement of the unit. Paint rails and steps with rust proof paint of white, gray or aluminum.

4-2.3 **Leveling.** Provide four individual portable leveling jacks to both level and stabilize the unit. Use a double-axle trailer unit with springs and axles sized for the necessary gross vehicle weight. Conform all trailer exterior lighting and braking systems to U.S. Department of Transportation specifications.

4-2.4 **Paint.** Paint trailer exterior white. Coat under-carriage with a protective corrosion inhibiting material.

4-2.5 **Wheels.** Design unit with removable wheels to allow trailer to be placed upon blocks.

4-3 **INTERIOR SPECIFICATIONS**. Make the shooting area of the trailer ballistically secure from possible escaping rounds in all directions. Specifically; the bullet trap, floor, sidewalls, ceiling, hatchway, light fixtures, doors, shooting booths and window area separating the shooting area from the range master control booth must withstand the following ammunition:

4-3.1 **Regular Handgun MFR.** .38 cal ball ammunition, .45 cal ball ammunition, 9mm ammunition, 12 gauge (00 buck) and slug shotgun ammunition.

4-3.2 **Regular Rifle MFD**. Includes all of the above (paragraph 4-3.1) and 5.56 and 7.62 ammunition as fired from any possible angle as close as six inches from to the surface.

4-3.3 **Shooting Area.** Shooting area includes bullet trap, 10 m (394 in) firing line, an approximately 1270 mm (50 in) staging area behind the firing line, and an approximately 2134 mm (84 in) range- master booth separated from the shooting area by a wall, bullet proof window and a bullet proof sliding door.

4-3.4 **Bullet Trap Construction.** Construct bullet traps as follows:

- Regular handgun MFR – each firing point will consist of at least 25 small lamellas, 1.8m (72 in) in length backed by 3 rows of long lamellas, 2.3 m (92 in) in length with each row of long lamellas completely covering the backstop. The backstop will consist of 8 mm (5/16 in) armor plate.

- Regular rifle MFR – the same as above except that 16 mm (5/8 in) armor plate will be used as the backstop.

- Reinforce all welds in and around the bullet trap and cover by a separate piece of metal.

4-3.5 **Bullet Trap Accessibility.** The bullet trap must be easily accessible for periodic maintenance. Construct walls, ceiling and floor as follows:

- Regular handgun MFR –1/4 inch hard rubber affixed to ¾ inch plywood with ¾ inch air space and then 5/16 inch steel.

- Regular rifle MRF –1/4 inch hard rubber affixed to ¾ inch plywood affixed to 16 gage steel with ¾ inch air space and then 5/16 inch armor plate.

4-3.6 **Hatchway.** Provide a hatchway approximately 1.8 meters (6 feet) in front of firing line, approximately 584.2 mm (23 in) in diameter, hinged at the rear and opening inward. Construct hatchway such that it and its operating mechanism is flush with the floor of the shooting area and can be used as an emergency exit. The hatchway must not compromise the ballistic security of the unit.

4-3.7 **Target Transport System.** Install three electrically driven trolley target transport systems used to transport targets from the firing line downrange to a minimum distance of 10 m (394 inches) from the firing line. Operate target transport systems from the range master control booth individually or collectively. Additionally, locate a separate control unit for each trolley system in each of the

shooting booths. Use target holders capable of accommodating targets from 0.15 m to 0.50 m (6 to 19 in) in width.

4-3.8 **Firing Area Surface.** Cover interior surface of firing area from the range master booth to approximately 3.7 m (12 ft) pass the firing line with a sound suppression material to maximize sound attenuation while minimizing post firing maintenance and lead particle/powder build-up. Materials should be washable.

4-4 **SHOOTING STALLS**. Equip each unit with three shooting stalls approximately 787.4 mm (31 in) in width with a minimum clearance height of 2 m (80 in). Space each stall the same distance apart (center to center) as the target frames. Provide each stall with blast protection from adjacent shooters and equip with a shelf that can be dropped out of the way. Provide in each stall: range signal condition lights (red, yellow, green), an intercom connection between the shooter and the range master control booth, a spent brass receptacle and an individual trouble light. Construct each stall to be ballistically secure from the others. Install a firing line security system consisting of a photoelectric beam positioned at the firing line approximately 300 mm (12 in) from the floor. Use security system that automatically switches all range signal condition lights to red and activates a horn or bell, when broken. Use system that can be reset *only* from the range master control booth.

(For cold weather MFR's – provide each stall with an infer-ray light to provide heat to the shooter.)

4-5 **LIGHTING**. For all general lighting, use high voltage fixtures, consisting of down-range lighting fixtures, firing line lighting fixtures, service lighting fixtures and an on/off control for each. Use incandescent lamps mounted in protected fixtures, equipped with light bulbs of 150W. For target lighting, use low-intensity reflection-type incandescent lamps controlled by the range master through individual controllers and a master dimmer. Make the level of light, as measured at the target face, adjustable between zero and maximum light.

4-6 **VENTILATION.**

4-6.1 **Range Master Control Area.** Provide range master control area with air conditioning – minimum of 12,660.7 kJ (12,000 BTU/hr) – and heating – over 10,550.6 kJ (10,000 BTU/hr). Locate air conditioning/heat unit in the range master control booth. Provide unit with a thermostat, heating / cooling selection switch and an on/off switch. The range master control booth must remain under a relative positive pressure with respect to the range in order to reduce infiltration from the range, thereby reducing the risk of lead contamination.

4-6.2 **Range.** Provide range with a push-pull ventilation system with a fan supplying air into the range. Supply air through an entrance vent located on the top part of the trailer, above the range master booth. Vent will extend the

length of the back of the trailer. The inside vent will be of the same design and will vent air down into the shooting area and across the firing line. Cover the inside of the venting system with the same material composition as required on the wall inside the range. An exhaust fan or fans will be located at the end of the bullet trap area and will exhaust air to the outside from a stack located at the top of the unit. Use a ventilation system that meets the standards stated in *Industrial Ventilation, A Manual of Recommended Practice*, by the American Conference of Governmental Industrial Hygienist (ACGIH). The ventilation system should exhaust a total volumetric air flow of approximately 2510.76 L/sec (5,320 cfm) and have an average transport velocity of 0.38 m/sec (75 fpm) – no less than 0.25 m/sec (50 fpm) at any point. Use an air exhaust filter that is durable and easy to clean. Filter covers will be held on by no more than four screws. Access to filter will be from the outside of the range.

4-7 **RANGE MASTER'S CONTROL BOOTH**. Install a control console that provides a functional grouping of the controls and displays for controlling the shooting areas lighting, range signal condition lights, target trolley systems and intercommunications between the shooter and the range master. Install a window in the wall separating the shooting area from the range master's control booth. Design the window to be ballistically secure, to maximize sound attenuation and allow the range master seated at the control console to observe all personnel in the shooting area. Provide a sliding door for access between the range master's control booth and the shooting area. Provide a chair and small desk for the range master that are capable of being secured while in transit. Unit will contain a GSA-approved weapons safe approximately 559 by 1270 by 9652 mm (22 by 50 by 38 in). Install a cabinet 559 by 7620 by 4572 mm (22 by 30 by 18 in) with double lockable doors. Inside there will be two shelves. Cabinet will be constructed to sit on top of the safe.

4-8 RANGE MASTER'S CONTROL CONSOLE

4-8.1 **General.** Design the range master's control console to be a front access type that can be removed from its mounting by sliding or swinging out, so that it will not be necessary to have rear access for installation or service.

4-8.2 **Legends.** Provide all legends in one family or compatible type-faces of various sizes and weights. Make all types faces of sufficient size and weight to be readable from a distance of eighteen inches by a person of normal eyesight when the panel is illuminated to 40 MFC. Provide primary control legends readable with 15 MFC illumination.

4-8.3 **Circuit Box.** Locate the circuit box for the range master's console adjacent to the console. Inside, provide a key-locked, master circuit box. Provide separate power circuits for each of the separate systems required.

4-8.4 **Switches**. Use first quality heavy-duty switches. Use monetary contact switches (push-button), indicator lights and jacks of quality and style compatible with the switches.

4-8.5 **Controls.** The control console provides fields for target lighting, dimmer controls for all lighting, general illumination and ventilation control, target transport system and range signal condition lights.

4-9 **AUDIO COMMUNICATION SYSTEM**. The audio communication equipment provides communications between each firing point and the range master booth and will allow the range master to monitor audio activity in the firing area. The system will allow for both individual and collective communications.

4-10 **POWER REQUIREMENTS**. Provide electrical power to the facility through an external, single point of connection. Provide for electrical power characteristics of 100 A, 120/208V, 3 phase, 4 wire, 60 Hz, wye connected. Provide a 15KW, 120/208 V, 3 phase, 60 Hz diesel generator, using #2 diesel fuel, with vibration isolated mounting system and an integral sub-base fuel storage tank. Provide integral fuel tank with a minimum capacity to permit 40 hours of operation between refueling. Provide a manual transfer switch for the generator and locate it in the range master's control booth. The generator will be located on the end of the trailer with the bullet trap. Provide the generator with both local and remote control panels. Locate remote control panel at the range master's control booth; include start and stop switches, alarms and fuel gauges.

Provide general-purpose electrical outlets in both the range and the range master's control booth.

4-10.1 **Overseas.** For MFR going overseas, requirement could be 50HZ.

4-11 **SUPPORT EQUIPMENT.** The following support equipment should be provided for each range:

- 4 rolls of linatex target backing curtains 6.4 mm by 1.2 m by 2.7 m (1/4 in by 48 in by 9 ft).
- Replacement air, oil and fuel filters (2 each) for generator.
- Complete replacement set of short and long lamellas.
- Replacement break pads for each target trolley, if applicable.
- One high-efficiency particulate air (HEPA) vacuum cleaner for lead clean-up which meets federal standards
- One roll of replacement cable for target trolleys.
- 4 noise-activated earmuffs for hearing protection.

4-12 **SET-UP, DATA REQUIREMENTS AND TRAINING**. Provide operating manuals, technical manuals, list of parts identifying each one and specific sub-assembly to which it applies, maintenance schedules and Navy tools unique to this facility. (See DD 1423)

4-13 **TECHNICAL EVALUATION**. Contractor is required to submit descriptive literature. Contact NAVFACENGCOM EICO (paragraph 1-5).

APPENDIX A

GLOSSARY of ABBREVIATIONS

AR	Army Regulation
CNO	Chief of Naval operations
DF	Direct Fire
EFA	Engineering Field Activity
EFD	Engineering Field Activity
EICO	Engineering Innovation and Criteria Office
FAA	Federal Aviation Commission
FL	Firing Line
FLFS	Firing Line Floor Surface
GDM	General Development Map
HEPA	High-Efficiency Particulate Air
LLF	Lower Limit of Fire
MAD	Misdirected and Accidental Discharges
MFR	Mobile Firing Range
NAVFACENGCOM	Naval Facilities Engineering Command
O	Open
OB	Overhead Baffled
OSHA	Occupational Safety and Health Administration
PB	Partially Baffled
RC	Ricochet
RSO	Range Safety Officer
SAR	Small Arms Range

SDZ	Surface Danger Zone
SOP	Standard operating Procedures
ULF	Upper Limit of Fire
USACE	United Stated Army Corps of Engineers

APPENDIX B

REFERENCES

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1. Naval Facilities Engineering Command, 1510 Gilbert Street Norfolk, VA 23511-2699 http://criteria.navfac.navy.mil/criteria	P-80, Planning Criteria for Navy and Marine Corps Shore Installations NAVFACINSTR 11010.44E, shore Facilities Planning Manual: A System for the Planning of Shore Facilities NAVFACINSTR 11014.53A, Small Arms Range Center of Expertise
2. U.S. Army Publishing Agency 2461 Eisenhower Ave. Alexandria, VA 22331-0302 http://www.asapa.army.mil	AR 385-63/MCO P-3570.1A, Policies and Procedures for Firing Ammunition for Training, Target Practice and Combat AR 385-30, Safety Color Code Markings and Signs
3. U.S. Department of Labor Occupational Safety and Health Administration Office of Public Affairs – Room N 3647 200 Constitution Avenue Washington, DC 20210 http://www.osha.org	29 CFR 1910.1025 29 CFR 1926.62 33 CFR Part 344

NON-GOVERNMENT PUBLICATIONS

1. American Conference of Government Industrial Hygienist (ACGIH) Worldwide 1330 Kemper Meadow Drive Cincinnati, OH 45240 http:///www.acgih.org/home.htm	Industrial Ventilation, A Manual of Recommended Practice

CAREY'S
SMALL ARMS RANGE VENTILATION

8201 W 183rd St; Suite B
Tinley Park, IL 60487
Phone: 708-532-2449
Fax: 708-429-2150
Website: careyscentral.com

Small Arms Range Ventilation Standards

Carey's Heating & Air Conditioning, Inc. has designed and built hundreds of small arms range ventilation systems since 1995. There are three main purposes for properly ventilating a small arms range.

1. The primary purpose for the ventilation of an indoor firing range is to remove contaminates created during the firing of a weapon from the respiratory zone of the occupants. Exploding primers containing lead styphnate and friction from the lead slug against the gun barrel create airborne lead. There is also carbon monoxide as well as other contaminates created during the firing of a weapon.
2. The second and equally important reason for the properly designed and installed ventilation and control system is to keep the range at a negative pressure to the surrounding base building space. Contaminates created on a small arms range need to be contained in the range space. This will prevent the ingestion of contaminates as well as keeping the surfaces free of contaminates in non-range spaces of the base building.
3. The final purpose is to remove the smoke from the range for properly seeing the targets.

The following is a summary of the EPA, NIOSH and OSHA standards as they apply to small arms range ventilation:

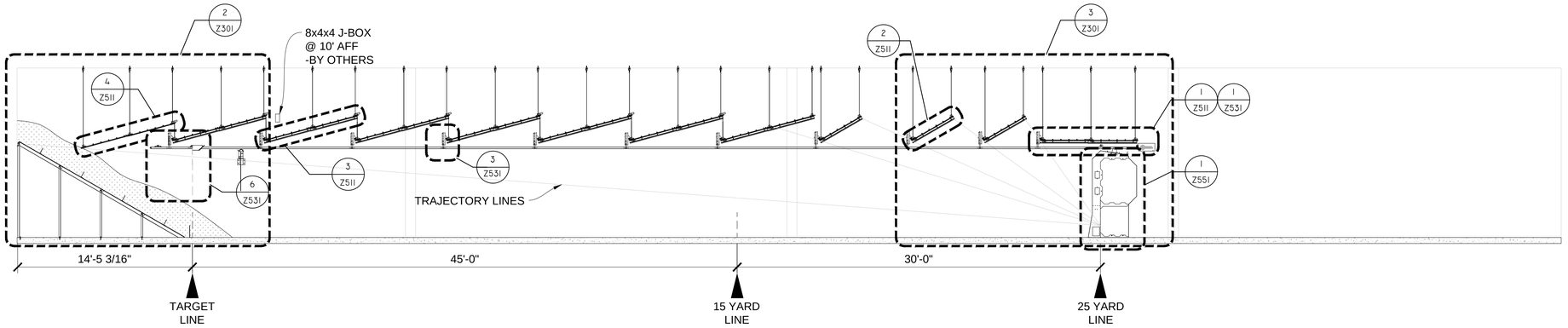
EPA:
TITLE 40--PROTECTION OF ENVIRONMENT CHAPTER I--ENVIRONMENTAL PROTECTION AGENCY PART 50--NATIONAL PRIMARY AND SECONDARY AMBIENT AIR QUALITY STANDARDS--Table of Contents Sec. 50.**12** National primary and secondary ambient air quality standards for lead. National primary and secondary ambient air quality standards for lead and its compounds, measured as elemental lead by a reference method based on appendix G to this part, or by an equivalent method, are: 1.5 micrograms per cubic meter, maximum arithmetic mean averaged over a calendar quarter. (Secs. 109, 301(a) Clean Air Act as amended (42 U.S.C. 7409, 7601(a)))

NIOSH and OSHA:

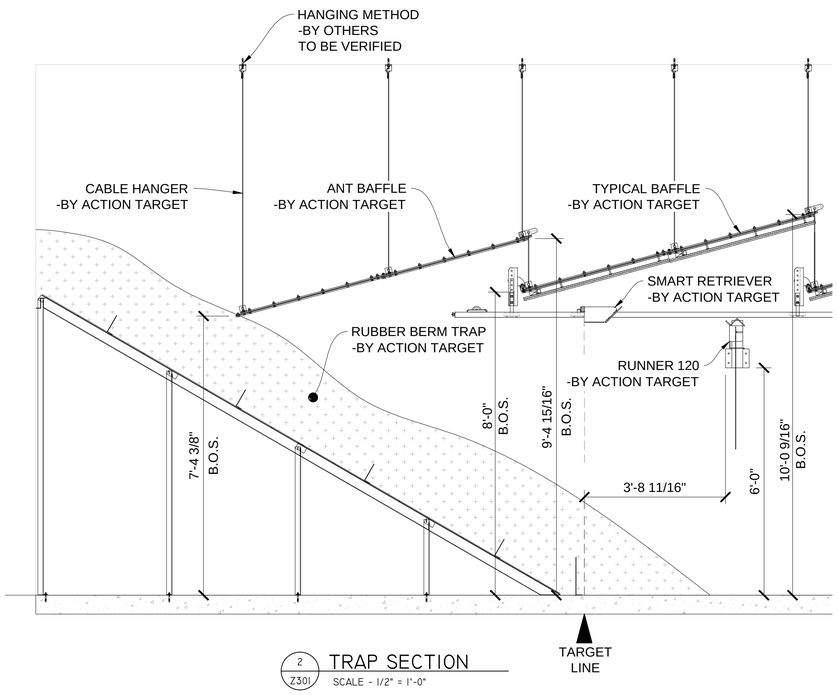
Established by NIOSH, the performance intent for firing range ventilation systems shall meet all the requirements outlined as recommendations and design considerations in HEW publication no. (NIOSH) 76-130, dated December, 1975, entitled "Lead Exposure Design Considerations for Indoor Firing Ranges". This design standard prefers an air flow velocity of 75 feet per minute average on the empty range. This design has consistently provided for the compliance within the established federal standards for airborne inorganic lead concentration limits.

When properly executed, lead concentrations are consistently maintained below the action level of 30 micrograms per cubic meter (30ug/m3) in an area where the limit shall not exceed 50 micrograms of lead per cubic meter (50ug/m3) of air over a time weighted average of eight hours as measured at the respiration zone of the shooters and the range officer when firing from the firing booths per OSHA 29 CFR. 1910.1025 and 1926.62.

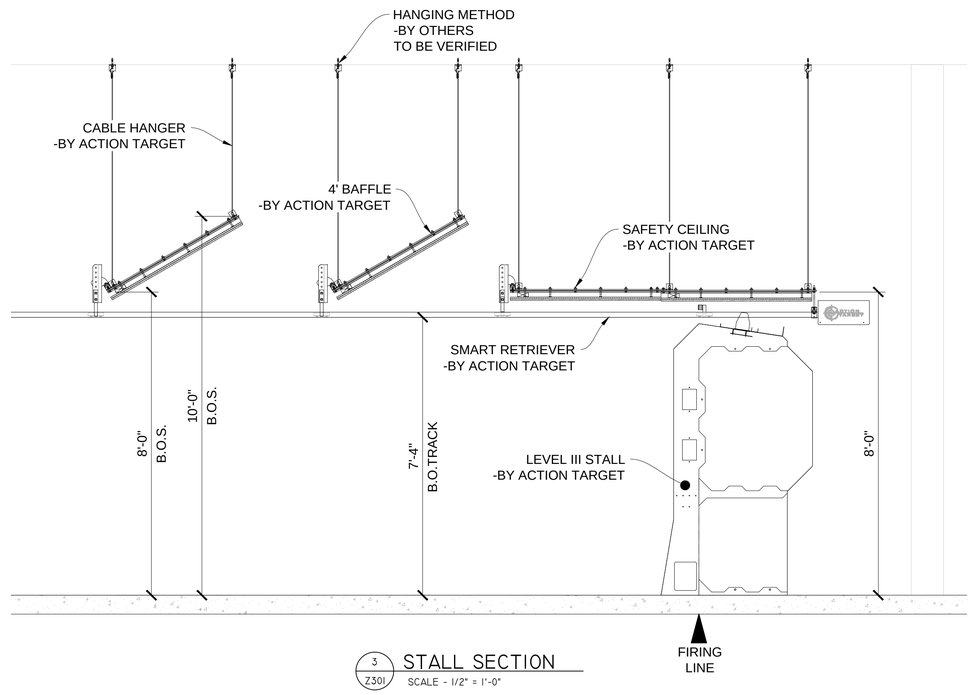
SAVED: FEBRUARY 7, 2012 15:28:09 BY: KEVINH AT: S:\PROJECTS\CLOSED\COMMERCIAL\SHORE GALLERIES\CAD_WORKING\SHORE GALLERIES V2-3.DWG



1 Z301 25 YARD RANGE SECTION
SCALE - 3/16" = 1'-0"



2 Z301 TRAP SECTION
SCALE - 1/2" = 1'-0"



3 Z301 STALL SECTION
SCALE - 1/2" = 1'-0"

ACTION TARGET
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PROJECT DESIGNER:	CHRIS HART
PROJECT DRAFTER:	JAMES SOVINE
DRAWN BY:	AL BYLILLY
APPROVED BY:	KEVIN HILL
DATE:	7-9-2012

NOTES / KEY:

SHORE GALLERIES

NO	BY	REVISION	DATE
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DRAWING TITLE:

25 YARD
RANGE SECTION

SCALED FOR ORIGINAL DRAWING AT 22" X 34"

DRAWING NUMBER:

Z301

SCHOMER AND ASSOCIATES, INC.

Consultants in Acoustics and Noise Control

Paul D. Schomer, Ph.D., P.E.
Member; Board Certified
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2117 ROBERT DRIVE
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PHONE: (217) 359-6602
FAX: (217) 359-3303

ATTN: Mr. Aaron N. Cook, AICP
Development Manager
Village of Lincolnwood
6900 North Lincoln Avenue
Lincolnwood, Illinois 60712

August 12, 2012

Dear Mr. Cook,

I have reviewed the materials related to the proposed installation of two indoor firing ranges and a gun shop (hereafter, "proposed business") next door to Ravenswood Studios. Consultants for the proposed business have presented wall and ceiling assemblies that they intend to install to ensure compliance with the Lincolnwood noise regulations. Consultants for Ravenswood Studios say that the actual execution of the construction to meet the noise reduction requirements as promulgated by consultants of the proposed business is very challenging, and they do not think it will be executed effectively.

This is a situation where both parties are correct. The design put forward by consultants of the proposed business should achieve the required sound reduction (the presently proposed ceiling system is apparently quite different from the ceiling system originally designed and evaluated by Ravenswood Studios' consultants). However, the consultants of Ravenswood Studios are correct in that it is very challenging to execute the construction with all sound leaks sufficiently minimized and all alternative sound pathways sufficiently isolated and attenuated.

My recommendation is that the proposed business be permitted to go forward, but that the occupancy of the premises be conditional on their conducting performance tests showing that the ranges--when used with the loudest firearm that will be used in the respective facility, firing the maximum number of rounds that will be used at one time in that facility--be tested and shown to conform to the Lincolnwood noise regulations. In addition, Lincolnwood and the proposed business's owners will have to agree on the maximum number of shooters that will be shooting at once when the range is put to use; that number is the number of shooters there should be during testing at the range. Also, because there may be degradation of the sound isolation systems (roof and/or ceiling) over time, the management for the proposed business should, if requested by the neighbors of the ranges, be required to make performance measurements after the first six months of operation. Thereafter, the range should be required to make further performance measurements at some interval like two to five years as stipulated by the Village, if the measurements are requested by the neighbors of the range.

Very sincerely,

Paul Schomer

Paul Schomer, Ph.D., P.E.
Member, Board Certified; Institute of Noise Control Engineering

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PAUL D. SCHOMER
Acoustical Engineer

BS, Electrical Engineering, University of Illinois, 1965.
MS, Electrical Engineering-Acoustics, University of California, Berkeley, 1966.
Ph.D., Electrical Engineering-Acoustics, University of Illinois, 1971.

EXPERIENCE

Dr. Schomer has extensive experience, publications, and patents in the areas of environmental noise and its assessment, human and community response to noise, instrumentation and methodology for the measurement and monitoring of noise, sound propagation, and acoustical measurements of building parameters. He is a consultant to industry and government and a research leader in acoustics. His recognition by his peers as an international leader in the area of environmental noise is demonstrated by his chapters in reference books, his more than 45 refereed publications, his leadership in Standards organizations and professional societies, and his awards and honors. Dr. Schomer is also standards Director for the Acoustical Society of America.

As an international leader in the area of environmental noise, Dr. Schomer is chairperson of the United States delegation to International Organization for Standardization (ISO) Acoustics and Noise committees, past chairperson of the American National Standards Institute (ANSI) Committee dealing with noise, chairperson of the ISO working groups which deal with environmental noise and with impulsive noise measurement, chairperson of the ANSI/ASA working group which deals with environmental noise, and he is the United States representative to the International Organization for Standardization in the areas of aircraft noise and impulsive sources. He is the Standards Director for the Acoustical Society of America, a past member of the Society of Automotive Engineers Aircraft Noise Committee, a principle contributor to current efforts in the area of standardizing airport noise monitoring, and former Executive Director, past vice-president for membership, and twice a past member of the board of the Institute of Noise Control Engineering. He is also a past adjunct Professor of Electrical and Computer Engineering (Acoustics) and member of the graduate faculty of the University of Illinois

Dr. Schomer has 44 years of experience dealing with noise measurement and the effects of noise on people and communities. This experience includes airport, aircraft, helicopter, construction and traffic noise, general industrial and urban noise, wind turbine noise, blast and mining noise, small arms gunfire noise. The citation for his selection as a Fellow of the Acoustical Society of America references his studies on community response to noise, and most of his work with the National Academy of Science has been concerned with noise assessment.

MEMBERSHIPS AND AWARDS

Fellow - Acoustical Society of America.

Member, Board Certified, Institute of Noise Control Engineering

Selected as Corps of Engineers Engineer of the Year and One of the Top 10 Federal Engineers of the Year (1990)—National Society of Professional Engineers

Several times a member of the board and/or officer; Institute of Noise Control Engineering.

Former Executive Director, Institute of Noise Control Engineering of the USA, Inc.

Standards Director, Acoustical Society of America

Chairman, Acoustical Society of America Committee on Standards

Head of U.S. Delegation, International Organization for Standardization, Technical Committee 43 (acoustics) and Subcommittee 1 (noise).

Convener (chairman), International Organization for Standardization, Working Group 45 dealing with environmental noise assessment.

Chairman, S.A.E. Construction Site Sound Level Subcommittee, S.A.E. ConAg Committee.

Past Member, S.A.E. Aircraft Noise Committee and the noise monitoring subcommittee.

Reviewer for *Applied Mechanics Review, Journal of the Acoustical Society of America,* and *Noise Control Engineering Journal.*

Fellowship, University of Illinois (1968-1971).

Registered Professional Engineer (DC).

Member, Institute of Noise Control Engineering, Acoustical Society of America, Institute of Electrical and Electronic Engineers, German Acoustical Society (DEGA), European Acoustical Association

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Sound Transmission Loss Between Spaces Connected by Multiple Paths: A New Measurement Technique, Ph. D. Thesis, University of Illinois, August 1971.

PATENTS

Logarithmic Statistical Distribution Analyzer, Patent No. 3995500.

Microphone Droop and Sensitivity Measurement Device, Patent No. 4347410.

TYPICAL PROJECT EXPERIENCE

AIRPORT NOISE ASSESSMENT AND PART 150 STUDIES

Conducting the acoustical analysis and measurements contained within airport Part 150 studies including (1) the generation of present and future, predicted noise contours, (2) the execution of noise monitoring, the comparison of monitoring results with noise contours, and the analysis of monitoring results by aircraft type, operation, and runway, and (3) the development and analysis of noise mitigation strategies.

HELIPORT DESIGN AND ASSESSMENT

Assessment of the heliport noise. Establishing the need for mitigation. Assessing mitigation alternatives.

ENTERTAINMENT NOISE

Evaluated measurements for a large, outdoor music venue. Evaluated band and DJ noise from a club as it affected the neighborhood. Suggested mitigation methods. Evaluated measurement and monitoring plans for an outdoor music performance arena.

EXPERT WITNESS REGARDING NOISE PREDICTION AND ITS EFFECTS ON PEOPLE

Numerous cases, the following are examples:
For the defense: Class action suit of homeowners against ARCO Oil.
For the plaintiff: Class action suit of homeowners against Peabody Coal Company.
For both of these, performed analysis of the physical noise and its predicted levels in the community, and assessed the received noise and its effect on individuals and the community.
For the defense/plaintiff: Predicted, measured and analyzed noise from parked outdoor refrigerator trucks in a special situation.
For the plaintiff: Predicted and analyzed the effect of strip-mining explosions on a distant factory

structure.
For the plaintiff: Class action and community suits against airport noise including as $128,000,000 settlement for the city of Minneapolis.

EXPERT WITNESS REGARDING THE AUDIBILITY AND NOTICEABILITY OF SIGNALS AND ALARMS
For the defense: Analyzed the audibility of gunshot sound.
For the defense: Analyzed the noticeability of off-road truck noise in a quarry delivery plant.
For the defense: Analyzed the audibility and noticeability of truck noise in the presence of other neighborhood noise.
For the plaintiff: Analyzed the audibility and noticeability of siren noise at cross intersection.
For the plaintiff: Analyzed the noticeability of sirens when there is more than one.
For the defense: Analyzed the audibility of breaking glass and its ability to set off a glass-break detector.
For the defense: Analyzed the ability of a fire alarm to wake up and warn a person.
For the plaintiff: Analyzed the ability of a fire alarm to warn someone.
For the defense: Analyzed the ability of a fireman's PASS device to be noticed at a fire scene.

GUN CLUBS/POLICE FIRING RANGES
Performed noise assessment and mitigation at several civilian and police small arms firing ranges including siting, layout, operations, and noise mitigating structures and fixtures.

INDUSTRIAL NOISE CONTROL--OUTDOORS
Performed noise assessment and mitigation at a variety of outdoor industrial operations such as an asphalt plant, a kitty-litter plant (similar drum to asphalt plant for drying clay), an ammunition disposal plant (again a heated drum), and grain elevators.

MOTOR RACEWAY NOISE
Performed assessment, evaluated existing and planned mitigation and developed alternatives. Evaluated management and operational plans and developed alternative strategies.

PARK SOUNDSCAPES
Review and develop research plans for the NPS to develop the basis for National and International Standards for assessing and measuring park soundscapes.

PRODUCT DEVELOPMENT
Design, testing and evaluation of outdoor warning sirens.

VEHICLE/HIGHWAY NOISE
Assessment of highway noise. Monitoring highway noise. Establishing the need for mitigation. Assessing mitigation alternatives.

WIND FARM NOISE ASSESSMENT

For the proponents, established noise criteria, propagation model, and assessment for 100 + wind farm, presented the acoustical results before a large, well-attended, public hearing.
For the proponents, measured the ambient for two, one-to-two turbine installations in Champaign County, Illinois.
For concerned parties, provided background noise measurements.
For concerned parties, developed a draft wind law noise ordinance.

ILLINOIS NOISE REGULATIONS

Examination of the adequacy of existing noise regulations contained in Subtitle H, 35 Illinois Administrative Code. Analysis of the existing rules and whether they appropriately encompass the various types of discontinuous noise and specifically, impulse noise. Recommendations for changes to sections of the Code dealing with definitions and regulatory levels.

REVISIONS TO ILLINOIS PROPERTY-LINE NOISE MEASUREMENT PROCEDURES

Examination of existing measurement procedures as related to American National Standards. Recommendation of measurement procedures for determination of octave-band 1-hour equivalent levels corrected for background ambient. (No American National or International Standards exist for this type of measurement, but these are the type required by the Illinois Pollution Control Board.)

HUMAN AND COMMUNITY RESPONSE TO NOISE

Conducting and supervising international research experiments designed to explain, qualify and quantify human and community response to noise of varying character, spectra and temporal patterns. This research concentrates on comparing and contrasting special noises such as small arms, rotary-wing aircraft, or large explosions to more common noise such as road vehicles or artificially generated noise. A key to this work is conducting these experiments in real houses with real sources of sound.

TEMPORAL SAMPLING STRATEGIES FOR MONITORING AIRPORT NOISE

Analysis of daily monitoring results from many of the nation's airports. Modeling of the results by auto-regressive moving average (ARMA) models, and analysis of the results by “Monte Carlo” methods. Recommendation of airport noise sampling strategies for obtaining the required degrees of precision.

Ravenswood Studio, Inc.

August 17, 2012

Village of Lincolnwood
Plan Commission

6950 Central Park Avenue – Text Amendment, Special Use, and Variations

Dear Plan Commission Members,

I am the founder and owner of Ravenswood Studio, Inc. We are located at 6900 N Central Park Avenue, adjacent to 6950 N Central Park Avenue. Some background information: we are a twenty year old privately held company. We do highly specialized design and fabrication work for corporate and cultural institutions around the country. We are a unique company with an extremely diverse client base. Here's an abbreviated list: Microsoft Corporation, John Deere, Houston Grand Opera, MacArthur Foundation, Western Union, Florida Grand Opera, New York City Opera, Mythbusters, Field Museum, Shedd Aquarium, Six Flags, Blue Man Group, Museum of Science and Industry and many more.

Executives from these companies come to Ravenswood Studio for everything from concept and preplanning to design, fabrication and installation. Client meetings and charrettes in our conference room and offices can last for several days. This type of work requires focused attention in a relatively quiet, normal, office environment. Our offices and the proposed shooting range will share a demising wall. Gunfire noise will be audible within our office. The highly annoying, percussive nature of gunfire noise will render our offices unusable. See the attached report from the acoustic engineering firm Pin Drop Acoustics.

The other concerning issue is parking. At the June 6th Plan Commission meeting village staff recommended 74 off street parking spots for this size and type of facility, the variance would be for zero. The public lot across the street has 24 spots and is mostly full. The weeks we tracked it there were between 18 and 24 cars parked during normal business hours. Introducing a facility of this size with no parking will cause serious problems for the existing businesses.

I am no expert on the impact of economic activity and we are a small company, but here are some Ravenswood Studio statistics for the twelve month period ending June 30, 2012.

Full time employees	46
Annual Payroll	$2,252,837.00
Average Hourly Wage	$23.33
2011 Property Taxes	$131,222.00

The type of jobs we offer are increasingly rare these days with more and more people forced to accept low paying, low skill retail positions. Wal-Mart average wage is $11.75! In our 5 1/2 years in Lincolnwood I have no doubt we've exceeded Shore Galleries 50 year payroll and employment record. I am not claiming that I'm a 'big guy' or that the 'little guy' doesn't matter. But does it make sense to drive me and my employees from the community?

To reiterate, our 6,000 sq ft office will become unusable sharing a wall with a shooting range. We will not be able to operate in our current location. Moving is expensive and risky in this economy. My life's work and that of many of my long time employees is at risk. Please consider not allowing the proposed zoning changes.

Sincerely,



Michael Shapiro
President
Ravenswood Studio, Inc.

ACOUSTICS REPORT

Ravenswood Studio Noise Impact

SUBMITTED TO: Ravenswood Studio, Inc.
DATE: 2012.08.17
PDA JOB #: 1102

Executive Summary

A new shooting range has been proposed adjacent to the existing facilities for Ravenswood Studios. The design studio portion of the Ravenswood Studios facility is sensitive to intrusive noise. An assessment of the potential noise impact was therefore conducted and is summarized in this report.

While the Lincolnwood Code requires a noise level of 60dBA at the property line, there is no feasible way to measure the noise level between the two buildings. It was determined that a noise level of 30dBA in the Ravenswood Studios space will correspond with a level of 60dBA between the buildings, and should therefore be used to assess compliance with the noise code.

The anticipated noise level within the shooting range was found to be 169dBA, which is significantly higher than the levels previously proposed by Shore Galleries. Similarly, the level of acoustic isolation between the range and Ravenswood Studios is significantly lower than proposed by Shore Galleries. Calculations were performed using the more realistic conditions, and it was found that noise levels within the Ravenswood Studios space are likely to be greater than 56dBA, and possibly much higher, with significant low-frequency content that adds to the disruptive nature of the sound.

Current projected noise levels would exceed the Lincolnwood Code and would disrupt business activities in Ravenswood Studios. However, there may be means of modifying the Shore Galleries construction and/or configuration, and potential options are presented.

Pin Drop
acoustics

201 W. Lake Street #169
Chicago, IL 60606
312.416.0382
pindropacoustics.com

Introduction

We understand that a local gun shop, Shore Galleries, has proposed moving to a new location adjacent to Ravenswood Studios. The new Shore Galleries space will include two shooting ranges consisting of sixteen stalls. We understand the eight of these stalls will be configured as a long rifle range to be located immediately adjacent to the Ravenswood Studios property.

One of the most significant concerns related to shooting ranges is the potential impact of noise on nearby properties. In this case, the design studio portion of Ravenswood Studios is the nearest location that could be impacted by noise from the rifle range. This report describes Pin Drop Acoustics' analysis of the potential noise impact from the Shore Galleries shooting ranges on Ravenswood Studios design studio.

It should be noted that we completed our review by relying, in part, on layout drawings and construction details as provided by Shore Galleries and on acoustic analyses performed by Spinnaker Multimedia Solutions, Inc. on behalf of Shore Galleries. Information provided by Shore and Spinnaker will be referenced later in this report.

Evaluation Criteria

The Village of Lincolnwood Code of Ordinances (§15.VI.E.6.20) requires that the noise level at the property line not exceed 60dBA during the daytime due to a source of noise on another property.

In this case, the "property line" is actually located between the building to be occupied by Shore Galleries and the Ravenswood Studios building. This is an inaccessible location, rendering direct measurements of the property line noise level unfeasible. The nearest location where noise can be evaluated is within the Ravenswood Studios space. Based on our review of the existing construction of the Ravenswood Studios exterior wall, we believe it is reasonable to expect at least 30dBA of sound attenuation from that wall. If the noise level between the buildings were to be 60dBA, this would result in a noise level of 30dBA within the Ravenswood space.

We therefore conclude that the appropriate means of evaluating compliance with the Village of Lincolnwood Code is to establish a maximum noise level of 30dBA within the Ravenswood Studios design studio.

We also reviewed the potential for noise from the rifle range to disrupt business activities within the Ravenswood Studios design studio. The sound of gunfire is very brief, yet very loud; this sort of sound is typically referred to as an "impulsive" sound. Human beings are especially sensitive to impulsive sounds, particularly those that occur at unpredictable intervals. Most national and

international standards apply a "penalty" to impulsive sounds, requiring a level least 5dB lower than the permissible sound from steady noise sources. The existing noise levels in the Ravenswood Studios design studio have been measured at a constant level of approximately 35 to 37dBA.

However, simply looking at the overall "A-weighted" noise level is insufficient when evaluating the potential disruptiveness of gunfire. The process of A-weighting a sound discounts the strength of low and high frequency sound, with the intent of matching the sensitivity of the human ear. This can be a reasonable process to follow when evaluating broadband noise, such as the sound of an air conditioning unit, and is therefore often used in outdoor noise codes. When the sound in question is predominantly a low-frequency noise, such as rifle fire, applying an A-weighting can lead to an underestimation of the disruptive effects. A more appropriate means of evaluation of a predominantly low frequency sound is either an unweighted or C-weighted measurement. Existing noise levels in the Ravenswood Studios design studio have been measured at a constant level of approximately 55dBC.

Looking purely from the standpoint of disruption of Ravenswood Studios business activities, we would recommend a maximum noise level of 30dBA and 55dBC within the design studio. (Note that the most modern sound level meters can simultaneously record both A-weighted and C-weighted levels).

We would therefore recommend that the following criteria be established to evaluate the noise levels from the Shore Galleries rifle range as they impact the Ravenswood Studios design studio:

- Maximum A-weighted sound level of 30dBA
- Maximum C-weighted sound level of 55dBC

Note that any meter used to evaluate these levels should be set to measure using "Impulse" time weighting.

Analysis of Proposed Conditions

To determine the level of noise impact on the Ravenswood Studios space, we have reviewed the following:

- Level of noise in the shooting range
- Extent of acoustic isolation provided by the construction between the range and the studio
- Resultant noise level in the studio

Noise Level Within Rifle Range

The rifle range is configured with eight stalls, all of which may be used at the same time. We are not aware of any restrictions on the type or caliber of weapon that might be fired.

The reports prepared by Spinnaker for Shore Galleries have assumed a noise level of 140dBA per weapon, with a maximum anticipated noise level of 149dBA combined due to eight weapons fired nearly simultaneously.

In our review of numerous published reports—several of which are appended to this report—we find that most rifles have been consistently measured at noise level of 155 to 165dBA. Even using the average noise level of 160dBA per weapon, this is 20dB higher than the levels used in the Spinnaker evaluation.

Based on our review of published data, we conclude that the noise level within the shooting range should be assumed to be 169dBA due to the near-simultaneous firing of eight weapons in the rifle range for the purpose of evaluating noise impact on the Ravenswood Studios space.

Level of Acoustic Isolation

We understand that the existing exterior walls of the Ravenswood Studios building and the Shore Galleries building are both 8″ grout-filled concrete block with an additional 4″ face brick. The two walls are separated by a nominal gap of an inch or less, but in reality this is mostly filed with mortar. On the Ravenswood Studios side of the wall, there is an additional gypsum board wall constructed approximately 3-1/2″ away from the concrete block wall.

An additional 8″ grout-filled concrete block wall is planned to form a straight wall within the rifle range. This new wall will be constructed approximately 2′-9″ away from the exterior wall. It is not entirely clear to us how high this wall is to be built, but indications are that it will extend to just above the height of the ceiling within the range. The ceiling within the range itself is a ballistic steel panel, but we understand there are significant gaps. The roof/ceiling configuration overall, however, is planned to have 3″ of gypsum concrete poured over the existing roof, with a ceiling of two layers of 5/8″ gypsum board with insulation (including 10″ of Foam Woflex) between the ceiling and the roof.

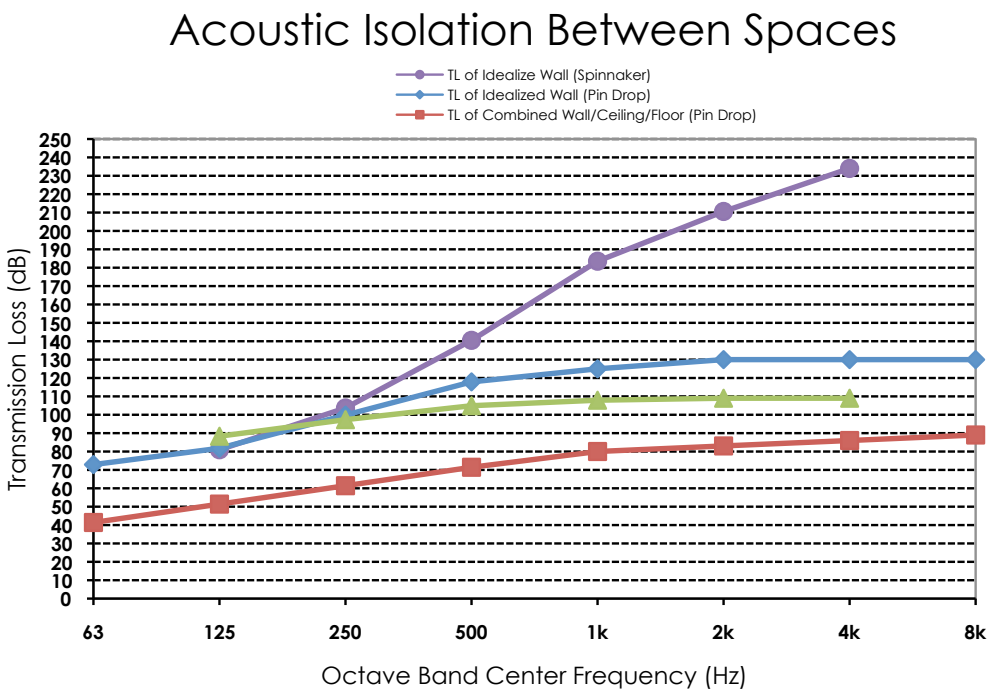
The Spinnaker report analyzes the isolation through the wall and through the roof as two independent paths: they report an overall rating of STC-105 for the walls, and STC-88 for the roof. In reviewing the calculations, we cannot accept the accuracy of the predicted levels of isolation. In the case of the wall, transmission loss values of over 200dB are reported and appear to have been used in subsequent calculations. These levels of isolation are not physically possible in real world construction, regardless of what

calculations may indicate, due to the way that sound travels through building structural elements. The calculations also do not appear to take into account sound levels below the range of the STC rating system, which extends to 125Hz. Rifle noise can contain significant energy below this frequency range.

We have conducted our own assessment of the proposed construction. In doing so, we have prepared our own calculations of the "idealized" wall construction to compare directly to the Spinnaker predications as well as calculations that take into account likely flanking paths through the ceiling of the rifle range and through the building structure.

Calculation	***Isolation at 63Hz (low frequency)***	***Isolation at 2kHz (high frequency)***	***Overall STC***
Spinnaker Idealized Wall	Not calculated	211dB	STC-105
Pin Drop Idealized Wall	73dB	130dB	STC-105
Pin Drop Combined Wall/Ceiling/Floor (assumes range wall is not continuous up to roof)	41dB	83dB	STC-84

The following chart illustrates the differences in calculated levels of isolation across the entire frequency spectrum.

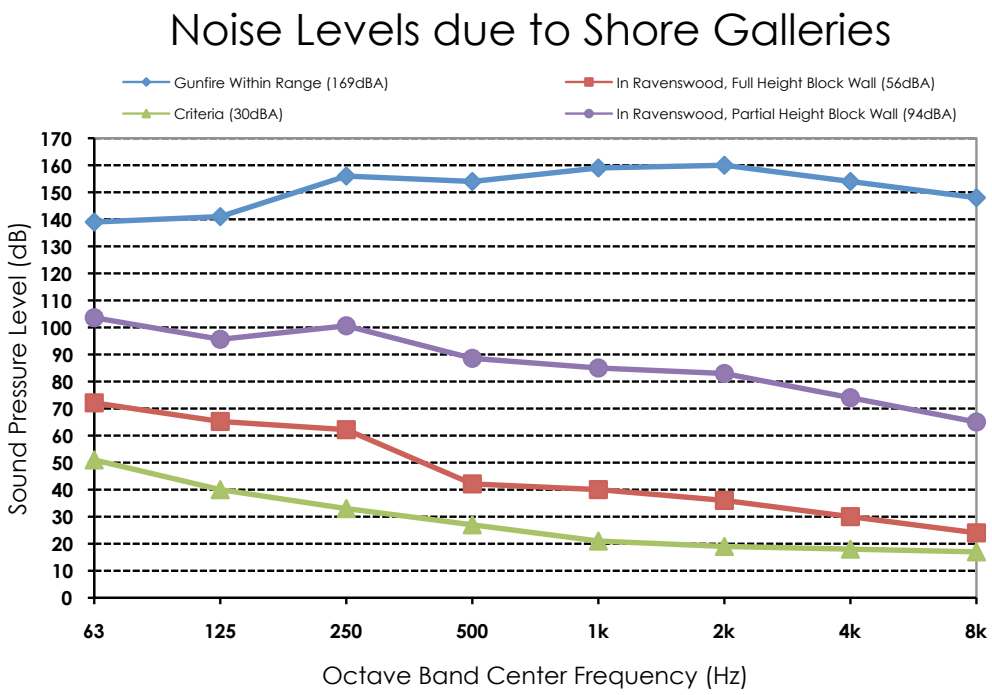


Projected Noise Levels Within Ravenswood Studios

Based on our assessment of the noise level within the range and the anticipated level of isolation provided by the proposed construction, we have calculated the following noise levels within the Ravenswood Studios design studio:

Calculation Method	*A-Weighted*	*C-Weighted*	*Note*
Spinnaker Report	30dBA	46dBC	Uses 149dBA range noise
Pin Drop Idealized Wall	56dBA	73dBC	Uses 169dBA range noise
Pin Drop Combined Wall/Ceiling/Floor	94dBA	106dBC	Uses 169dBA range noise, assumes range wall is not continuous up to roof but leaves over the top of the wall

The following chart provides additional detail illustrating the anticipated noise levels across the entire frequency range. As can be observed from the chart, the most significant issues are at low frequencies.



Based on our assessment of the sound levels within the rifle range, the level of isolation between spaces using the construction proposed by Shore Galleries, and the resultant noise levels within the

Ravenswood Studios, we conclude that the noise levels within Ravenswood Studios would be both exceed the Lincolnwood Code and would cause disruption in the Ravenswood Studios space.

Possible Means of Improvement

The impact of sound from the Shore Galleries rifle range on the Ravenswood Studios design studio has been found to be excessive based on the current proposed layout and type of construction. With some modifications to the proposed construction, however, we believe that these concerns might be alleviated.

Option 1 – Modify Layout/Construction of Rifle Range

The primary concerns at this point are 1) Noise that passes out of the range through the ceiling and then transmits through the walls and roof structure into the Ravenswood space, and 2) Noise that transmits into the floor of the range and travels through the floor slabs into the Ravenswood space. To alleviate these concerns, all three of the following steps would need to be implemented together:

- SAW CUT: A saw cut could be made through the floor of the facility around the range (outside the walls) and filled with a resilient material. This would break the path of transmission through the floor slab.
- CAP THE RANGE: The range could be capped with a poured concrete slab that spans across the walls of the range. This would effectively create a freestanding concrete "bunker" with 8" thick grout-filled concrete blocks on all four sides of the range with an 8" thick poured concrete roof on the top (walls would not extend full height to the roof). All ventilation openings and passageways would need to be detailed to ensure that they do not create weak links in the isolation system.
- INCREASE SPACE: The space between the existing exterior wall and the new range wall could be increased from 2'-9" to a minimum of 5'-0".

Option 2 – Move Ranges Within Facility

The other option would be move the ranges from the south end of the facility to the extreme north end of the facility (which is currently indicated as retail space). The added distance would provide sufficient attenuation through the floor slabs and the roof structure.

We acknowledge that this would require the transition from a mix of short and long ranges to result in only short range facilities.

Conclusions

In the current configuration, noise from the Shore Galleries rifle range are likely to result in unacceptable noise levels within the Ravenswood Studios space, from the perspectives of both the Lincolnwood Code and the disruption of activities in the Ravenswood Studios space.

There are means of reducing the potential noise impact, either through modification of the range construction or through the reconfiguration of the Shore Galleries space to move the range location.

End of Report

Gregory Miller, PE, INCE
Principal

Profile



Greg brings sixteen years of experience as an acoustics consultant to Pin Drop Acoustics, having worked on hundreds of projects around the world. As a principal, Greg works in all aspects of acoustics design. After receiving a Bachelor of Engineering from The Cooper Union for the Advancement of Science and Art, Greg spent the first five years of his career at New York-based Cerami and Associates, one of the country's leading noise and vibration control consultancies. For the nine years prior to founding Pin Drop Acoustics, Greg was part of Chicago-based Talaske, an internationally recognized leader in the acoustic design of performance spaces. At Talaske Greg served as the acoustics department manager and managed the firm's efforts on some of their largest and most important projects.

Greg is a member of the Committee on Architectural Acoustics for the Acoustical Society of America, is a full member of the Institute of Noise Control Engineers, and is a licensed professional engineer in Illinois and Oregon (Oregon licensure specifically in Acoustics Engineering). He has been an invited lecturer at the Illinois Institute of Technology, Judson University, City University of New York, the Acoustical Society of America, and the United States Institute of Theatre Technology.

Project Experience

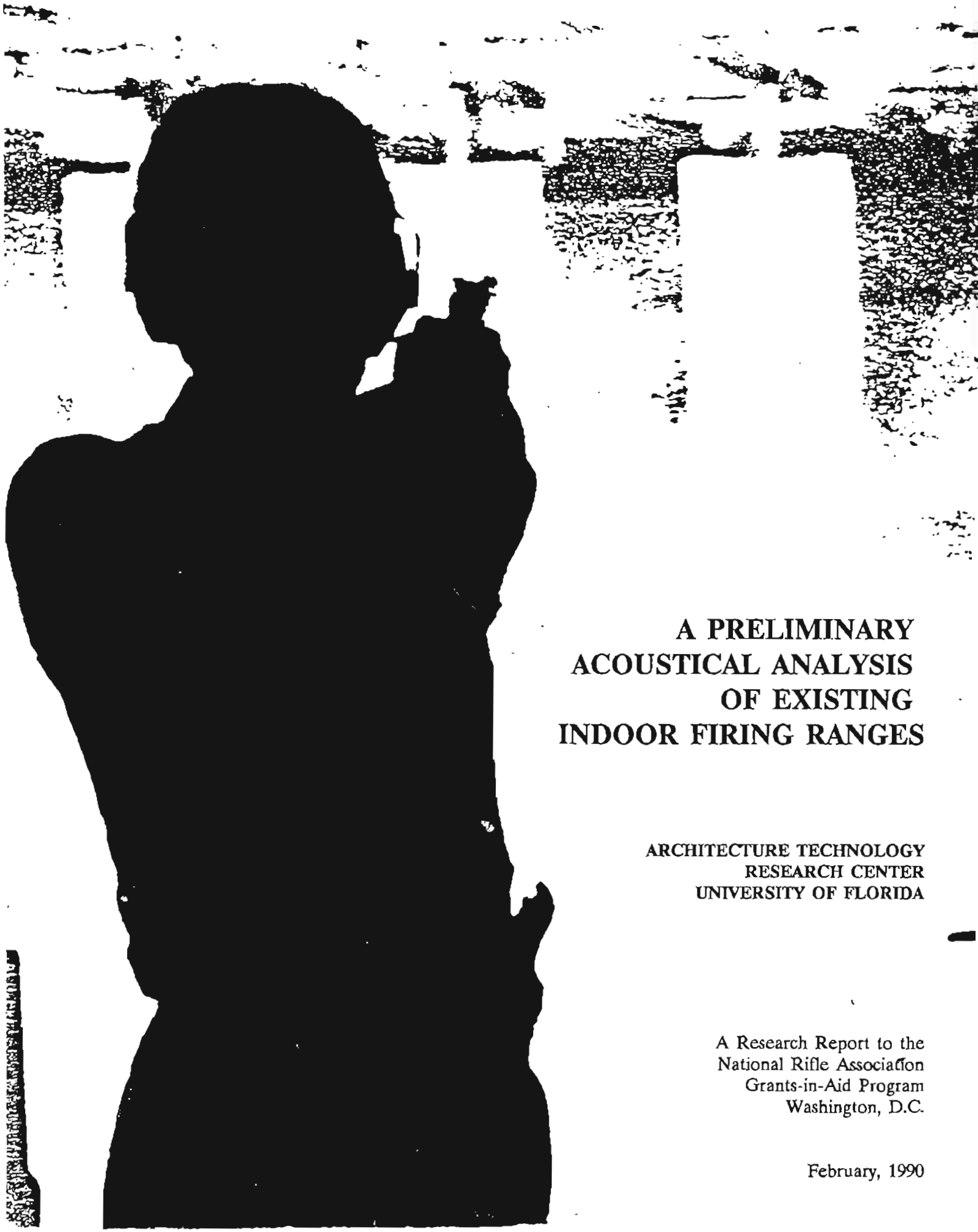
Projects at Pin Drop Acoustics include: Union Pacific Train Noise Evaluations, Glenview; McAninch Arts Center, Glen Ellyn; College Church, Wheaton; Akoo Studios, Rosemont, Illinois; St. Joseph Seminary Chapel, Chicago; BP Americas Chicago Headquarters & Trading Floor; PNC Bank Tower, Pittsburgh

Greg's past projects, prior to launching Pin Drop Acoustics, include: Guthrie Theater, Minneapolis; Harman Center for the Arts, Washington DC; The Empire Theater, Barbados; Bruno Walter Auditorium (NYPL for Performing Arts at Lincoln Center), New York; Wentz Concert Hall, Naperville; Lookingglass Theatre, Chicago; Modern Art Museum of Ft. Worth; BP Americas Chicago Headquarters; Kirkland & Ellis Headquarters, Chicago; The Wharton School, Philadelphia; Compass Church of Naperville

Contact

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REPORT DESCRIBING RESEARCH ON GUNFIRE NOISE LEVELS



A PRELIMINARY ACOUSTICAL ANALYSIS OF EXISTING INDOOR FIRING RANGES

ARCHITECTURE TECHNOLOGY
RESEARCH CENTER
UNIVERSITY OF FLORIDA

A Research Report to the
National Rifle Association
Grants-in-Aid Program
Washington, D.C.

February, 1990

A PRELIMINARY ACOUSTICAL ANALYSIS OF EXISTING INDOOR FIRING RANGES

A Research Report to the
National Rifle Association
Grants-in-Aid Program
Washington, D.C.

by

Shirley Jin, David Eplee and Gary W. Siebein

Illustrations by
Richard P. Cervone and "Ed" Wei-Wa Chiang

Architecture Technology Research Center
Department of Architecture
University of Florida
Gainesville, Florida 32611

(904)-392-0205

February, 1990

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Sergeant Gary Hoffman of the Gainesville Police Department, Gainesville, Florida; Sergeant Clements and Officer Grandage of the Miami Beach Police Department, Miami Beach, Florida; and Mr. Milton E. Watson of the Federal Law Enforcement Training Center, Brunswick, Georgia for arranging for us to take field measurements of gun shots at the facilities under their jurisdiction.

All of the acoustical consulting firms who responded to the survey mailed as part of this research, most especially those listed below who shared in detail their experiences in range design with us.

Dr. Angelo Campenella of Campenella Associates, Columbus Ohio;
Mr. William Cavanaugh of Cavanaugh-Tocci Associates, Sudbury, Massachusetts;
Mr. Bertram Y. Kinzey, Jr., Gainesville, Florida; and
Mr. Earl Mullins of Paoletti-Lewitz Associates, San Francisco, California.

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ABSTRACT

The goal of this research was to develop preliminary guidelines for the acoustical design of indoor firing ranges. A survey was sent to acoustical consulting firms to determine the extent of experiences and knowledge in the field today regarding the acoustical design of indoor firing ranges. The methods used for measuring the loudness of impulsive sounds were also studied. Loudness and octave band spectra for different types of weapons were presented. Case studies of several existing firing ranges were used to identify other design issues. The report addresses many of the acoustical questions that must be answered in the design of an indoor firing range.

INTRODUCTION

The noise produced by firearms is a very important consideration in the development and operation of a firing range. The noise of almost any gun surpasses the limits which can, with sufficient repetition, cause permanent hearing damage to those near the explosive sound. The noise can cause interference with the work, conversation, or activities of those in adjoining rooms. Annoyance caused by the noise can extend to the neighborhoods surrounding the firing range.

The goal of this study was to compile information on the acoustical design of indoor firing ranges. There are existing studies concerning the potential hearing damage to those using firing ranges and the effectiveness of protective devices.

There is no single source of information and data available on the acoustical design of indoor firing ranges at the present time. In order to gain information about the existing knowledge regarding the acoustics of indoor firing ranges, a survey was sent to all the architectural acoustical consulting firms who are members of the National Council of Acoustical Consultants. A copy of the survey can be found in Appendix 1.

The overall result from the survey was the anticipated conclusion that there is not a readily available source of information on the expected noise levels from firearms and the requirements for architecturally isolating the impulsive sound. The problem of noise emission from indoor firing ranges to the community is extremely important and is a state-of-the-art challenge. Case studies of existing firing ranges were carried out to more fully define the acoustical design issues involved in firing range design. Detailed studies of measurement techniques for impulsive sounds were also carried out to determine the loudness and frequency content of gunshots.

SURVEY OF ACOUSTICAL CONSULTING FIRMS

A survey was sent to all acoustical consulting firms who were members of the National Council of Acoustical Consultants in order to gain information about the existing knowledge regarding the acoustics of indoor firing ranges. A copy of the survey can be found in Appendix 1. The consultants were asked to provide any information they had on the noise levels of firearms and the design solutions they had used for firing ranges. Surveys were sent to a total of eighty six firms. Of the twenty two firms responding to the survey only five stated that they had previous experience designing indoor firing ranges. Two of the firms provided acoustic data on the sound levels of fire arms. None of the firms had made post occupancy evaluations of the completed buildings to determine the success of their designs.

The overall result from the survey was the anticipated conclusion that there is not a readily available source of information on the expected noise levels from firearms and the requirements for architecturally isolating the noise produced in indoor firing ranges. Several consultants made comments related to concerns they have regarding indoor firing ranges. They included the following:

1. The problem of noise emission from indoor firing ranges to adjacent rooms and to the community is extremely important. It is a state-of-the-art challenge.

2. The material on the acoustical design of firing ranges currently available from the N.R.A. should be significantly expanded.

3. Certain acoustical materials could have disastrous effects on the occupants of a firing range in case of fire. A letter from George Leighton to the National Council of Acoustical Consultants Newsletter relating to this matter is included in Appendix 2. Problems with maintenance and the accumulation of lead in porous sound absorbing materials were also mentioned.

The construction types and design recommendations described by the consultants will be discussed in a later section of this report.

MEASUREMENT OF NOISE PRODUCED BY GUNSHOTS

The noise created by a gun is a short impulse of sound. There are a number of parameters of a single impulse which may be of importance to the measurement and transmission of the sound including:

1. the peak pressure level;
2. the rise time;
3. the pressure wave duration (A duration); and
4. the frequency spectrum.

Each of these will be defined in turn. Parameters 1-3 are illustrated in Figure 1 below.

The Peak Pressure Level is the highest pressure level achieved (expressed in dB re: 2×10^{-5} N/m^2).

The Rise Time is the time taken for the single pressure fluctuation that forms the initial or principal positive peak to increase from ambient levels to the peak pressure level. For guns the rise time can be as short as a few microseconds (Coles, et al, 1967).

The Pressure Wave Duration (A-duration) is the time for the initial or principal pressure wave to rise to its positive peak and return momentarily to ambient. (If the initial wave is of smaller amplitude than some of the subsequent waves the A-duration is taken from the largest pressure wave).

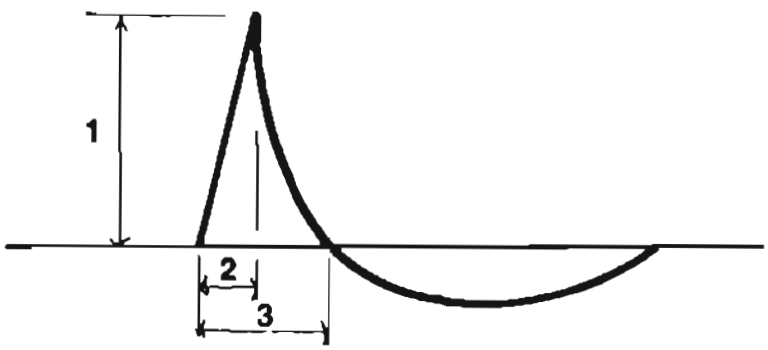


Figure 1. Idealized Waveform of an Impulse. Notice the peak level (1); the rise time (2); and the A-duration (3) shown in the sketch.

The Frequency Spectrum is the acoustic frequencies that make up the pulse. The acoustic frequency spectrum is important because the acoustic attenuation of structural materials typically vary as a function of frequency.

Acoustic impulses are usually measured with a microphone. The most important attribute of a microphone is its accuracy in measuring the pressure of the pulse. The rise time of the microphone is very important to accurate measurement. If an impulsive sound reaches its peak in a time much less than the rise time of the microphone it will decay significantly before the microphone reaches its peak. This will cause the microphone to provide a measurement that is less than the actual pressure. The rise-time of the microphone depends on several factors. The most important are listed below.

1. **The frequency response of the microphone and associated equipment.** The rise time is proportional to the upper limiting frequency of the microphone and other equipment used. For example sound level meters which acoustical consultants typically use have a frequency response of 18,000 Hz. An 18,000 Hz. pure tone has a rise time of approximately 14 microseconds. If an impulse sound reaches its peak in much less than 14 microseconds it will decay significantly before the microphone reaches its peak.

2. **The integration time constant of the associated readout equipment.** Sound level meters necessarily have an integration time which depends on which type of readout is chosen. When the meter is set on "peak" the integration time is minimized.

3. **The transit time.** The transit time of a transducer is a function of its diameter (D), and the incident angle (q). The transit time is proportional to D(sin q). Therefore normal incidence will minimize the transit time.

4. **The peak pressure.** The design and operation of a condenser microphone is such that the output signal is proportional to the displacement of its diaphragm. Measuring high pressures forces the diaphragm into relatively large displacements. If the diaphragm does not move linearly at the large displacement then the rise time capability will deteriorate. Frequently an attenuator must be attached to the microphone of a sound level meter to accurately record the levels of very loud noises.

Since the sound impulses produced by guns have a rise time of only a few microseconds the acoustic measurements of the gun shots made with a sound level meter give peak readings which are lower than the actual peak levels due to the frequency response of the sound level meter and its integration time constant. The smaller the diameter of a microphone, the higher its frequency response, and therefore the faster its rise time. The signal to noise ratio typically decreases as the microphone diameter decreases.

In order to compare measurements made with a sound level meter with a 1/2 inch microphone and measurements made with a 0.1 inch diameter microphone connected directly to an oscilloscope, a series of identical measurements were made using a spark discharge as the source. Previous tests had shown that the pressure wave and amplitude of the spark

source is similar to that produced by a gunshot (Cremer, 1982). The spark source has the additional advantage that it is more consistent than gunshots in it characteristics for the purposes of this experiment.

The spark source was a Grozier Technical Systems GTS-51 Spark Generator. The sound level meter was a General Radio model 1982. The output from the meter was fed to a Nicolet Explorer Digital Oscilloscope in order to view the rise time of the pulse recorded by the sound level meter. The 0.1" diameter microphone was made by Bolt, Beranek and Newman (BBN). It was designed to measure impulses from a spark discharge in architectural models. The BBN microphone has a frequency response of about 300,000 Hz. This corresponds to a rise time capability of about 1 microsecond. The signal from the BBN microphone was amplified by a Grozier Technical Systems GTS-20 Amplifier and fed into the Explorer Digital Oscilloscope . Both of the microphones were calibrated with a General Radio pistonphone at 114 dB at 1000 Hz. Garinther and Moreland (1965) have found that a microphone can be used to measure high pressures without being calibrated at high pressures, as long as the pressure to be measured does not produce nonlinear diaphragm motion.

The spark discharge was measured with both microphones at positions one to sixteen feet from the source with the microphones perpendicular to the direction of propagation of the sound wave (grazing angle). A 20 dB attenuator attached to the sound level meter prevented nonlinear diaphragm displacements of the microphone condenser. Figures 2 and 3 show a typical pressure vs. time history of the shock waves produced by the spark discharge to illustrate the differences between the recording devices. A series of oscilloscope traces showing the pressure vs. time histories of the shock waves produced by the spark discharge recorded using both methods is contained in Appendix 3. The peak levels for the BBN microphone were measured from the oscilloscope trace amplitudes. The peak levels for the sound level meter (SLM) could be read directly from the meter.

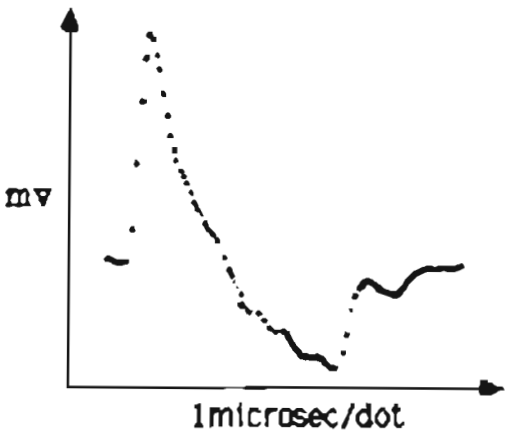


Figure 2. Spark discharge measured by the BBN microphone at 1 foot.

Peak level	150 dB
Rise time	5 microsec.

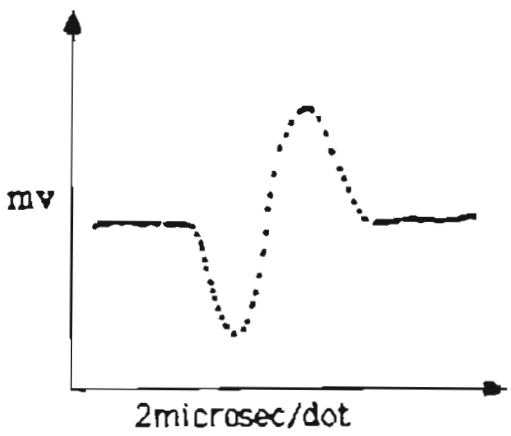


Figure 3. Spark discharge measured by the SLM 1 foot.

Peak level	140 dB
Rise time	26 microsec.

Data were also taken with the microphones at normal incidence at each position. The sound level meter measured 4 dB higher at each position. The BBN microphone was erratic measuring levels 1 to 7 dB higher than the levels measured at grazing angle. The oscilloscope pressure-time histories for the BBN microphone at normal incidence showed a nonlinear decrease in pressure from the maximum to the minimum. This decrease should be linear as in the classic "N" shape of a shock wave (Garinther and Moreland, 1965). This linear decay can be seen in the above figures of the pressure-time histories with the microphone at grazing incidence. Therefore, the data taken at grazing angle incidence are assumed to be more accurate and were used for comparing the two microphones.

Table 1 summarizes the data shown in Figures 2 and 3 as well as the data presented in Appendix 3. The rise time of the sound level meter is significantly longer than the rise time of the BBN Microphone as expected. The percentage difference between the readings of the two meters is also shown in the table. The data indicate that the readings made with the sound level meter should be increased by approximately 5% to give levels which are close to the levels measured by the 0.1" BBN microphone for impulsive sounds produced by the spark generator.

TABLE 1

Variation in Lp and Rise Time at Different Distances Between the Spark Source and the Microphone Measured with the BBN and SLM Microphones

	0.1" BBN Microphone		S L M (1/2" Mic)		
Distance (feet)	RT(msec)	Lp(dB)	RT(msec)	Lp(dB)	%D.
1	5	150	26	140	7
2	6	141	21	134	5
4	6	135	34	128	6
8	8	128	35	122	5
12	8	124	40	118	4
16	11	121	40	115	5

The impulses produced by the spark source have an A-duration of about 30 microseconds. Since the A-duration of impulses from guns are on the order of 200 microseconds the correction factor required when measuring the sound levels of guns may be less than that required for spark discharges. Data were taken using a .38 caliber revolver firing blanks (Lamothe and Bradley, 1985). It was found that the variation in sound level caused by differences in the blanks themselves was several dB. Therefore, it was not possible to make meaningful measurements reflecting the measuring capabilities of the microphones.

Architectural acoustical measurements are often tape recorded so that the signals can be analyzed in the laboratory. The Nagra IV-SJ Recorder used by many acoustical consultants has an upper level frequency response of 40,000 Hz. when the recording speed is 15 in/sec. In order to determine whether or not the tape recorder would cause an error in the sound pressure levels of impulsive sounds a series of spark discharges were measured with the signal from the BBN microphone fed directly into the oscilloscope and with the signal tape recorded first. The pulses fed directly into the oscilloscope had a rise time of 4 microseconds while the tape recorded signals had a rise time of about 24 microseconds. The sound pressure level averaged 4 dB lower for the tape recorded signals.

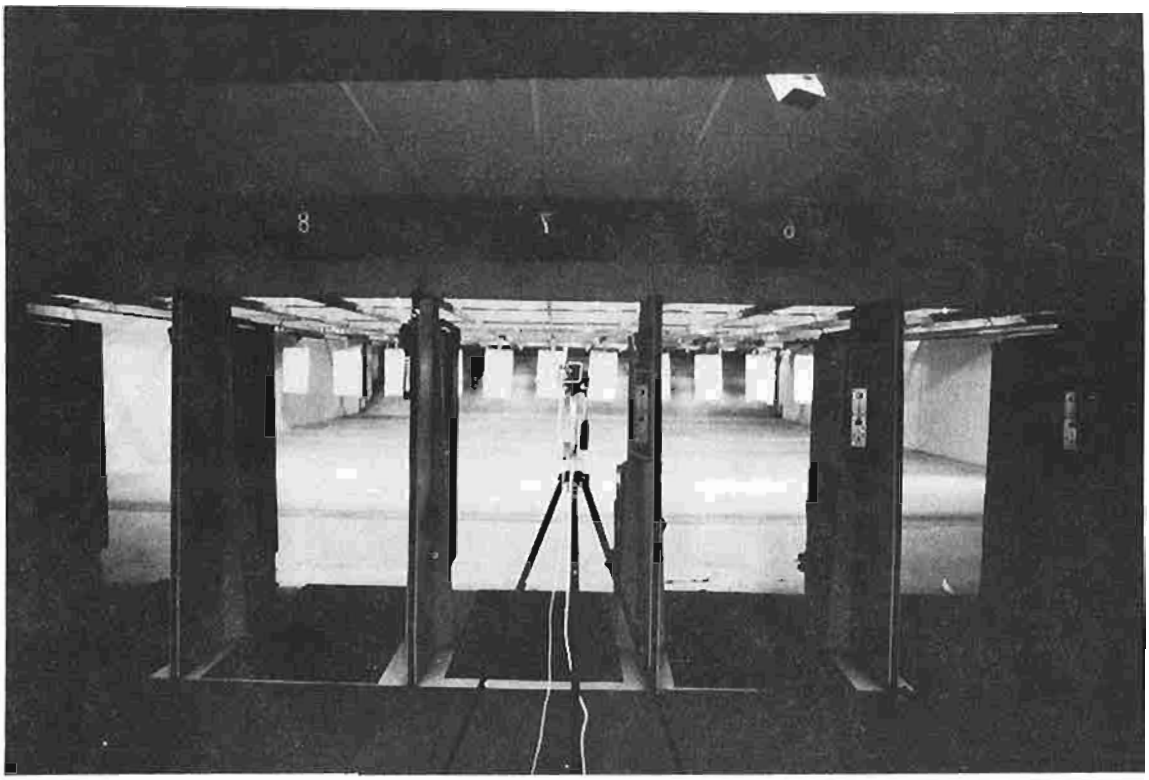


Figure 4. Photograph of the tripod with the 1/2" diameter microphone and the 1/8" diameter microphone mounted at 5 ft. 6 in. above the floor, 6 ft. behind the firing line at the center of the range for the measurements at the Federal Law Enforcement Training Center in Brunswick, Georgia.

In another experiment, approximately two minutes of gunshots were recorded in an indoor firing range at the Federal Law Enforcement Training Center in Brunswick, Georgia. A Thorn-EMI instrumentation tape recorder was used with a recording speed of 60 i.p.s. A Bruel and Kjar 1/2" diameter microphone (model 4134) was connected to an FM channel and a 1/8" diameter Bruel and Kjar microphone (model 4138) was connected to a direct record channel. The microphones were mounted on a tripod 5 feet 6 inches above the floor, 6 feet behind the firing line in the range. They were separated by approximately 3 inches as shown in figure 4. Twelve law enforcement officers were firing during the time period the recording was made. Calibrating the 1/8" diameter microphone was extremely difficult. The peak

sound pressure levels recorded with the 1/8" microphone were consistently 0.5-5% higher than those recorded with the 1/2" microphone. The average difference for over 30 peak pressures measured was 3.1%.

The conclusions from the experiments with the equipment indicate that measurements of peak sound pressure level made with a 1/2 inch microphone and a sound level meter will give peak sound pressure levels that are lower than the actual peak sound pressure levels. **A correction of approximately 5 % should be made to readings taken with a 1/2 inch microphone and a sound level meter.** Tape recorders with a 40,000 Hz. maximum frequency response should not be used for the evaluation of peak sound pressure levels of impulsive sounds.

GUIDELINES FOR INDOOR FIRING RANGE DESIGN

INTRODUCTION

It is easy to discuss any acoustical situation in terms of the three basic components listed below.

1. **The sound source.** In this instance, the peak sound pressure levels of fire arms and the octave band frequency spectrum of the sound are of immediate concern. There is no single source containing this information that is available to designers of indoor firing ranges.

2. **The path of sound travel.** This includes the air in the building as well as the walls, floor and ceiling of the firing range. Two concerns are important. The first is the **reflection** of sounds from the walls, floor and ceiling of the range that increases the loudness of the gunshots when they are fired indoors (as opposed to outdoors). The second concern is the sound that is **transmitted** through the walls, floor and ceiling of the range to adjacent rooms or to the community.

3. **The receiver of sound.** People using adjacent rooms for work activities and people living in the adjoining community should not be annoyed or disturbed by the sounds from the firing range.

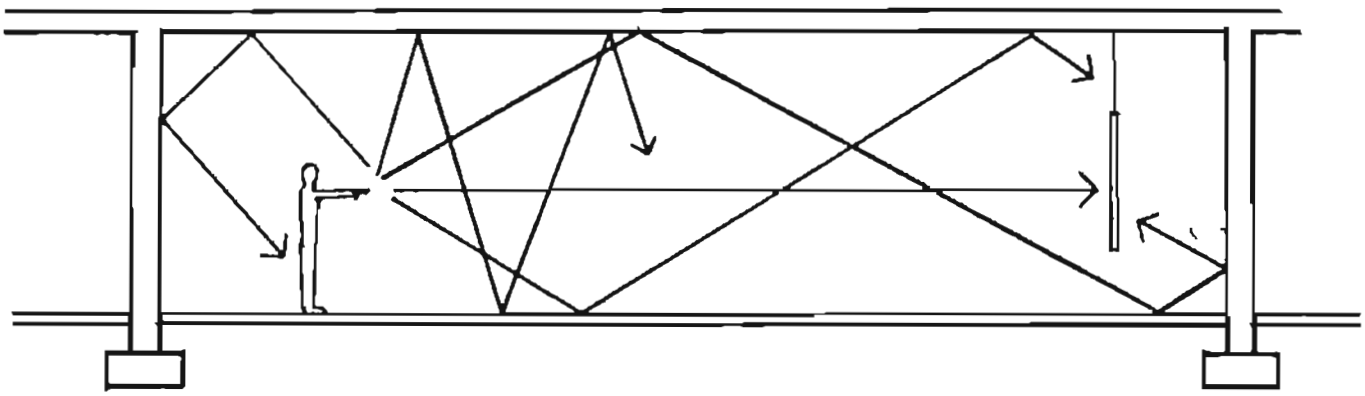


Figure 5. Concept sketch of sound source, paths and receivers in an indoor firing range. Sounds reflected from the walls, floor and ceiling increase the sound levels in the room. The sound is then transmitted through the walls, floor and ceiling to adjacent rooms.

SOUND LEVELS PRODUCED BY FIRE ARMS

Sound levels produced by fire arms were collected from several sources and measured in the field as a part of this study. The sound levels of several guns used by the Gainesville, Florida Police Department were measured outdoors with a General Radio type 1982 sound level meter (SLM) with a 20 dB attenuator and a windscreen attached to it. The attenuator was necessary because

the peak sound pressure level of gunshots close to the gun often exceeds the maximum sound pressure level the sound level meter can measure. The windscreen is necessary to minimize the effects of wind noise on the measurements. Measurements were made at four locations with the sound level meter 6 feet from the gun and at four locations with the sound level meter 12 feet from the gun. Figure 6 shows the measurement positions of the sound level meter relative to the gun.

The sound level meter was oriented at an angle of 70° to the horizontal in the direction of the gun. All measurements were made with a person firing the gun in the standing position. The microphone and gun were in approximately the same horizontal plane, 5 feet above the ground. The microphone was located to the right of the person firing the weapon. Four gun-ammunition combinations were measured. Only factory loaded cartridges were used. The peak sound pressure levels (max., peak, hold, flat) are given in Tables 2 through 5. The numbers in parentheses are the measured values increased by 5% (as discussed above).

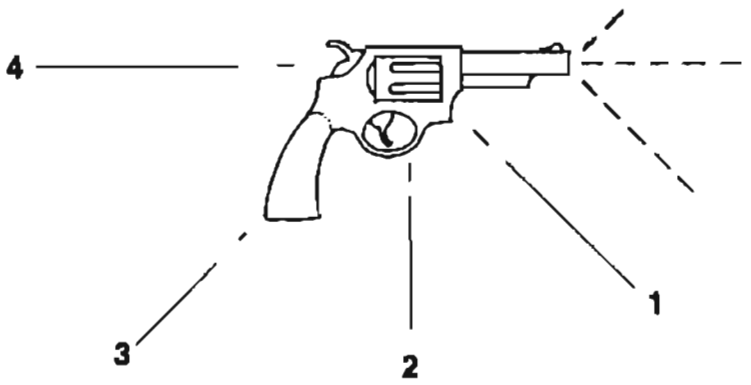


Figure 6. Measurement positions for data shown in tables 2 through 5.

TABLE 2

Sound Levels of a Ruger Security 6 Gun with a .38 Special + Winchester Silvertip Bullets

	Peak Lp (dB)			
Distance	Position			
(feet)	1	2	3	4
6	157(165)	152(160)	149(156)	145(152)
12	152(160)	146(153)	141(148)	138(145)

TABLE 3

Sound Levels of Ruger Security 6 Gun with 357 Magnum Winchester Silver Tip Bullets

	Peak Lp (dB)			
Distance	Position			
(feet)	1	2	3	4
6	163(171)	155(163)	155(163)	149(156)
12	159(167)	150(158)	148(155)	146(154)

TABLE 4

Sound Levels of a Smith and Wesson 659 Gun with 9 mm. Winchester Silver Tip Bullets

Distance (feet)	Peak Lp (dB) Position 1	2	3	4
6	160(168)	154(162)	149(156)	147(154)
12	153(161)	149(156)	145(152)	143(150)

TABLE 5

Sound Levels of a Smith and Wesson 645 Gun with 45 ACP Winchester Silver Tip Bullets

Distance (feet)	Peak Lp (dB) Position 1	2	3	4
6	159(167)	155(163)	152(160)	147(154)
12	153(161)	150(158)	145(152)	144(151)

The sound pressure levels in the direction of the gun were not measured but can be estimated from the directionality of the data to be 5 to 10 dB higher than the levels at position 1.

TABLE 6

Peak Pressure Levels of Firearms - Cartridge Combinations*

Firearms	Cartridge	Peak Lp (dB)	Distance(feet)
9mm automatic	9mm, 115gr.	151	7.2
357 mag.revolver	38sp., 158gr.	152	3.9
357 mag.revolver	357mag., 158gr.	161	4.6
45 automatic	45 ACP, 320 gr.	160	4.3
41 mag. revolver	41 mag., 210gr.	161	3.9
44 mag. revolver	44 mag., 240 gr.	171	3.3
22 rifle	22LRHV, 40gr.	142	6.9
12 gauge shot gun	3-3/4 dr.equiv.	149	4.3
22 revolver	22 short blank	142	3.9

*This table is adapted from "Noise of Police Firearms", by P.G. Weissler, et al., J. Acoustical Soc. Am., 56, 1515 (1974). The following abbreviations are used: LRHV-long rifle high velocity; dr. equiv-dram equivalents of black powder; ACP-automatic Colt pistol; gr-grains.

The noise of various police firearms have been measured by Weissler and Kobal (1974). They measured the sound pressure levels at the left ear of the shooter and at the approximate location of a person next to the shooter on a firing range. A 1/8th inch B & K (model number 4138) microphone was used with the signal fed directly into an oscilloscope. The microphone was directed perpendicular to the ground. The guns and their peak sound pressure levels at a position corresponding to position 2 in figure 6 are listed in Table 6. One of the guns was louder than the guns listed above. It was the 0.44 cal. Magnum revolver with 0.44 cal, 240 grain lead bullets. A sound level of 171 dB was measured at 3.3 feet from the gun.

Garinther and Moreland (1965) measured the sound pressure level of an M14 rifle at several distances from the muzzle at a position corresponding to our position 2. They used a Ballistic Research Laboratories shock tube to make the measurements. The axis of the microphone was located parallel to the axis of the gun and at the same level. Their results are shown in table 7.

TABLE 7

Measured Peak Lp for the M14 Rifle
Lp (dB)

Distance in Feet				
0.8	1.6	3.3	6.6	13.1
184.5	179.0	171.7	165.0	155.9

This table is adapted from "Transducer Techniques for Measuring the Effect of Small Arms Noise on Hearing", by G.R. Garinther and J.B. Moreland, Technical Memorandum 11-65, U.S. Army Human Engineering Laboratories, Aberdeen Proving Ground, Md., 1965.

The data in Tables 2 through 7 provide information on the sound levels from guns which can be used in the architectural acoustical design of a firing range. Since the shock waves produced by guns are of short duration (< 200 microsec) it is unlikely that more than one gun will be fired simultaneously. However the reverberation of the room must be considered if a large number of guns are being fired as the sound level can build up through multiple reflections. Absorbent materials will reduce the reverberation. Care must be taken in using absorbent materials however, to avoid materials which will trap the lead particles given off by guns. The build up of lead in an indoor firing range can be a severe health hazard. In addition, materials which pose a fire hazard must be avoided.

Octave Band Noise Levels Produced by Firearms

The data presented here are preliminary spectra obtained through a variety of methods by several consultants and the researchers. Future research is necessary to define an appropriate method to obtain design octave band noise levels for use in the acoustical design of indoor firing ranges. This section will be revised pending the results of subsequent research.

Much of the data presented here were taken with 1/2" microphones and recorded with a tape recorder so that the sound pressure levels might not represent the true peak level. However, the spectra do give the relative sound pressure levels for the various octave bands. The highest sound pressure levels for the firearms tested generally occurred in the 1000 Hz. and 2000 Hz. octave bands. Levels within 10 dB of the level at 2000 Hz. extended from 250 Hz. to 4000 Hz.

TABLE 8
Octave Band Sound Pressure Levels for Selected Firearms

	Octave Band Center Frequency							
Measurement	63	125	250	500	1000	2000	4000	8000
Max. Lp peak recorded 6 ft. behind the firing line, 5 ft. 6 in. above the floor at FLETC indoor range with 12 shooters firing 9 mm. handguns with wadcutter loads by Siebein. A GR 1982 SLM and Nagra IV-SJ tape recorder were used. The recordings were analyzed on a B & K 2131.	125	126	139	143	139	140	133	129
Average peak Lp recorded over 2 minutes of gunfire by 12 shooters using .357 magnum with type RP shells, 6 ft. behind the firing line at 5 ft. 6 in. above the floor at FLETC by Siebein and Cervone. They used a Thorn-EMI recorder at 60 i.p.s. with a B & K 1/2" microphone played back through an IVIE PC-40 analyzer. This assumes the gunshots approach a steady state condition.	112	114	120	124	124	124	122	121
Peak Lp measured by Richard E. Moore at FLETC 6 ft. behind the firing line at 5 ft. 6 in. above the floor.								
0.38 JHP S & W 19		122	136	136	141	138	142	138
0.38 JHP, 110 grain		119	135	135	134	136	133	135
0.38 Wadcutter		108	124	133	138	134	135	136
Peak Lp of 1 shooter at his ear in an indoor range at FLETC using a S & W 0.38 caliber handgun with a 2 1/2" barrel measured by Julia Royster. She used a GR 1958 with 5314 preamp, 1767 attenuator and 13191 microphone.								
Wadcutter 148 grains		121	134	139	145	147	148	143
JHP 110 grains		134	145	147	152	153	150	146
Magnum 110 grains		140	155	152	157	159	153	147

Peak sound level data taken by the individuals listed above and several other respondents to the survey mailed in this research showed general agreement among values measured for different gun-ammunition combinations. Earl Mullins of Paoletti-Lewitz found a difference of approximately 15 dB between measurements made 5 ft. behind the firing line to 4 ft. 6 in. below the muzzle of a gun (directly underneath it). Measurements made by Siebein showed a 13-18 dB increase in peak levels recorded in the direction of fire compared to those measured behind the shooter. Mullins also found approximately a 8-12 dB increase from the position 5 ft. behind the shooter to the ear of the shooter. These measurements were all made with a sound level meter in the max., linear, peak mode with an attenuator. Mullins data recorded at the ear corresponds well with Royster's data taken at the same position.

SOUND LEVELS IN INTERIOR SPACES

The level of sound in interior spaces is sustained in the room due to the reflection of the sound from the walls, floor and ceiling of the room. Sound decreases due to geometric spreading as one moves further from the gun. Most guns are directional sound sources. They propagate more noise in the direction the barrel is pointing. The sound level decreases as one moves around the sides to the rear of the gun. It is possible to estimate the sound level produced at various distances from the gun indoors using formula 1 below.

$$Lp_{D2} = Lp_{D1} - [DT_1 - DT_2] \qquad (1)$$

where: Lp_{D2} = sound pressure level (in dB) at the desired location in the room.
Lp_{D1} = sound pressure level (in dB) a reference location. This would typically be the peak sound pressure level measured at a specified distance from the gun in a given direction of interest.
DT_1 = distance term at the location where the loudness of the gun was measured.
DT_2 = distance term from the location in the room where one wants to estimate the sound pressure level to the gun.

$$DT = 10 \log \left[\frac{Q}{4\pi D_1^2} + \frac{4}{R} \right] + 10 \qquad (2)$$

Q = directivity factor of the source.
D_1 = distance from the measurement position to the gun when it was fired.
R = room constant of the room. This is equal to the sum of the absorption coefficient (α) in each octave band for each material in the room multiplied by the surface area (S) of each material in the room.

$$R = \Sigma S_i \alpha_i = S_1\alpha_1 + S_2\alpha_2 + S_3\alpha_3 + \ldots + S_i\alpha_i + A_1 + A_2 + \ldots + 4mv \qquad (3)$$

where: S_1 = surface area of each material
α = acoustical absorption coefficient at a specific octave band
A_1 = specific groups of absorbers such as people.
$4mv$ = air absorption term. The m is the absorption usually expressed as sabins per 1000 cubic feet of air and v is the room volume (usually divided by 1000).

This calculation is then repeated for each octave band. A computer spreadsheet using popular software such as Lotus 1-2-3 , Quattro or other readily available programs can be constructed to perform these calculations.

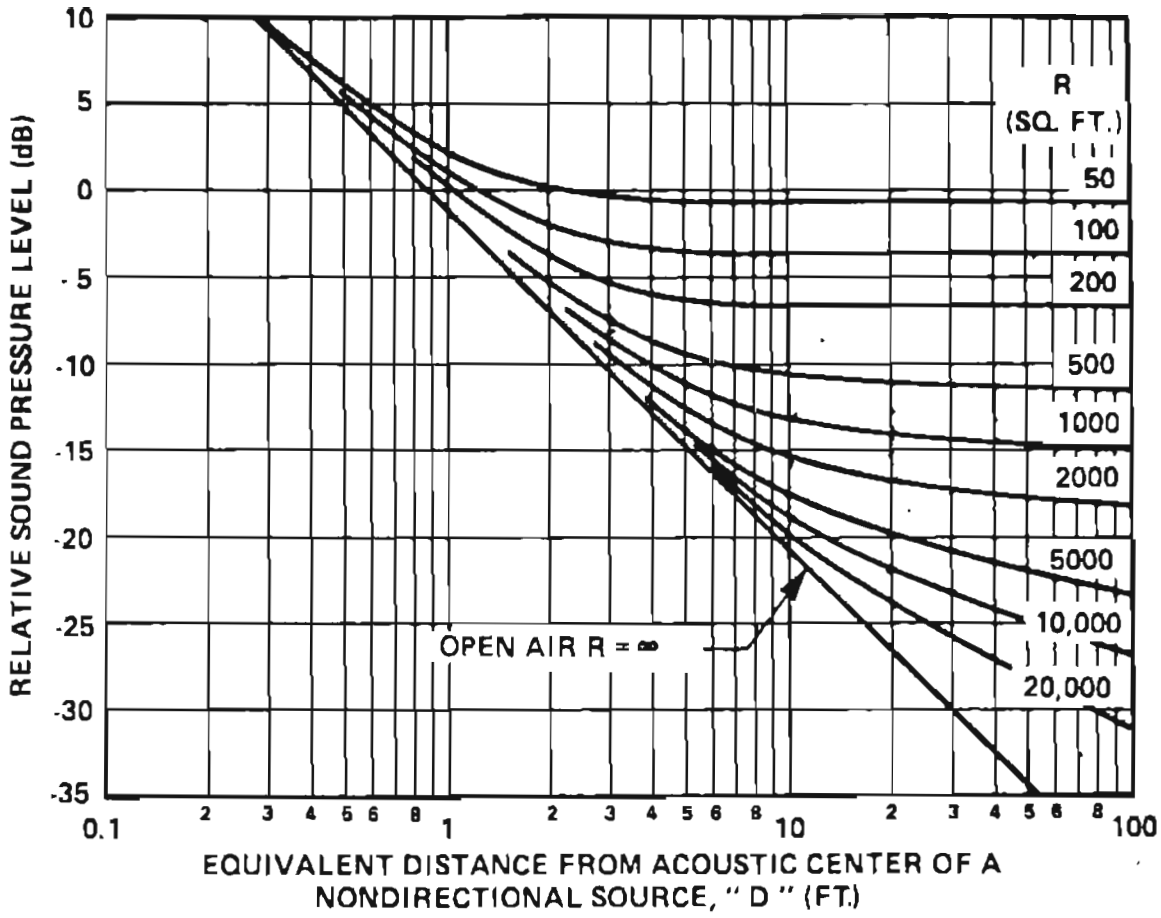


Figure 7. Values for the Distance Terms (DT_1 and DT_2) are presented for different values of the room constant (R) and distance (D). One can estimate the room constant using formula (3) above. Using this figure, one can then find DT_1 and DT_2 quite easily (Miller, 1981, p.4-9).

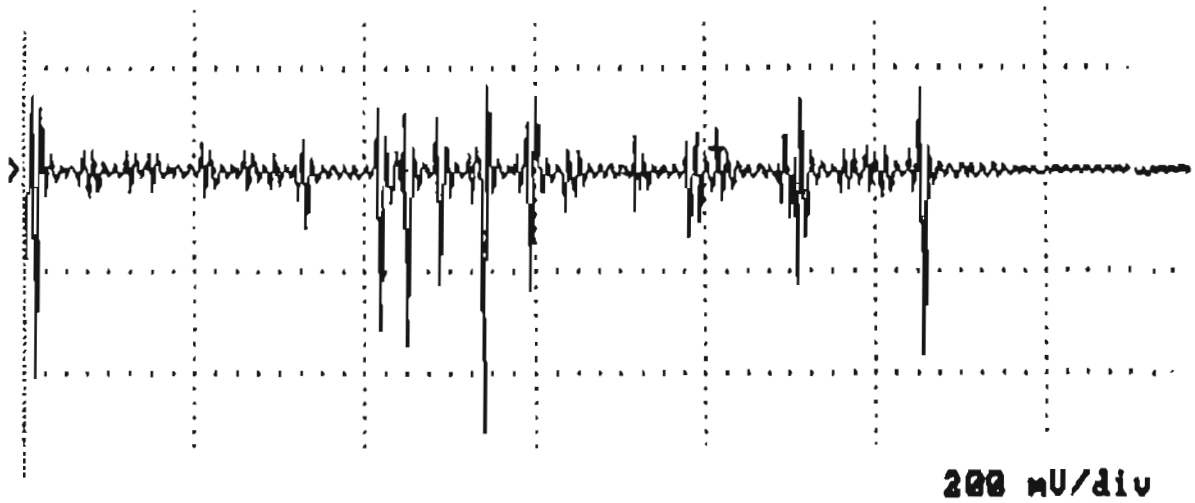


Figure 8. Sound pressure (volts) vs. time (milliseconds) plot of approximately 20 seconds of firing by 12 shooters in an indoor firing range at the Federal Law Enforcement Training Center in Brunswick, Georgia. Notice the peaks when the guns are discharged with the subsequent reflections from the room surfaces. The smooth line at the far right of the graph is the background or ambient noise level. Acoustical consultants would normally view a graph like this in decibels (or logarithmic units) on the vertical scale. This would reduce the size of the peaks above the subsequent reflections somewhat.

It is unusual for more than one gun to fire at exactly the same instant due to the extremely short duration of the direct pulse of noise. However, due to the prolonging of sounds in the room by reflections (reverberation) from the room surfaces, when several people fire in an indoor range, all of the guns contribute to the build-up of reverberant sound in the room. In large indoor ranges where ten or more individuals are firing more or less simultaneously (as in a training routine) an almost continuous fluctuation of the loud noises occurs. This situation approaches a steady state noise condition. This is marked by distinct events as each gunshot fires that fall off to a more or less steady level.

Example 1. Estimate the sound level in an indoor firing range that has 6 firing positions. The range is 26 ft. wide, 95 ft. long and 10.5 ft. high. The floor and ceiling are initially assumed to be poured concrete. The walls will be painted concrete masonry units (c.m.u.). The effect of a 3 ft. x 7 ft. door will be negligible in this instance and will be omitted from the calculation. Assume 0.38 caliber handguns with 110 grain magnum loads will be used.

STEP 1. Calculate the room constant (R) of the Firing Range in each octave band.

An inventory of the materials used in the room and the area of each interior surface is needed for this calculation.

Ceiling	95 ft. x 26 ft. =		**2470 sq. ft.**
Floor	95 ft. x 26 ft. =		**2470 sq. ft.**
Walls	2 X (95 ft. x 10.5 ft.) =	1995 sq. ft.	
	2 x (26 ft. x 10.5 ft.) =	546 sq. ft.	
	Subtotal Wall Area		**2541 sq. ft.**

Next, the absorption coefficients of the room surface materials in each octave band are found from a reference book such as *Architectural Acoustics* by M. David Egan. Then the surface area of each surface is multiplied by the absorption coefficient as shown in the table below. The tables shown below are print outs of a spreadsheet developed by the researcher to perform these repetitive calculations on Lotus 1-2-3. Table 9 simply lists the wall surfaces, their respective surface areas and the octave band absorption coefficients for each material.

TABLE 9
Tabulation of Absorption Coefficients and Surface Areas of Building Materials used in the Firing Range in Example 1

		Octave Band Center Frequency					
Surface	Area	α_{125}	α_{250}	α_{500}	α_{1000}	α_{2000}	α_{4000}
Ceiling (concrete)	2470	0.01	0.01	0.02	0.02	0.02	0.02
Floor (concrete)	2470	0.01	0.01	0.02	0.02	0.02	0.02
Walls (painted c.m.u.)	2541	0.10	0.05	0.06	0.07	0.09	0.08
People (per person)	7	2.00	3.00	4.00	5.00	5.00	4.00
Air (per 100 cu. ft.)	26	0.09	0.20	0.49	1.20	2.90	7.40

In Table 10, the surface area of each material was multiplied by its absorption coefficient to yield the sound absorption (expressed in sabins or sq. ft. of absorption). The room constant (R) is the total at the bottom of each column. There is a different room constant for each octave band.

TABLE 10
Tabulation of the Room Constants for the Firing Range in Example 1

Surface	Octave Band Center Frequency					
	$S\alpha_{125}$	$S\alpha_{250}$	$S\alpha_{500}$	$S\alpha_{1000}$	$S\alpha_{2000}$	$S\alpha_{4000}$
Ceiling (concrete)	25	25	37	49	49	49
Floor (concrete)	25	25	37	49	49	49
Walls (painted c.m.u.)	254	127	152	178	229	203
People (per person)	14	21	28	35	35	28
Air (per 100 cu. ft.)	2	5	13	31	75	192
Totals (room constants)	**320**	**203**	**267**	**343**	**438**	**522**

STEP 2. Calculate the sound pressure level at the floor of the range 10 ft. behind the firing line.

The next table in the sequence tabulates the calculations from formula (1) above. The sound pressure levels in each octave band for the weapon of interest are chosen. The measurement location is noted. The distance term (DT_1) for this distance is found on figure 9. The distance from the shooter to the point of interest (adjacent to the floor) is noted. The distance term (DT_2) to this location is found on figure 9. The two distance terms are combined with the original sound pressure level (Lp_{D1}) to find the sound pressure level at the point of interest.

Line 1. In this case, the weapons were 0.38 handguns with 110 grain magnum loads. The data in Table 8 was measured at the ear of the shooter. This would be approximately 3 ft. from the gun. This term is Lp_{D1}.

Line 2. Assume that no more than 2 guns will fire simultaneously. A term of 10 log(number of simultaneous sources) is **added** to the original levels.

Line 3. The distance term (DT_1) from the original measurement position to the gun is read from figure 9. The distance used is 3 ft. The room constants in each octave were calculated in Step 1. above.

Line 4. The distance term (DT_2) is read from figure 9. The distance used is 13 ft. This includes the 3 ft. from the gun to the firing line and the 10 ft. behind the firing line to the point of interest. The room constants calculated in Step 1. above in each octave band are used again.

Line 5. The total sound level in each octave band is calculated using formula (1) above. This is Lp_{D2}.

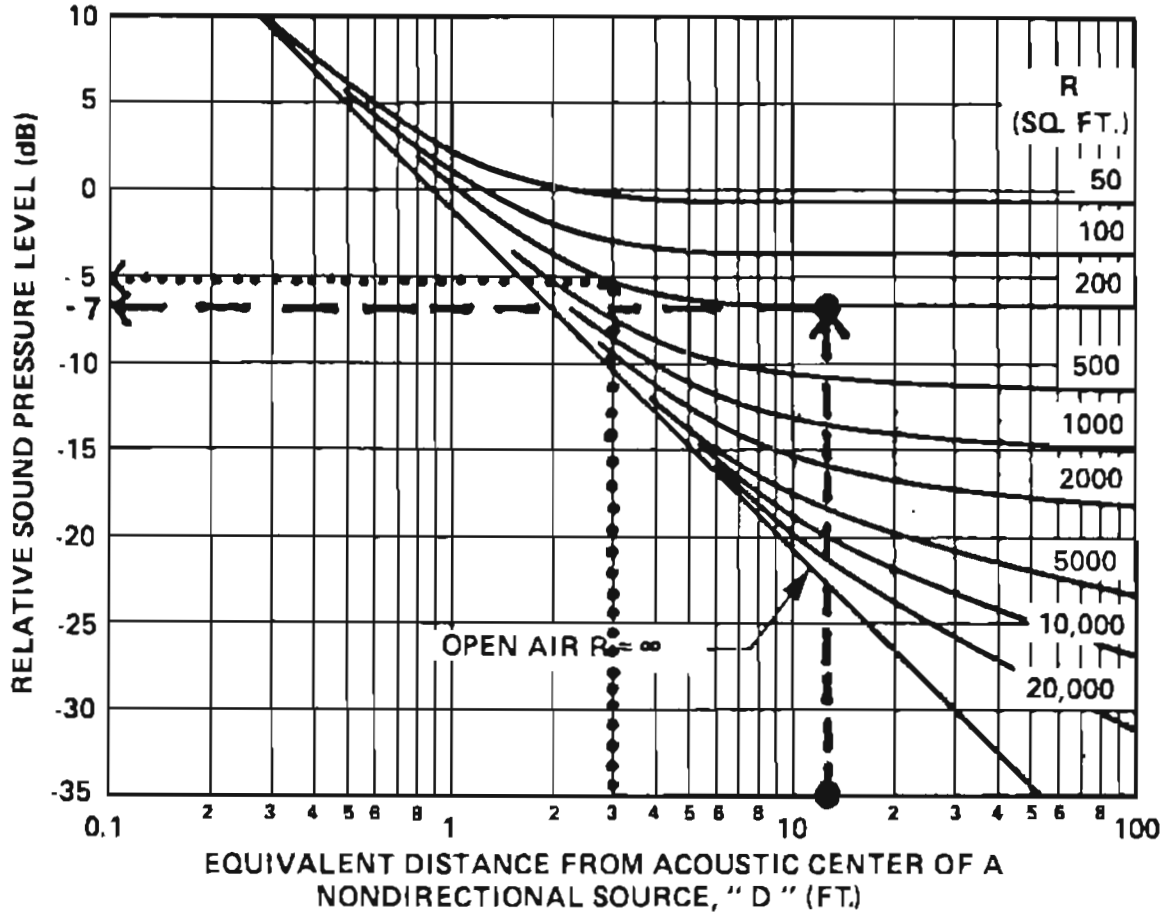


Figure 9. Values for the Distance Terms (DT_1 and DT_2) are presented for different values of the room constant (R) and distance (D). Using the estimate of the room constant in the 250 Hz. octave band calculated in Table 10 above, DT_1 at 3 ft. and DT_2 at 13 ft. are found (Miller, 1981, p.4-9).

TABLE 11
Tabulation of Formula (1) to Determine the Peak Sound Pressure Levels
10 ft. Behind the Firing Line in Example 1

	Octave band center frequency					
	125	250	500	1000	2000	4000
Noise level of guns (read from Table 8)	140	155	152	157	159	153
Effects of multiple sources (10 log 2)	+3	+3	+3	+3	+3	+3
DT_1 at 3 ft.	+6	+5	+6	+7	+7	+8
DT_2 at 13 ft.	-8	-7	-7	-8	-9	-10
Total sound level at floor (Lp_{D2})	**141**	**156**	**154**	**159**	**160**	**154**

THE USE OF SOUND ABSORBENT MATERIALS

Sound absorbent materials reduce the build-up of noise in a room due to repeated reflections from the room surfaces. The sound waves are absorbed rather than reflected. The acoustical effect of adding sound absorbent materials to a room can be estimated using formula (4) below. The amount of noise reduction in dB is calculated by taking 10 log of the room constant after the sound absorbent material has been added to the room divided by the room constant before the sound absorbent material was added to the room.

$$NR = 10 \log \frac{A_2}{A_1} \qquad (4)$$

where: NR = the noise reduction achieved by adding absorbent material to the room
A_2 = the room constant in a given octave band calculated after the sound absorbent material has been added to the room.
A1 = the room constant in the same octave band calculated before the sound absorbent material has been added to the room.

EXAMPLE 2. Consider the area behind the firing line in the range described in Example 1 as a separate room. Given the extent of the dividers that are typically used between firing positions, this assumption is fairly correct. The room is 26 ft. wide, 12 ft. deep and 10.5 ft. tall. To begin with assume that the two side walls and the rear wall of the range are built of concrete masonry units (c.m.u.). There is a 4 ft. by 10 ft. viewing window on the rear wall of the range. As in Example 1, the effect of the door will be neglected in this calculation.

STEP 1. **Estimate the room constant of the room before adding absorbent materials to it.**

First, the surface areas of each material must be calculated.

Ceiling		26 ft. x 12.0 ft. =			**312 sq. ft.**
Floor		26 ft. x 12.0 ft. =			**312 sq. ft.**
Walls	(side)	12 ft. x 10.5 ft. x 2 =		252 sq. ft.	
	(rear)	26 ft. x 10.5 ft =	273 sq. ft.		
Glass		10 ft. x 4.0 ft. =	40 sq. ft.		**40 sq.ft.**
	Net rear wall		233 sq. ft.	233 sq. ft.	
Subtotal wall area				485 sq. ft.	**485 sq. ft.**
Dividers at firing line					**280 sq. ft.**

Next, a spread sheet is constructed similar to the one used in Example 1. This is shown in Appendix 4. The existing room constants in each octave band are calculated. Notice that the effect of the shooters has been included in the calculation.

STEP 2. **Estimate the room constant of the room after adding the absorbent materials to the room.** The noise reduction will be estimated for adding an acoustical tile ceiling to the room, carpet on the floor and slotted concrete masonry units for the wall surfaces. A spread sheet is copied with the additional information added to it and the absorption coefficients of the new materials added.

STEP 3. **The noise reduction is calculated in each octave band using formula (4).** The room constant after the absorption has been added in each octave band is divided by the room constant in the same octave band before the sound absorbent material was added. Multiplying the logarithm of this number by 10 will yield the noise reduction stated in decibels.

In general a reduction in noise of 5-6 dB would be perceived by most people as being quieter. A reduction of 10 dB would be perceived as being one half as loud as the original condition. This is very difficult to achieve in actual buildings. A noise reduction of 2-3 dB would be barely noticeable to most people. In this case, the added absorption would result in 3-7 dB noise reductions.

BACKGROUND OR AMBIENT NOISE LEVELS IN ROOMS

The background or ambient noise levels in rooms are usually described by Noise Criteria (NC) Curves. The NC curves present octave band spectra of sound pressure levels that provide a satisfactory ambient sound to people. The shape of the curves reflects that higher noise levels can be tolerated or are viewed as acceptable in the lower octave bands. This is due to the fact that the human ear is less sensitive to these frequencies. Unfortunately, the NC curves and the associated research pertain to steady noises such as the noise produced by an air-conditioning system. Table 12 below lists typical NC targets for different activities.

TABLE 12

Typical NC Targets Used for Different Activities (ASHRAE, 1987)

Activity	TARGET NC
Executive office	25 - 30
Private office	30 - 35
Computer equipment rooms	40 - 45
Public circulation	40 - 45

Extreme caution must be used in describing background noise created by impulses such as gunshots in terms of equivalent noise criteria. Future research is needed to quantitatively define the background noise levels produced by gunshots. **A general rule-of-thumb is to use a target NC curve that is 5 points less than the NC curve typically used for a given activity to account for the effect of impulses.**

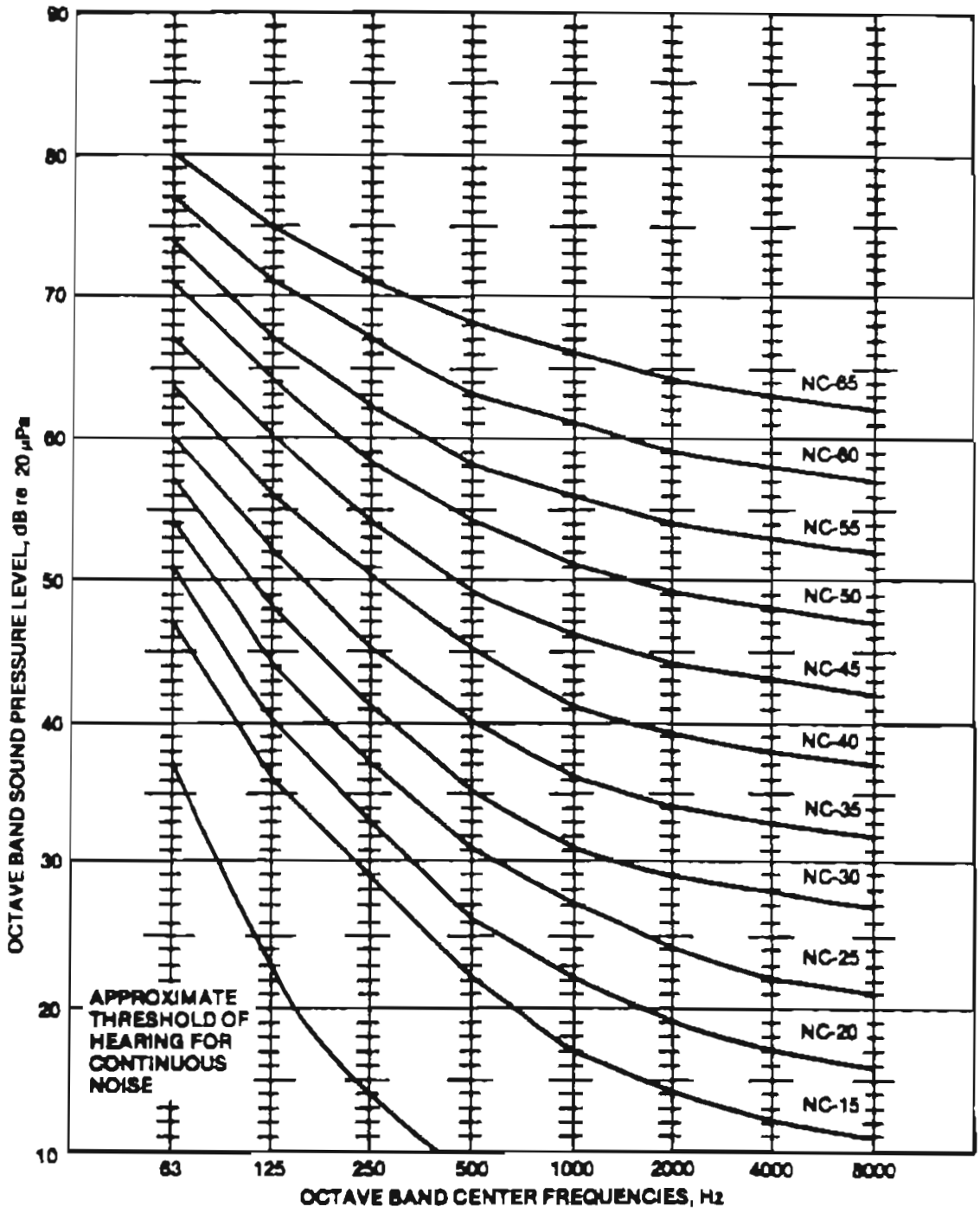


Figure 10. Noise Criteria (NC) curves for specifying the background noise levels in rooms (ASHRAE, 1987; p. 52.3)

SOUND TRANSMISSION LOSS

The walls, floor and ceiling of the firing ranges attenuate some of the sound that moves through them to adjacent rooms or to the exterior. Sound transmission loss refers to how much sound energy (expressed in dB) is lost or attenuated as it passes through the walls, floor and ceiling of the room. Sound transmission loss is also calculated on an octave band basis. Data for typical construction assemblies can be found in many references (such as Egan, 1988; or Miller, 1982). Manufacturers of building materials also have sound transmission loss test reports on their products.

The sound transmitted through the walls, floor and ceiling of the room is estimated by the formula listed below.

$$Lp_R = Lp_S - TL - 10 \log (a_2/s) \qquad (5)$$

where: Lp_S = the sound pressure level (in dB) in the (adjacent) receiving room.
Lp_S = the sound pressure level (in dB) in the firing range (Lp_{D2}) calculated above.
TL = the transmission loss of the construction between the two rooms.
a_2 = the absorption in the receiving room calculated as the room constant (R) described above.
S = surface area of the wall, floor as ceiling between the room.

It is not sufficient to use single number sound transmission class (STC) data in situations involving gunshots. Transmission loss data for the extensive construction required between a firing range and a room such as an office on a floor below that should be relatively quiet is not readily available. A qualified acoustical consultant should be contacted to make recommendations in situations with these requirements.

EXAMPLE 3. Estimate the sound transmission loss of a floor/ceiling system needed between a firing range and a computer equipment room located immediately below. The computer equipment room is 252 sq. ft. with 8 ft. high walls. The walls are made of gypsum board. The ceiling is acoustical tile and the floor is carpeted. The area of the floor between the range and the office is 252 sq. ft.

STEP 1. A spread sheet is constructed to calculate the room constant of the receiving room (the computer equipment room). This process is identical to that described in Examples 1 and 2 above. The areas of the walls, floor and ceiling are tabulated. Then the absorption coefficients for each of the materials are found in reference books. This calculation is included in Table 13 below.

TABLE 13
Tabulation of Surface Areas and Absorption Coefficients for the Computer Equipment Room in Example 3

		Octave Band Center Frequency					
Surface	Area	α_{125}	α_{250}	α_{500}	α_{1000}	α_{2000}	α_{4000}
Ceiling (acoustical tile)	252	0.58	0.59	0.69	0.86	0.84	0.75
Floor (carpet)	252	0.02	0.06	0.14	0.37	0.60	0.65
Walls (gypsum board)	512	0.29	0.10	0.05	0.04	0.07	0.09

TABLE 14
Tabulation of the Room Constants for the Computer Equipment Room in Example 3

Surface	Octave Band Center Frequency					
	$S\alpha_{125}$	$S\alpha_{250}$	$S\alpha_{500}$	$S\alpha_{1000}$	$S\alpha_{2000}$	$S\alpha_{4000}$
Ceiling (acoustical tile)	146	149	174	217	212	189
Floor (carpet)	5	15	35	93	151	164
Walls (gypsum board)	148	51	26	20	36	46
Totals (Room constants)	**300**	**215**	**235**	**330**	**399**	**351**

STEP 2. The octave band spectrum for the noise source is found from Example 1 above.

STEP 3. The desired NC level is selected for the activity in the receiving room. In this case, NC 40 was selected as 5 points below the NC 45 that would have been selected for a computer equipment room with a steady intruding noise.

STEP 4. The NC level for the room and 10 log a2/S are subtracted from the octave band levels of the noise source to yield the required transmission loss of the floor/ceiling between the firing range and the computer equipment room.

TABLE 15
Tabulation of Transmission Loss Required in the Floor/Ceiling Construction in Example 3

Item	Octave Band Center Frequency					
	125 Hz.	250 hz.	500 Hz.	1000 Hz.	2000 Hz.	4000 Hz.
Gun	141	156	154	159	160	154
NC 40	56	50	45	41	39	37
10 log a_2/S	1	-1	-1	1	2	2
Required TL	**84**	**107**	**109**	**117**	**119**	**114**

The values for the required transmission loss can be compared to values for typical construction assemblies in a reference book (such as (Egan, 1987); or (Miller, 1982)) or to manufacturers' data on specific products. The high transmission loss required in this circumstance is extremely difficult to achieve. The best answer in this situation is to locate the firing range as far as possible from any sensitive activities. Examples of the elaborate constructions used when firing ranges are located within buildings containing other activities are included in the section on Case Studies of Existing Indoor Firing Ranges.

CASE STUDIES OF EXISTING INDOOR FIRING RANGES

Case studies for several indoor firing ranges are presented below. The information was gathered from two sources. The researchers made site visits to two of the ranges to gather information and to perform field measurements. Several of the consultants who had experience in the design of indoor firing ranges shared their measurements and design strategies with the researchers.

CASE STUDY 1
MIAMI BEACH POLICE STATION
Miami Beach, Florida

Bertram Y. Kinzey, Jr.
Consultant in Architectural Acoustics

Sound level measurements were made at the indoor firing range of the Miami Beach Police Department. The range is located on the fifth floor (top floor) of the building. The fire arm used primarily at the range is a .38 caliber revolver with .38 P+ special ammunition. A shot gun is also used occasionally. The sound level of the .38 caliber revolver was measured at a position about five feet behind the firing line. Three shooters were firing but not simultaneously. The measuring position relative to two of the shooters would correspond to position 3 of the previous outdoor measurements (refer to figure 6). The highest level recorded by the sound level meter during the measurement period was 148 dB. This agrees well with the level measured for the .38 revolver outdoors. The level of the shot gun was measured five feet directly behind the person firing the gun. The level measured was 152 dB. This agrees with the data reported by Weissler (1974).

A diagram of the 5th floor of the police department is shown in figure 11 with approximate sound levels measured in adjacent rooms noted on the drawing. The air conditioning system that is turned on when the firing range is in use creates a background noise level of 105 dB in the firing range, the viewing room behind the range and in the vestibule between the firing range and the viewing room. A powerful air conditioning system is needed to remove the lead particles from the air. Persons exposed to just this noise should wear ear protection to prevent permanent hearing loss (Suter, 1989).

When the .38 revolvers were fired the peak Lp measured two feet behind the glass in the viewing room was 108 dB. Since this is just 3 dB above the background level, the transmitted sound pressure level of the pistols is 105 dB. This is a reduction of 43 dB between the firing range and the viewing room. The reduction is provided by the construction which includes a window, the wall itself, and a vestibule which provides two doors between the range and viewing room.

The two doors are solid core with continuous gaskets along the head, jambs and sill. The window is made of double glazing in a hollow metal frame. The wall is 8" concrete block with acoustical isolation pads and angle brackets with sponge pads at the connections with the ceiling and floor. Air conditioning ducts completely cover the wall on the firing range side.

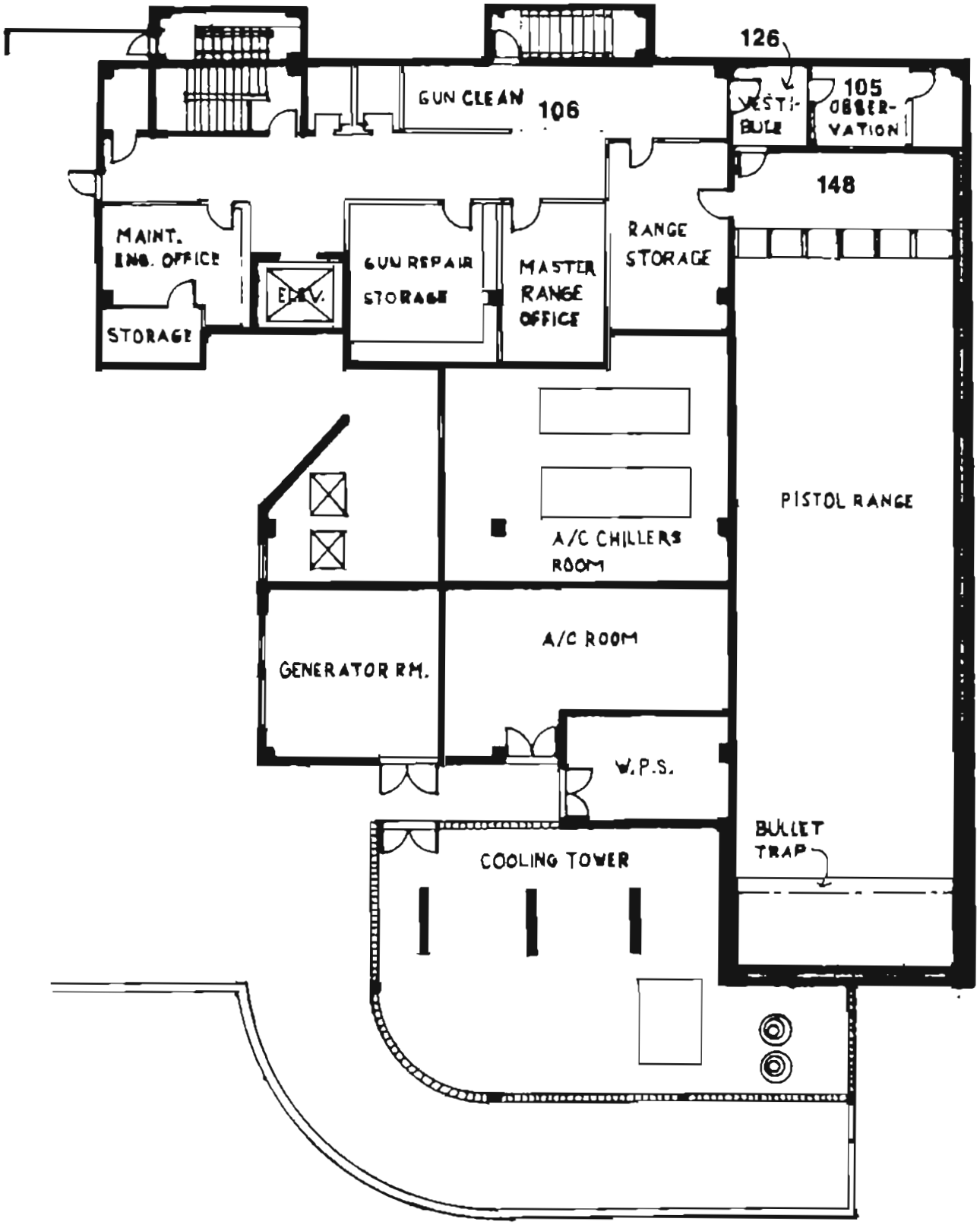


Figure 11. Floor plan of the fifth floor of the Miami Beach Police Department showing the firing range. Noise levels measured in adjacent areas are also noted on the plan.

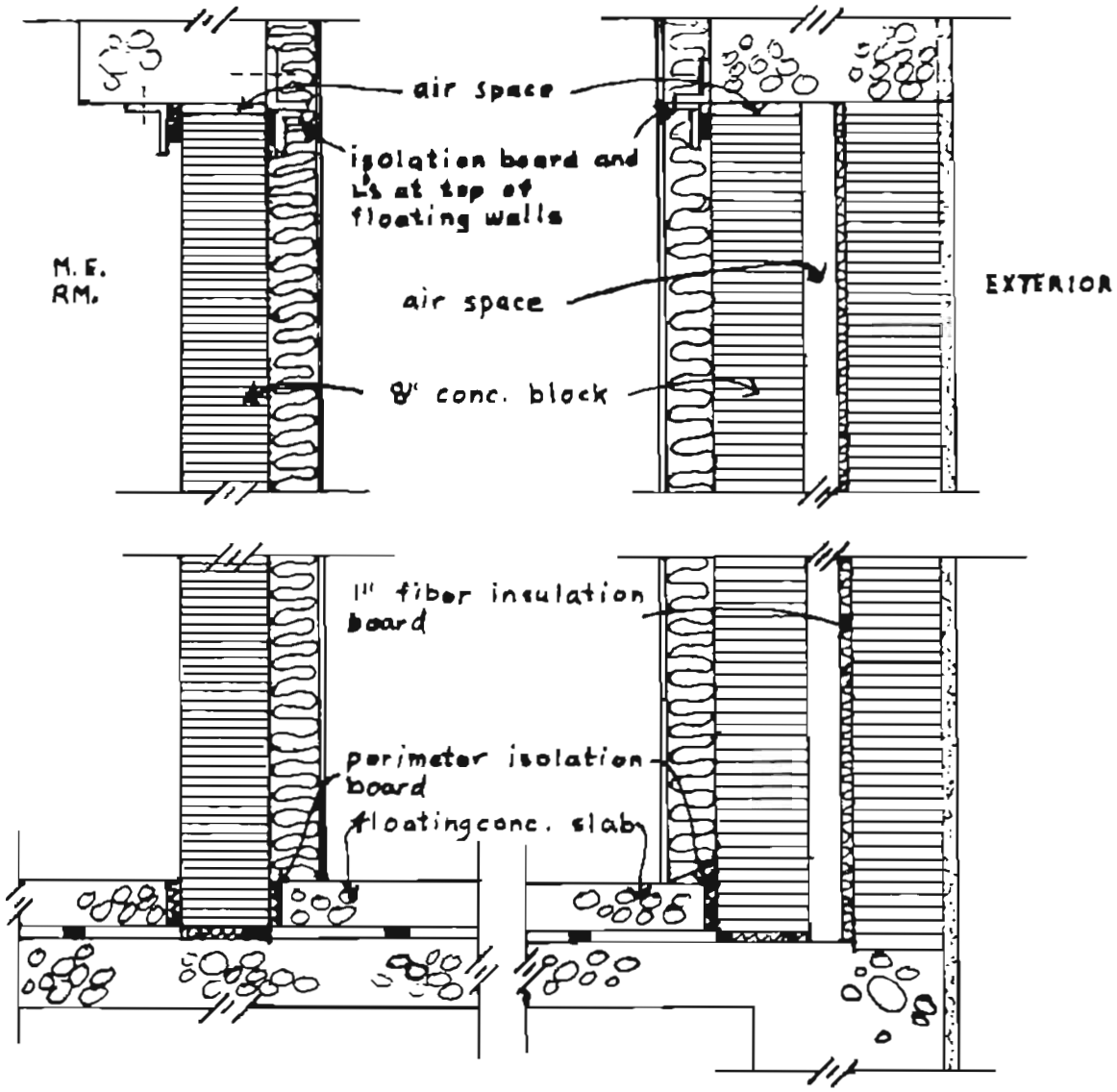


Figure 12. Wall section used in the indoor firing range at the Miami Beach Police Department.

The sound pressure level in the vestibule when the pistols were fired was 126 dB. Therefore, the door between the vestibule and the firing range reduced the sound pressure level by 18 dB. The background level in the corridor five feet from the vestibule door was 98 dB. The highest level measured when the guns were fired was 106 dB.

On the roof above the range the noise from the guns was inaudible due to the noise of the air conditioning systems. This varied from 98 dB to 104 dB. The sound from the guns was also inaudible on the ground outside the building.

The range has six firing positions. It is enclosed by concrete block walls. The walls shown as a double line in the diagram of Figure 11 (with the exception of the end wall) are constructed of

two layers of eight inch concrete block separated by a four inch air space and one layer of one inch fiberglass insulation board attached to the inside surface of one of the layers of concrete block. Three and one half inch blanket insulation is attached to the inside wall and it is covered with metal paneling. Acoustic isolation pads, angles with sponge pads, and air spaces are used to isolate the walls acoustically from the floor and ceiling. (The end wall is the same except that the inside layer is four inch concrete block rather than eight inch block and it is not covered by blanket insulation or metal paneling.)

The floor is a four inch floating concrete slab with a one inch air space between it and another four inch concrete slab. Isolation fiberboard covered with sealant separates the floating slab from the walls. The ceiling is a concrete slab supported by concrete beams. It is covered with three inch insulation board. An acoustical ceiling is provided over the firing area, the vestibule, and the viewing room.

On the fourth floor beneath the shooting end of the firing range there are rooms of computer equipment. People are not normally in these rooms. The guns could not be heard above the background noise of the machines. Beneath the other end of the range, where the bullets are trapped, there is office space. In this area the guns could be heard but the level was several dB less than that of normal conversation. The people who worked in these offices expressed some annoyance with the gunshots even though the measured sound levels were below the levels measured while people were talking in the room.

The main conclusion that can be drawn from the Miami Beach Police firing range analysis is that it is best to separate the range from occupied spaces with unoccupied spaces. The unoccupied spaces could be used for storage, HVAC, or other mechanical or electrical equipment. Persons directly involved with the functioning of the range may not object to hearing the guns and could occupy adjacent spaces if the sound is reduced to a safe level. A safe level of 85 dB or less was not achieved in the rooms directly adjacent to the range at Miami Beach but was achieved on the fourth floor through the use of the floating concrete slab.

CASE STUDY 2
FLETC FIRING RANGE
Brunswick, Georgia

The Federal Law Enforcement Training Center at Brunswick, Georgia has a dedicated firing range building. There are centrally-located offices for staff and instructors, locker rooms and classrooms organized along a central corridor. Each firing range has its own classroom, powder room and control room. The ranges where measurements were performed were designed for twelve firing positions. The building is constructed with slotted concrete blocks on the interior surfaces, an air space and precast concrete panels on the exterior. The building has a slab-on-grade floor and a concrete roof deck. The slotted concrete blocks (such as Soundblox manufactured by the Proudfoot Co.) provide both sound absorption in the ranges themselves to reduce the build-up of reverberant noise levels and reasonable sound transmission loss to prevent the transmission of noise to the exterior or to adjacent rooms.

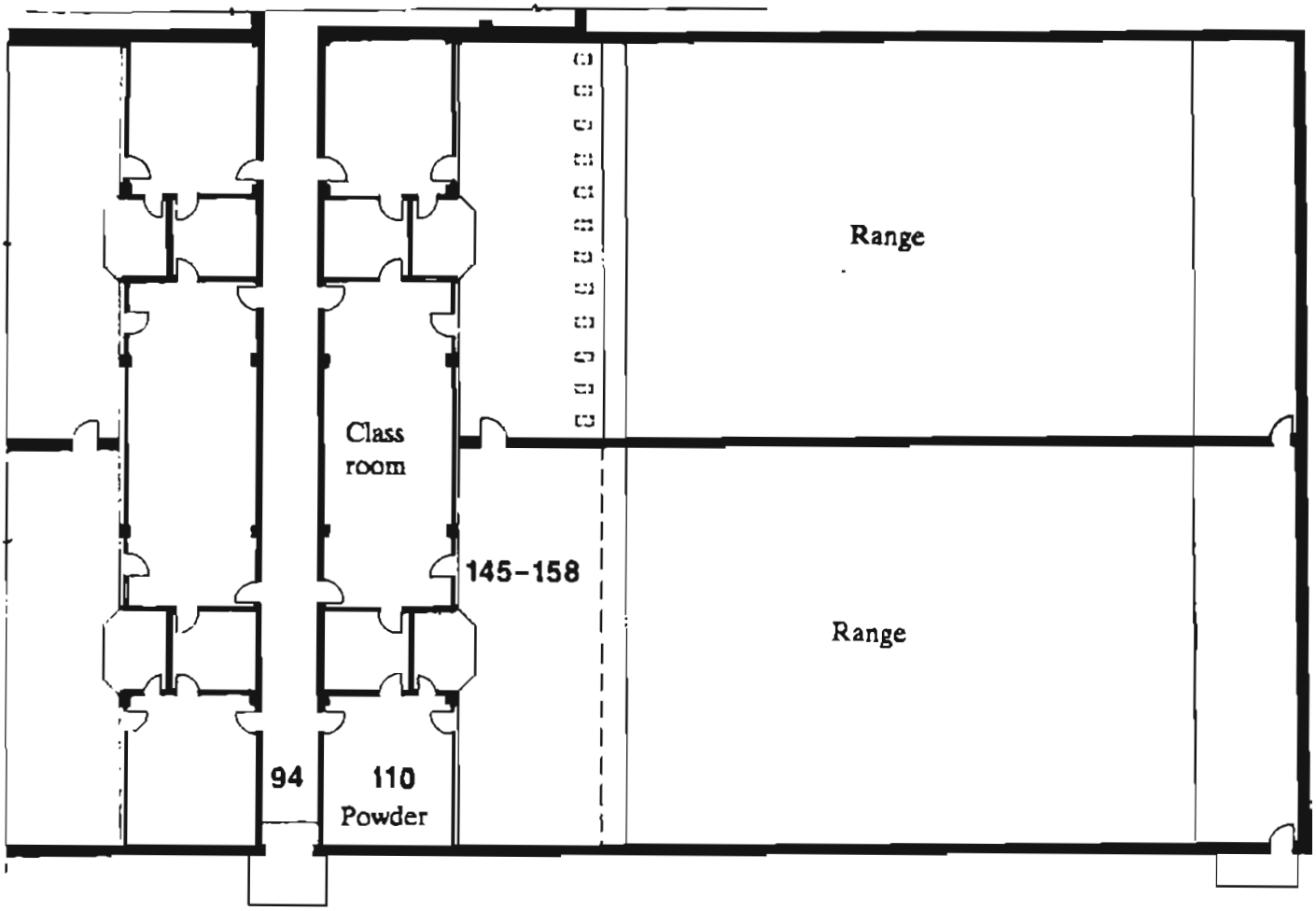


Figure 13. Floor plan of the indoor firing ranges at the Federal Law Enforcement Training Center in Brunswick, Georgia. This is a partial plan of the facility. There is a central lobby and offices located at the top of this drawing. There are also additional ranges after the lobby similar to those shown.

The floor plan of one-half of the building shown in figure 13 has approximate sound levels measured at various points in the building while one of the ranges was being used shown on it. The effects of the single doors are clearly evident here. The concrete masonry walls have a STC of approximately 45. The solid core, gasketed doors have an STC of approximately 25-28. The noise levels in the powder rooms and the corridors are clearly a result of noise transmitted through the doors as opposed to the concrete masonry walls themselves.



Figure 14. Interior photograph of the area behind the firing line at the Federal Law Enforcement Training Center in Brunswick, Georgia. Notice the acoustical tile ceiling, the carpeted floor and the slotted concrete blocks on the walls. These are all sound absorbent surface that reduce the build-up of sound in the room. The partitions between the shooters' positions are absorbent as well.

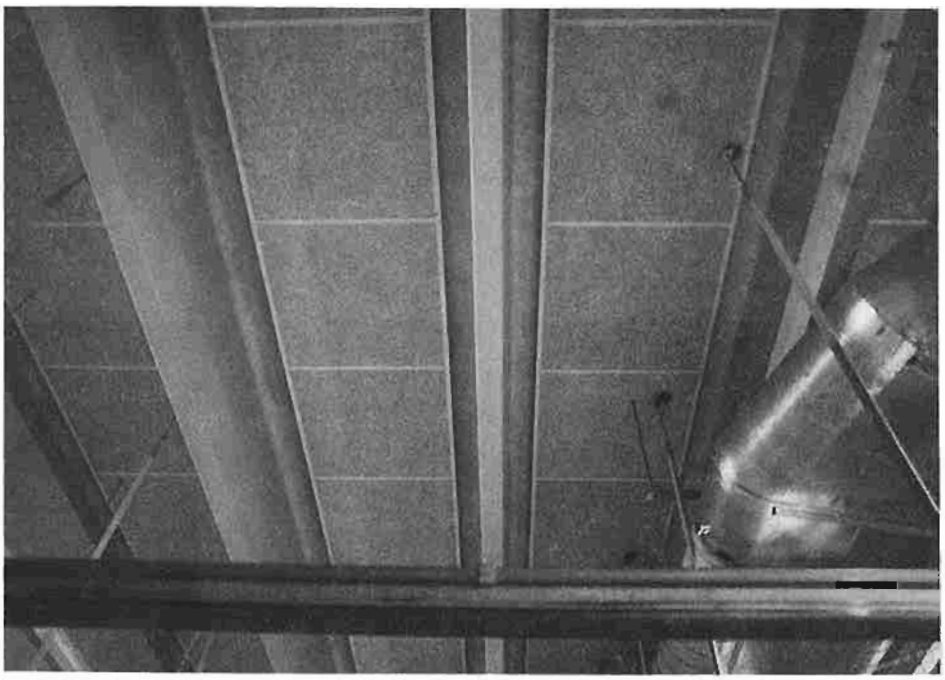


Figure 15. Photograph of the sound absorbing panels located on the ceiling of the firing range behind the metal bullet deflector panels.

CASE STUDY 3
FORSYTHE RANGE
Cleveland, Ohio

Campenella Associates
Consultants in Acoustics

This firing range is a two-story building . The upper story houses the HVAC units, storage and the retail/reception area. The lower level houses the firing range. The firing range is located below grade as shown in figure 16 with concrete masonry walls backed with soil and a sound absorbing interior finish. The floor and ceiling are a concrete slab. Campenella stated in the survey that the ranges were located below grade to avoid the community noise problems that had plagued another local range. He also stated that "community noise is by far the major consideration in the design of indoor firing ranges. Improper facade treatment will void the use of the structure for gun firing purposes".

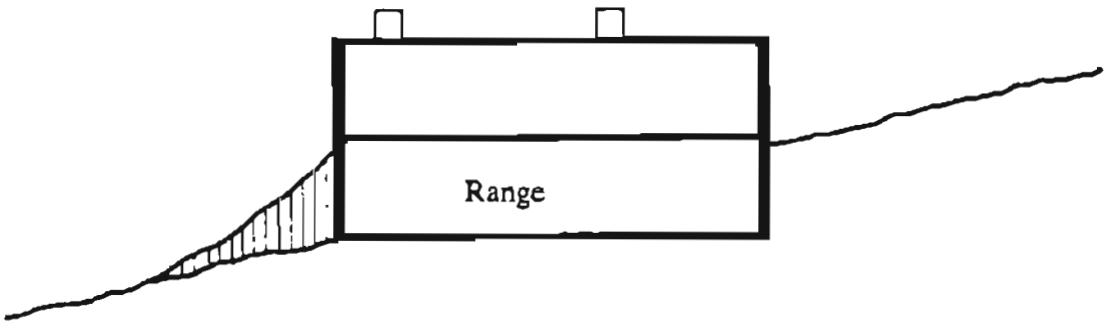


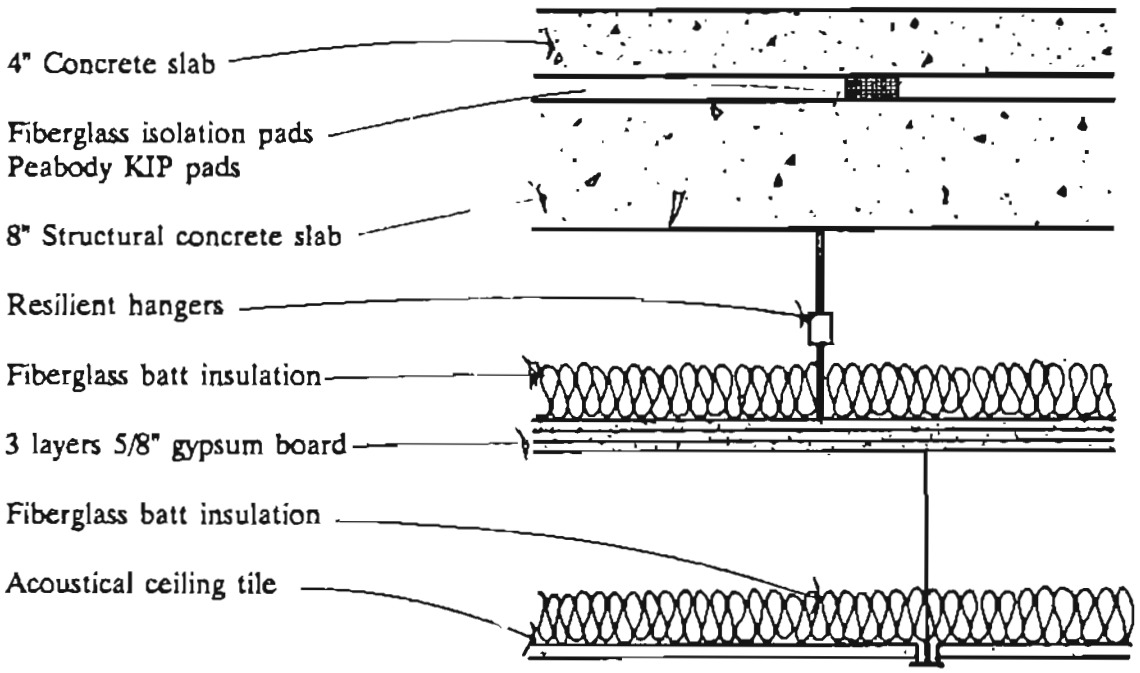
Figure 16. Schematic diagram of the Forsythe Firing Range. The range is located on the bottom floor. A berm has been constructed on the lower side. The upper side was below existing grade. Therefore, the entire range uses the earth to attenuate the loud sounds so they will not annoy adjacent neighbors. The reception area, store and air-conditioning equipment are located on the upper level.

CASE STUDY 4
INDOOR FIRING RANGE
G.S.A. BUILDING
Oakland, California

Paoletti/Lewitz Associates
Consultants in Acoustics

Earl Mullins of Paoletti/Lewitz Associates reported on a firing range with eight firing positions placed below a rooftop penthouse and above open plan offices in the G.S.A. building. The floor/ceiling assemblies consisted of a four inch floating concrete slab above an air space separating it from an eight inch slab. Three layers of 5/8 inch gypsum board and insulation were hung from the eight inch slab by resilient hangers. A lay-in ceiling with acoustical tile and insulation was suspended from the gypsum board. This assembly (as shown in figure 17) was designed to provide a noise criteria of 35 in the offices below. The walls were constructed with 4 layers of gypsum board and a 1/4" thick steel plate on one side and 3 layers of gypsum board on the other side of a large (18") air space with three layers of sound absorbing batts in the cavity (refer to figure 18). Solid core wood doors with gaskets were used.

FIRING RANGE



OFFICE

Figure 17. Section through the floor/ceiling construction used in the G.S.A. Building between an indoor firing range and an office.

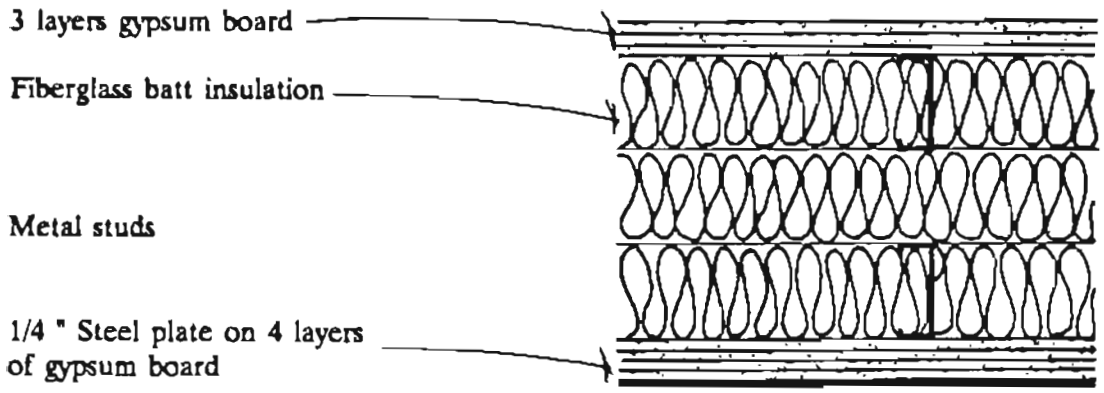


Figure 18. Wall section used at the G.S.A. Firing Range between the firing range and a room with NC-50 background noise level. The inside clear dimension of the wall is 18".

CASE STUDY 5
WARWICK POLICE DEPARTMENT
Warwick, Rhode Island

Cavanaugh-Tocci Associates
Consultants in Acoustics

This is a six position range located in the police station. The range was located in the basement with concrete walls and soil for the exterior construction is shown in figure 19.

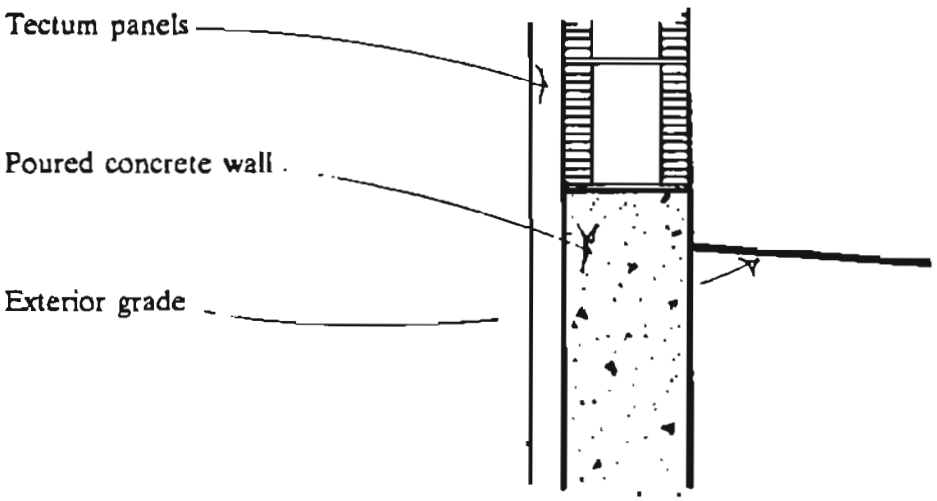


Figure 19. Wall section of construction used in the Warwick Police Department Firing Range.

CASE STUDY 6
WOBURN POLICE DEPARTMENT
Woburn, Massachusetts

Cavanaugh-Tocci Associates
Consultants in Acoustics

This is a 1320 sq. ft. range with five positions located within the police facility. The tectum panels used in the range are sound absorbent to help reduce the build-up of reverberant sound in the room. An acoustical tile ceiling was added over the area behind the firing line for this reason as well. The consultants tried to make the range as absorbent as possible given the constraints posed by the bullet deflectors and other necessary equipment.

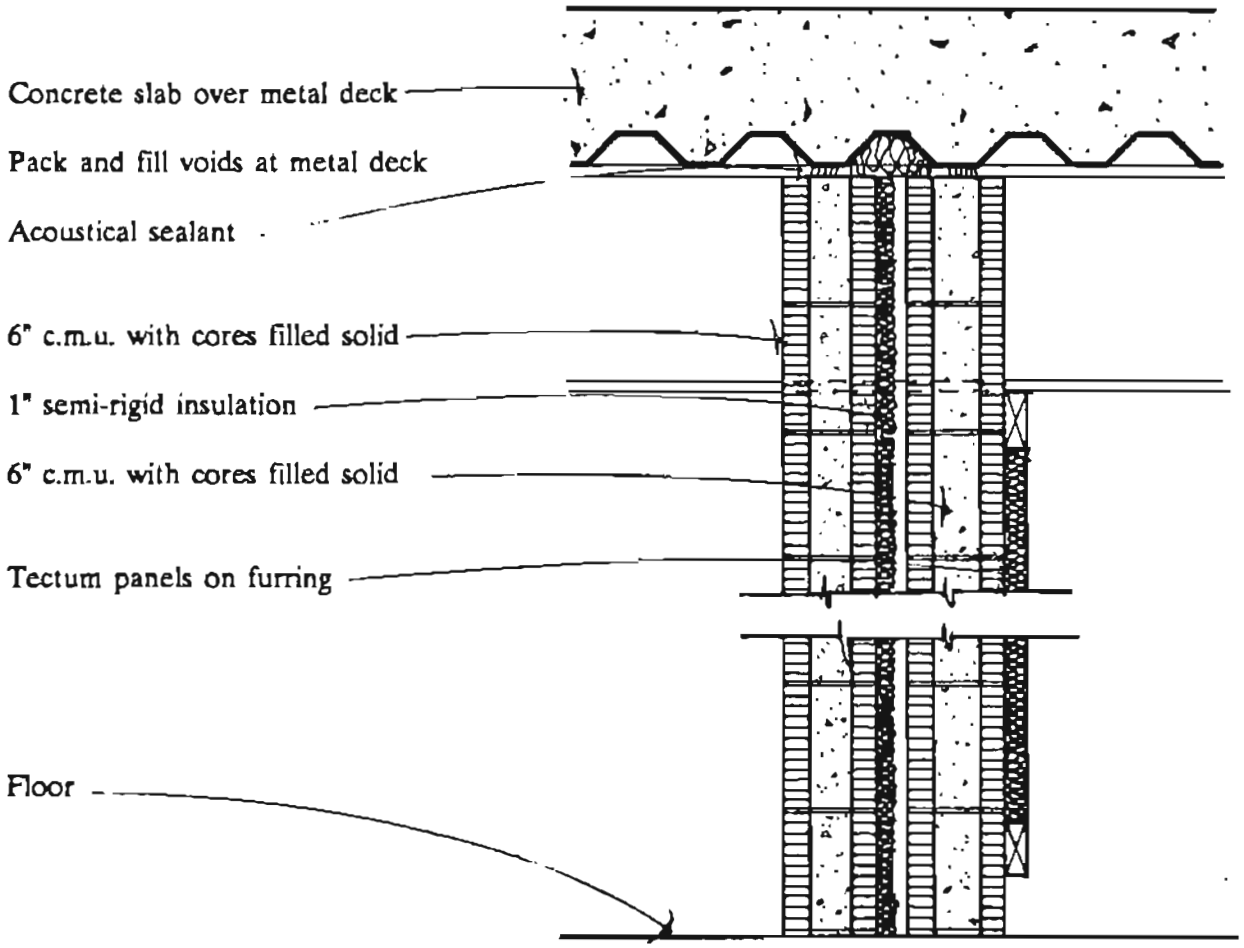


Figure 20. Wall section at the Woburn Police Department Firing Range.

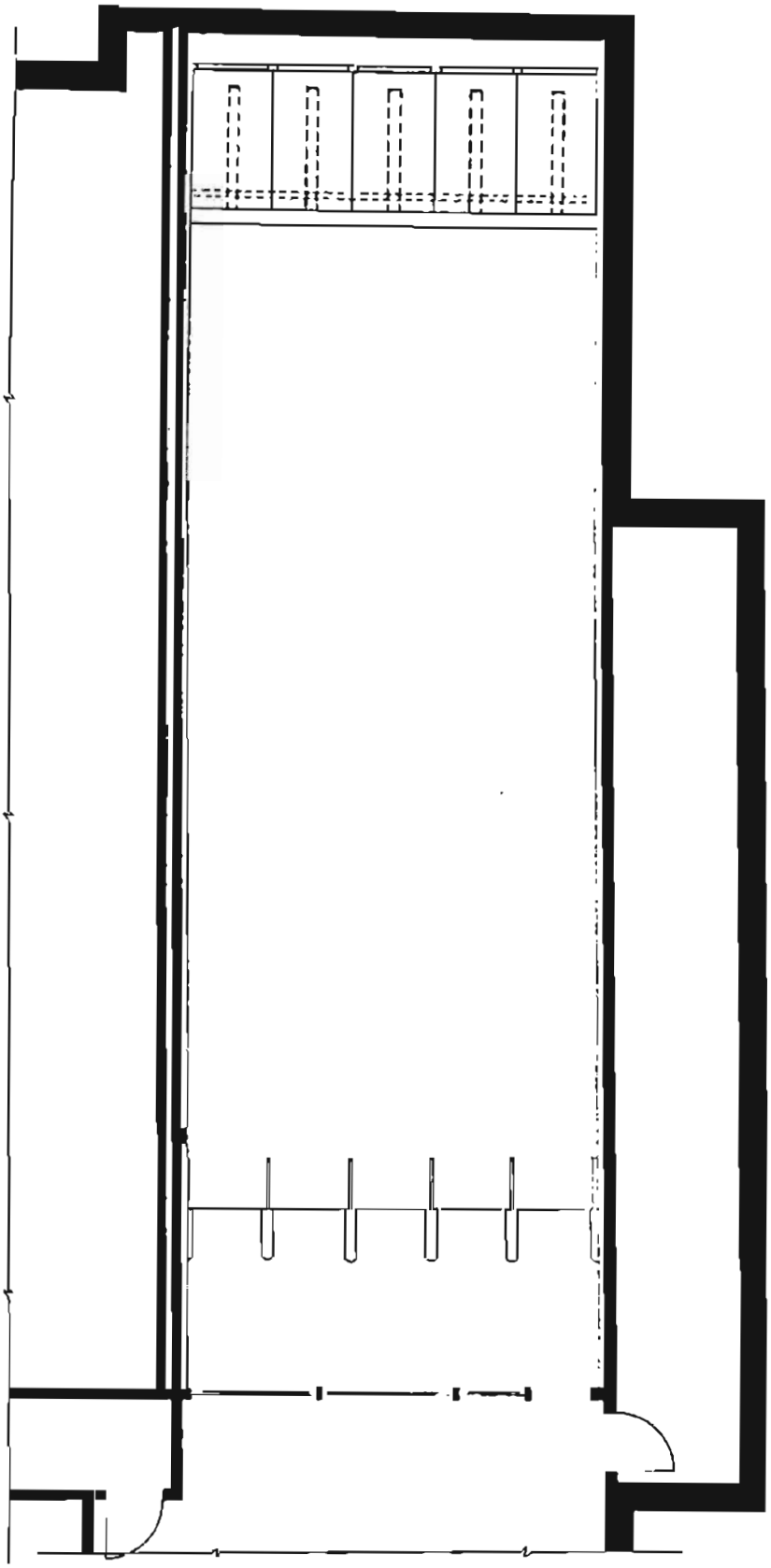


Figure 21. Floor plan of the Woburn Police Department Firing Range. Notice the double wall adjoining the interior spaces in the building (refer to figure 20 for a section of this wall).

CASE STUDY 7
F.D.L.E. FIRING RANGE
Tallahassee, Florida

Kinzey and Siebein
Consultants in Architectural Acoustics

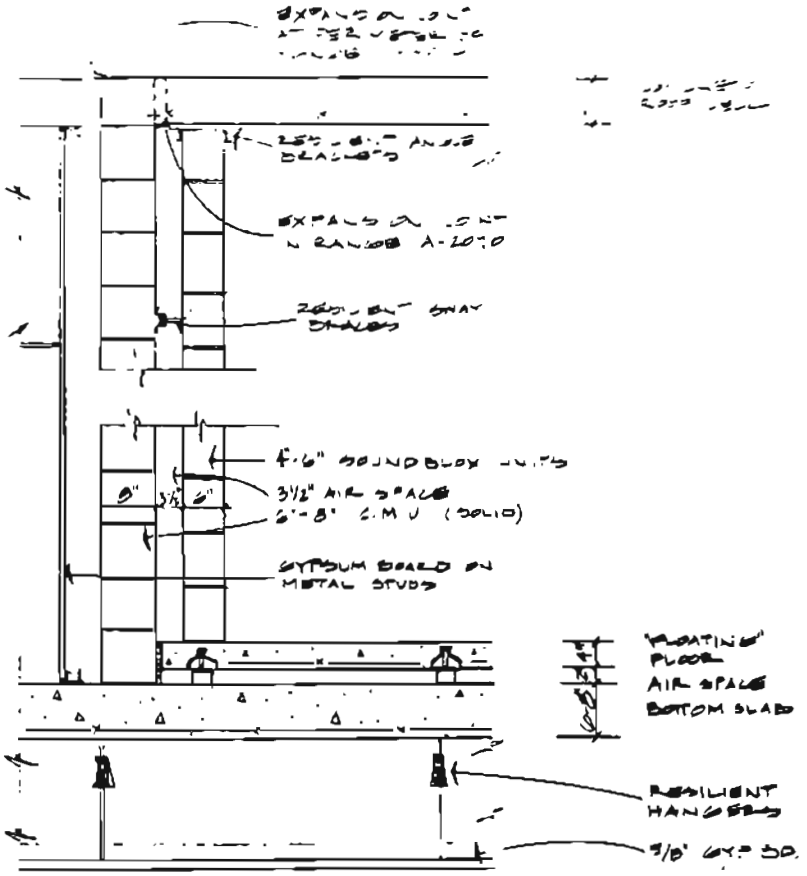


Figure 22. Wall section through the firing range at the Florida Department of Law Enforcement Building in Tallahassee, Florida.

The Florida Department of Law Enforcement Building in Tallahassee, Florida will have two firing ranges located within the building when it is completed. A six-position firing range will be located on the third floor and a test range for ballistics work will be located on the second floor. The six-position practice range was surrounded by walls and floor as shown in figure 22. A vestibule with gasketed, solid core doors was located between the range and the adjacent corridor. The corridor completely encircles the range. There are gasketed, solid core doors between this corridor and the adjacent parts of the building. There are also a second series of STC 50-55 walls between this corridor and the adjacent office spaces to minimize the transmission of sound through the building. Expansion joints were called for in the structural slab to further isolate the range from the rest of the building. Extensive construction is necessary when firing ranges must be located near office or other occupancies requiring acoustical privacy.

CONCLUSIONS

As metropolitan areas become more and more densely populated the acoustical requirements for indoor firing ranges will increase. It is important to construct the firing ranges in such a way that the noise produced is not transmitted to the surrounding environment. Otherwise, it is likely to cause extreme annoyance and a public outcry against the firing range. It is imperative that an acoustical consultant be involved at the earliest stages of the design in order to achieve the required sound isolation. It is hoped that the information in this report on the sound levels produced by various fire arms and the effect of the various types of construction used in the existing indoor firing ranges presented above will be helpful to those who will build new indoor firing ranges in the future.

Several topics for further research were identified during this study. They are listed below.

1. A statistical analysis of gunshots from different weapons and different numbers of shooters to determine more precisely design octave band spectra to be used to determine appropriate construction type used in buildings. Furthermore, it would be desirable to quantitatively determine the extent to which the fire from multiple weapons approaches a steady noise (as opposed to individual impulses).

2. Research on the annoyance caused by impulse noises (such as gunshots) to those in adjacent areas is necessary. It would be desirable to express this annoyance in some of the standard metrics that are used in the acoustics community already. Relating the noisiness of impulses to equivalent NC curves for use in building design or L_{DN} or other community noise descriptors would be helpful.

3. A study of the community noise problems encountered from gunshots transmitted through building facades is a state-of-the-art challenge according to one of the survey respondents and should be addressed.

4. Another survey respondent stated that research to study the applicability of using NC curves to describe background noises consisting of impulses is necessary as well.

5. Updating of this preliminary study with more detailed case studies of other firing ranges including relative cost information would be a valuable resource to those wishing to construct firing ranges in the future.

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APPENDIX 1

SURVEY SENT TO ACOUSTICAL CONSULTING FIRMS

NATIONAL RIFLE ASSOCIATION
GRADUATE RESEARCH FELLOWSHIP

AN ACOUSTICAL ANALYSIS OF EXISTING INDOOR FIRING RANGES

Please return the completed survey to:

Shirley Jin
Department of Architecture
231 ARCH
University of Florida
Gainesville, Florida 32611

Acoustical consulting firm: _____

Survey completed by: _____
(name) (title)

Please photocopy the survey sheets for additional facilities.

1. Do you wish to receive a copy of the results of this research? (A fee for duplication may be charged.)

   yes ( )
   no ( )

2. Please provide the name and address of the indoor firing range you have designed.

3. What is the size (square footage, number of stories) of the total facility?

4. What is the size of the firing range?

   less than 4 firing positions, specify number ( )
   4 to 6 positions ( )
   6 to 8 positions ( )
   8 to 10 positions ( )
   more than 10 positions, specify number ( )

5. What is the principal use of the firing range?

public recreational ( )
private recreational ( )
police ( )
military ( )

6. What gun types are used at the firing range?

rifles, specify ( )

handguns( )
9mm ( )
.38 cal. ( )
.44 cal. ( )
others, please specify

7. What is the configuration of the building? (Attachment of a floor plan and sections would be helpful to our study.)

8. What is the primary building material?

concrete masonry units ( )
brick masonry ( )
cast in place concrete ( )
pre-cast concrete ( )
gypsum on studs ( )
other, please identify ( )

9. Please sketch a typical wall assembly of the firing range. (Attach a separate sheet if desired.)

10. Please sketch a typical floor/ceiling assembly of the firing range if it is a two story facility. (Attach a separate sheet if desired.)

11. What architectural devices are used to isolate the firing range?

sound alcoves ( )
door types, please specify

door hardware, please specify

other, please specify

12. What type of air conditioning and ventilation equipment are used for the firing range?

13. What was the NC goal for the rooms surrounding the firing range?

20 ( )	40 ( )	other ( )
25 ( )	45 ( )	
30 ( )	50 ( )	
35 ( )	55 ( )	

14. What was the STC goal for the firing range wall?

20 ( )	40 ( )	60 ( )
25 ( )	45 ( )	65 ( )
30 ( )	50 ( )	70 ( )
35 ( )	55 ( )	other ( )

15. Were existing facilities studied in the design process of the new facility?

yes ( )
no ( )
If yes, which ones?

16. Were noise levels of guns measured in the design process?

yes ( )
no ( )

17. If so, is any data available?

yes ( )
no ( )
If yes, please send a copy if possible.

18. Have there been complaints by the occupants about the acoustics of the facility? If so, what type?

yes ( )
no ( )

19. Have you taken post-occupancy NC measurements in rooms adjacent to the firing range?

yes ( )
no ( )

20 ( )	40 ( )
25 ( )	45 ( )
30 ( )	50 ( )
35 ( )	55 ( )

20. Have you taken post-occupancy STC measurements of the firing range wall?

yes ( )
no ( )

20 ( )	40 ( )	60 ( )
25 ( )	45 ( )	65 ( )
30 ( )	50 ( )	70 ( )
35 ( )	55 ( )	75 ( )

21. Are there details or issues which are not addressed above which you would include in another facility of this type?

APPENDIX 2

DANGERS OF FLAMMABLE SOUND ABSORBENT MATERIALS

This document is a letter from George C. Leighton, Acoustical Consultant, published in the National Council of Acoustical Consultants newsletter.

LETTER TO THE EDITOR

The opinions expressed are those of the author and do not represent those of the National Council of Acoustical Consultants.

Dear Editor:

I am writing regarding my research on acoustical design of indoor firing ranges to inform you of the potential hazards associated with the use of flammable sound-absorbing material—specifically SONEX, manufacturing by Illbruck (a European firm) in Minneapolis.

SONEX is a convoluted polyurethene acoustical foam. Being a petrochemical product, it will burn when exposed to extreme heat or flame. When polyurethene foam burns, it emits dense, toxic, choking smoke. Phosgene, cyanide, and carbon monoxide gasses are reportedly some of the products of combustion. It should be noted that the convoluted surface exposes a very large surface area which helps promote combustion. Fire codes generally prohibit the use of foam in occupied spaces, and insurance companies regard this as a flammable wall for insurance purposes.

The SONEX brochure shows an indoor shooting range lined with "SONEX. The beautiful way to kill noise." It can also be a beautiful way to kill people. A local radio station reported that a recent fire in a "fireproof" Pasadena, California gun shop was traced by the Fire Marshall to the polyurethene foam lining in the basement shooting range — it was ignited by the muzzle blast from a gun. Four people died; another, a little girl, was terribly burned.

In its brochure, Illbruck has specifically marketed SONEX for use in indoor shooting ranges, test chambers, recording studios, computer rooms, and office walls. In the event of fire, this is a potentially lethal product, and this use should have been banned years ago. Should Illbruck be held criminally liable for advocating this use and for any death and injuries that may have resulted from such usage?

SONEX, like most polyurethane foam, is rated as UL 94 self-extinguishing. The important thing to note here, is that this is not a nonflammable foam; it is a self-extinguishing foam. As long as flame is held to the surface, it will continue to burn. After the flame is removed, it will self-extinguish in 30 seconds without flaming, dripping particles. Please note that Illbruck points out that these tests (UL 94) do not simulate actual field use conditions. In the field, a fire could start, for example, in a waste paper basket in a corner. The flames would spread up the wall, igniting the whole wall, which would continue in flames as long as the waste basket continued burning. An additional problem is that in a closed room, there is a heat build-up and when the plastics reach a high enough temperature, they will vaporize and flash with the common roll-over flame that is associated with aircraft cabin fires, where the whole interior is suddenly engulfed in flames.

The British recently discovered the extent of the problem with combustion particles from burning plastics. In their investigation of a Boeing 737 post-crash fire, they discovered that particle density was so great that visibility was immediately reduced to zero, making it impossible for passengers to find their way to the exits. They were also startled to discover that many victims died not from the fire, but from suffocation. Their breathing passages were totally blocked with soot particles!

Illbruck has recently introduced a new product, SONEX I, which is represented as essentially non-flammable. This should render it suitable for wall coverings, although I have not seen any approval for this purpose. As an interesting sidelight, if you will check the SONEX I brochure under "Breaking The Code," you will note that Illbruck introduces this as new material which can now be used in interior applications where previously foams could not be used. If you read it very carefully, you will note that this is a tacit admission that their original product should never have been advertised and sold for that purpose.

I have a deep personal interest in helping others avoid the horror of burning to death or, if surviving, having disfigurement and disabilities, both mental and physical. I crashed and burned in an aircraft, was trapped in the aircraft, engulfed in flames, fought my way out, clothes half burned off, over 50% second and third-degree burns, and had to go 2 1/2 miles through the wilderness to find my way to medical help. This was followed by 2 1/2 months in the burn center where I was given only a one-in-ten chance of survival, emerging as a basket case with an ensuing 3 1/2 years in surgery and therapy, totally disabled, to regain functional use of my body. I know first-hand that surviving the fire is just the beginning. What can follow is weeks, perhaps months of screaming, agonizing pain that leaves people scarred mentally and emotionally. This is the ordeal that faced the little girl who survived the fire in the Pasadena gun shop shooting range.

I would hope that my letter will serve as a warning to the owners of SONEX-lined ranges to get the stuff out before their shooting range is turned into a death trap.

Remember, "SONEX. The beautiful way to kill noise" can also be a beautiful way to kill people.

Sincerely,
George E. Leighton,
Acoustical Consultant

DALLAS SYMPHONY RECEIVING NATIONAL ACCLAIM

The Meyerson Symphony Center in Dallas is receiving national acclaim with extensive writeups in trade as well as general publications.

Designed by Artec Consultants of New York, the hall has "won raves from conductors, critics and audiences, and high praise from such esteemed artists as Isaac Stern and Leontyne Price," according to the Newark, NJ "Star-Ledger."

APPENDIX 3

PRESSURE VS. TIME HISTORIES OF IMPULSES USING DIFFERENT RECORDING TECHNIQUES

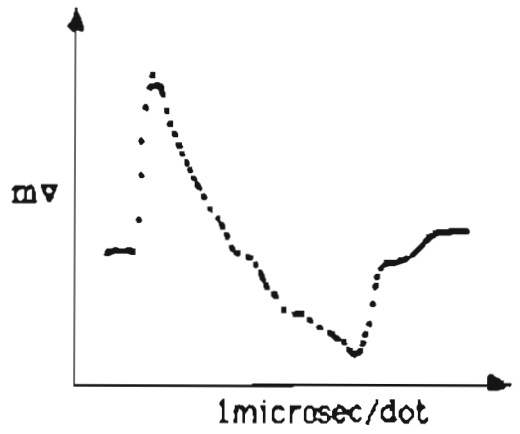


Figure 23. Spark discharge measured by the BBN microphone at 2 feet.

Peak Lp = 141 dB
Rise Time = 6 microseconds

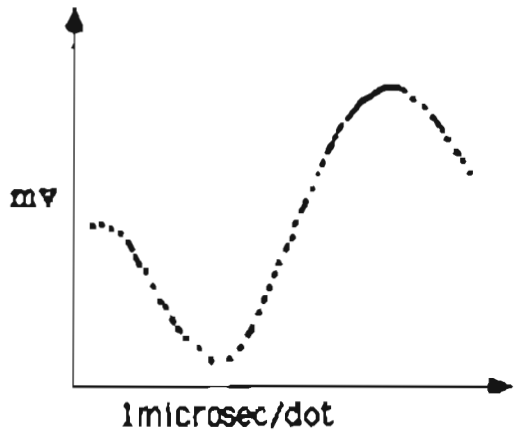


Figure 24. Spark discharge measured by the SLM at 2 feet.

Peak Lp = 134 dB
Rise Time = 31 microseconds

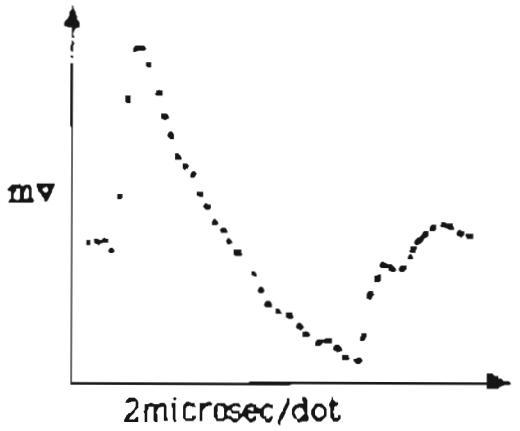


Figure 25. Spark discharge measured by the BBN microphone at 4 feet.

Peak Lp = 135 dB
Rise Time = 6 microseconds

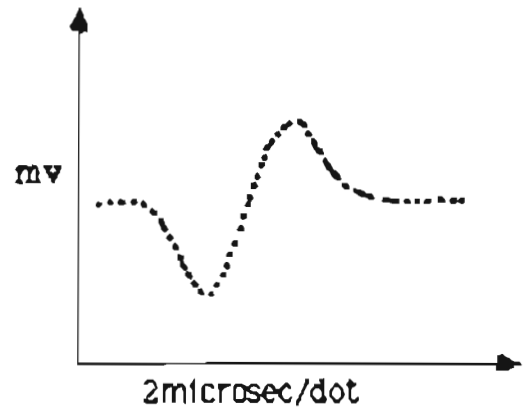


Figure 26. Spark discharge as measured by the SLM at 4 feet.

Peak Lp = 128 dB
Rise Time = 34 microseconds

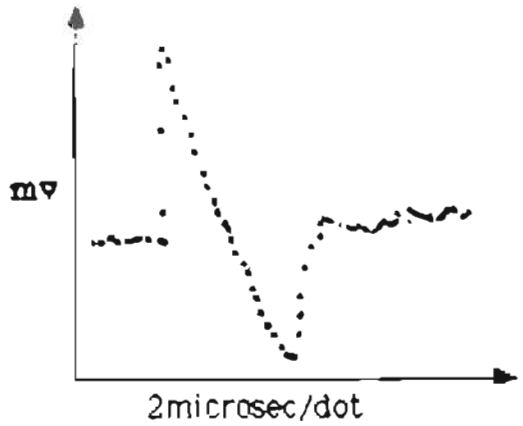


Figure 27. Spark discharge measured by the BBN microphone at 8 feet.

Peak Lp = 128 dB
Rise Time = 8 microseconds

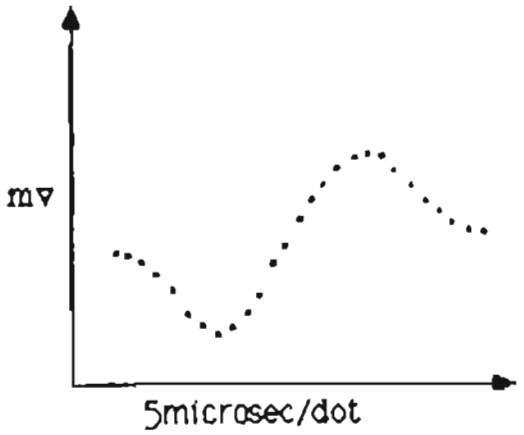


Figure 28. Spark discharge measured by the SLM at 8 feet.

Peak Lp = 122 dB
Rise Time = 35 microseconds

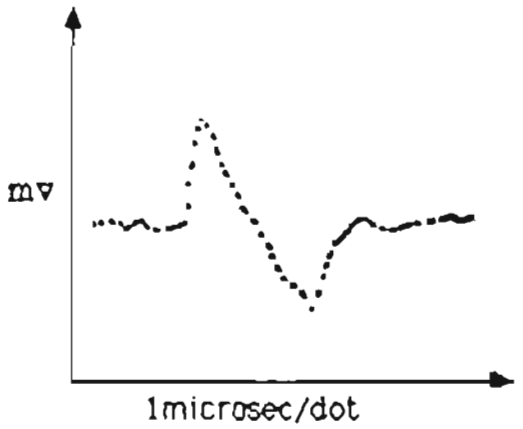


Figure 29. Spark discharge measured by the BBN microphone at 12 feet.

Peak Lp = 128 dB
Rise Time = 8 microseconds

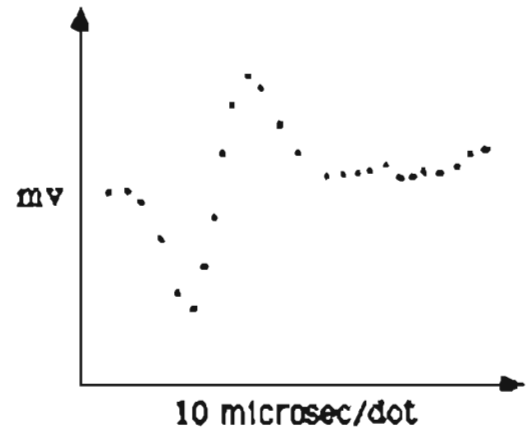


Figure 30. Spark discharge measured by the SLM at 12 feet.

Peak Lp = 118 dB
Rise Time = 40 microseconds

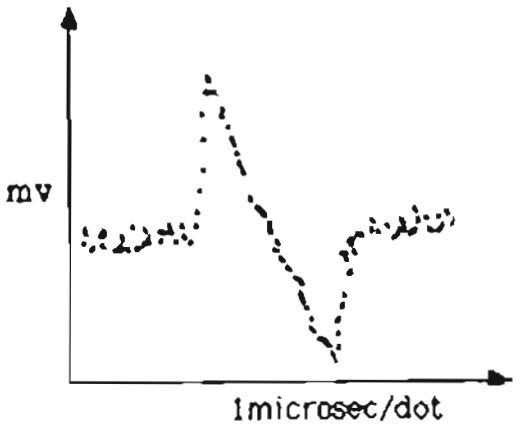


Figure 31. Spark discharge measured by the BBN microphone at 16 feet.

Peak Lp = 128 dB
Rise Time = 8 microseconds

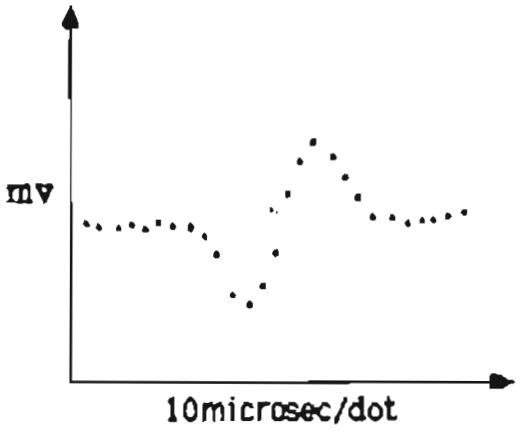


Figure 32. Spark discharge measured by the SLM at 16 feet.

Peak Lp = 115 dB
Rise Time = 40 microseconds

APPENDIX 4

TABULATION OF PROCESS USED IN EXAMPLE 2

FIRING RANGE EXAMPLE
NRA REPORT
CALCULATION 2
AS IS

SURFACE	AREA	ALPHA 125	ALPHA 250	ALPHA 500	ALPHA 1000	ALPHA 2000	ALPHA 4000
CEILING (CONCRETE)	312	0.01	0.01	0.02	0.02	0.02	0.02
FLOOR (CONCRETE)	312	0.01	0.01	0.02	0.02	0.02	0.02
WALLS (C.M.U. PTD.)	485	0.10	0.05	0.06	0.07	0.09	0.08
PARTITIONS (FIBERBOARD)	280	0.15	0.28	0.62	0.94	0.64	0.92
WALLS (GLASS)	40	0.18	0.06	0.04	0.03	0.02	0.02
7 PEOPLE	7	2.00	3.00	4.00	5.00	5.00	4.00
AIR	3	0.09	0.20	0.49	1.20	2.90	7.40
TOTALS	1436						
ALPHA BAR							
VOLUME	3276						

TOTALS	S(ALPHA) 125	S(ALPHA) 250	S(ALPHA) 500	S(ALPHA) 1000	S(ALPHA) 2000	S(ALPHA) 4000	S(ALPHA) 8000
CEILING (CONCRETE)	3	3	5	6	6	6	6
FLOOR (CONCRETE)	3	3	5	6	6	6	6
WALLS (C.M.U. PTD.)	49	24	29	34	44	39	34
PARTITIONS (FIBERBOARD)	42	73	174	263	179	258	210
WALLS (GLASS)	7	2	2	1	1	1	1
7 PEOPLE	14	21	28	35	35	28	28
AIR	0	1	1	4	9	22	34
TOTALS	118	127	243	349	280	360	319
ALPHA BAR	0.08	0.09	0.17	0.24	0.19	0.25	0.22

FIRING RANGE EXAMPLE
NRA REPORT
CALCULATION 2
ADDED ABSORPTION - ABSORBENT CEILING
WALL PANELS

SURFACE	AREA	ALPHA 125	ALPHA 250	ALPHA 500	ALPHA 1000	ALPHA 2000	ALPHA 4000	ALPHA 8000
CEILING (ACOUSTICAL TILE)	312	0.78	0.93	0.83	0.99	0.99	0.94	0.95
FLOOR (CARPET)	312	0.02	0.06	0.14	0.37	0.60	0.65	0.30
WALLS (8" SLOTTED C.M.U.)	485	0.72	1.12	0.69	0.67	0.58	0.41	0.30
PARTITIONS (FIBERBOARD)	280	0.14	0.10	0.06	0.05	0.04	0.03	0.03
WALLS (GLASS)	40	0.18	0.06	0.04	0.03	0.02	0.02	0.02
7 PEOPLE	7	2.00	3.00	4.00	5.00	5.00	4.00	4.00
AIR	3	0.09	0.20	0.49	1.20	2.90	7.40	11.40
TOTALS	1436							
ALPHA BAR								

TOTALS	S(ALPHA) 125	S(ALPHA) 250	S(ALPHA) 500	S(ALPHA) 1000	S(ALPHA) 2000	S(ALPHA) 4000	S(ALPHA) 8000
CEILING (ACOUSTICAL TILE)	237	290	259	309	309	293	296
FLOOR (CARPET)	6	19	44	115	187	203	94
WALLS (8" SLOTTED C.M.U.)	349	543	335	325	281	199	146
PARTITIONS (FIBERBOARD)	39	28	17	14	11	8	8
WALLS (GLASS)	7	2	2	1	1	1	1
7 PEOPLE	14	21	28	35	35	28	28
AIR	0	1	1	4	9	22	34
TOTALS	653	904	685	803	833	754	607
ALPHA BAR	0.45	0.63	0.48	0.56	0.58	0.53	0.42
REVERB TIME (SABINE)	0.25	0.18	0.23	0.20	0.19	0.21	0.26
REVERB TIME	0.18	0.11	0.17	0.14	0.13	0.15	0.20
NOISE REDUCTION	7.42	8.51	4.50	3.61	4.74	3.21	2.79
TOTAL NR	4.65						

REPORT INCLUDING RESEARCH ON GUNFIRE NOISE LEVELS

Noise and Lead Exposures at an Outdoor Firing Range – California

Lilia Chen, MS, CIH
Scott E. Brueck, MS, CIH

Health Hazard Evaluation Report
HETA 2011-0069-3140
September 2011

DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
NIOSH *National Institute for Occupational Safety and Health*

The employer shall post a copy of this report for a period of 30 calendar days at or near the workplace(s) of affected employees. The employer shall take steps to insure that the posted determinations are not altered, defaced, or covered by other material during such period. [37 FR 23640, November 7, 1972, as amended at 45 FR 2653, January 14, 1980].

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Abbreviations

µg/100 cm^2	Micrograms per 100 square centimeters
µg/dL	Micrograms per deciliter
µg/m^3	Micrograms per cubic meter
AIHA	American Industrial Hygiene Association
ACGIH®	American Conference of Governmental Industrial Hygienists
AL	Action level
BLL	Blood lead level
CFR	Code of Federal Regulations
dB	Decibel
dBA	Decibel, A-scale
dBC	Decibel, C-scale
Hz	Hertz
m^3	Cubic meter
mg/m^3	Milligrams per cubic meter
MDC	Minimum detectable concentration
MQC	Minimum quantifiable concentration
min	Minute
MSDS	Material safety data sheet
NAICS	North American Industry Classification System
NIHL	Noise-induced hearing loss
NIOSH	National Institute for Occupational Safety and Health
NRR	Noise reduction rating
OEL	Occupational exposure limit
OSHA	Occupational Safety and Health Administration
PBZ	Personal breathing zone
PEL	Permissible exposure limit
PPE	Personal protective equipment
REL	Recommended exposure limit
SLM	Sound level meter
TLV®	Threshold limit value
TWA	Time-weighted average
WEEL™	Workplace environmental exposure level

Highlights of the NIOSH Health Hazard Evaluation

The National Institute for Occupational Safety and Health (NIOSH) received a technical assistance request from a federal government agency in California. Although no health symptoms or hearing loss were reported, the requestor was concerned about exposures to noise and lead among firing range instructors at an outdoor firing range.

What NIOSH Did

- We evaluated noise and lead exposures in April 2011.
- We took personal measurements for noise and lead.
- We took surface wipe samples and hand wipe samples for lead.
- We measured sound levels at different frequencies during live fire training.

What NIOSH Found

- Employee exposures to noise were above the NIOSH recommended exposure limit.
- Peak noise levels were above 160 decibels during gunfire.
- Employee exposure to lead did not exceed occupational exposure limits.
- We found lead on surfaces.
- Students appeared to have good hand washing practices.

What Managers Can Do

- Establish a hearing conservation program that includes annual audiograms for instructors.
- Require instructors and students to wear dual hearing protection during weapon fire, and provide training to ensure proper use. Dual hearing protection includes ear plugs and earmuffs.
- Consider supplying non-lead bullets and primers for classes.
- Require students and instructors to wash hands before eating, drinking, or using tobacco products.
- Notify employees and students that picnic tables have lead on them. Tell employees about the potential for getting lead from the table into their food or from their hands into their mouth. Managers should share this information with the firing range owner.

What Employees Can Do

- Wear dual hearing protection during weapon fire. Dual hearing protection includes ear plugs and earmuffs.
- Continue to use good hygiene practices. Wash your hands before eating, drinking, or using tobacco products.

Summary

On February 25, 2011, NIOSH received a technical assistance request from a federal government agency to assess exposures to noise and lead of firing range instructors at an outdoor firing range in California. On April 11–12, 2011, NIOSH investigators evaluated employee exposures to noise and lead during a 3-day basic firearms course.

Eight students and five instructors contributed 14 personal noise dosimetry measurements over 2 days. During live fire training, we measured sound levels and octave band noise frequency levels with a type 1 SLM. We took 16 PBZ air samples and six surface wipe samples for lead. We also used a colorimetric wipe test to test for lead on hands.

Noise monitoring results indicated that all participants' TWA noise exposures exceeded the NIOSH REL, some exceeded the OSHA AL, but none exceeded the OSHA PEL. However, noise dosimeter microphones and electronic circuitry do not adequately capture peak noise levels above the maximum range of the instrument, therefore, personal TWA noise measurements from gunfire noise using dosimeters should be interpreted cautiously. These measurements can underrepresent noise exposure and hearing loss risk from gunfire noise. Sound level meter measurements revealed that peak noise levels during gunfire were greater than 160 dB.

None of the lead PBZ air sampling results exceeded applicable OELs. Results varied from Day 1 to Day 2, which was likely due to the meteorological conditions. Under different meteorological conditions and employee proximity to the gun smoke source, exposures may be higher. Lead was found on the outdoor picnic table surface where we observed employees eating lunch. Employees appeared to have good hand hygiene as no lead was found on the hand wipes after washing.

Because of the high noise levels in firing ranges, double hearing protection is necessary. The noise levels generated by the firearms warrant a hearing conservation program, which should meet the requirements of the OSHA hearing conservation standard [29 CFR 1910.95]. Firing range instructors should have yearly audiometric evaluations to measure hearing levels and identify hearing loss. Reviewers of audiograms should be aware of potentiating and synergistic effects of ototoxins such as lead and solvents. To reduce lead exposures, use of non-lead bullets and non-lead primers should be considered as it becomes economically feasible. Good personal hygiene should continue to be encouraged to reduce the potential for lead ingestion.

Personal noise measurements taken during a basic firearms course at an outdoor firing range exceeded the NIOSH REL. Personal lead air measurements did not exceed applicable OELs, but lead was found in air samples and on a picnic table where employees ate lunch. Employees should wear double hearing protection and participate in a hearing conservation program.

Keywords: NAICS 922190 (Other Justice, Public Order, and Safety Activities), firearms, lead, noise, impulse noise, impulsive noise, hearing loss, shotguns, rifles, outdoor firing range, ototoxins, ototoxicity

Introduction

On February 25, 2011, NIOSH received a technical assistance request from a federal government agency to assess exposures to noise and lead among firing range instructors at an outdoor firing range in California. No employees had reported hearing loss or health concerns to management. On April 11–12, 2011, NIOSH investigators evaluated employee exposures to noise and lead during a 3-day basic firearms training course.

Firing range instructors teach 1- to 3-day basic and refresher firearm courses to other federal government employees who carry a firearm for their job. They instruct courses approximately five times a year at a rented public outdoor firing range that is closed to the public on the days the course is taught. The basic firearms course we evaluated included classroom and field practice components, with about 6 hours per day of field practice. Students completed qualifying exams on the last day of the course. The class had three to five instructors and eight students. Three instructors were always present on the firing range with the eight students. Most of the class was taught at a straight lane outdoor range where students fired at paper targets, with earth backing behind the targets. Students spread out approximately 4 feet apart in a line about 15 yards away from the targets. During live fire exercises, instructors stood about 2–3 feet behind students. Students used shotguns (12 gauge) and two types of rifles (.30-06 or .45-70) (Figure 1). Students did not use revolvers (.44 caliber) in this course, but in some other courses revolvers are also used. During the qualifying exams, students used parts of the skeet range and clay courses. The instructors selected ammunition for the course. Shotguns used rifled lead slugs. Rifles used bullets with partial or full copper metal jacket over lead. All the primers contained lead. The number of rounds fired in a typical training day varied depending on the class size and experience. Towards the end of the course, the instructors taught students how to clean the firearms.



Figure 1. Firearms used for training (from left to right: 12-gauge shotgun, .30-06 rifle, and .45-70 rifle).

The instructors brought all equipment, ammunition, PPE, and teaching materials to the firing range. They did not store any of their property at the range. All instructors and students wore safety glasses and earmuffs. During our evaluation, students wore 3M (St. Paul, Minnesota) Peltor® Tactical™ 6-S with an NRR of 19 dB, and instructors wore Peltor® PowerCom Plus™ with an NRR of 25 dB during live fire. The agency had no blood lead monitoring program and no hearing conservation program although a draft hearing conservation program written by the agency safety specialist had been submitted to management. We obtained MSDSs for the chemicals used for cleaning the firearms.

Assessment

We held an opening meeting on April 11, 2011, with employer and employee representatives. On April 11 and 12, 2011, we interviewed several instructors; observed classroom and field activities; measured outdoor temperature, wind direction, and velocity; and sampled for noise and lead.

Eight students and five instructors contributed 14 personal noise dosimetry measurements over 2 days. Students and instructors wore integrating noise dosimeters on Day 1 of sampling. However, only instructors wore dosimeters on Day 2 of sampling. We measured area noise levels and performed octave band frequency spectrum analysis (measurement of noise levels in different frequencies) with two SLM and real-time frequency analyzers. The SLMs were mounted on tripods at a height of approximately 5 feet to represent the ear position of a standing shooter. We placed the tripods with SLMs on each end of the firing line approximately 4 to 6 feet from the student (Figure 2). Because of safety concerns and risk of interfering with students and instructors, we were not able to place SLMs closer during live fire training sessions. However, during some of the qualifying exams, we handheld the SLMs approximately 1 to 2 feet from the instructor's ear.



Figure 2. Sound level meter at firing line during firearm training exercises.

We took 16 personal breathing zone air samples and six surface wipe samples for lead. Surfaces tested included areas that people frequently touched, such as the trigger and forend of the firearm, doorknobs, and restroom water faucet handles. We also used a colorimetric wipe test to test for lead on hands.

More information on OELs and health effects for noise and lead can be found in Appendix A. More information on sampling methodology for noise and lead can be found in Appendix B.

Noise

Results from the personal dosimetry measurements are provided in Table 1. Results indicated that all participants' TWA noise exposures exceeded the NIOSH REL, some exceeded the OSHA AL, but none exceeded the OSHA PEL. Noise dosimeter microphones and electronic circuitry do not adequately capture peak noise levels above the maximum range of the instrument and "clip" noise levels at approximately 145 dB. Previous research on the use of dosimeters for gunfire measurements concluded that these electroacoustic limitations produce errors in calculating TWA noise levels from impulsive noise environments [Kardous et al. 2003; Kardous and Willson 2004]. Therefore, personal TWA noise measurements from gunfire noise collected with dosimeters should be interpreted cautiously and considered to underrepresent noise exposure and hearing loss risk from gunfire noise.

Table 1. Personal noise dosimetry results*

Job title	Duration	OSHA AL			OSHA PEL			NIOSH REL		
	(h:mm)	TWA† (dBA)	TWA 8-hr‡ (dBA)	Dose§ (%)	TWA† (dBA)	TWA 8-hr‡ (dBA)	Dose§ (%)	TWA† (dBA)	TWA 8-hr‡ (dBA)	Dose§ (%)
Student	5:00	***89***	***85***	***50***	89	85	50	***100***	***97***	***1598***
Student	4:54	87	84	44	87	84	44	***99***	***96***	***1269***
Student	4:59	88	84	44	87	84	44	***98***	***96***	***1269***
Student	5:04	86	82	33	86	82	33	***97***	***95***	***1007***
Student	4:52	86	83	38	86	82	33	***98***	***95***	***1007***
Student	4:57	84	80	25	84	80	25	***95***	***93***	***634***
Instructor	4:59	***89***	***85***	***50***	88	84	44	***98***	***96***	***1269***
Instructor	4:53	***89***	***86***	***57***	88	85	50	***96***	***94***	***799***
Instructor	4:55	82	78	19	82	78	19	***93***	***91***	***400***
Instructor	5:37	***88***	***85***	***50***	87	85	50	***97***	***96***	***1269***
Instructor	4:59	86	83	38	86	83	38	***97***	***95***	***1007***
Instructor	5:42	84	82	33	84	81	29	***95***	***94***	***799***
Instructor	6:30	83	82	33	82	80	25	***95***	***94***	***799***
Instructor	6:34	78	75	13	78	74	11	***90***	***88***	***200***
Exposure Limits			85	50		90	100		85	100

* Exposures at or exceeding exposure limits are highlighted in bold and italicized font.
† TWA noise exposures for the duration of the noise monitoring period
‡ Projected 8-hour TWA assuming that noise exposures beyond the measured duration were below 80 dBA
§ Dose is based on TWA 8-hour noise exposure.

One-third octave band noise frequency measurements collected when students were shooting .45-70 rifles are shown in Figure 3. These measurements showed that the highest sound pressure levels (125 dB) occurred at 500 Hz, and were greater than 110 dB across all the one-third octave bands from 125 Hz to 20,000 Hz. Measurements taken during shooting of the 12-gauge shotgun and the .30-06 rifle had similar results. Octave band measurements provide information about the frequency distribution of noise. Because the energy from noise is usually widely distributed over many frequencies, the frequency range is broken into a smaller range of frequencies (called bandwidths), the most common being the octave band (defined as a frequency band where the upper band frequency is twice the lower band-edge frequency).

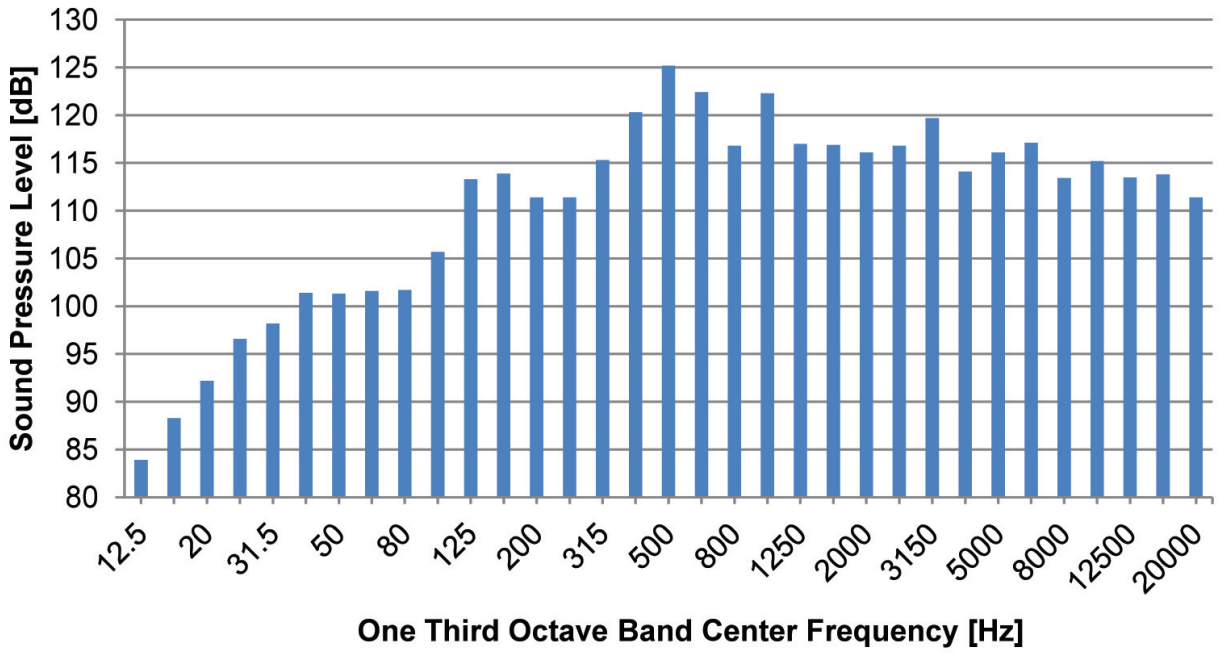


Figure 3. One-third octave band noise frequency levels of four rifles (.45-70) being fired over a 90-second period during a basic firearms training course.

Octave band analysis allows for determination of the dominant noise frequencies and can be useful for identifying potential engineering controls. For example, if low frequency noise is dominant (i.e., the highest octave-band sound levels occur in frequencies of 500 Hz or less), noise is likely generated by vibration, and noise controls that reduce or isolate the vibration from tools or equipment might decrease noise levels. If high frequency noise is dominant (i.e., the highest octave band sound levels occur in frequencies of 2,000 Hz or greater), noise enclosures, barriers, or sound absorption systems are typically the most effective approach [Driscoll and Royster 2003]. One of the

primary sources of noise generated during gunfire is the muzzle blast during firing, which generates high noise across the mid to high frequency range. The only potentially effective noise control method to reduce students' or instructors' noise exposure from gunfire is through the use of noise suppressors that can be attached to the end of the gun barrel. However, some states do not permit civilians to use suppressors on firearms.

Peak sound levels ranged from 154.6 dB to 163.1 dB during shooting exercises. Peak levels for the 12-gauge shotgun and .30-06 rifles were slightly higher than for the .45-70 rifle (Table 2). During training exercises, students typically fire a series of shots in succession followed by several minutes without shooting for instruction. An example of peak sound levels during 1 minute of shooting a .30-06 rifle is shown in Figure 4. Eight peaks greater than 160 dB and several others greater than 150 dB can be seen during this time period.

Table 2. Peak sound level range for firearms

Firearm	Peak Sound Level Range (dB)	Ammunition Weight (Grains)
12-Gauge Shotgun	154.6 – 162.7	438
.45-70 Rifle	155.2 – 159.9	350
.30-06 Rifle	158.7 – 163.1	173

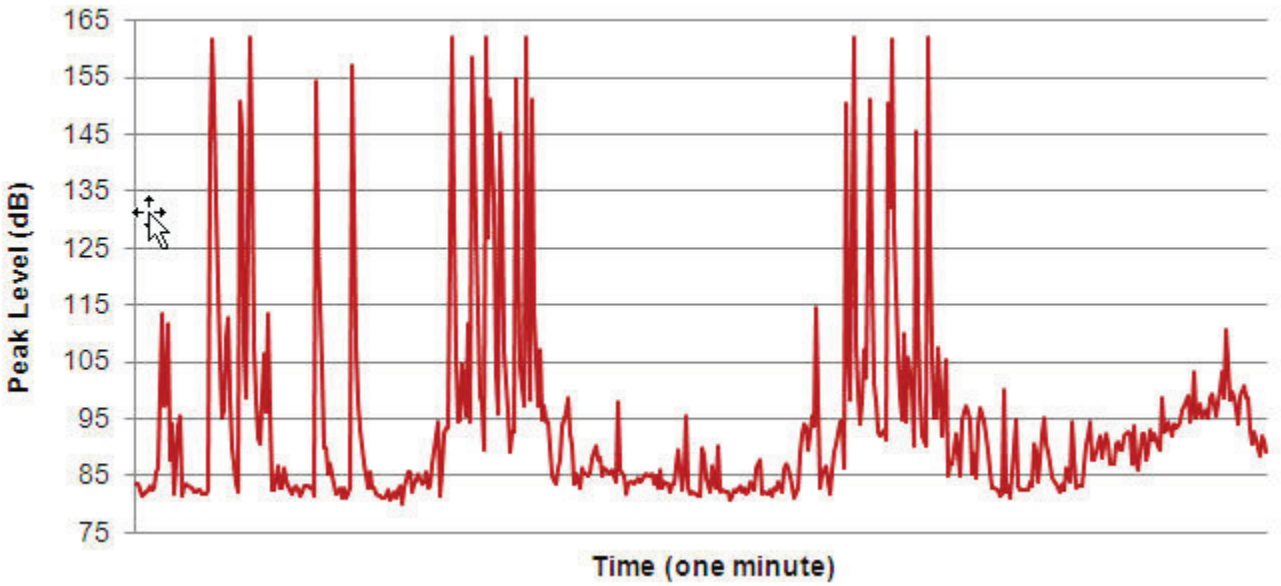


Figure 4. Peak sound levels during one minute of shooting .30-06 rifles in a training exercise.

Research has shown that repeated exposure to impulse noise can result in permanent NIHL [Patterson and Hamernik 1992; Pekkarinen et al. 1993; Chan et al. 2001]. Noise produced by impulsive noise, such as gunfire, has sufficient intensity to permanently damage unprotected ears in a very short period of time; damage can occur in minutes rather than the days or years typical of industrial noise exposure. The OSHA PEL and NIOSH REL state that exposure to impulse noise should not exceed 140 dB. However, peak impulse is not the sole factor in hearing damage. Other factors such as duration of the impulse and frequency of exposure also have an effect on hearing loss.

Because of the high noise levels in firing ranges, double hearing protection is necessary to protect hearing. Research has reported that double hearing protection can provide the additional noise reduction needed in high noise level environments [Berger 1983]. However, proper insertion of hearing protection is critically important to ensure proper noise attenuation. NIOSH has previously identified poor insertion of formable hearing protection into the ear canals [NIOSH 2005].

To estimate hearing protector attenuation NIOSH recommends using subject fit data based on the American National Standards Institute's standard S12.6-1997 [ANSI 1997]. However, if no subject fit data are available, NIOSH recommends adjusting the hearing protectors' ratings by subtracting 25% from the manufacturer's labeled NRR for earmuffs and subtracting 50% from the manufacturer's labeled NRR for formable earplugs. An additional 5 to 10 dB of attenuation can be added for use of dual hearing protection [NIOSH 1998]. Figure 5 shows the range of estimated noise attenuation that could be achieved for properly fitted and worn ear plugs and earmuffs, using NIOSH noise attenuation calculations for unweighted or dBC noise exposure levels. For dBA noise exposure levels, an additional 7 dB should be subtracted from the derated NRR.

On the basis of hearing protection worn by instructors and students during the training class (instructors: Peltor® PowerCon Plus™ with an NRR of 25 dB; students: Peltor® Tactical™ 6-S with an NRR of 19 dB), the estimated hearing protector attenuation using the NIOSH hearing protector derating formula is 19 dB for instructors and 14 dB for students. If instructors and students wore earmuffs with an NRR of 33 dB along with properly inserted ear plugs, their estimated attenuation for dual

protection using the NIOSH hearing protector derating formula would increase to 30–35 dB. In tests of hearing protection using an acoustic mannequin, NIOSH found that in some instances double hearing protection actually provided more peak noise attenuation than the NIOSH hearing protector derating formula calculates [NIOSH 2003, 2005].

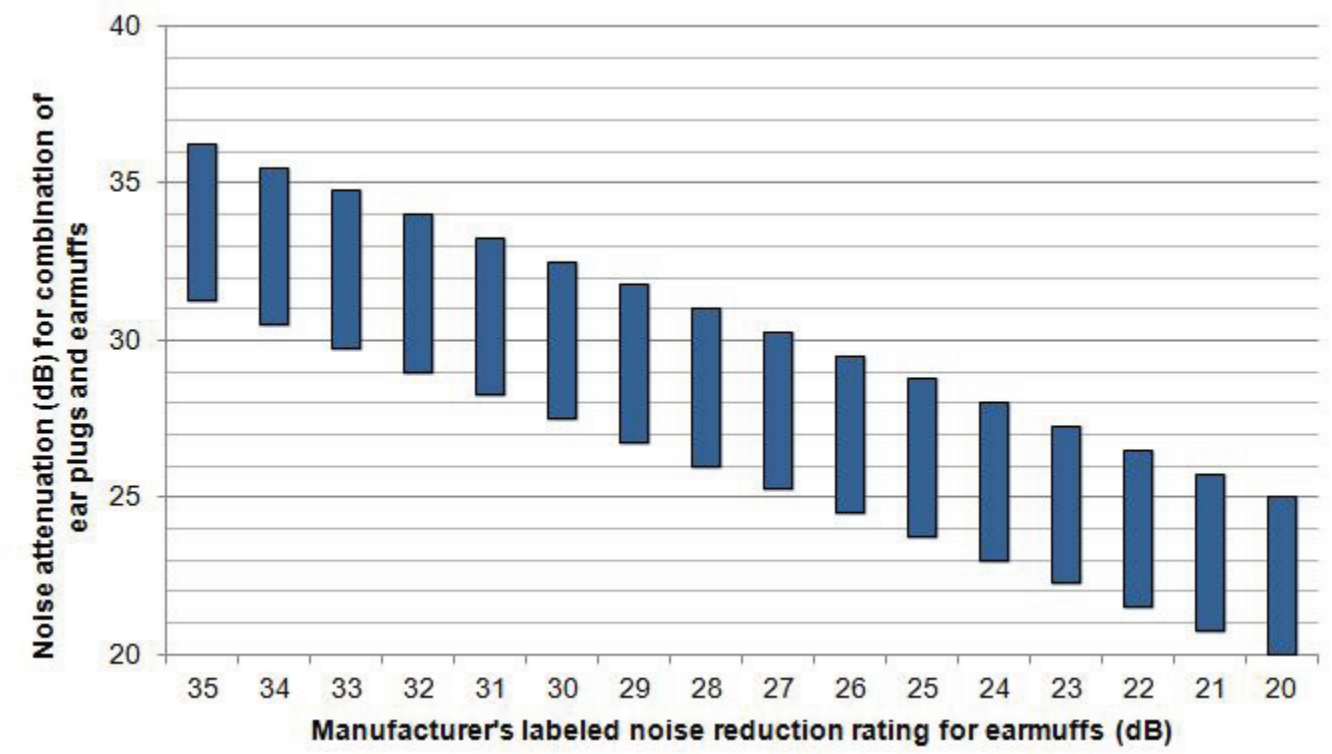


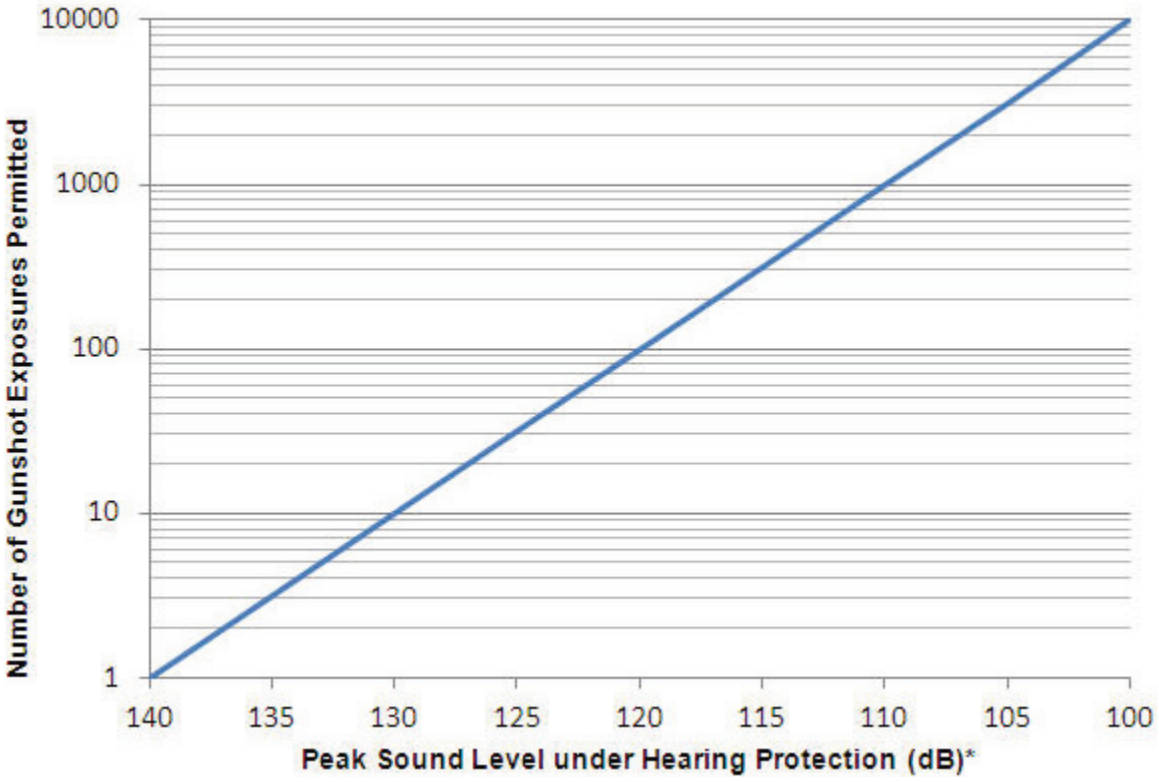
Figure 5. Range of estimated noise attenuation (dB) for combination of properly fitted and worn insert type ear plugs and earmuffs, based on NIOSH noise attenuation calculations for unweighted or dBC noise levels.

In 2002, NIOSH proposed a simplified formula to reduce the risk of exposure to impulse noise in terms of the number of gunshot impulses to which a person can be exposed per day [NIOSH 2002]:

$$N = 10^{((140 - PI)/10)}$$

where N is the number of gunshot exposures permitted, and PI is the peak impulse level in dB under hearing protection. PI is determined by subtracting the noise attenuation for hearing protection from the peak noise exposure level for a gunfire impulse.

Figure 6 shows the number of gunshot exposures permitted on the basis of peak noise levels under hearing protection. For example, if the peak noise level under hearing protection is 120 dB, applying this formula yields N=100 gunshots. The NIOSH proposed formula is a conservative estimate and does not take into account the duration of the impulse, its spectral content, or its energy.



*Peak sound level under hearing protection is calculated by subtracting the estimated noise attenuation for hearing protection from the peak noise exposure level for a gunfire impulse.

Figure 6. Number of gunshot exposures permitted using NIOSH recommendations [NIOSH 2002], based on peak sound levels (dB) under hearing protection.

Lead

We collected 16 PBZ area air samples on students and instructors for lead. None of our results exceeded applicable OELs. These results are listed in Table 3. Results from Day 1 were very low with only one quantifiable PBZ air sample. Results from Day 2 were higher than Day 1, with the highest lead exposure found on an instructor at 15 µg/m^3. The concentration differences between Day 1 and Day 2 were most likely due to the meteorological conditions. On Day 1, the wind moved gun smoke down the course and away from the employees. On Day 2, the wind was mild and moved gun smoke up the course towards the employees. On Day 2, it is possible that students' exposures would have been even higher than the instructors' because of their closer proximity to the smoke sources. Past studies looking at lead exposure to outdoor firearm instructors found that despite "natural ventilation" at outdoor firing ranges, PBZ levels exceeded OSHA, NIOSH, and ACGIH

Results and Discussion (continued)

OELs of 50 µg/m^3 as an 8-hour TWA [Goldberg et al. 1991; Tripathi et al. 1991; Mancuso et al. 2008]. Studies have also shown that jacketed or non-lead bullets can reduce lead concentrations [NIOSH 1986; Tripathi et al. 1991; NIOSH 1995] in air and on surfaces. Although we did not find air lead levels that exceeded the OELs, it is possible that airborne lead levels could be higher during certain meteorological conditions, and care should be taken to minimize lead exposures.

Table 3. PBZ air sampling results for lead*

Day	Type	Sampling Time (min)	Sample Volume (m^3)	8-hr TWA* Concentration (µg/m^3)
1	Student	307	0.61	1.02
1	Student	302	0.59	[0.82]
1	Student	300	0.59	[0.75]
1	Student	306	0.60	[0.70]
1	Student	303	0.60	[0.57]
1	Student	307	0.61	[0.51]
1	Student	267	0.53	[0.44]
1	Student	304	0.60	[0.49]
1	Instructor	305	0.60	ND
1	Instructor	300	0.59	ND
2	Instructor	370	0.72	15
2	Instructor	364	0.70	4.3
2	Instructor	313	0.61	1.5
2	Instructor	359	0.70	1.2
2	Instructor	315	0.62	[0.66]
2	Instructor	297	0.58	ND
MDC†				0.32
MQC†				1.3
NIOSH REL (8-hr TWA)				50
OSHA PEL (8-hr TWA)				50
ACGIH TLV (8-hr TWA)				50

Values in brackets indicate levels between the MDC and MQC.

*Concentrations were calculated to reflect an 8-hour TWA by assuming no lead exposure beyond the measured duration.

†Based on an air volume of 0.62 m^3.

The highest levels of surface contamination for lead were found on the firearms, which was expected (Table 4). Lead levels were much lower on surfaces where frequent contact occurs, such as door and sink handles. Lead was found on the outdoor picnic table surface where we observed employees eating lunch, so care should be taken to prevent lead from transferring from the table surface to food or hands to mouth.

Table 4. Lead surface wipe sampling results

Location	Concentration (µg/100 cm^2)
Rifle forend*	1.0
Shotgun stock*	0.68
Rifle stock*	0.10
Picnic table	0.08
Men's restroom sink handles*	0.03
Door handle into classroom*	0.02

* Approximated 100 cm^2 surface area

All students showed a positive result for lead on their hands immediately after returning from the range after live firearms practice. After hand washing, no positive result was observed on the hand wipes (Figure 7). We also asked one instructor to use the wipes after returning from the range and washing hands. The instructor's hand wipe results showed a negative result. Aside from an occasional demonstration, the instructors did not usually handle firearms. These results indicate that students had good hand hygiene.

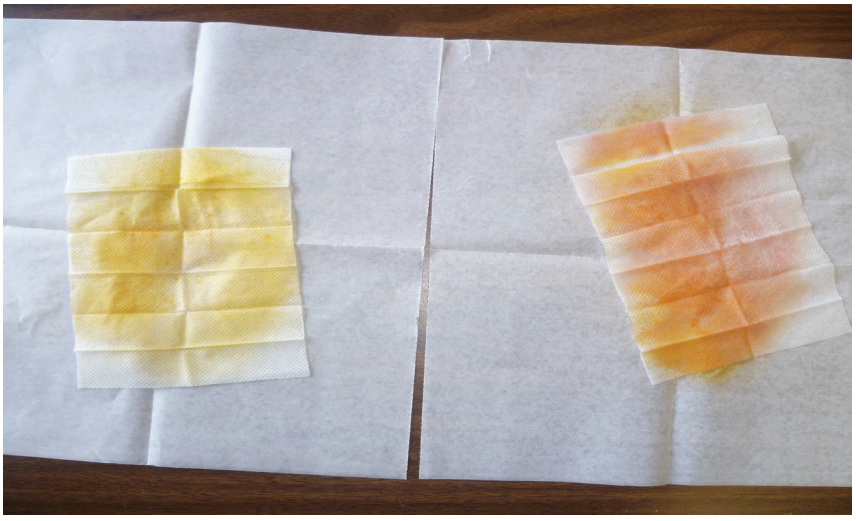


Figure 7. The left wipe, taken from a student who had just returned from the shooting range and had not yet washed hands, is positive for lead. The right wipe, taken after the student had washed hands, is negative for lead.

Ototoxins

Ototoxins are chemicals that can cause hearing damage when absorbed into the body. Studies have shown that exposure to some chemicals, such as lead and some solvents, can cause hearing loss [Sliwinska-Kowalska et al. 2004; Hwang et al. 2009]. The mechanism of loss is not well understood, but it is hypothesized that ototoxins entering the blood stream damage inner ear structures, causing nerve damage and/or oxidative stress [Henderson et al 2006; Johnson and Morata 2010]. Some chemicals may not cause hearing loss alone, but can exacerbate hearing loss caused by noise (potentiation). Some chemicals may cause a synergistic effect, where the combined effect of the two exposures is greater than either alone. It is difficult to distinguish whether hearing loss is caused by ototoxicants or excessive noise, as both losses appear similar on pure tone audiograms and have many other similar characteristics (e.g., bilateral loss, loss starting in the high frequencies).

Solvents are used to clean firearms after use. Although none of the ingredients listed on the MSDS that were given to us had been observed as ototoxicants, users should be aware that moderate exposures (below or around the OEL) to solvents such as toluene [Morata et al. 1993; Chang et al. 2006], xylene, and mixtures of solvents [Sliwinska-Kowalska et al. 2004; Fuente et al. 2009] have been shown to be associated with hearing loss [Sliwinska-Kowalska et al. 2007].

The ACGIH states that, "In settings where there may be exposures to noise and to carbon monoxide, lead, manganese styrene, toluene, or xylene, periodic audiograms are advised and should be carefully reviewed" [ACGIH 2011]. The U.S. Army recommends annual audiometric monitoring when workers are exposed to air concentrations that are at or exceed 50% of the most stringent OEL criteria for a variety of ototoxicants including solvents and lead [U.S. Army 2009]. The highest lead PBZ air concentration (15 mg/m^3) did not exceed 50% of the NIOSH REL, but because meteorological factors may cause variations in worker exposure, it is possible that exposure on a different day could be higher. We were also told that some instructors shot recreationally, which would contribute to their overall lead and noise exposures. Reviewers of employees' audiometric tests should be aware of possible additive, potentiating, or synergistic effects between noise exposure, solvents, and lead when evaluating audiograms.

Conclusions

Personal noise measurements taken during a basic firearms course exceeded the NIOSH REL, some exceeded the OSHA AL, but none exceeded the OSHA PEL. Peak sound levels exceeded 160 dB. Because of the high noise levels in shooting ranges, the use of double hearing protection is necessary. The noise levels generated by the firearms warrant a hearing conservation program, and firing range instructors should have yearly audiometric evaluations. Personal lead air measurements did not exceed applicable OELs, but lead was observed in the air and on some surfaces. Meteorological conditions and employee proximity to the gun smoke may greatly affect exposures. Reviewers of audiograms should be aware of potentiating and synergistic effects of ototoxins. To reduce lead exposures, use of non-lead bullets and non-lead primers as they become economically feasible should be considered. Good personal hygiene should be encouraged to reduce lead ingestion potential.

Recommendations

On the basis of our findings, we recommend the actions listed below to create a more healthful workplace. Our recommendations are based on the hierarchy of controls approach (refer to Appendix A: Occupational Exposure Limits and Health Effects). This approach groups actions by their likely effectiveness in reducing or removing hazards. In most cases, the preferred approach is to eliminate hazardous materials or processes and install engineering controls to reduce exposure or shield employees. Until such controls are in place, or if they are not effective or feasible, administrative measures and/or personal protective equipment may be needed. PPE is the least effective means for controlling employee exposures. Proper use of PPE requires a comprehensive program, and calls for a high level of employee involvement and commitment to be effective.

1. The noise levels generated by the firearms warrant a hearing conservation program. At a minimum, the program should meet the requirements of the OSHA hearing conservation standard [29 CFR 1910.95]. Another source for designing an effective hearing loss prevention program is the NIOSH occupational noise criteria document [NIOSH 1998].
2. Firing range instructors should have yearly audiometric evaluations to measure hearing levels and identify hearing loss. Reviewers of audiograms should be aware of potentiating and synergistic effects of ototoxins, such as lead and solvents, on hearing loss.

3. Instructors and students should wear dual hearing protection (ear plugs and earmuffs) during weapons fire. For maximum protection, select earmuffs and ear plugs that provide a high level of noise attenuation. Because of the critical importance of proper use and fit, train students and instructors how to properly wear hearing protection. Encourage the use of dual hearing protection during recreational shooting.
4. Consider using non-lead bullets and non-lead primers as they become economically feasible.
5. Employees should follow safe work practices identified by the firing range and employer. They should continue good personal hygiene practices including hand washing before eating, drinking, smoking, and leaving the range.
6. Assume that picnic tables are contaminated with lead, and take precautions to prevent transfer of lead from surface to food or hands to mouth (e.g., cover the table with a disposable tablecloth before eating). This information should be shared with the range owner.

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Appendix A: Occupational Exposure Limits and Health Effects

In evaluating the hazards posed by workplace exposures, NIOSH investigators use both mandatory (legally enforceable) and recommended OELs for chemical, physical, and biological agents as a guide for making recommendations. OELs have been developed by federal agencies and safety and health organizations to prevent the occurrence of adverse health effects from workplace exposures. Generally, OELs suggest levels of exposure that most employees may be exposed to for up to 10 hours per day, 40 hours per week, for a working lifetime, without experiencing adverse health effects. However, not all employees will be protected from adverse health effects even if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a preexisting medical condition, and/or a hypersensitivity (allergy). In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the employee to produce adverse health effects even if the occupational exposures are controlled at the level set by the exposure limit. Also, some substances can be absorbed by direct contact with the skin and mucous membranes in addition to being inhaled, which contributes to the individual's overall exposure.

Most OELs are expressed as a TWA exposure. A TWA refers to the average exposure during a normal 8- to 10-hour workday. In the United States, OELs have been established by federal agencies, professional organizations, state and local governments, and other entities. Some OELs are legally enforceable limits, while others are recommendations. The U.S. Department of Labor OSHA PELs (29 CFR 1910 [general industry]; 29 CFR 1926 [construction industry]; and 29 CFR 1917 [maritime industry]) are legal limits enforceable in workplaces covered under the Occupational Safety and Health Act of 1970. NIOSH RELs are recommendations based on a critical review of the scientific and technical information available on a given hazard and the adequacy of methods to identify and control the hazard. NIOSH RELs can be found in the NIOSH Pocket Guide to Chemical Hazards [NIOSH 2010]. NIOSH also recommends different types of risk management practices (e.g., engineering controls, safe work practices, employee education/training, personal protective equipment, and exposure and medical monitoring) to minimize the risk of exposure and adverse health effects from these hazards. Other OELs that are commonly used and cited in the United States include the TLVs recommended by ACGIH, a professional organization, and the WEELs recommended by the AIHA, another professional organization. The TLVs and WEELs are developed by committee members of these associations from a review of the published, peer-reviewed literature. They are not consensus standards. ACGIH TLVs are considered voluntary exposure guidelines for use by industrial hygienists and others trained in this discipline "to assist in the control of health hazards" [ACGIH 2011]. WEELs have been established for some chemicals "when no other legal or authoritative limits exist" [AIHA 2011].

Outside the United States, OELs have been established by various agencies and organizations and include both legal and recommended limits. The Institut für Arbeitsschutz der Deutschen Gesetzlichen Unfallversicherung (IFA, Institute for Occupational Safety and Health of the German Social Accident Insurance) maintains a database of international OELs from European Union member states, Canada (Québec), Japan, Switzerland, and the United States. The database, available at http://www.dguv.de/ifa/en/gestis/limit_values/index.jsp, contains international limits for over 1,500 hazardous substances and is updated periodically.

NIOSH investigators encourage the use of the traditional hierarchy of controls approach to eliminate or minimize identified workplace hazards. This includes, in order of preference, the use of (1) substitution or elimination of the hazardous agent, (2) engineering controls (e.g., local exhaust ventilation, process enclosure, dilution ventilation), (3) administrative controls (e.g., limiting time of exposure, employee training, work practice changes, medical surveillance), and (4) personal protective equipment (e.g., respiratory protection, gloves, eye protection, hearing protection).

Below we provide the OELs and surface contamination limits for the compounds we measured, as well as a discussion of the potential health effects from exposure to these compounds.

Lead

Lead is ubiquitous in U.S. urban environments due to the widespread use of lead compounds in industry, gasoline, and paints during the past century. Exposure to lead occurs via inhalation of dust and fume and via ingestion through contact with lead-contaminated hands, food, cigarettes, and clothing. Absorbed lead accumulates in the body in the soft tissues and bones. Lead is stored in bones for decades, and may cause health effects long after exposure as it is slowly released in the body.

Symptoms of chronic lead poisoning include headache, joint and muscle aches, weakness, fatigue, irritability, depression, constipation, anorexia, and abdominal discomfort [Moline and Landrigan 2005]. Overexposure to lead may also result in kidney damage, anemia, high blood pressure, infertility and reduced sex drive in both sexes, and impotence. In most cases, an individual's BLL is a good indication of recent exposure to lead, with a half-life (the time interval it takes for the quantity in the body to be reduced by half its initial value) of 1–2 months [Lauwerys and Hoet 2001; Moline and Landrigan 2005; NCEH 2005]. Elevated zinc protoporphyrin levels have also been used as an indicator of chronic lead intoxication, however, other factors, such as iron deficiency, can cause an elevated zinc protoporphyrin level, so the BLL is a more specific test for evaluating occupational lead exposure.

Under the OSHA general industry lead standard (29 CFR 1910.1025), the PEL for airborne exposure to lead is 50 µg/m^3 for an 8-hour TWA. The standard requires lowering the PEL for shifts exceeding 8 hours, medical monitoring for employees exposed to airborne lead at or above the AL of 30 µg/m^3 (8-hour TWA), medical removal of employees whose average BLL is 50 µg/dL or greater, and economic protection for medically removed workers. Medically removed workers cannot return to jobs involving lead exposure until their BLL is below 40 µg/dL. NIOSH has an REL for lead of 50 µg/m^3 averaged over an 8-hour work shift [NIOSH 2010]. ACGIH has a TLV for lead of 50 µg/m^3 (8-hour TWA), with worker BLLs to be controlled to or below 30 µg/dL, and designation of lead as an animal carcinogen [ACGIH 2011].

The NIOSH REL is consistent with the OSHA PEL, which is intended to maintain worker BLLs below 40 µg/dL. This is also intended to prevent overt symptoms of lead poisoning, but is not sufficient to protect workers from more subtle adverse health effects like hypertension, renal dysfunction, and reproductive and cognitive effects [Schwartz and Stewart 2007; Schwartz and Hu 2007; Brown-Williams et al. 2009]. Adverse effects on the adult reproductive, cardiovascular, and hematologic systems, and on the development of children of exposed workers, can occur at BLLs as low as 10 µg/dL [Sussell 1998]. Recommendations from the March 2007 edition of Environmental Health Perspectives' Mini-Monograph on adult lead exposure and from the Association of Occupational and Environmental Clinics include advising workers and shooters that BLLs should be kept below 10 µg/dL [CSTE 2009].

In homes with a family member occupationally exposed to lead, care must be taken to prevent "take home" of lead, that is, lead carried into the home on clothing, skin, hair, and in vehicles. High BLLs in resident children and elevated concentrations of lead in the house dust have been found in the homes of workers employed in industries associated with high lead exposure [Grandjean and Bach 1986]. Particular effort should be made to ensure that children of persons who work in areas of high lead exposure receive a BLL test. The current CDC screening guidelines for children use 10 µg/dL as a "level of concern" in order to intervene and prevent long-term cognitive deficits [CDC 2005].

Lead-contaminated surface dust represents a potential source of lead exposure, particularly for young children. This may occur either by direct hand-to-mouth contact, or indirectly from hand-to-mouth contact with contaminated clothing, cigarettes, or food. Previous studies have found a significant correlation between resident children's BLLs and house dust lead levels [Farfel and Chisholm 1990]. In the workplace, generally there is little or no correlation between surface lead levels and employee exposures because ingestion exposures are highly dependent on personal hygiene practices and available facilities for maintaining personal hygiene. No current federal standard provides a permissible limit for lead contamination of surfaces in occupational settings.

Noise

Noise-induced hearing loss is an irreversible, sensorineural condition that progresses with exposure. Although hearing ability declines with age (presbycusis), noise exposure produces more hearing loss than that resulting from aging alone. This NIHL is caused by damage to nerve cells of the inner ear (cochlea) and, unlike some conductive hearing disorders, cannot be treated medically [Berger et al. 2003]. In most cases, NIHL develops slowly and usually occurs before it is noticed. Hearing loss is often severe enough to permanently affect a person's ability to hear and understand speech. For example, people with hearing loss may not be able to distinguish words such as "fish" from "fist." [Suter 1978].

The dBA is the preferred unit for measuring sound levels to assess employee noise exposures. The dBA noise scale is weighted to approximate the sensory response of human ears to sound frequencies near the hearing threshold. Because the dBA scale is logarithmic, increases of 3 dBA, 10 dBA, and 20 dBA represent a doubling, tenfold increase, and hundredfold increase of sound energy, respectively. Noise exposures expressed in dBA cannot be averaged by taking the arithmetic mean.

The OSHA noise standard [29 CFR 1910.95] specifies a PEL of 90 dBA as an 8-hour TWA. The OSHA PEL is calculated using a 5 dB exchange rate. This means that a person may be exposed to noise levels of 95 dBA for no more than 4 hours, 100 dBA for 2 hours, 105 dBA for 1 hour, etc. An employee's daily noise dose, on the basis of duration and intensity of noise exposure, can be calculated according to the formula:

$$\text{Dose} = 100 \times (C1/T1 + C2/T2 + \ldots + Cn/Tn),$$

where Cn indicates the total time of exposure at a specific noise level, and Tn indicates the reference duration for that level as given in Table G-16a of the OSHA noise regulation. Doses greater than 100% exceed the OSHA PEL.

When noise exposures exceed the PEL of 90 dBA, OSHA requires that employees wear hearing protection and that an employer implement feasible engineering or administrative controls to reduce noise exposures. The OSHA noise standard also requires an employer to implement a hearing conservation program when 8-hour TWA noise exposures exceed the AL 85 dBA. The program must include noise monitoring, employee notification, observation, audiometric testing, hearing protectors, training, and record keeping.

NIOSH [NIOSH 1998] and ACGIH [ACGIH 2011] recommend an exposure limit of 85 dBA as an 8-hour TWA. A more conservative 3 dB exchange rate is used in calculating these exposure limits. Using NIOSH criteria, an employee can be exposed to 85 dBA for 8 hours, but to no more than 88 dBA for 4 hours, 91 dBA for 2 hours, 94 dBA for 1 hour, etc. According to the NIOSH REL, 12-hour exposures must be 83.2 dBA or less.

Audiometric evaluations of employees' hearing thresholds must be conducted in quiet locations, preferably in a sound-attenuating booth, by presenting pure tones of varying frequencies at threshold levels (i.e., the level of a sound that the person can just barely hear). Zero dB hearing level represents the hearing level of an average, young individual with good hearing. OSHA requires hearing thresholds to be measured at test frequencies of 500, 1,000, 2,000, 3,000, 4,000, and 6,000 Hz. Individual employee's annual audiograms are compared to their baseline audiogram to determine if a standard threshold shift has occurred. OSHA states that a standard threshold shift has occurred if the average threshold values at 2,000, 3,000, and 4,000 Hz have increased by 10 dB or more in either ear when comparing the annual audiogram to the baseline audiogram [29 CFR 1910.95]. The NIOSH-recommended hearing threshold shift criterion is a 15-dB shift at any frequency in either ear from 500–6,000 Hz measured twice in succession [NIOSH 1998]. Both of these hearing threshold shift criteria require at least two audiometric tests.

The audiogram profile is a plot of the hearing test frequencies (x-axis) versus the hearing threshold levels (y-axis). For many employees, the audiogram profile tends to slope downward toward the high frequencies with an improvement at the audiogram's highest frequencies, forming a "notch" [Suter 2002]. A notch in the audiogram of an employee with otherwise normal hearing may indicate the early onset of hearing loss. The notch from occupational noise can occur between 3,000 and 6,000 Hz [ACOM 1989; Osguthorpe and Klein 2001]. However, it is generally accepted that a notch at 4,000 Hz indicates occupational hearing loss [Prince et al. 1997]. An individual may have notches at different frequencies in one or both ears [Suter 2002]. For this evaluation, a notch is defined as the frequency where the hearing level is preceded by an improvement of at least 10 dB and followed by an improvement of at least 5 dB.

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Noise Dosimetry

Noise dosimeters (Larson Davis, Provo, Utah, Spark™ models 706RC or 705P) were attached to the wearer's belt, and a small remote microphone was fastened to the wearer's shirt at a point midway between the ear and outside of the shoulder. A windscreen provided by the dosimeter manufacturer was placed over the microphone to reduce or eliminate artifact noise, which can occur if objects bump against an unprotected microphone. The dosimeters were set up to collect data using different settings to allow comparison of noise measurement results with the three different noise exposure limits referenced in this health hazard evaluation, the OSHA PEL and AL and the NIOSH REL (Table B1). During noise dosimetry measurements, noise levels below the threshold level are not integrated by the dosimeter for accumulation of dose and calculation of TWA noise level.

The dosimeters averaged noise levels every second. At the end of the sampling period, the dosimeter was removed and paused to stop data collection. The noise measurement information stored in the dosimeters was downloaded to a computer for interpretation with Larson Davis Blaze® software. The dosimeters were calibrated before and after the measurement periods according to the manufacturer's instructions.

Table B1. Dosimeter settings

Parameters	OSHA AL	OSHA PEL	NIOSH REL
Response	Slow	Slow	Slow
Exchange rate	5	5	3
Criterion level	90	90	85
Threshold	80	90	80
Upper limit	115	115	115

Area noise levels and octave band noise frequency analysis (measurement of noise in different frequencies) were measured with System 824 SLM and real-time frequency analyzers (Larson-Davis, Provo, Utah). The SLMs were equipped with 0.25-inch random incidence Type 1 microphones; the instruments measured noise levels between 16 and 170 dBA. Sound level and octave band frequency spectrum measurements were collected at a sample rate of 51,200 times per second and averaged eight times per second. The SLMs were calibrated before and after the measurement periods according to the manufacturer's instructions. SLMs were either handheld or mounted on a tripod at a height of approximately 5 feet.

Lead in Air

Air samples for lead were collected on 37-millimeter diameter, 0.8-micron pore-size mixed cellulose ester filters using SKC Air Check® 2000 air sampling pumps (SKC Inc., Eighty Four, Pennsylvania) calibrated at a flow rate of 2 liters per minute. The inlet port of the sampling pump was connected to the sampling media with Tygon® tubing. For PBZ samples, the sampling media were attached to the employee's lapel

within the breathing zone, roughly defined as an area in front of the shoulders with a radius of 6 to 9 inches. Samples were analyzed by inductively coupled plasma according to NIOSH Method 7303 [NIOSH 2011].

Lead on Surfaces

We collected six surface wipe samples for lead. Surface samples were collected with premoistened Palintest® dust wipes (Palintest USA, Erlanger, Kentucky). The collection procedure was as follows: (1) identify the area to be sampled, (2) put on a pair of disposable nitrile gloves, (3) place the wipe flat on surface as defined by the 10 centimeter by 10 centimeter disposable template and wipe surface using three to four horizontal S-strokes, side-to-side so that entire surface is covered, (4) wipe the area with three to four vertical S-strokes, (5) wipe the area with three to four diagonal S-strokes, and (6) place the wipe in a sterile container. A new template and a pair of disposable gloves were used for each wipe sample. The wipe samples were digested and analyzed by inductively coupled argon plasma according to NIOSH Method 9102 [NIOSH 2011].

Lead on Hands

Hand wipe samples were collected and analyzed with a commercially available dust wipe (Full Disclosure® Instant Wipes, SKC Inc., Eighty Four, Pennsylvania) conforming to the American Society for Testing and Materials Standard E 1792 (Specifications for Wipe Sampling Materials for Lead in Surface Wipes). After collection, each wipe was sprayed with a 5% leaching solution of acetic acid to solubilize lead and lead compounds into lead ions. The wipe was then sprayed with a chilled solution of sodium rhodizonate, a chemical that reacts colorimetrically to the presence of lead by changing from yellow to red. The visual limit of identification for the method is approximately 17–20 micrograms per sample.

Reference

NIOSH [2011]. NIOSH manual of analytical methods (NMAM®), 4th ed. Schlecht PC, O'Connor PF, eds. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication 94–113 (August, 1994); 1st Supplement Publication 96–135, 2nd Supplement Publication 98–119; 3rd Supplement 2003–154. http://www.cdc.gov/niosh/nmam/. Date accessed: September 2011.

Acknowledgments and Availability of Report

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REPORT INCLUDING RESEARCH ON GUNFIRE NOISE LEVELS

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From the National Institute for Occupational Safety and Health

Reducing Exposure to Lead and Noise at Indoor Firing Ranges

Summary

Workers and users of indoor firing ranges may be exposed to hazardous levels of lead and noise. The National Institute for Occupational Safety and Health (NIOSH) recommends steps for workers and employers to reduce exposures.

Description of Exposure

According to the Bureau of Justice Statistics, more than 1 million Federal, State, and local law enforcement officers work in the United States [DOJ 2004]. They are required to train regularly in the use of firearms. Indoor firing ranges are often used because of their controlled conditions (see Figure 1). In addition to workers, more than 20 million active target shooters practice at indoor firing ranges. Law enforcement officers may be exposed to high levels of lead and noise at indoor firing ranges. NIOSH estimates that 16,000 to 18,000 firing ranges operate in the United States.

Several studies of firing ranges have shown that exposure to lead and noise can cause health problems associated with lead exposure and hearing loss, particularly among employees and instructors. Lead exposure occurs mainly through inhalation of lead fumes or ingestion (e.g., eating or drinking with contaminated hands) (see Figure 2) [NIOSH 2009].

Exposure Limits

Lead

OSHA has established limits for airborne exposure to lead (see 29 CFR 1910.1025*). The standard creates the action level and the permissible exposure limit (PEL). The action level for airborne lead exposure is 30 micrograms per cubic meter of air ($\mu g/m^3$) as an 8-hour time weighted average (TWA). The OSHA PEL for airborne exposure to lead is 50 $\mu g/m^3$ as an 8-hour TWA, which is reduced for shifts longer than 8 hours.

The NIOSH recommended exposure limit (REL) for airborne lead is 50 $\mu g/m^3$ as an 8-hour TWA. A worker's blood lead level (BLL) should remain below 60 μg lead/100g of whole blood [NIOSH 2009].

*Code of Federal Regulations. See CFR in References.



Figure 1. Law enforcement officers during shooting practice.

Noise

For noise exposure, the OSHA limit is a maximum PEL of 90 decibels, A-weighted (dBA), averaged over an 8-hour time period (see 29 CFR 1910.95).

The NIOSH REL for noise (8-hour TWA) is 85 dBA using a 3-dB exchange rate [see NIOSH 1998]. Exposure to impulse noise, such as that



Figure 2. Emissions from the discharge of firearms.

which comes from weapons, cannot exceed 140 dB sound pressure level (SPL).

Avg over entire duration, not peak (not applicable)

Case Studies

Case 1—Lead exposure of school rifle teams

The Alaska Environmental Public Health Program initiated a statewide review of school-sponsored rifle teams after a team coach was found to have an elevated BLL of 44 μg/dL. The review examined six rifle teams using three indoor firing ranges. Teams using two of the firing ranges did not show elevated BLLs. The other three teams used a firing range with extensive lead contamination. The teams showed elevated BLLs.The highest level was 31 μg/dL, which is above the level considered elevated (25 μg/dL). The firing range was voluntarily closed and arrangements were made for a thorough evaluation [State of Alaska 2003; NIOSH 2009].

Case 2—Noise exposures of Federal and local law enforcement officers

NIOSH investigators conducted live-fire noise exposure evaluations of Federal and local law enforcement officers at indoor and outdoor firing ranges. Measurements were conducted on a variety of law enforcement firearms. Peak sound pressure levels ranged from 155–168 dB SPL. A-weighted, equivalent (averaged) levels ranged from 124–128 dBA. Hearing protectors were also evaluated. Earmuffs had a mean peak reduction of 26 dB; earplugs alone had a mean peak reduction of 24 dB. The mean peak reduction for combined earmuffs and earplugs was 44 dB. NIOSH recommended the use of this double protection for impulsive noise and also noise abatement strategies, modifications to the firing range structure, and a hearing conservation program [NIOSH 2009].

Recommendations

Workers and shooters at firing ranges should take the following steps to protect themselves:

- Take training, follow safe work practices, and participate in health monitoring programs.
- Use personal protective equipment (PPE):
  - Use double hearing protection (earplugs and earmuffs).
  - Wear respirators and full protective outer clothing for maintenance activities that involve close contact with lead dust or spent bullets.

- Wear gloves and eye protection when using chemicals to clean weapons or firing range surfaces.

- Practice good hygiene:
  - Wash hands, arms, and face before eating, drinking, smoking, or contact with others.
  - Change clothes and shoes before leaving the facility.
  - Wash clothes used at the firing range separately from family's clothes.

- Report symptoms to your employer and get medical attention when needed:
  - Common health effects of lead poisoning in adults include reproductive effects, nausea, diarrhea, vomiting, poor appetite, weight loss, anemia, fatigue or hyperactivity, headaches, stomach pain, and kidney problems.
  - If you suspect you have been exposed to lead, even if you have no symptoms, get your blood lead level tested.
  - Exposure to high noise levels can cause hearing loss, tinnitus (ringing in the ear), stress, high blood pressure, fatigue, and gastro-intestinal problems.

Employers should take the following steps to protect workers and shooters at firing ranges:

- Provide workers and shooters with training and information about hazards:
  - Inform pregnant workers and shooters about possible risks to the fetus.
  - Ensure that workers are aware of symptoms that may indicate a health problem.
  - Tell workers about participating in medical surveillance programs and getting blood lead levels tested, even if they don't show symptoms.

- Establish effective engineering and administrative controls:
  - Install an effective supply air and exhaust ventilation system.
  - Maintain and replace air filters regularly.
  - Apply appropriate noise control measures to limit noise inside the range and in nearby areas.
  - Keep the firing range and other workplace areas clean using proper cleaning procedures such as wet sweeping and HEPA vacuuming of surfaces.
  - Provide workers with lockers and places to wash to avoid take-home contamination.
  - Limit length of time that workers and shooters use the firing range: rotate assignments and provide quiet, clean, break areas.

- Provide workers with protective equipment:
  - Provide hearing protection devices such as earplugs and earmuffs.
  - Provide skin protection, eye protection, and NIOSH-approved respirators for workers who clean lead-contaminated areas.
  - Provide floor mats, knee pads, and shoe covers to limit transfer of lead to clothing.

- Review OSHA requirements for medical monitoring for lead (29 CFR 1910.1025(j)) and noise (29 CFR 1910.95(d)(e)(g)(h)).

- For best medical and lead management practices, consult the Association of Occupational and Environmental Clinics, Kosnett et al. [2007] and NASR [2005].

Acknowledgments

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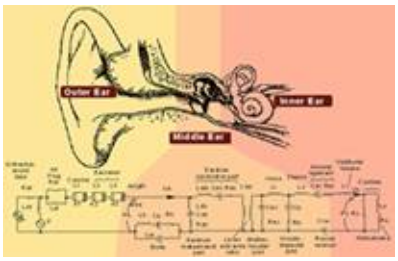
Reducing Exposure to Lead and Noise at Indoor Firing Ranges

DHHS (NIOSH) Publication No. 2010–113

REPORT INCLUDING RESEARCH ON GUNFIRE NOISE LEVELS

Weapon Noise Exposure of the Human Ear Analyzed with the AHAAH Model

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Predicting the hazard from intense impulses, such as weapons fire or airbags, has remained an intractable problem. The U.S. Army has developed a theoretically based mathematical model of the ear designed to predict such hazards. To establish its validity as a predictor of hazard for the human ear, data from the literature (a waveform and changes in hearing sensitivity) were processed with the model and its ability to predict the onset of unacceptable threshold shift (25 dB or more) in the 95 percentile ear was determined. For comparison, MIL STD-1747(D) and A-weighted energy were also used to compute hazard for the same data. The primary dataset was that of the US Army's "Albuquerque Studies" (53 different cases) and other impulses from the literature (16 additional predictions). The AHAAH model predicted correctly in 95% of the cases, the MIL STD-1474(D) was correct in 38% of the cases and A-weighted energy was correct in 25% of the cases. Errors for all methods tended to be in the direction of over-prediction of hazard. The AHAAH model is not only more accurate but has the advantage of being theoretically based, which improves the likelihood of its being correct on new impulses with novel pressure histories.

I. Introduction

Rating the noise of intense impulse noises has been a perplexing technical problem for many years. The recent consensus of the scientific community has been that none of the existing standards is accurate (Chan, Ho, Kan, Stuhmiller, & Mayorga, 2001; NATO, 2000; 1987). A long-term effort at the ARL has recently produced the auditory hazard assessment algorithm for the human ear (AHAAH) (Kalb & Price, 2002; Price & Kalb 1987, 1991, 1998). AHAAH is essentially a theoretically based electroacoustic analog of the ear designed to predict hazard from any intense sound. The prediction is based on pressure measurements in the free field, at the tragus or at the eardrum, the effects of which are propagated though the middle ear and end in the calculation of basilar membrane displacements. Then, algorithms calculate the "dose" (summed mechanical stresses) at 23 locations within the cochlea. The output is in auditory hazard units that yield a prediction of immediate threshold shift, which in turn also provides a prediction of permanent threshold shift and hair cell loss. A copy of this software and instructions about its operation are now downloadable at the AHAAH website at **http://www.arl.army.mil/AHAAH/**.

A. Need for accuracy

Ideally, a noise standard should be theoretically based, easy to use, unambiguous in its application and most importantly, for the military, it should predict hazard accurately. The need for accuracy is critical from two perspectives. If the true hazard is under-estimated, hearing loss will be produced in the exposed population. In addition to the great personal loss associated with deafness are the costs of force preservation and loss in mission effectiveness. The other perspective is just as compelling, however. If the true hazard is over-estimated, then weapons designs will be limited, the chances of mission success will suffer and casualties will result because of limited range or power of the weapon system. Neither inaccuracy is acceptable; both types must be avoided. Actually, the argument regarding the need for accuracy can be made for noise hazard assessment in the civilian world as well. A current example would be the problem of airbag design in the automobile industry where underestimation of hazard will result in loss of hearing in those exposed (Yaremchuck, 1998; Fleischer, Muller, Heppelman, & Bache, 2002; Price, 1998a; Saunders, Slattery & Luxford, 1998) and overestimation of hazard could result in ineffective airbag designs that would fail to protect from injury. Here too, the goal of a DRC should be accurate prediction of hazard. The purpose of this paper is to document the accuracy of the AHAAH procedure in predicting threshold shift in human data and to compare it with other methods of analysis.

B. Data analysis

AHAAH operates by processing a digitized waveform. High resolution digital recordings provide the best analysis. Failing that, pictures of waveforms can be digitized but there is a great loss in dynamic range as you go from the visual to the digitized auditory world. A good visual display can provide only about 30 dB of dynamic range, enough where peak pressures are being measured; but not good enough where an algorithm employs all the information in the waveform. In the pressure regime around weapons, it is relevant to note that a

reduction of 30 dB from 185 dB is still 155 dB! Therefore, formal analysis with AHAAH had to be restricted to those waveforms for which digitized recordings were available. Of course, in order to confirm the prediction of hazard, it was also necessary that human threshold shift data also had to be available for exposures to the waveforms.

Today there are about 70 exposures that meet these requirements. Most of these (53) come from the U.S. Army's recent experiments using human volunteers (Johnson, 1998,1994). The remainder come from the impulse noise literature of the 1960s and more recent studies. An additional critical point is that the all the newer data from experiments are from subjects with protected ears, whereas the earlier studies were typically done with subjects wearing no hearing protection.

Even when the digitized waveforms and human threshold shift data are available, comparisons between studies and criteria are complicated by a lack of a common basis in reporting data. Studies may provide unique measures of effect, e.g., number of impulses to reach some criterion (some amount of threshold shift in an ear(s) at some frequency(s), number of subjects reaching a criterion threshold shift, number of subjects not recovering in a given time period, etc. Because of the way they were derived, criteria do not use a common data set or use the same data to predict a satisfactory outcome.

To cut through this Gordian knot of non-common information use, in this report we adopted a viewpoint that provides a common method of comparison. DRCs are now commonly designed to protect the 95 percentile ear (most susceptible). So the problem for comparison of rating methods becomes determining whether any given exposure will produce an unacceptable threshold shift in the 95 percentile ear, now commonly held to be 25 or more decibels at any frequency. At the very high exposure levels around weapons (well in excess of 140 dB peak), the loss mechanism is thought to be mechanical stress - akin to a fracture or a strain in the musculo-skeletal system. It appears that 25 dB of threshold shift is tolerable and would be expected to produce no permanent threshold shift from at least occasional exposure (Johnson, 1998; NATO, 2000, 1987).

In this article, we will consider the Army's recent experiments first, then the individual studies.

II. ANALYSIS OF The Exposure Data

A. The Albuquerque studies

The U.S. Army has conducted the most extensive set of studies of impulse noise exposure of protected ears ever undertaken (Johnson, 1998, 1994; Patterson, Mozo, Gordon, Canales & Johnson, 1997). Given that they were conducted at a facility near Albuquerque , NM, they have become collectively referred to as "the Albuquerque studies". The studies were well and carefully conducted, documented far more completely than previous work and represent the greatest source of data about protected human exposure to intense impulses of which we are aware. In them, the exposure pressures were also far higher than in most studies, higher even than those around modern weapon systems. The highest peak pressures tested were in excess of 195 dB! Given the difficulty and cost in conducting such research with human volunteers, it seems unlikely that this database will be superseded in the foreseeable future.

There were, however, a number of surprises during the conduct of the study that affected the essential design of the experiment and its interpretation. Fortunately, the study was documented well enough that effects of these unusual situations are for the most part known. We will consider first the essential design of the study and then comment on the features that warrant special attention.

1. Design of the studies

The design of this series of studies was based on the concept that exposure to impulses produced by exploding C4 charges of differing weights and physical locations would simulate exposures to generic large caliber weapons used by the Army. The exposure scheme was delineated as diagrammed in Table I. Each level of the exposure was intended to be a 3-dB increase in the peak pressure of the impulse and a doubling of its energy.

	NUMBER OF IMPULSES				
LEVEL	6	12	25	50	100
7		x	x	x	x
6					
5					
4					
3					
2					
1					

Table I. Exposure matrix for the Albuquerque studies

A particular exposure was considered dangerous for a subject if it produced a 25-dB or greater threshold shift at any test frequency. This was referred to as a "full audiometric failure". In practice, however, if a threshold shift of 15 to 24 dB was produced at a particular level, the experimenters were unwilling to expose that ear to the next higher level. In such a case, a "Conditional Failure" was recorded at the next higher level.

Subjects entered the exposure matrix (Table I) at the lower left corner (Level 1, 6 impulses) wearing a circum-aural hearing protective device and if they had no significant threshold shift they progressed to the next higher exposure, Level 2, 6 impulses, and so on up the left side of the matrix as indicated by the "up" arrow. When they reached Level 7, 6 impulses, and passed it, they dropped back to Level 6 and were exposed to increasing numbers of impulses, as indicated by the right-pointing arrow. If they received no significant threshold shift, they were exposed to the next higher number of impulses. If they reached Level 6, 100 impulses, they had successfully completed the course of exposures. If, however during the course of traveling this path, a subject experienced a significant threshold shift, he was dropped down in level and moved toward more impulses at the lower level and so on.

In the initial conception of the study, it was presumed that failures would occur as the levels increased and that the subjects would "migrate""on a "just safe""path through the matrix at lower levels and increasing numbers of impulses. It was also presumed, on the basis of existing DRCs that double hearing protection would be needed in order to complete the matrix but it was not necessary. In fact, the ear appears to be surprisingly robust and such failures occur less often than might be expected. As a result, only a few subjects were tested on the interior cells of the matrix (Levels 1 through 5 and 12, 25, 50, and 100 impulses) and the data there are only suggestive.

2. The exposures

The free field impulses were designed to be Friedlander-like impulses characteristic of Army weapons. The apparatus necessary to produce these impulses took two basically different configurations. The exposure referred to in the reports as the 5-meter conditions had a bare charge suspended about 3 m above a concrete pad, 5 meters from the subjects. For the 3-meter and 1-meter exposures, a mortar-like exposure device was fabricated and the subjects were seated on a circular expanded metal platform with their ears just above the level of its "muzzle,",about 3 m above the ground. The subjects were located either 1 or 3 meters (approximately) from the edge of the barrel, thus the designation 3 meter and 1 meter conditions. In acoustic terms, the A-durations of the impulses were about 2.6 msec, 1.5 msec and 1.0 msec respectively. The pressure histories of the impulses and their energies, etc. have been reported in Patterson et al. (1997) and in Figure 3 of Chan et al. (2001).

The reverberant impulses were produced in a steel-walled chamber (3M x 3M x 2.44M) and had much longer durations. They were intended to simulate weapons fired from bunkers, within rooms, or the pressure history within the crew compartments of fighting vehicles. An explosive charge was fired outside the chamber at the end of a barrel that extended into the chamber. The B-durations for these impulses were several hundred milliseconds long. The waveforms for these impulses have been published in Johnson (1998), and an example of the pressure history of the impulse in the room appears in Figure 1. Note that the x-axis in this figure is 500 msec long. The actual peak pressures of these impulses were 184 dB at Level 7 and 182.5 dB for level 6. The impulse that the ear actually saw, however, was that

under the muff. An example of that waveform is presented in Figure 2. It is apparent that most of the high frequencies have been attenuated by the muff and that the peak pressure is lower (about 174 dB for the level 6 impulse). For the reverberant impulses, exposure was limited to one round at all levels of Tables 1 and two and three rounds only at level 6.

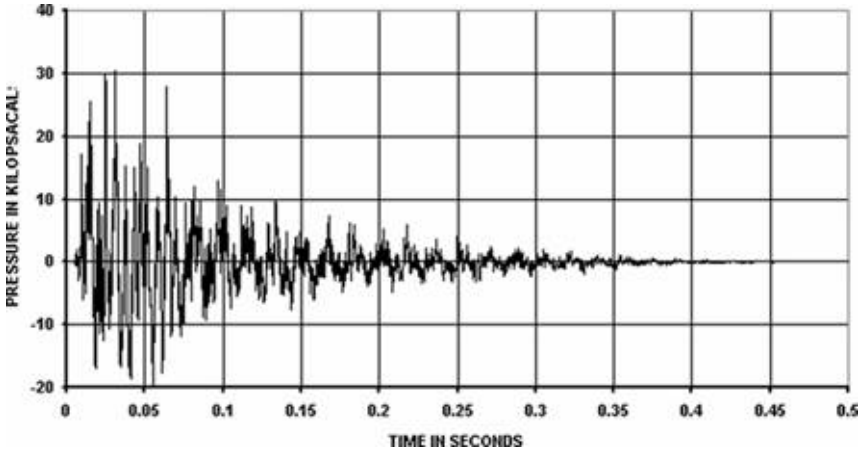


Fig. 1. Pressure history of a typical impulse in the reverberant field.

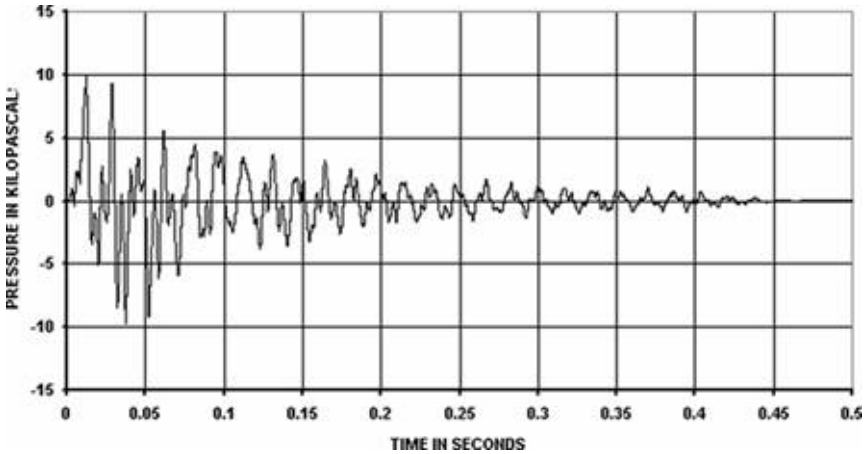


Fig. 2. Pressure history for the Level 6 reverberant impulse under the ear muff.

For the non-reverberant impulses, subjects were seated during all exposures with their heads in a chin-rest and their right ear facing the impulse source. For the reverberant impulses, the left and right ears were tested about equally. The non-test ear (typically the left ear) always wore double hearing protection. Impulses were delivered 1 minute apart following a countdown (ten, nine, eight, seven ----) that was audible because of a peak-limiting talk-through circuit in the muff. Subjects were well aware of when the impulse was coming and in fact, depended on the countdown. In one test, a set of trials was attempted without the preparatory countdown and subjects were simply unwilling to tolerate the higher exposure levels.

3. Audiometry

A baseline of thresholds was determined for each subject by automatic audiometry before any noise exposure (to be acceptable, a subject's tests had to have a standard deviation of less than 4 dB). Thresholds were determined just before exposures, then immediately afterward and changes were followed until they had resolved. Two types of "audiometric failure" were recognized in the study. Any threshold shift greater than 25 dB at any one frequency was defined as a "full audiometric failure". Threshold shifts between 15 and 25 dB, however, were taken as evidence that the ear was being stressed and the experimenters were justifiably reluctant to continue by exposing that ear to the next higher condition. These were the "conditional failures" mentioned earlier.

This level of shift was apparently well chosen. If it had been lower, then occasional audiometric variability would have given false-positive results. If higher levels of threshold shift were required, then the risk of permanent hearing loss would have been much higher. In fact, all subjects recovered to their pre-exposure thresholds.

4. The hearing protector

The Racal muff was chosen originally because it represented a moderately effective hearing protector that had a talk-through circuit and

could be worn under an infantry helmet (used in the tests). It was possible that when the pressures rose to the point where the muff did not provide adequate protection, an earplug could be added and exposure continued. The unexpected result from the first 5-meter study was that the muff alone provided adequate protection for all subjects. MIL-STD-1474 had predicted that double hearing protection would not be adequate. The experimenters then made a critical decision. The seal on the right muff (toward the impulse source) was defeated when eight plastic tubes were inserted (2.3 mm inside diameter, four open to the front and four open to the rear). This leak was intended to simulate a badly fitting ear seal and perhaps more closely replicate the fit during field conditions. The 5-Meter study was rerun with these muffs followed by the 3-meter and 1-meter conditions as well as a reverberant room exposure to simulate firing from an enclosure.

5. Problems with the studies

a. The hearing protector. First is the question regarding the attenuation of the hearing protector. Conventional wisdom is that passive hearing protectors are essentially linear devices with respect to level, i.e., measured attenuation is independent of level. In contrast, the modified muff was non-linear with respect to amplitude, i.e. its attenuation got better as a function of level (as much as 11 dB!). And even the unmodified muff, at these very high sound pressure levels, was non-linear at the highest pressures (its attenuation became progressively worse by 5 to 6 dB at the highest level). These points are illustrated in Fig. 1 where the attenuation at each level is plotted (A-weighted SEL under the muff was subtracted from the A-weighted SEL in the free field). Free field peak pressures changed approximately 18 dB in 3-dB steps from Level 1 to Level 7. Under the muff, however, pressures rose 7.2 dB (1m data), 11.6 dB (3m data), 12.2 dB (5m data), or 15.1 dB (5m good muff).

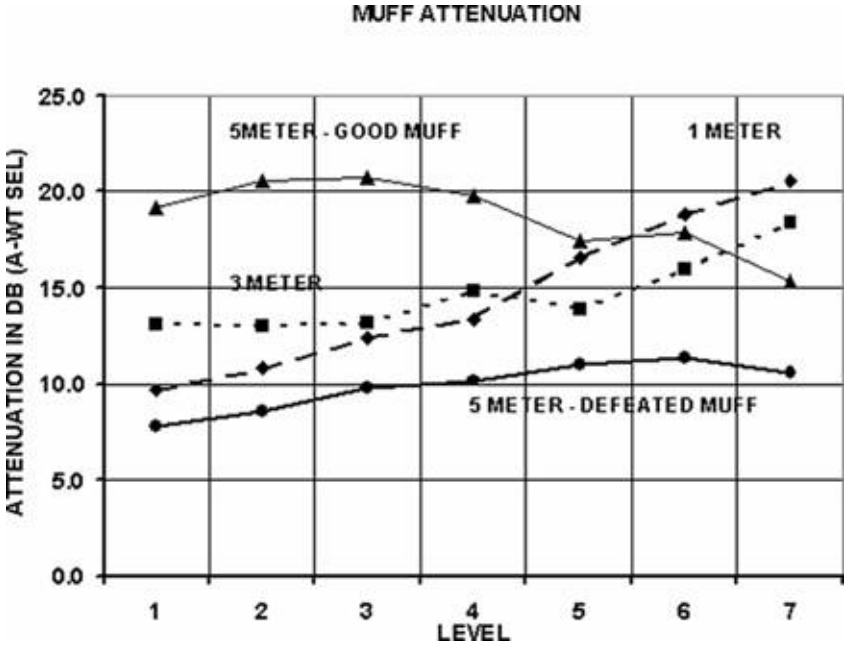


Fig. 3 Attenuation of the earmuffs used in the Albuquerque studies as a function of the exposure level. Free field SPLs increased 3 dB for each change in level. (Peak free field pressure for Level 1 was 179 dB for the 1-meter condition, 178 dB for the 3-meter condition and 173 dB for the 5-meter condition. Data from Patterson et al. (1997) and calculated from pressure histories distributed on a CD.)

An analytical technique or impulse noise standard, such as MIL STD-1474, which uses the pressure measured in the free field and/or makes a single value correction for any hearing protector obviously misses this detail in these data. On the other hand, AHAAH uses the waveform measured under the protector for its calculation and can in principle evaluate all the impulses in the Albuquerque tests without bias.

b. Limitations of the data set. A second concern is that we have no full exposure measured under the muff for an individual subject. We are fortunate to have the sample recordings distributed with the Albuquerque reports; however, it is not possible to follow a full exposure for any individual subject. The interest in doing a full analysis of the subjects' exposures is a function of the potential for individual impulses to have large effects ,and unique circumstances in the fit of the protector or the pressure history of a specific impulse, for instance, may have had an impact on the data. By way of illustration, with impulses at these levels (as high as 195 dB peak), the forces imposed by the acoustic wave are considerable. A picture in a report by Johnson and Patterson (1993) shows a muff (one not used in the experiments) to have been lifted entirely off a manikin head about 40 msec after the initial wave front arrived. Levels above 180 dB are truly intense noise exposures and have the ability to produce unexpected effects, such as the non-linearity in Fig. 1 or movement of the muffs during the exposure (actually observed in the tests [Johnson, 1994]). Estimating the effect of 50 or 100 impulse exposures for more than 300 subjects, based on data from five or six impulses includes some uncertainty. Change in hearing at these levels sometimes occurs very

suddenly, as though one impulse were particularly bad (Johnson, 1999). It is also true that sound fields around explosive sources can have occasional "hot" spots. Given the possible importance of such "rare events," it would have been interesting to have had full recordings of the exposures.

c. Generalizability of the Albuquerque studies. There could be overall questions as to whether the Albuquerque studies truly reproduced the critical variables associated with real weapons exposures and whether the hazard around weapons has been truly assessed. Consider first the subjects and the muffs. The modified muff was obviously a unique device. There is, of course, neither such a thing as a "generic protector" nor any way to create a modification that correctly simulates "field fit" during all conditions and the protector, as used, was one of many possibilities. In fact, for dismounted infantry in combat it is likely that a plug will be worn rather than a muff. It is also true that all leaks should not be thought of as equal in their effect. For example, hole size and orientation could make a protector both amplitude and azimuth sensitive. Further, there is serious concern that in the experiments the protectors were carefully fitted to the subjects and they were always exposed in a specific orientation to the impulse source (ear was facing the source, holes in muff at grazing incidence). The practical hearing conservationist can only aspire to such rigorous adherence to protocol in the field in training and dream of it during conditions of combat. Finally, given the relatively high energies that were demonstrated to be tolerable in these tests, it might be tempting to assume that hearing protection "doesn't really matter" or that just any protector or modification of a protector is acceptable. Such assumptions would be disastrous.

The impulses did, to at least a first approximation, resemble those around real weapons. However, the noise field around weapons is complex and because of reflective surfaces may have unique features in every deployment. Coupled with the fact that the orientation of the Soldier is not fixed, real exposures are much more variable than the exposures in the Albuquerque studies. For example, the ground reflection of the impulse is always present for weapons fired in the open; yet because of the different geometry of the exposure situation, it was very much reduced in the 1-m and 3-m exposures. In the case of real weapons, there is usually considerable un-burnt propellant at the muzzle. Given hot propellant in a turbulent cloud coupled with sudden availability of oxygen, there may be occasional "hot spots" in the noise field because of secondary combustion where the pressures might be 10 or more decibels higher than the impulse from the muzzle. A similar caution with respect to generality applies to the reverberant impulse in the Albuquerque studies. The first several milliseconds of the impulse from a weapon fired from within an enclosure are unaffected by the enclosure. Once the pressure reaches reflective surfaces and returns, however, the latter part of the impulse becomes a function of the size of the enclosure, the reflectivity of its walls, the venting, and its specific geometry as it interacts with the active impulse source. One exposure condition hardly exhausts the possibilities and may not include critical ones.

Finally, the rate of fire in these studies was slow, about 1 impulse per minute. Soldiers are capable of firing weapons such as the 105 mm howitzer about once every 3 seconds or 20 rounds per minute (Paragallo & Dousa, 1979) ,and Gatling gun-type weapons can fire several thousands of rounds per minute. No one study can do everything, but it is worth noting that the rate of fire variable has not really been explored.

6. Interpretation of the data sets

Evaluating the Albuquerque data set with the AHAAH model was for the most part a straightforward exercise. The available data include digitized waveforms from subjects being exposed to almost all the conditions. Pressure histories were recorded in the free field and under the subjects' muffs for a few of the subjects and a number of the impulses. This type of data is just exactly what the model needs. The one exception is that we had no pressure histories under the muff for subjects wearing the defeated muff in the 5-m condition. Fortunately, data were available from preliminary work done with the experimenters themselves in which data had been recorded under the muff for this condition.

a. Interpretation of failures. An intuitive approach to the data sets might assume that within a data set (5-m, 3-m, 1-m, etc.) there is a similarity between all the impulses and that a failure at some given peak level would naturally imply a failure at higher levels as well. However, analysis with the model suggests that such an assumption is not warranted. Had the impulse pressure histories been identical in shape at all levels, then there would have been no question; however, the shape of the pressure history changed in significant ways as a function of level. As a result, the model's analysis indicated that the hazard from the impulses did not grow monotonically with peak level. The result was that for the 1-m and 3-m series of exposures the greatest hazard was predicted to come from the middle levels of peak pressures and actually became lower as the peak pressure rose higher. This state of affairs is presented in Figure 4 for the 1-m exposure condition, 95 percentile ear.

The basis for this inversion of predicted effect lies in the non-linear action of the middle ear coupled with the details of the waveform. In effect, the shape of the impulse following the initial peak pressure changed as pressure rose, so that the effect of the impulse was greatest in the mid-levels of the range. This interaction is discussed at some length in Appendix A. The point is that the prediction, while it may be surprising, is not irrational. If true, then it does not follow that failure at a lower level of this condition implies failure at higher levels. Thus, in scoring failures in the Albuquerque studies, failure at higher levels was not presumed unless the higher exposure level actually contained

a larger number of AHUs.

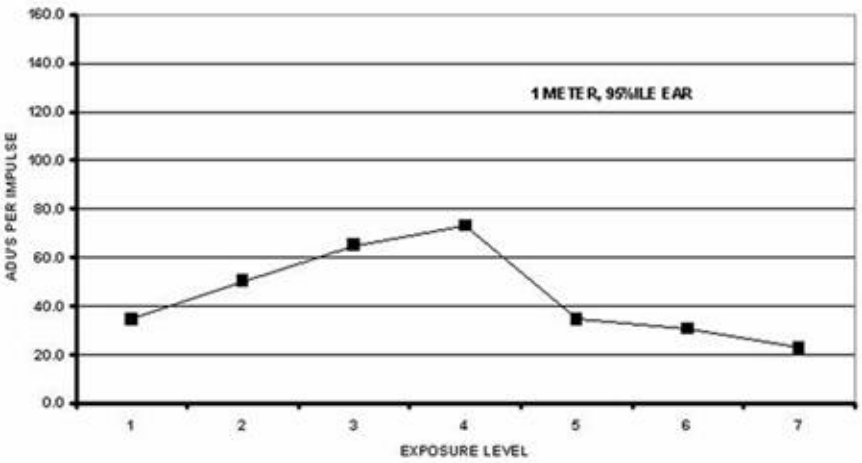


Figure 4. Plot of AHUs per impulse for pressure histories under the muff for the 1-meter exposure, 95 percentile ear.

A statistical problem inherent in the design of the study is that once a subject failed, he did not remain part of the exposure group and the group had lost its most susceptible subject. Had the impulses truly been an ascending series, then assuming failure at the higher levels would have dealt with the question of the loss of the susceptible subject. To have avoided this problem, there should have been a new group of subjects for each condition, but such an approach was simply not practical. In the end, the question of whether to consider failure at lower levels as indicating failure at higher levels turns out to be something of a tempest in a teapot. The data have been analyzed using the different approaches (see Appendix 2) and in the end, there is essentially no difference in assessment of the accuracy of the ear model's prediction.

b. Establishing the 95%ile failure. A statistical argument was developed (Johnson, Patterson, Nelson, Ripple, Mundie, Christensen, and Bova, 1990; Patterson and Johnson, 1994) that in a sample size of 60, one can be roughly 95% confident that the true 95 percentile subject lies between the exposures in which one and six subjects show a significant threshold shift. Alternatively put, when there is no threshold shift exceeding 25 dB, we can be 95% confident that the exposure is safe for the 95 percentile subject. Likewise, when six ears show a threshold shift of 25 or more dB, we can be 95% confident that the 95 percentile threshold shift also exceeds 25 dB. When 1 to 5 subjects show threshold excess threshold shifts, the exposure is indeterminate-- it could be either safe or hazardous. In such cases, the prediction was given the benefit of the doubt and not counted as incorrect.

c.The AHAAH calculation. From the standpoint of the model, unacceptable threshold shift was predicted to occur in the 95 percentile ear when an exposure totaled 500 AHUs. Therefore, with waveforms recorded under the hearing protector, fiveor more impulses from each exposure condition (as available) were run through the model and their average was taken to be characteristic of that exposure level. The total exposure, of course, was the number of AHUs per impulse multiplied by the number of impulses. Because the Albuquerque studies included an audible countdown before each impulse, we presume that the subjects were "braced" for the event and that their middle ear muscles had contracted before the exposure. In support of this contention is the fact that the warning was very important to the subjects. When the experimenters tried one series of experiments without the clear warning, the subjects did not want to complete the exposure series.

d. Predictions by other methods. For comparison purposes, the predictions of MIL-STD-1474 have been calculated by Patterson et al. (1997) and are presented. There has also been an interest in using A-weighted energy as a measure of hazard, even for intense impulses (Dancer, 2000). If such a measure works, it has great advantages in measurement and in the ability to combine exposures from a variety of sources and levels, with and without hearing protection. It would also be compatible ISO-1999. For a free field measure (subject absent), the application of an 85 dB Laeq8 criterion is clear. However, where the measure is under a protector, some adjustment should be made for the fact that the measure includes higher pressures in some frequency regions because of the acoustic effects of the head and external ear. The proposal to use such an energy measure usually contains a caveat against using it above 160 dB peak pressures because of a possible critical level. This would eliminate virtually all the exposures in the Albuquerque studies even when measured under the protector. Nevertheless, it would be instructive to do an A-weighted energy calculation just to see over what range such a measure might apply. In terms of energy, an 85-dB Laeq8 exposure contains 8.7 J/m2. Exposures less than that would be rated safe; more than that, hazardous.

7. Pass/Fail analysis of the Albuquerque data

The critical question with respect to human hazard is what exposure conditions, in which 60 subjects had been tested, resulted in between

one and six failures (that being the window of confidence for the 95 percentile ear). Unfortunately, these data were not immediately available; however the exposure charts documenting each Ss path through the exposure matrix were (Johnson, 1994, Figures E-1 through E-45). Therefore, each subject's path through the exposure was individually traced. As outlined earlier, failures at lower levels were not counted as failures at higher levels unless they contained more AHUs, but within a level, failures at lower numbers of impulses were counted as presumptive failures for higher numbers of impulses.

The data summaries developed in this analysis appear in Tables II through VII which follow.

1 METER DATA					
LEVEL	NUMBER OF IMPULSES				
	6	12	25	50	100
7	56\2				
6	59\0	56\2	54\8	49\10	37\13
5	63\1	3\2	4\2	7\5	12\9
4	64\0				
3	64\0				
2	65\2				
1	66\0				

Table. II. Summary for the 1-M exposure condition (number of ears\number of failures). (These data clearly indicate a 95 percentile exposure for Level 6 between 6 and 25 impulses. The values in higher numbers of impulses in Level 5 are not large enough to be taken too seriously; however they do represent a very high failure rate.)

3 METER DATA					
LEVEL	NUMBER OF IMPULSES				
	6	12	25	50	100
7	56\2				
6	62\2	62\3	58\7	57\9	36\11
5	66\2	2\2	1\1	3\3	3\3
4	69\1				
3	68\0				
2	68\0				
1	68\0				

Table III. Summary of tests for the 3-M condition (number of ears\number of failures). (In this case it is clear that the 95 percentile exposure for Level 6 lies somewhere between something less than 6 impulses and less than 25 impulses. The values in Level 5 are too small to be conclusive, but they do represent an extraordinarily high rate of failure and are included for interest.)

5 METER DATA MODIFIED MUFF					
LEVEL	NUMBER OF IMPULSES				
	6	12	25	50	100
7	57\0				
6	60\1	60\1	60\1	60\2	62\4
5	60\1				
4	61\0				
3	61\0				
2	61\0				
1	61\0				

Table IV. Summary for 5-M modified muff exposure (number of ears\number of failures). (The pattern of failures at Level 6 is a bit problematic. The conditional failure at L6/6 is a presumptive failure at the 12- and 25-impulse conditions, with additional failures happening at the 50- and 100- impulse conditions.)

5 METER DATA GOOD MUFF					
LEVEL	NUMBER OF IMPULSES				
	6	12	25	50	100
7	49\0				
6	58\0	56\0	53\0	44\0	39\0
5	59\0				
4	62\0				
3	62\0				
2	62\0				
1	62\0				

Table V. Summary for 5-m unmodified muff exposure (number of ears\number of failures) (in essence, no auditory failures).

REVERBERANT DATA			
LEVEL	NUMBER		
	1	2	3
7	59\0		
6	59\0	59\0	58\0
5	61\0		
4	61\0		
3	63\0		
2	63\0		
1	64\0		

Table VI. Summary for reverberant exposures (number of ears, number of failures).

8. Evaluation of predictions by three methods

A convenient summary of the data can be seen in the following tables. In each, the predicted hazard of an exposure (either safe or hazardous) is compared with the actual outcome of the exposure (again either safe or hazardous). The criterion for hazard is a significant threshold shift in the ear of the 95 percentile subject. Evaluations by MIL-STD-1474, A-weighted energy and AHAAH are presented. The codes for the exposures listed in the exposure evaluation tables are presented in Table X.

In the following three tables, a matrix of outcomes is presented. Entries in the upper left and lower right quadrants are correct predictions (safe prediction/safe outcome or hazardous prediction/hazardous outcome). Entries in the upper right and lower left quadrants represent errors (safe prediction/hazardous outcome or hazardous prediction/safe outcome). As noted earlier, both types of error are costly and should be avoided. The entries in the table are codes indicating the exposure conditions being reported. The codes are presented in Table X.

EVALUATION BY MIL STD-1474										
		OUTCOME								
		SAFE							HAZARDOUS	
PREDICTION	SAFE	01	T1	T2						
		F1	F2	F3						
		G1	G2	G3						
		R1	R2							
	HAZARDOUS	O2	O3	O4	O5	O5	O7	O8	O9	OF	OH
		T3	T4	T5	T6	T7	T8		T9	TF	TH
		F4	F5	F6	F7	F8	F9		FF	FH	
		G4	G5	G6	G7	G8	G9	GF	R9		
		GH	R3	R4	R5	R6	R7	R8			

Table VII. Evaluation of hazard by MIL-STD-1474. (The current MIL STD was correct in its evaluation of 20 of the exposures and incorrect in 33, an accuracy of 38%. Its errors were all in the direction of over-predicting hazard.)

EVALUATION BASED ON A-WEIGHTED ENERGY										
		OUTCOME								
		SAFE							HAZARDOUS	
PREDICTION	SAFE	G1	G2	G3						
		R1								
	HAZARDOUS	O1	O2	O3	O4	O5	O6	O7	O8	O9	OF	OF
		T1	T2	T3	T4	T5	T6	T7	T8	T9	TF	TH
		F1	F2	F3	F4	F5	F6	F7	F8	FF	FH	F9
		R2	R3	R4	R5	R6	R7	R8	R9			
		G4	G5	G6	G7	G8	G9	GF	GH			

Table VIII. Evaluation by A-weighted energy. (A-weighted energy was successful in 13 cases of 53, an accuracy of 25%. This method erred in over-predicting the true hazard. The amount of error in the over-prediction was sizable, often 10 to 20 dB.)

EVALUATION BY AHAAH									
		OUTCOME							
		SAFE							HAZARDOUS
PREDICTION	SAFE	O1	O2	O3	O4	O5	O6	O7	O8
		T1	T2	T3	T4	T5	T6	T7	T8
		F1	F2	F3	F4	F5	F6	F7	F8
		G1	G2	G3	G4	G5	G6	G7	G8
		G9							
		R1	R2	R3	R4	R5	R6	R7	R8
	HAZARDOUS		GF	GH	R9				O9 OF OH T9 TF TH F9 FF FH

Table IX. Evaluation by AHAAH. (AHAAH was correct in all but three cases for an overall accuracy of 94%. Its three errors were also in the direction of over-predicting hazard.)

EXPOSURE CODES					
CODE	CONDITION	LEVEL/RDS	CODE	CONDITION	LEVEL/RDS
O1	1-METER	L1/6	F6	5-METER	L6/6
O2	1-METER	L2/6	F7	5-METER	L7/6
O3	1-METER	L3/6	F8	5-METER	L6/12
O4	1-METER	L4/6	F9	5-METER	L6/25
O5	1-METER	L5/6	FF	5-METER	L6/50
O6	1-METER	L6/6	FH	5-METER	L6/100
O7	1-METER	L7/6	G1	5-M GOOD MUFF	L1/6
O8	1-METER	L6/12	G2	5-M GOOD MUFF	L2/6
O9	1-METER	L6/25	G3	5-M GOOD MUFF	L3/6
OF	1-METER	L6/50	G4	5-M GOOD MUFF	L4/6
OH	1-METER	L6/100	G5	5-M GOOD MUFF	L5/6
T1	3-METER	L1/6	G6	5-M GOOD MUFF	L6/6
T2	3-METER	L2/6	G7	5-M GOOD MUFF	L7/6
T3	3-METER	L3/6	G8	5-M GOOD MUFF	L6/12
T4	3-METER	L4/6	G9	5-M GOOD MUFF	L6/25
T5	3-METER	L5/6	GF	5-M GOOD MUFF	L6/50
T6	3-METER	L6/6	GH	5-M GOOD MUFF	L6/100
T7	3-METER	L7/6	R1	REVERBERANT	L1/1
T8	3-METER	L6/12	R2	REVERBERANT	L2/1
T9	3-METER	L6/25	R3	REVERBERANT	L3/1
TF	3-METER	L6/50	R4	REVERBERANT	L4/1
FH	3-METER	L6/100	R5	REVERBERANT	L5/1
F1	5-METER	L1/6	R6	REVERBERANT	L6/1
F2	5-METER	L2/6	R7	REVERBERANT	L7/1
F3	5-METER	L3/6	R8	REVERBERANT	L6/2
F4	5-METER	L4/6	R9	REVERBERANT	L6/3
F5	5-METER	L5/6			

Table X. Codes used in the tables evaluating the predictions of the various DRCs. (The data are all for protected hearing and are from the Albuquerque studies. All data except those labeled "good muff" were from subjects wearing the modified muff used in those studies.)

9.Effectiveness of the three methods of analyzing hazard

The evaluations with AHAAH are highly consistent with the hearing loss data in these studies (94% accurate). The three cases of inaccurate prediction (5-m, good muff, 50 and 100 impulses and reverberant room, level 6, three impulses) were in the direction of over-sensitivity.

In contrast, both the MIL-STD-1474 and the A-weighted energy measures did poorly in rating the hazard (38% and 25% accuracy, respectively). Their errors occurred in the direction of over-conservatism, which protects hearing. However, the user could pay a price in system performance if this over-restrictive approach were adopted.

A. Additional studies

Only a handful of studies are available to further test AHAAH. For a variety of practical concerns, it is understandable that over many years ,only a modest amount of research has been done in which the human ear has been exposed to intense impulses. There were a few

"exploratory studies" that used a variety of impulse sources to produce varying amounts of threshold shift, measured in various ways, usually with relatively small numbers of exposed subjects. The impulse was typically described by a none-too-detailed picture of a pressure history. Given that AHAAH needs a digitized pressure history to process, there are not many pieces of research in the literature that can be examined. Nevertheless, there are several challenges of the model that test its ability to predict hearing loss with both protected and unprotected exposures. They include impulses with the 7.62 mm rifle, the Belgian FNC rifle, the German G3 rifle and a 120 mm mortar. Studies using the M72 light anti-tank weapon (LAW) and spark-gap discharges, although lacking in some details also provide general tests of the fit of the model to human data. From the clinical literature we also have some indication of exposures that have produced permanent threshold shifts in human subjects. Given that each is unique, we will consider them one at a time.

In doing the hazard analyses of these impulses, the AHAAH algorithm and the A-weighted energy methods can be used. MIL STD-1474(D) does not allow any exposure without hearing protection when the peak level is above 140 dB; hence its accuracy for these impulses cannot be tested.

B. Analysis of other impulses

1. Rifle impulses: 7.62 mm

Hodge and associates at the former U.S.Army Human Engineering Laboratory (Hodge, Gates, Solderholm, Helm & Blackmer, 1964; Hodge & McCommons, 1966; Hodge, McCommons & Blackmer, 1965) conducted an extended series of pioneering studies. In those studies the unprotected left ears of Soldiers were exposed to 25 or 50 impulses produced by a weapon firing a 7.6 2mm round at 155 or 158 dB peak pressures. There was no specific signal to the subject that an impulse was coming, but the rounds were fired at regular 5-second intervals, so it is reasonable to suppose that subjects knew when at least the second and successive rounds were coming. The reports of these studies included a careful rendering of only the initial peak of the pressure history and could not be used for analysis with AHAAH. Fortunately, we had more recently recorded several impulses from the M-14 rifle, which also fired the same 7.62 mm round. The peak levels of the recorded rounds were adjusted to those levels used in the studies. It is probably not an exact reproduction of the waveform, but we believe that it is very close to that used in the studies. Varying numbers of subjects were used (7, 12, 28) and reported the upper and lower limits, quartiles, means, medians, and standard deviations of the threshold shifts.

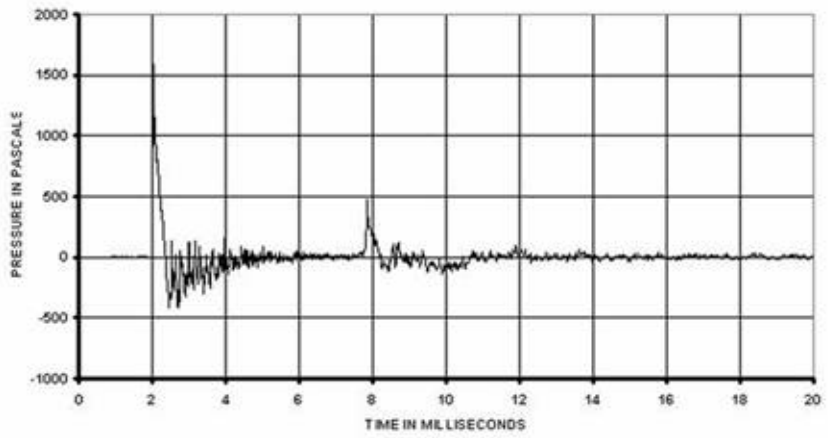


Figure 5. Pressure history of 7.62-mm rifle impulse at the subjects' ear position used in the exposures used by Hodge et al. (1964, 1965, 1966).

a. Threshold shift data. In essence, three exposure conditions, 50 rounds at 155 and 158 dB and 25 rounds at 158 dB, repeatedly produced maximum threshold shifts of 40, 50, or even 70 dB. The third quartile data in Hodge et al. (1964) were also well above 25 dB. And in other cases (Hodge & McCommons, 1966), the mean plus 1.64 standard deviations (95% of standard normal distribution) were also above 25 dB at 4 and 6 kHz. All these exposures would be rated as hazardous by the rules of the current analysis. Hodge et al also noted that 25 rounds at 158 dB produced a little less threshold shift than 50 rounds at 155 dB (no statistical test, however).

b. Analysis with AHAAH. Although there was no countdown, the timing of the impulses was regular and when the exposures were repeated with the same subjects, the result and its variability were the same. This would argue for the use of a "warned" calculation.

1. The 155-dB exposures. The 155-dB impulses produced 16.6 AHUs/impulse (warned) and 118 AHUs unwarned. Therefore, 50 rounds at 155 dB would contain 830 AHUs, which would rate the exposure as hazardous. It would also predict a threshold shift of 39 dB at ½ hour. This falls between the third quartile (16 dB) and the upper limits of 68 and 75 dB at 4 and 6 kHz respectively (measured at 2 min) (Figure 2, Hodge et al., 1965). In terms of A-weighted energy, each impulse contained 0.27 J/M2 and a 50 round exposure, 13.5 J/M2, which

would also be rated as hazardous on the basis of its energy content.

2. The 158 dB exposures. At this level, each impulse resulted in 22.3 AHUs (warned) and 153 AHUs (unwarned). This means that a 50-impulse exposure would produce 1115 AHUs and a 25-impulse exposure, 558 AHUs. Both are considered hazardous. AHAAH predicts 47 and 28 dB of compound threshold shift (CTS) respectively (at ½ hour) and that is close to the result in the experiments. The study using the 50 round exposure had only seven subjects (Hodge et al., 1964), but the upper threshold shift was 54 dB temporary threshold shift after two minutes (TTS2) at 4.0 kHz and the third quartile shift was 48 TTS2 dB at 6 kHz. The 25-impulse exposure had 28 subjects (Hodge & McCommons, 1966) and the highest shift was 53 dB TTS2, with a third quartile of about 10 dB TTS2. In keeping with the conclusion of Hodge and McCommons (1966) that the 50-round exposure at 155 dB was somewhat worse that 25 rounds at 158 dB, AHAAH's analysis concurs: 830 AHUs for the 50 round exposure and 558 for the 25-round exposure.

c. Analysis with A-weighted energy. In terms of A-weighted energy, the 25-round exposure contained 13.3 J/m2 and the 50-round exposure, twice that. Both would correctly be rated as hazardous on this basis.

2. Rifle impulses: FNC rifle (5.56 mm)

Brinkman (2000) reported two exposures conducted in Germany in 1978 with the Belgian FNC rifle. In one experiment, 51 troops fired six rounds from a standing position with no hearing protection and in the other experiment, 53 Soldiers fired five rounds similarly.

a. Threshold shift data. In the first case, 11 subjects showed threshold shifts greater than 25 dB and in the second, 9 subjects showed shifts greater than 25 dB. In both cases, recoveries of these shifts took from 30 minutes to 16 hours. Given the size of the shifts and the number of subjects showing them, both exposures would be rated as hazardous by the standard being used in this analysis.

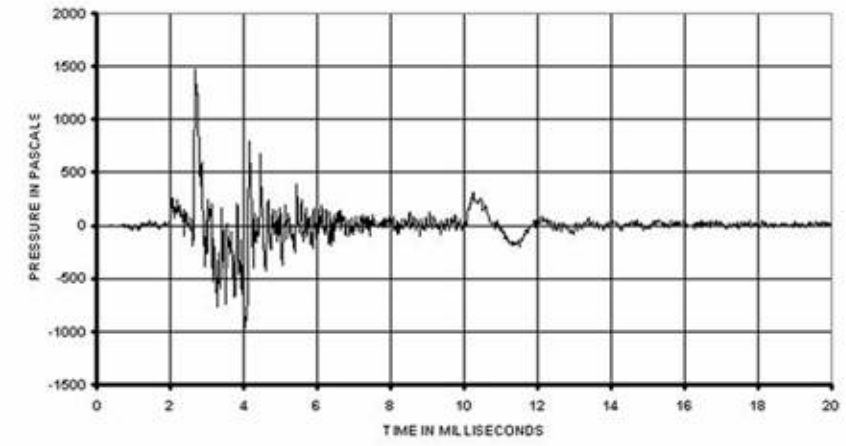


Figure 6. Pressure history of FNC rifle impulse at firer's ear position.

b. Analysis by AHAAH. No waveforms were available from the 1978 study; however, as part of the work of NATO RSG 29, Panel 8, Brinkmann recorded impulses from the FNC rifle for use with AHAAH. Because the Soldiers fired their own weapons, a "warned" middleear muscle calculation was appropriate. The analysis showed an average of 156.8 AHUs per impulse (7 impulses analyzed). The two exposures would have been to 940 and 784 AHUs, respectively, both in the hazardous range and consistent with the threshold shift data.

c. Analysis with A-weighted energy. Each impulse contained an average of 1.4 J/m2, which means that the exposures contained 8.4 and 7 J/m2 respectively. Both of these would be rated as safe on the basis of A-weighted energy. This is the only instance in which any method has rated an exposure as safe that was in fact hazardous.

3. Rifle impulses: The G3 rifle

The standard weapon in the German army was the G3 rifle. Pfander (1974) reported that as part of their training, 78 Soldiers had fired 5 rounds without hearing protection and were tested just before and just after the firing.

a. Threshold shift data. Pfander's method of reporting data grouped Soldiers on the basis of how long it took them to recover; thus, it is not possible to determine exactly how many Soldiers had a particular threshold shift. However, from the data reported, we can say that some Soldiers in four sub-groups had threshold shifts of 30 dB, and others in two more sub-groups had threshold shifts of 50 dB (the groups had long recovery times (3 to 6 days) and included 16 Soldiers) (Pfander, 1974, Figure 38). Clearly, this is a hazardous exposure. In fact, these data were instrumental in changing German training. This study was the last in which German Soldiers in training were allowed to fire with

no protection (Pfander, 1982).

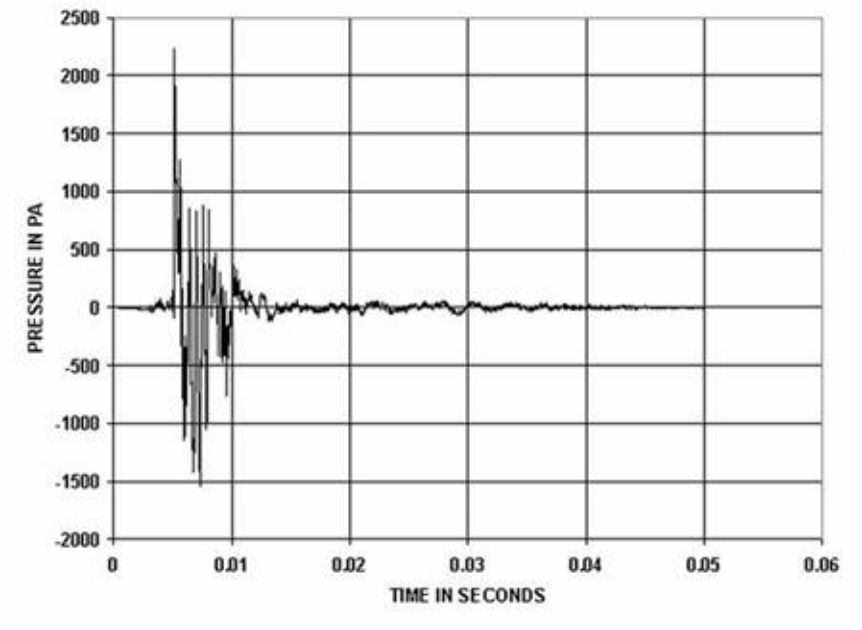


Figure 7. Pressure history for G-3 rifle at firer's ear.

b. Analysis by AHAAH. No pressure history from the original study was available, but as part of the NATO research study group's (RSG) work, Brinkmann also supplied an impulse from the G3 rifle for analysis that is presented in Fig. 7. In the study by Pfander, the Soldiers had fired their own weapons; therefore a warned exposure is appropriate. The impulse contained 178.3 AHUs. In the tests, an exposure consisted of 892 AHUs, which is in the hazardous range and consistent with the threshold shift data.

c. Analysis with A-weighted energy. The G3 rifle impulse at 161 dB peak, contained 4.2 J/M2; therefore, the exposure was to 21 J/M2, which would correctly be considered hazardous.

4. M-72 Light anti-tank weapon (LAW) exposure

The following study is not an ideal test of the AHAAH model because we lack the original pressure histories and because the experimenters excluded what may have been the most susceptible subjects. However, the outcomes are not "subtle" and the data do represent a check on the reasonableness of the model's predictions in extreme cases. Garinther and Hodge (1971) and Hodge and Garinther (1970) exposed subjects with no hearing protection to an impulse from the M-72 LAW (a shoulder-fired rocket). Exposures were at grazing incidence and at a peak pressure of 161 dB, 8 m to the left and right rear of the rocket. The experimenters fired the rocket remotely following a short countdown, presumably audible by the subjects. They also allowed subjects to fire one round unprotected at the firer's position (179 dB peak pressure). The subjects had volunteered, saying that they had done the same thing before in combat (Garinther, 2000). The same study also had them fire with hearing protection (V-51R plugs, experimenter fit). The primary problem with the analysis is that we lack the pressure histories needed. We do have one digitized impulse from the M-72 LAW (presented in Figure 8), but it differs in appearance from the pressure histories reported in the studies. A second concern is that the authors note that some subjects were dropped from the study "because of slow recovery". The study had used relatively large numbers of subjects (86 ears during some conditions), but it is reasonable to suppose that the subjects dropped had the more susceptible ears, critical for an analysis seeking to identify them. Therefore, only the most tentative comparisons are warranted from these data.

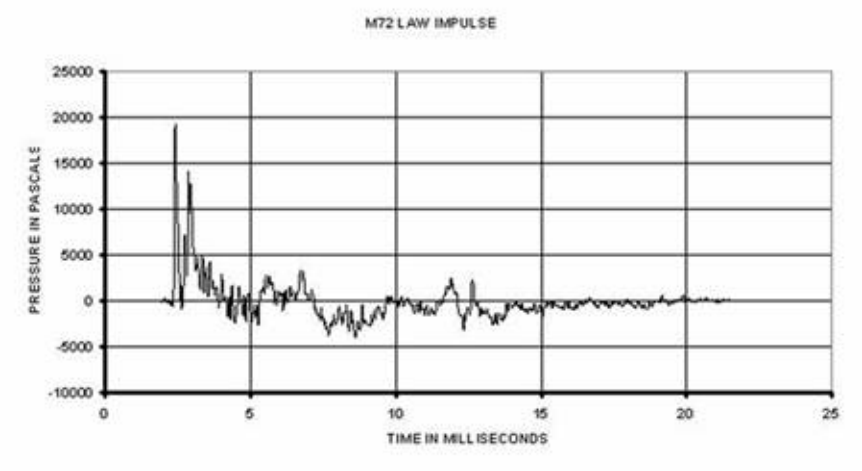


Figure 8. Pressure history of LAW impulse.

a.Threshold shift data. The unprotected exposures at 161 dB were within the Committee on Hearing and Bioacoustics (CHABA) limits and were interpreted as supporting the CHABA criterion (Hodge & Garinther, 1970). They would also be considered safe by the standard used in this report. It was also clear that the 179-dB exposure with unprotected ears was very hazardous, and exposures were stopped early. The protected exposures to exposures as great as 184 dB peak were shown to be safe.

b. Analysis with AHAAH. Given the one digitized impulse, we were able to change its apparent pressure by scaling within the computer. Real changes in pressure history would of course involve different distances with different arrival times for the ground reflections, etc. Given all the caveats, it appears that AHAAH is at least in the right "ballpark." The 161-dB impulse produced 105 AHUs warned and 516 AHUs unwarned. Such an impulse could be "just safe" as the data suggest. The 179 dB impulse produced 921 AHUs warned and 4217 AHUs unwarned, somewhere between dangerous and very dangerous (as the data suggest). AHAAH predicted 12.5 dB of CTS for the median ear 7 dB of CTS were observed. For the protected ears, AHAAH says that the firing should be safe (as it was).

c. Analysis with A-weighted energy. The impulse analyzed contained 1.5 J/M2 when the peak pressure was 161 dB and 114 J/M2 when at 179 dB. These agree with the first being safe and the second, hazardous.

5. Mortar Impulses

This study is not an ideal test of the AHAAH model because it was primarily a test of a new non-linear earplug design worn by mortar crews. Even though the number of ears tested was small, the data were carefully collected for an intense exposure during nearly true operational conditions. The French army tested a non-linear earplug by having mortar crews (seven crews of four men) fire a 120-mm mortar while wearing the new earplug. The non-linear plug was also inserted in the ear canals of an acoustic manikin specifically designed for such tests. The plugs were designed to attenuate minimally at low sound pressure levels (>110 dB), to promote communication and situation awareness and to attenuate much more at high sound pressure levels in order to provide protection from intense impulses. The troops were professional mortar crewmen and in the test, they fired as a crew normally does, i.e., as loader, ammunition handler, section chief, and gunner. They did fire the mortar with a lanyard (rather than just dropping the round), which means that the instant of firing was known. They fired 7 rounds (peak pressures of 185 dB at the firer's head) while wearing the non-linear earplug. The free field pressure at the firer's location is portrayed in Figure 9. The section chief and ammunition handler were exposed to somewhat lower peak pressure levels than the other crewmen. The number of subjects actually tested was relatively small (7 Soldiers at the area of maximum pressure). On the other hand, these were real troops doing their jobs, not precisely positioned, immobile subjects, which adds at least face validity to this test.

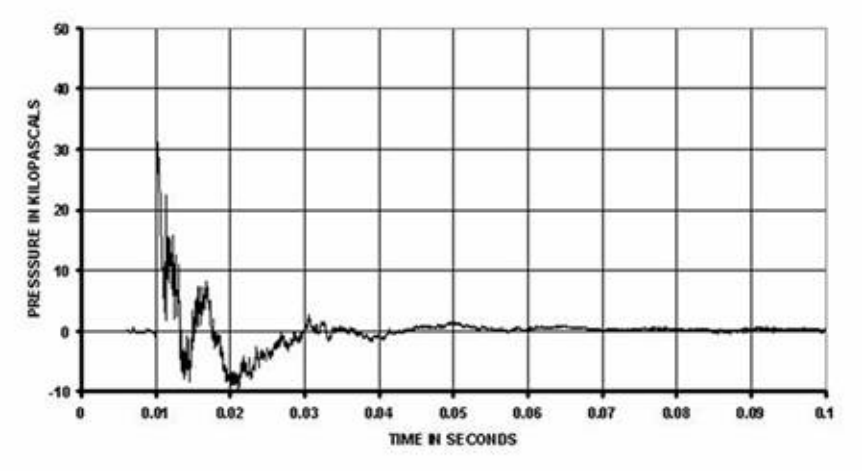


Figure 9. Free field pressure history of 120 mm mortar impulse at the firer's head location. (The peak pressure is 185.5 dB SPL.)

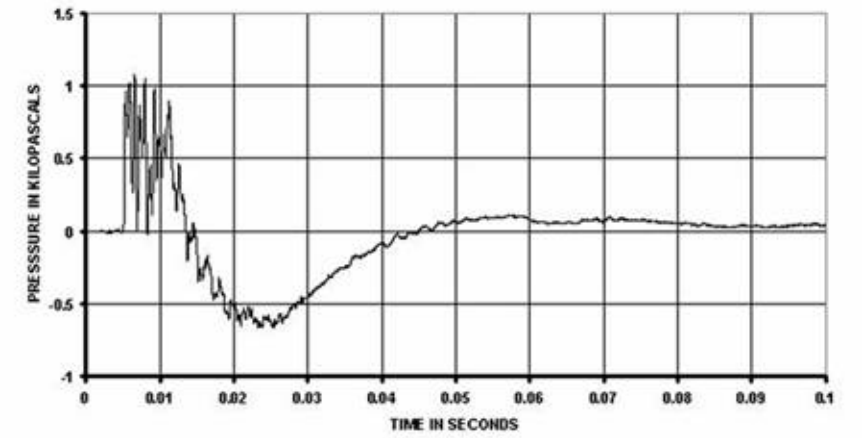


Figure 10. Pressure history of 120 mm mortar impulse at the eardrum position under the non-linear ear plug location.)Manikin situated at firer's head position.)

a. Threshold shift data From the standpoint of the plug design ,the test was a success because no subject experienced a significant threshold shift

b. Analysis with AHAAH. Digitized recordings of the pressures at the eardrum position of the acoustic manikin were made available for analysis with the ear model (Figure 10). The hazard calculated for the round in the figure was 7.2 AHUs for a warned ear and 36.8 AHUs for an unwarned ear. For a seven round exposure the total dose would have been 50.4 and 257.6 AHUs, respectively; both rated as safe exposures.

c. Analysis with an A-weighted energy measure. Individual impulses under the hearing protector had A-weighted energies of about 1 J/m2, the total for seven rounds being less than the 8.7 J/m2, that would have been rated hazardous. A-weighted energy would have correctly rated this exposure as safe.

d. Analysis with MIL-STD-1474D. Given that hearing protection was worn MIL-STD-1474(D) allows an estimate of hazard. The free field impulse in Figure 9 had a peak pressure of 185.5 dB and a B-duration of 15.6 msec, which would allow less than 1 round with single hearing protection. Since seven rounds produced no unacceptable threshold shift in anyone, we conclude that the current standard is overprotective.

6. Spark gap impulses

Loeb and Fletcher (1968) developed a spark gap impulse generator and were able to produce impulses at a 166-dB peak. By combining various numbers of gaps sequentially fired, they produced A-durations of 36 microseconds (3 gaps) to 96 microseconds (6 gaps). Subjects were exposed to one impulse per second in the free field in an anechoic chamber. The pressure histories reported in the report were detailed enough to be digitized by scanning and the fact that they were presented in an anechoic chamber meant that reflected waves were

essentially not present. In terms of spectrum, the 6-gap impulse produced its peak energy at about 3 kHz, which is where the ear is tuned best and is maximally susceptible. The 3-gap impulse had its spectral peak at about 8 kHz. From a theoretical standpoint, these particular tests of the model were interesting. All the other impulses we have examined had their spectral peaks below the mid-range, which is common for most impulses in real life. So in effect we have tested the low frequency to mid-frequency portion of the model. These two sets of impulses, however, test the mid-frequency to high-frequency portion of the model.

In these experiments, 72 subjects were tested. Exposure began with one impulse and continued with increasing numbers of impulses until a criterion shift (30 dB) had been reached at some frequency. Not surprisingly, shifts tended to be highest at 4.0 kHz and above. Because of the pattern of data taking and reporting, it is not possible to make a simple statement regarding the state of the 95 percentile ear for a given number of impulses. However, an interesting observation or two can be made. First, the 6-gap impulse was very effective at producing threshold shift. One impulse was enough for some subjects to reach the 30 dB criterion and the median subject reached it in four impulses! Secondly, the 3-gap impulse was much less hazardous; the median subject reached the criterion shift with 88 impulses.

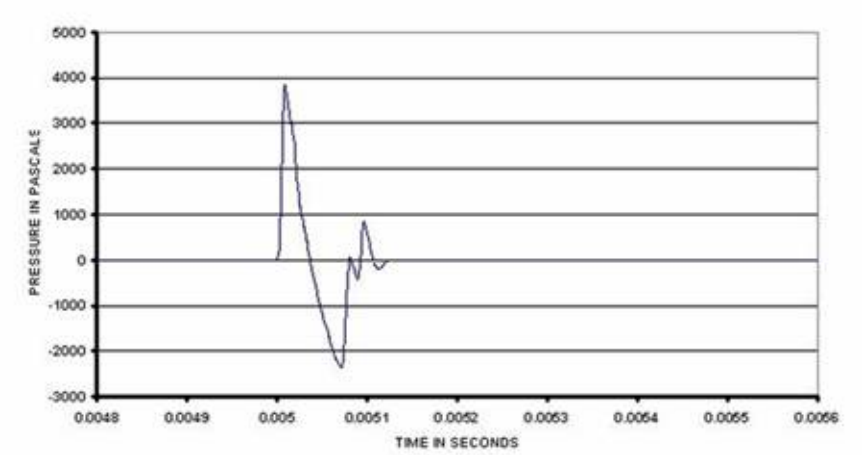


Figure 11. Pressure history of 3-gap impulse used by Fletcher and Loeb (1968).

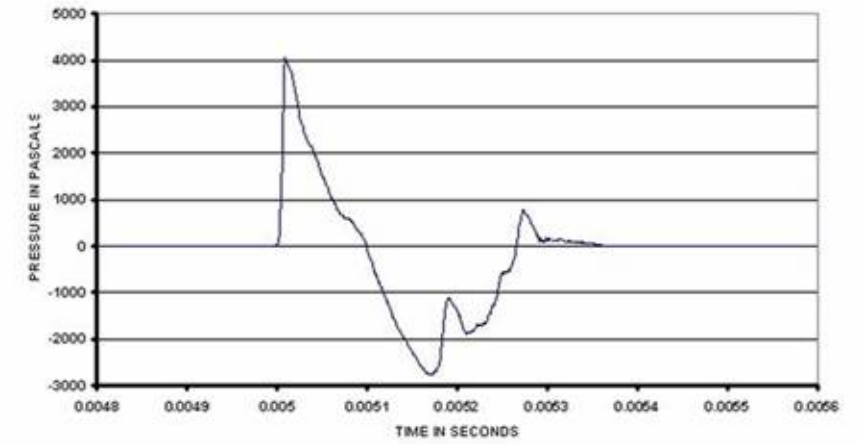


Figure 12. Pressure history of 6-gap impulse used by Fletcher and Loeb (1968).

a. Analysis with AHAAH. The exposures came at 1 impulse/sec. Presumably the subjects would have known just when the second and successive impulses were coming and the middle ear muscles were involved.

Each 6-gap impulse produced 176.1 AHUs (warned) and 995.4 AHUs (unwarned). AHAAH predicts that the 6-gap impulse is indeed hazardous. Thus, one impulse, unwarned, is predicted to produce 44 dB CTS in the 95 percentile ear. Even when subjects were warned, four impulses would be predicted to produce 34 dB of CTS. This is in keeping with the TTS data from Loeb and Fletcher (1968) in which they report that 0.5 impulse (!) caused a criterion shift in at least one ear. For the median ear, AHAAH predicts 56 AHUs (warned) and 342 AHUs unwarned. It is dangerously close to game playing, but we note that one unwarned and three warned impulses produce 510 AHUs (a CTS of 26 dB). Certainly, AHAAH's predictions are close to what occurred for the 6-gap impulse.

The 3-gap impulse, for the 95 percentile ear, produced 31.6 AHUs (warned) and 186 AHUs (unwarned). For the median ear, it produced 6.5

AHUs warned and 186 AHUs unwarned. Loeb and Fletcher (1968) report that a criterion shift was reached with as few as 11 impulses for this condition and the median ear reached criterion with 88 impulses. AHAAH predicts 15.6 dB of shift for a 95 percentile warned ear. If the first impulse were unwarned, the total becomes 502 AHUs, or 25 dB of CTS. AHAAH predicts for the median ear that 92 impulses would produce a 30-dB CTS -- remarkably close to the 88 impulses they found.

The close correspondence between the predicted shift and the actual shift is, to a first approximation, a confirmation that the model is doing what it should at its high frequency end. On the other hand, the data of Fletcher and Loeb showed a lot of loss at very high frequencies (8 kHz to 16 kHz) (as might be expected), but the model showed less loss than occurred. It is difficult to access just what to make of this outcome. It may be that the model does not transmit energy at these very high frequencies as well as it should, or the relatively large losses may be a function of the fact that at the base of the cochlea, when a few cells are impaired, no additional cells at even higher frequencies that are available to carry information to the 8th nerve. In the middle and apical portions of the cochlea, a loss of some cells at one location can be compensated as the intensity of a signal rises and the pattern of action on the basilar membrane moves basal-ward. Once you are at the basal end, this mechanism is no longer functional and the audiometric losses grow rapidly. The test of this hypothesis would be to do the histology and discover the actual pattern of cell loss.

b. Analysis with an A-weighted energy measure. The 6-gap impulse contained 2.3 J/m2 and the 3-gap impulse 0.38 J/m2. Four 6-gap impulses at 9.2 J/m2 fall just over the line and rate as hazardous. For the 3-gap impulse, 11 impulses contain 4.2 J/m2 and 88 impulses, 33.4 J/m2. These values are also in the right general area.

7. AT4 Exposure (antitank rocket)

There is one case in the literature that provides a consistency check on the model (Vause & LaRue, 2001). A Soldier in training inadvertently fired one round from an AT-4 rocket launcher from a kneeling position while wearing no hearing protection. He immediately experienced vertigo, tinnitus, and hearing loss so severe that he had to communicate by writing during the audiometric examination the following day. Fortunately for science, his baseline audiogram was available from his entrance physical, and of course full audiometric work-ups were available from the post-exposure examinations. By 21 days' post-exposure his hearing levels remained at 50 to 60 dB in the mid-range and sad to say, he was released from active duty with the Army because of his hearing disability. A single case study such as this is hardly definitive, but it can be argued that an accurate hazard rating system should predict that this exposure could be very hazardous for at least a susceptible ear.

We are also fortunate to have digitized waveforms of an AT-4, recorded during weapons tests.

a. Analysis with AHAAH. In this case the question is whether the model predicts that such a degree of trauma could have occurred. If it pronounced the firing of one such round as safe, then it would have shown insufficient sensitivity. The waveform in Figure 13 would produce 5774 AHUs in the unwarned ear and 856 AHUs in the warned ear-- a hazardous rating in either case. However, it is interesting to note that the higher number of AHUs would be expected to produce about the PTS that in fact resulted. AHAAH appears to be in the right ballpark.

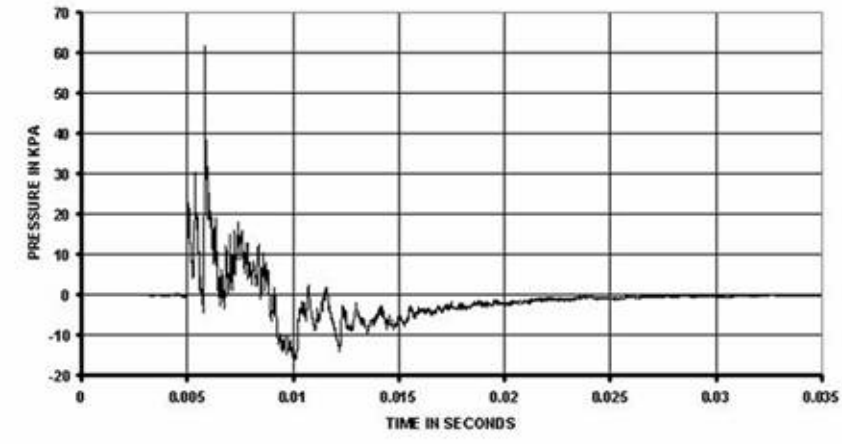


Figure 13 Pressure history of AT4 rocket firing, gunner's ear position, kneeling (Peak pressure level is 189.8 dB.)

b. Analysis with an A-weighted energy measure. The waveform in Figure 13 contains 783 J/m2, which is clearly in the hazardous region.

8. Exposure to a toy horn

Finally, a case has been reported by Royster, Royster, Price, McMillan, and Kileny (1999) of a 39 -month-old boy who exposed himself to several "toots" from a bicycle horn which was a small version of the classic British taxi horn (rubber bulb blowing a reed at the base of a coiled brass cone). The horn was capable of producing more than 150 dB peaks in its mouth for about 80 msec. The child immediately complained of pain and tinnitus and at 6 days showed a 50dB hearing loss (HL) in the exposed ear (HL had been 10 dB thre

Click Tables 1 and 2 for

The Decibel (dB) & Sound Measurement

(What do those dBs mean?)

The Decibel (dB)

Most individuals have heard the word "decibel" used to describe how loud something is. It's probably no surprise that a 100 decibel (dB) noise would be a lot louder than a 50 dB noise. What may be surprising, however, is that 100 dB isn't twice as loud as 50 dB (60 dB is approximately twice as loud as 50 dB!). And zero dB doesn't mean "no sound." This confuses a lot of people, but a brief explanation of sound and the decibel scale, plus a few analogies (for those who dread algebra), follow.

Any vibrating object creates local changes in atmospheric pressure. These pressure fluctuations travel as waves through the air to our ears, and we experience sound. How rapidly an object vibrates determines its frequency or "pitch." Musicians often use the term "pitch" as a synonym for frequency. Technically, frequency (measured in Hertz or Hz) is what we measure; pitch is what we perceive. The intensity, or what we call "loudness," depends on how great these pressure changes are. Sound pressure level (SPL) is the objective measure of sound intensity, loudness is the perceptual correlate. Sound pressure level is normally expressed in decibels sound pressure level (dB SPL). The reason for not expressing SPL as a unit of pressure (e.g. Pascals) follows.

The metric unit of pressure is the Pascal (Pa). Under optimal conditions, the lowest pressure that can be heard by a person with normal hearing is approximately 0.00002 Pa (= 20mPa). The loudest sound pressure that most humans can tolerate is about 200 Pascals, which is 10 million times greater than the lowest sound pressure that can be heard. Dealing directly with so wide a range is cumbersome; consequently, the decibel scale was devised to make sound measurements manageable. The decibel scale quantifies sound level by taking the logarithm of the ratio between a sound pressure divided by a reference pressure and multiplying this result by 20, thus allowing us to compress a very wide pressure range into more easily managed numbers. By definition, the reference pressure (0 dB) for the sound pressure level scale is 20 microPascal (mPa). Here's an example to demonstrate how the decibel scale allows us to compress a wide pressure range to a more manageable range:

The average sound pressure of speech at a distance of 5 ft. is about 0.064 Pa. The SPL, in decibels, is

$$20\log \frac{0.064\ \text{Pa}}{0.00002\ \text{Pa}} = 20\log 3200 = 70.1\ \text{dB SPL.}$$

(Note that the pressure of speech at this distance is 3200 times greater than the faintest sound pressure we can detect.)

It is important to note that if we double the pressure we won't double the SPL. If we double the pressure from our previous example, we get

0.064 Pa x 2 = 0.128 Pa. In units of dB, this is

$$20\log \frac{0.128\ \text{Pa}}{0.00002\ \text{Pa}} = 20\log 6400 = 76.1\ \text{dB SPL, a 6 dB increase.}$$

Similarly, we can show by calculation (or measurement) that if two rifles differ in SPL by 6 dB, the "louder" rifle is creating twice the sound pressure (in Pascal, not SPL) of the "quieter" rifle.

It is reasonable to assume that doubling the sound pressure would result in a sound that is twice as loud. Unfortunately, this isn't the case. Our perceptual response to intensity (and frequency) isn't linear, so what we perceive as being twice as loud isn't a simple function of sound pressure, or even sound power (see note 3). A very good approximation, however, is that a 10 dB increase in SPL will result in a doubling of "loudness." A rifle producing a SPL of 150 dB is approximately twice as loud as a rifle producing 140 dB. Here's a real-life analogy to help clarify the decibel (dB) and perceived loudness:

At a distance of 5 ft., the SPL of normal speech is approximately 70 dB SPL (we can easily measure this with a sound level meter—more on this below). If another person starts talking (also 5 ft. away), the SPL doesn't increase to 140 dB (this would be deafening!). What we would measure with the sound level meter is, in fact, more along the lines of a 3 dB increase. Perceptually, two people talking at once is louder than one person talking, but not twice as loud. If we had 10 people talking simultaneously in a room, we'd measure about 80 dB; this is approximately twice as loud as a single talker. We're assuming, of course, that no one is screaming or whispering.

For high-intensity sounds, a 3 dB change in SPL is quite noticeable. For example, compare the SPL of one rifle #7 (7mm) with its cover on (no BOSS) and with its muzzle brake (BOSS) on. The measured difference is (163.6 – 159.5) dB SPL = 4.1 dB. The difference in loudness is quite apparent. With regard to high-intensity sounds, a 1dB change in SPL is noticeable, even to the untrained ear. (Note: For low-intensity sounds, a 1 dB change is barely discernable—this has to do with the physiology of the human ear.) In summary, a rifle that produces a SPL of 141 dB is slightly "louder" than one producing 140 dB. A rifle producing 143 dB SPL is quite a bit louder, and a rifle producing 150 dB SPL is twice as loud (which is pretty loud considering 140 dB is loud enough). Readers should be aware that a 10-dB increase in SPL is equivalent to a three-fold increase in pressure on the eardrum.

The Measurement Process

Sound can be expressed in terms of power, pressure, or sound pressure level (SPL). Readers are referred to note 3 for an explanation of the relationship between sound power and sound pressure. Measuring sound power directly is difficult because it requires measuring the movement of the individual air molecules. Fortunately, it is relatively easy to measure the sound pressure level (SPL) directly using a sound level meter. Basically, the sound level meter consists of a pressure-sensitive microphone connected to an electronic voltmeter. The microphone converts sound pressure into an analogous electric voltage. Circuitry within the sound level meter (SLM) converts the signal from the microphone to an electrical equivalent of sound pressure level. The meter displays the voltage in units of dB SPL.

The "response time" (a meter-dynamic characteristic) of most sound level meters, even cheap ones, can be switched from "SLOW" to "FAST." In the FAST mode, the sound level meter must accurately respond to a signal of 200 millisecond (0.2 second) duration. Measuring steady-state noise (e.g. noise produced by machinery) is straightforward because the sound's duration is typically

greater than 0.2 second. Unfortunately, sound level meters don't accurately measure the SPL of rifles because the duration of the sound (excluding echoes from surrounding hills or trees) is very short. For this reason, impulse precision sound level meters were initially used. But the response time in IMPULSE mode proved to be too slow for accurately measuring the SPL of rifle shots.

BIG NOTE: Sound level meters (SLM) used to perform noise surveys aren't designed to measure peak noise levels; they're designed to accurately measure steady-state noises such as noise produced by machinery. A SLM used for measuring steady-state noise (even in FAST response mode) will not accurately measure the SPL of a rifle shot. A SLM in SLOW response mode will barely detect a rifle shot! As I had discovered during previous firearms testing, a SLM designed to measure short-duration (e.g. 10 millisecond) impulse noises won't accurately measure the peak pressure produced by a muzzle blast.

Reader's familiar with sound measurement may question this, so let me explain a scenario I encountered when I first began analyzing muzzle blasts.

During one day of testing, about 15 different rifles were fired. I held the sound level meter close to the shooter's right ear and positioned myself so as not to interfere with the measurement. Two different sound level meters were used: A Larson-Davis model 800B and a Brüel & Kjær model 2209. The first of 15 rifles tested was a small-bore target rifle. With CCI Mini Group shorts, a reading of 105 dB SPL was obtained (IMPULSE mode). In the FAST mode, a reading of 102 dB was obtained. The lower reading in FAST mode was expected. In the IMPULSE mode, a 117 dB reading was obtained using Super-X Expiditer ammo (same target rifle). So far, the measurements looked reasonable. The next rifle tested was an UltraLight 280 using Winchester Super-X ammo. I measured 136 dB SPL which seemed reasonable compared to the small-bore rifle's modest SPL. What became an obvious problem (obvious meaning 15 rifles later) was that all of the high-power rifles gave approximately the same reading of 133 dB SPL in IMPULSE mode, and a more compressed reading in FAST mode.

The problem at that time became apparent while testing a .22/250 with and without its muzzle brake (BOSS). Anyone who's fired a rifle (or has been in the vicinity of a rifle) with a muzzle brake knows that it's a lot louder than the same rifle/ammo without the muzzle brake. However, my first day of testing using supposedly "objective" measurements fell short of demonstrating this: I measured 133 dB SPL with and without the boss!

After a day of testing and suspect results, I made a few phone calls. I spoke with several other people who also perform noise surveys and know the OSHA guidelines for measuring noise in factories, etc. Unfortunately, nobody was able to provide any insight to the problem I was experiencing. One possibility that I had considered was that the sound level meters were "overloading" due to the intensity of the rifle shots. But both the Larson-Davis and Brüel & Kjær meters have built-in overload indicators. I briefed through the Instruction and Applications manual for the B&K sound level meter. A chart showed that the meter reading, even in IMPULSE mode, is (as was suspected) affected by the duration of the signal. The only available option was to measure the peak pressure level (versus sound pressure level) produced by each rifle, or record the rifle shots and observe the waveform on a storage oscilloscope. Both the L-D and B&K sound level meters are precision laboratory instruments and are capable of measuring peak pressures. A storage oscilloscope wasn't available at the original test site, but I was equipped with a portable Sony DAT (digital audio tape)

recorder. The recorded rifle shots were recorded using a DAT recorder and subsequently analyzed using a spectrum analyzer and a digital storage oscilloscope (more on this below).

The reason for not using the sound level meters in PEAK (peak pressure) mode from the start was because this created another (but surmountable) problem. The maximum pressure that could be measured was 140 dB (peak pressure) before overload occurred. For small caliber rifles and pistols, this wasn't a problem. But the peak pressure level (PPL) at the shooter's ear exceeded 140 dB with the majority of the firearms tested. The problem, then, was how to determine the PPL at the shooter's ear without overloading the instruments. The only way to do this was to move the sound level meters a sufficient distance from the shooter so that even the loudest rifle wouldn't overload the meter. In order to determine the PPL at the shooter's ear, a "correction factor" would have to be added to the results obtained with the meter some distance from the rifle. It was desirable to get the SLM as close as possible to the rifles in order to maximize the "signal-to-noise ratio." In short, if the meter is too far away, other noises (environmental, wind, etc.) would be nearly as loud as the noise being measured and possibly obscure the measurement. Fortunately, even the quietest rifle shots were loud enough at 50 ft. to be much louder than the ambient, or background, noise.

Fifty feet was chosen because this was the minimum distance from the loudest rifle that wouldn't cause the meters to overload in PEAK mode. A correction factor of 25 dB was determined empirically as follows: A small-bore rifle was fired while the meter was held at the shooter's ear. (Unlike the larger rifles, this didn't overload the meter.) Several shots were fired from the same rifle to ensure measurement repeatability. Next, the sound level meter was placed 50 ft. behind the shooter (and free of obstructions). The same small-bore rifle was fired again. The measured PPL at 50 ft. was 25 dB less than at the shooter's ear; hence the 25 dB correction factor.

Readers who have been able to follow this discussion thus far may question the difference between dB SPL (which is the normal unit for sound measurement) and dB PPL. Peak pressure level measurements and SPL use the same reference pressure of 20 microPascal (= 0 dB). Conventional sound pressure level (SPL) measurements reference sound or noise that has a duration exceeding several cycles of vibration. Peak pressure levels measure the single greatest change in pressure, even though the duration may only be half of a cycle. This is justifiable when measuring the intensity of firearms because the peak pressure can occur within one vibratory cycle, plus the ear can perceive the loudness differences of such noise.

The results using PPL in lieu of SPL correlate well with our perception of loudness. (Note: This is true for rifle shots, but not necessarily all types of noise.) One noteworthy difference in the results obtained using PPL versus SPL comes to mind. During my first day of testing, I measured 132 dB SPL for an M30 Carbine using GI ammo. The .22/250 (with BOSS) gave a reading of 133 dB SPL. This would lead us to believe that the Browning is only 1 dB louder than the M30 and would suggest a discernible, but not big, difference in loudness. Results obtained using peak pressure measurements yielded a much greater difference. The M30 measured 123 dB PPL (at 50 ft.) and the Browning 22/250 measured 137 dB PPL (again, at 50 ft.). The difference here is 14 dB. Anyone in the vicinity of the test site would have told you that there was a huge difference in loudness between these two rifles. Measurements using PPL reveal this difference; conventional SPL measurements did not.

Two sound level meters, a Brüel & Kjær (B&K) model 2209 impulse precision sound level meter and a Larson-Davis 800B, were used to make recordings of the rifle shots. The output of the B&K meter was connected to the right-channel input of a Sony DAT (digital audio tape) recorder. The Larson-Davis SLM was connected to the left-channel of the recorder. Recordings of the rifle shots were analyzed using a Tektronix model 7854 digital storage oscilloscope and SpectraPLUS (Pioneer Hill) spectrum analyzer software. The maximum pressure level using the analyzer was used primarily to confirm the results obtained using the SLM. Note: Both the L-D and B&K meters were calibrated before testing began. Calibration readings were obtained after we completed our testing to verify that the sound level meters did not incur damage during testing.

Table 1 (click here for pdf file) shows the sound intensity of various firearms using peak pressure level (PPL) measurements. The second column, labeled "dB PPL (SLM)" is the reading obtained directly from the Larson-Davis model 800B SLM (mode = PEAK) plus the 25 dB correction. The right-most column, labeled "Pascals peak (RTA)" is the peak pressure (in Pascals) measured via the spectrum analyzer software.

Here are a few observations: The blast noise emanating from a rifle with a muzzle brake is measurably more intense than the same rifle without a muzzle brake. The .300 Win Mag bolt action (using xxx ammo—see Table 1) measured 7.3 dB more intense with the BOSS than without the BOSS. Note: A 7.3 dB increase in PPL is a 2.3-fold increase in sound pressure, as shown below:

$$20\log \frac{[2.32P]}{P} = 20\log \frac{2.32}{1} = 20 \times 0.365 = 7.3 \text{ dB}$$

Similarly, the Browning .22/250 (40 grain) measured 7.8 dB more intense with its BOSS than without it. Other comparisons can be made using Table 1.

Note: When comparing firearm peak pressure levels using Table 1, remember that a 1 dB difference can be heard, a 3 dB increase is “quite a bit” louder, and a 10 dB increase is “twice as loud.”

Noise and Hearing Loss

Noise surveys using sound level meters are performed in workplaces to determine if workers are at risk for hearing loss. Two primary variables dictate guidelines previously set forth by OSHA: The sound’s intensity ("loudness") and the time duration a worker is exposed to noise. According to OSHA guidelines, workers exposed to noise at or below 85 dB SPL(A) are not required to wear hearing protection. Workers exposed to noise levels at 90 dB SPL(A) for up to 8 hours must wear hearing protection. For 95 dB SPL(A), the maximum exposure time is 4 hours; for 100 dB SPL(A) the maximum time is 2 hours—this function of SPL versus time is known as the "5 dB exchange rate." When the noise level increases 5 dB, the maximum safe exposure time is halved. Workers are required to wear hearing protection anytime a noise level exceeds 115 dB SPL(A). But even with these guidelines, approximately 50% of workers could experience some hearing loss at these levels without hearing protection.

The effects of hearing loss as a result of blasts (such as those produced by firearms) isn't as well documented as occupational hearing loss. There are individuals who have suffered permanent hearing loss as a result of shooting, but the effects of single, loud-

noise events varies from person to person. One common complaint shooters have isn't hearing loss, but tinnitus (a "ringing in the ear"). It should be noted that tinnitus frequently accompanies hearing loss resulting from noise exposure.

The most well-known aftereffect of exposure to high-intensity sound is the change in auditory sensitivity. If an individual's auditory threshold (hearing sensitivity) is measured before and after an exposure, the difference in hearing threshold levels is, by definition, the threshold shift (TS). If the threshold shift later disappears, then it is called a temporary threshold shift (TTS). If the shift does not disappear, the final measured threshold shift is called a permanent threshold shift (PTS).

The most undesirable aftereffect of exposure to high-intensity sound is a PTS. Sound-induced PTS is commonly divided into two categories depending on whether the loss was produced by a single, short exposure at a very high intensity (acoustic trauma) or by repeated longer exposures to noise at more moderate sound pressure levels. It is clear from animal studies that in acoustic trauma the inner ear has been subjected to such stress that its mechanical (or elastic) limit has been exceeded. Various structures of the organ of Corti, including hair cells (the individual receptor cells within the inner ear), may become partly or wholly detached. Additionally, one or more of the several membranes in the cochlea may be ruptured, allowing an intermixture of fluids of different composition, thereby poisoning hairs cells that survived the mechanical stress. The end consequence is a pronounced loss of hearing sensitivity at the frequencies correlated with the locus of this destruction.

Less is known about acoustic trauma in humans, although it is not at all rare. Victims of acoustic trauma seldom have had a recent audiogram that would enable the amount of threshold shift to be determined with certainty. And unlike controlled studies utilizing animals, information regarding the exposure level and duration isn't always known. Finally, differences among people in susceptibility to damage are so great that single cases show that acoustic trauma is possible from a given exposure but not that it is inevitable to everyone exposed. In other words, a given exposure, however it is measured, does not produce the same hearing loss in every ear.

Figure 1 (click here) below shows a comparison of single noise exposures that have been shown to be "without hazard" to the average young healthy ear (circled symbols) and those that have apparently produced 15 dB or more of permanent threshold shift in at least one person (symbols in squares). The dashed line, representing 8 hours of exposure at 100 dB SPL or its energy equivalent (more on this below), divides single exposures that are "probably safe" from those that are capable of causing permanent damage in individuals (ref. 1). Note: Physiological damage to the cochlea by high-intensity sound is not necessarily reflected in a measurable PTS. Evidence from both animal and human studies implies that several hundred of the hair cells that have been presumed to be important in the process of hearing may be destroyed before a change in threshold is measurable (ref. 2).

Four of the exposures labeled in the figure are from the studies of Davis et al. (ref. 3) on the effect of noise: Point D—32 minutes at 130 dB SPL; Point M—1 minute exposure to a 2-kHz tone at 130 dB SPL; Point S—8 minute exposure to a 4-kHz tone at 120 dB SPL. Davis himself received a 30 dB increase in his preexisting high-frequency hearing loss after exposure for 20 minutes to a 500-Hz tone at 140 dB SPL (Point H). Other points in Figure 1 include Point SN (ref. 4)—0.4 second at 153 dB (an exposure designed to be equivalent to the sound produced by the opening of an air bag); Point E—1 minute at 135 dB (ref. 5); Point O—the

effect of the ring of a cordless telephone in which the same transducer was used for the ringer as well as voice, and produced a measurable PTS in a small fraction of those individuals exposed (ref. 6); and Point L (ref. 7)—an exposure of "a few seconds" to a tone of about 138 dB SPL that was being used to elicit the acoustic reflex (and produced additional damage in two individuals who already had considerable hearing loss).

The "8 hours at 100 dB SPL energy equivalent" exposure duration for any intensity greater than 100 dB SPL can be calculated using the following equation:

$$\frac{2.88 \times 10^4 \text{ seconds}}{\text{Antilog}[(\text{SPL(dB)}-100\text{ dB})/10]} = \text{time (seconds)}.$$

Similarly, the exposure intensity for any duration less than 8 hours can be calculated using

$$10\log\frac{2.88 \times 10^4 \text{ seconds}}{\text{time (seconds)}} + 100 \text{ dB} = \text{SPL (dB)}.$$

Table 1 shows the sound pressure level of each firearm (plus respective ammo and attachments) tested. The "Exposure duration" (the abscissa in Fig. 1) to single rifle shots was measured using a storage oscilloscope for each rifle tested; the results are shown in Table 2 (click here for pdf file). The duration of multiple gun shots is simply the duration of a single shot times the number of shots fired Superimposing the points whose X-Y coordinates are X=time & Y=SPL onto Fig. 1, we can determine the likelihood of safety or the possibility of damage for each firearm tested. If the point appears above the dashed line in Fig. 1, a permanent threshold shift is possible.

Figure 2 (click here) shows an extension of the plot shown in Fig. 1. The time scale has been modified to show points that are similar to the duration of the blast noise (e.g., 3.5 milliseconds). The line in Fig. 2 still represents the energy equivalent of 8 hours at 100 dB SPL. The duration of each blast was measured using a digital storage oscilloscope—refer to Fig. 3 (click here) for an example. Because of the complexity of each waveform encountered, only the duration of the noise at its maximum compression and rarefaction is shown in Table 2 (click here for pdf file). Residual peaks exceeding 140 dB SPL at times greater than 10 milliseconds can be seen on the oscilloscope printouts, but their contribution to risk was not taken into account. It is interesting to note that the "louder" rifles also have measurably longer blast duration in addition to greater peak pressures; this is a significant observation because it is the combination of duration and intensity that determine the "equivalent energy" of the noise. Rifle #5 with its respective BOSS (see Fig. 3) produces both great enough SPL and blast duration that three successive rifle blasts would put the shooter at risk for permanent hearing damage resulting from acoustic trauma.

Important Notes: **The measurements shown in Table 1 are for the actual sound pressure levels encountered at a distance of one foot away from the shooter's ear. The shooter would encounter additional noise (i.e., a greater SPL) in the ear resulting from closer proximity to the rifle's muzzle plus sound transmitted via bone conduction. Sound transmission via bone conduction is very real: Audiologist routinely use bone conduction to test patients' sensorineural (a.k.a. "nerve") hearing thresholds. A "bone conduction" transducer is placed on the mastoid process (bump behind the ear) to transmit sound to the**

inner ear via bone conduction. Similarly, a shooter's head placed on the rifle stock allows energy travelling through the rifle stock to be transmitted to the inner ear (this is in addition to the airborne blast noise). In short, the values presented in Table 1 would be the minimum sound pressure levels encountered by the shooter for each of the rifles tested.

Another important consideration regarding risk criteria is the "equivalent energy" theory: The idea that "equivalent energy" will result in the same amount of damage for a given person may be insufficient in determining risk for intensities greater than 150 dB SPL. One study (ref. 8) showed that 30 impulses (or "rounds") of simulated gunfire at 150 dB SPL peak level created a temporary threshold shift (TTS) in a particular ear, whereas 300 impulses of the same pulse shape at 140 dB SPL (to maintain the same total energy) usually produced no TTS in the same individual. This suggests that 3 impulses at 160 dB SPL would create an even greater TTS for the same individual than 30 impulses at 150 dB SPL, even though the "equivalent energy" is the same. In conclusion, greater sound pressure levels are at least, if not more, damaging than their lower-intensity, but longer duration, "energy equivalent" SPLs.

In addition to studies showing that high-intensity impulse noise affects the cochlea differently than does continuous noise, there are logical reasons why the equivalent energy theorem can't always predict risk for hearing damage. Logically, we know there are levels associated with impulses that are dangerous with just one exposure. But at lower levels, individuals can withstand almost an infinite number of the same "signature" impulses (same waveform, but at a lower intensity) without harm. Also, most of the data supporting the equivalent energy theorem have been large-scale demographic studies. Controlled laboratory studies using animals (e.g., ref. 9) have shown that hearing loss resulting from exposure to impulse noise of equal energy increases with peak level. To iterate: The danger of hearing loss resulting from a single exposure to high-intensity impulse noise is at least as great as what we would predict using Figures 1 or 2.

Another important question is "What is the risk using the same rifle and ammo (rifle #5 with xxx ammo) without its respective BOSS?" The peak pressure level without the BOSS is 157.5 dB PPL, and the duration of a single blast is 3.5 milliseconds (click here for Fig. 4). The maximum "safe" exposure time for 157.5 dB SPL is 51 milliseconds and is the time equivalent of 15 successive blasts. (Note that the blast duration is shorter for the same rifle/ammo combination without its BOSS.) Of the rifles tested, the rifle/ammo combinations that would put shooters at highest risk for hearing loss are rifles #5 and #9 with there respective BOSS plus high velocity or high-energy ammo. At 165.5 dB SPL (rifle #5), an exposure longer than 8 milliseconds would put the shooter in the "danger zone." This is slightly greater than the duration of two shots, but less than three rifle shots at the measured duration of 3.5 milliseconds per shot (click here for Fig. 5). As previously stated, the shooter would experience a minimum SPL of 165.5 (without hearing protection), and the duration of exposure to a single shot is at least 3.5 milliseconds. It is entirely possible that a single rifle shot at this intensity and duration could cause a temporary or permanent threshold shift! The calculations and measurements provide us with information that can be used in conjunction with prior studies to suggest what is "possible" or "likely" versus what is "unlikely" (but not impossible!!). Similarly, rifle #9 with its BOSS plus high-energy ammo (click here for Fig. 6) measured 164.5 dB

SPL and 3.8 milliseconds duration. Again, the shooter would be in the "danger zone" between 2 and 3 shots. Referring to Figures 5 and 6, we see that there's a lot of energy subsequent to the primary compression/rarefaction of these blasts; consequently, the actual duration of exposure is greater than the value used in the above calculations, and the chances of a PTS are increased.

Additional Measurements and Notes

Sound level meters are but one type of instrument used to analyze sound: Other measuring devices are used to measure characteristics of sound other than intensity. One such device is known as a "spectrum analyzer." In general, spectrum analysis refers to a detailed observation of the individual parameters of a signal. In acoustics, the parameters of interest are time, frequency and amplitude. A simple example of spectrum analysis can be demonstrated using a prism. White light shown through a prism reveals that white light is actually composed of many colors. In essence, this is spectrum analysis because we see the color spectrum of white light.

Like light, most noise or sounds (other than pure tones) are made up of discrete tones or "colors." More accurately, any sound at a given time can be expressed as the sum of its individual frequency components. To give an example, a piano and violin sound different from one another, even when playing the same note. The reason for this is because each instrument produces harmonics, or overtones, in addition to a fundamental frequency or "pitch." A spectrum analyzer allows us to see the frequencies, or harmonics, that make up such sounds. A violin produces different harmonics than a piano or a flute; consequently, they sound different from each other. The same goes for the human voice: A man and woman talking at the same volume, or sound pressure level, are readily distinguishable. We can also use a spectrum analyzer to study the noise resulting from blasts.

Many of us claim we can identify a rifle shot from a pistol or a shotgun blast. Clearly, this isn't just a function of loudness because some rifles are louder than pistols, others aren't, etc. What allows us to distinguish a pistol from a rifle is the relative combination of frequencies that make up their individual, or characteristic, sound. The technique used to generate a plot of a sound's individual frequency components is called Fourier Transformation, named for the French mathematician who developed the technique. I used "Fast Fourier Transform" (FFT) spectrum analysis to obtain the results shown. Visual inspection of these plots gives evidence that not all firearms sound the same, but perhaps similar. Though not demonstrated here, other types of blasts, such as a balloon popping, don't sound like firearms.

Notes

Note 1. The Sony DAT recorder was "calibrated" as follows: An acoustic calibrator was attached to the microphones of the Larson-Davis and B&K SLMs. The calibrator provides a 1 kHz (1000 c.p.s.), 114 dB SPL acoustic signal. At this SPL, the DAT's record level was set at minus 34 dB. This allowed the Sony DAT to record signals as loud as 148 dB SPL without distorting. With a 114 dB input and the record level set to -34 dB, the electrical output was 163 millivolts. The recordings were later analyzed using a digital storage oscilloscope and spectrum analysis software. Here are two examples:

1. 7mm Mouser (no BOSS). Using a storage oscilloscope, a peak voltage of 1017 millivolts was measured. (A storage oscilloscope is needed because the duration of this signal is about 0.003 seconds.) Using 163 millivolts = 114 dB as the reference, we get

$$20 \log \frac{1017 \text{ mV}}{163 \text{ mV}} = 20 \log 6.24 = 15.9 \text{ dB}.$$ The 1017 mV signal is 15.9 dB greater than the 114 dB reference; the actual PPL (at 50 ft.) is then 114 dB + 15.9 dB = 129.9 dB and is exactly what we measured using the SLM in PEAK mode.

2. .270 cal with BOSS; 150 grain. The measured peak voltage was 2865 millivolts.

$$20 \log \frac{2865 \text{ mV}}{163 \text{ mV}} = 20 \log 17.6 = 24.9 \text{ dB}.$$ Adding this to 114 dB gives 138.9 dB, which is what we measured using the SLM.

Note 2. The 25 dB correction factor is explained in the text. Distance from the source and air itself account for the attenuation (very high frequencies are absorbed more readily by air because the acoustic energy is dissipated in the form of friction). Spectral analysis indicated that most of the energy produced by the blasts (rifles, shotguns, and pistols) was in the low- to mid-frequency range of audible frequencies. For this reason, the correction factor is accurate for all firearms tested, regardless of their PPL.

Note 3. Relationship between sound pressure and sound power. Sound pressure level (SPL) measurements use a reference pressure of 0.00002 Pascal (Pa). A reference power could be used, but this requires measuring the movement of the individual air molecules. The relationship between power (I) and pressure (P) is

$$I \text{ (power)} = \frac{P^2}{Z_a}$$ where Z_a is the impedance (mechanical resistance) of air.

What's important to note here is that if we double the pressure P, we get a four-fold increase in power (Z_a doesn't change). Consequently, if we use power (either acoustical or electrical) as our decibel (dB) reference, we no longer multiply the log of the ratio by 20. Instead, we multiply the log of the ratio by 10. An example demonstrates that our end result in dB is the same.

As previously shown, doubling the pressure gives us a 6 dB increase in SPL. Using the above equation ($I = P^2/Z$), we see that doubling the pressure gives four times the power. Our dB equation using power is

$$10 \log \frac{\text{Power}}{\text{Pwr}_{(\text{ref})}}.$$ If power increases 4X, we get 10 log (4) = 6 dB.

This is why adding a second loudspeaker to your stereo only adds 3 dB SPL to the overall loudness. Imagine that your stereo is delivering 4 watts to the right loudspeaker. We connect the left channel's loudspeaker, so now we have a total of 8 watts. Using our

ubiquitous dB formula, we get

$$10 \log \frac{8 \text{ watts}}{4 \text{ watts}} = 10 \log (2) = 3 \text{ dB increase in SPL.}$$

Remember, 3 dB is a noticeable increase in loudness, but a 10 dB increase is needed for the sound to be perceived as "twice as loud." Incidentally, a 10 dB increase is equivalent to a 10 fold increase in power (not to mention a 3.16 fold increase in pressure). This means 40 watts, not 8 watts, is twice as loud as 4 watts.

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Table 1. Peak Pressure Levels of Various Firearms

Rifle #	Description	dB PPL (SLM)	Pascals peak (RTA)
1.	7 mm Mouser	154.9	1160
2.	.270 cal with BOSS; 130 grain Power Point	164.6	3140
2.	.270 cal with BOSS; 150 grain	163.9	3110
2.	.270 cal with attachment—No BOSS; 130 grain	158.1	1660
2.	.270 cal with attachment—No BOSS; 150 grain	157.3	-
3.	(?) No BOSS, no attachment; 130 grain	157.9	1520
3.	(?) No BOSS, no attachment; 150 grain	157.1	1400
4.	Browning .22/250 with BOSS; 40 grain	163.1	2960
4.	Browning .22/250 with BOSS; 55 grain	162.9	2790
4.	Browning .22/250 with cover—No BOSS; 40 grain	155.3	-
4.	Browning .22/250 with cover—No BOSS; 55 grain	154.1	-
5.	.300 Win Mag bolt with cover—No BOSS; xxx ammo	157.5	1630
5.	.300 Win Mag bolt with cover—No BOSS; high velocity	161.5	2380
5.	.300 Win Mag bolt with BOSS; xxx ammo	164.8	3170
5.	.300 Win Mag bolt with BOSS; high velocity ammo	165.5+	3240
6.	7 mm “Plain Jane”; 140 grain	158.3	1660
6.	7 mm “Plain Jane”; 160 grain	157.5	1545
7.	7 mm with BOSS; 140 grain (same as #6 ammo)	163.6	3110
7.	7 mm with BOSS; 160 grain (same as #6 ammo)	163.5	3110
7.	7 mm with cover—No BOSS; 140 grain (same as #6)	159.5	1880
7.	7 mm with cover—No BOSS; 160 grain (same as #6)	157.8	1460
8.	.300 Win Mag plain barrel; 180 grain	158.3	1650
8.	.300 Win Mag plain barrel; 180 grain high velocity	158.8	1780
9.	.338 Win with cover—No BOSS; 210 grain	157.1	1470
9.	.338 Win with cover—No BOSS; 250 grain	156.8	1430
9.	.338 Win with cover—No BOSS; 250 grain high energy	161.5	1530
9.	.338 Win with BOSS; 210 grain	164.5	3230
9.	.338 Win with BOSS; 250 grain	163.8	3100
9.	.338 Win with BOSS; 250 grain high energy	164.5	3200

Table 2. Duration of Peak Pressure Levels for Various Firearms

Rifle #	Description	dB PPL (SLM)	Duration (millisec)
1.	7 mm Mouser	154.9	3.3
2.	.270 cal with BOSS; 130 grain Power Point	164.6	3.5
2.	.270 cal with BOSS; 150 grain	163.9	3.8
2.	.270 cal with attachment—No BOSS; 130 grain	158.1	3.5
2.	.270 cal with attachment—No BOSS; 150 grain	157.3	-
3.	(?) No BOSS, no attachment; 130 grain	157.9	3.4
3.	(?) No BOSS, no attachment; 150 grain	157.1	3.2
4.	Browning .22/250 with BOSS; 40 grain	163.1	2.9
4.	Browning .22/250 with BOSS; 55 grain	162.9	3.1
4.	Browning .22/250 with cover—No BOSS; 40 grain	155.3	-
4.	Browning .22/250 with cover—No BOSS; 55 grain	154.1	-
5.	.300 Win Mag bolt with cover—No BOSS; xxx ammo	157.5	3.5
5.	.300 Win Mag bolt with cover—No BOSS; high velocity	161.5	3.0
5.	.300 Win Mag bolt with BOSS; xxx ammo	164.8	4.1
5.	.300 Win Mag bolt with BOSS; high velocity ammo	165.5+	3.5
6.	7 mm “Plain Jane”; 140 grain	158.3	3.7
6.	7 mm “Plain Jane”; 160 grain	157.5	3.4
7.	7 mm with BOSS; 140 grain (same as #6 ammo)	163.6	3.7
7.	7 mm with BOSS; 160 grain (same as #6 ammo)	163.5	3.6
7.	7 mm with cover—No BOSS; 140 grain (same as #6)	159.5	2.8
7.	7 mm with cover—No BOSS; 160 grain (same as #6)	157.8	3.5
8.	.300 Win Mag plain barrel; 180 grain	158.3	3.5
8.	.300 Win Mag plain barrel; 180 grain high velocity	158.8	4.0
9.	.338 Win with cover—No BOSS; 210 grain	157.1	3.5
9.	.338 Win with cover—No BOSS; 250 grain	156.8	3.8
9.	.338 Win with cover—No BOSS; 250 grain high energy	161.5	3.7
9.	.338 Win with BOSS; 210 grain	164.5	3.4
9.	.338 Win with BOSS; 250 grain	163.8	3.8
9.	.338 Win with BOSS; 250 grain high energy	164.5	3.8

Mr. Merkel presented the item. He indicated that the Annual Appropriation Ordinance and Certificate of Estimated Revenues by Source are for fiscal year 2012-13 which began on May 1, 2012 and will end on April 30, 2013. The documents establish the legal limit of the Village's expenditures during the fiscal year. Mr. Merkel also provided an overview of the budget process. No comments were made by the Village Board. No comments were made by members of the public. President Turry closed the Public Hearing.

Trustee Swanson moved to approve the Annual Appropriation Ordinance and the Certificate of Estimated Revenues by Source as presented in one omnibus vote. Trustee Heidtke seconded the motion.
Upon Roll Call by Acting Village Clerk Petroshius the results were:
AYES: Trustees Patel, Heidtke, Leftakes, Elster, Sprogis-Marohn, Swanson
NAYS: None
The Appropriations Ordinance for fiscal year 2012-13 was approved and the Certificate of Estimated Revenues by Source for fiscal year 2011-12 was approved.

14. Consideration of a Recommendation by the Plan Commission Relative to Shore Galleries 1) Request for Text Amendments to the Zoning Code to add Firearms as a Special Use in the MB District, to add Definition of Firearms Dealer, and to add Off-Street Parking Requirements for Firearms Dealer, 2) Special Use Approval to Permit a Firearms Dealer in the MB District, 3) Variation From the Zoning Code to Permit an Addition to Encroach into the Required Front and Side Yard Setbacks and a Variation from the Zoning Code to Permit a Firearms Dealer with Fewer than the Required Number of Off-Street Parking Spaces, and 4) Municipal Code Amendment to Section 9-15-2-4 Regarding License Issuance for Firearms Dealer; all to Permit a Firearms Dealer and Range at 6950 Central Park Avenue

President Turry read aloud a prepared statement for the audience outlining the standards of conduct that were to be followed for the purpose of an efficient review and discussion of this item. Mr. Cook presented this item via PowerPoint. He presented that Mitchell Shore owner and President of Shore Galleries, a Lincolnwood business that has been located at 3318 Devon Avenue since the 1950's, desires to relocate and expand their business at 6950 Central Park Avenue. The existing Shore Galleries store sells firearms and provided for a limited non-public shooting area. The proposed Shore Galleries store would sell firearms and provide for a 16-stall public shooting area. Four legislative actions are required for the proposed gun store to be relocated and receive zoning authorization: 1) a Municipal Code text amendment to allow relocation/expansion of their business; 2) a Zoning Code text amendment authorizing the sale of firearms and a shooting range; 3) a Special Use; and 4) zoning variations. Pictures of the proposed store, plans, and maps were presented. This matter had been presented during a Public Hearing before the Plan Commission on June 6, 2012 where it received a 5-1 vote in favor of the relocation of the store. Since the Public Hearing staff received two letters in support and two letters in opposition of the store's relocation plus a petition of people opposed to the store's relocation. This matter was also discussed at the July 10, 2012 Park and Recreation Board meeting. Stewart Cuspner, a representative on behalf of Shore Galleries, provided additional information regarding their desire to relocate their store within the Village and answered clarifying questions from the Village Board. Discussion ensued.

President Turry then indicated that the Public Comment portion of the agenda item was to begin. Acting Clerk Petroshius read aloud the names of those wishing to speak during public comment which were as follows:

Order Number	Name	Address	Position (Support/Oppose)
1	Mark A. Yohanna	6639 Spokane Avenue, Lincolnwood, IL	Support
2	Rich Eddington	807 Davis, Evanston, IL	Support
3	Dennis Anderson	1934 Garland Avenue, Highland Park, IL	Support
4	Walter Klinser	6518 Navajo Avenue, Lincolnwood, IL	Support
5	Roselle S. Friedman	6736 North Lawndale Avenue, IL	Oppose
6	Stanley Wilk	4830 Chase Avenue, Lincolnwood, IL	Support
7	Buzz Alpert	7220 North Keeler Avenue, Lincolnwood, IL	Oppose
8	Nick Sievers	1108 Forest, Wilmette, IL	Support
9	Marc Bermann	6727 North Drake Avenue, Lincolnwood, IL	Oppose
10	Jeremy Margolis	6400 North Cicero Avenue, Lincolnwood, IL	Support
11	Zvie Liberman	6530 North Kimball Avenue, Lincolnwood, IL	Support
12	Joseph Fivelson	2820 West Jarvis Avenue, Lincolnwood, IL	Support
13	Kathy O'Brien	3837 West Fitch Avenue, Lincolnwood, IL	Support
14	Nan Rumsey	6851 North Cherry Lane, Lincolnwood, IL	Support
15	Diane S. Shapiro	4170 North Marina, Chicago, IL	Support
16	R. F. Nussbaum	6742 North Kimball Avenue, Lincolnwood, IL	Support
17	Paul Domer	6851 North Cherry Lane, Lincolnwood, IL	Support
18	Carol Krikorian	4854 West Sherwin Avenue, Lincolnwood, IL	Oppose

19	Matthew Domer	6851 North Cherry Lane, Lincolnwood, IL	Support
20	Marc M. Jens	7202 Keystone Avenue, Lincolnwood, IL	Support
21	Arthur Rubin	6727 North Trumbull Avenue, Lincolnwood, IL	Support
22	Michael Shapiro	6900 North Central Park, Lincolnwood, IL	Oppose
23	Donald Gelfund	7310 Tripp Avenue, Lincolnwood, IL	Support
24	John Ernst	6608 Keating Avenue, Lincolnwood, IL	Support
25	Alan Gluck	6990 North Central Park Avenue, Lincolnwood, IL	Oppose
26	Charles Halevi	4224 Pratt Avenue, Lincolnwood, IL	Support
27	Brad Blumenthal	6716 North Monticello Avenue, Lincolnwood, IL	Support
28	Peter Coorlas	6525 Tower Circle Drive, Lincolnwood, IL	Support
29	Chris Hart	Provo, Utah	Support
30	Aleks Kasevic	6864 Lockwood, Lincolnwood, IL	Oppose
31	Judith Snyder	7267 North East Prairie Road, Lincolnwood, IL	Oppose
32	Kevin Snow	932 Hazel, Deerfield, IL	Oppose
33	Mark Lazar	6557 North Lincoln Avenue, Lincolnwood, IL	Oppose
34	Mallard Casteel	8417 Kimball Avenue, Skokie, IL	Support
35	Glen Ragaishis	407 North Ashland, LaGrange Park, IL	Oppose
36	Oleg Gnobshtesh	6714 North Drake Avenue, Lincolnwood, IL	Support

President Turry closed the public comment portion of the item and proceeded to allow Mr. Cuspner to respond to some of the comments. President Turry then added for the record the following petitions: 1) a list of 96 City of Chicago residents opposed to the relocation of Shore Galleries; 2) a list of 43 Village of Lincolnwood residents opposed to the relocation of Shore

Galleries; 3) a list of 150 Village of Lincolnwood residents in support of the relocation of Shore Galleries.

Discussion ensued regarding sales tax received from the proposed store, sound issues from gunfire and sound regulations, and environmental impacts. After a lengthy discussion the Village Board determined that the Plan Commission did not fully vet all issues and therefore decided to remand the matter back to the recommending body. There was consensus among the Village Board to direct the Plan Commission to review parking impacts of the proposed store, the expanded scope of the proposed store in comparison to the existing store, and issues surrounding the installation of a 16-stall shooting range.

Trustee Sprogis-Marohn remanded the matter back to the Plan Commission, directing the recommending body to review parking impacts of the proposed store, the expanded scope of the proposed store in comparison to the existing store, and issues surrounding the installation of a 16-stall shooting range. Trustee Swanson seconded the motion.
Upon Roll Call the results were:
AYES: Trustees Patel, Heidtke, Leftakes, Elster, Sprogis-Marohn, Swanson
NAYS: None The motion Passed.
The matter was remanded to the Plan Commission for their meeting on August 22, 2012.

15. Approval of a Recommendation by the Park and Recreation Board to Adopt an Ordinance Waiving Chapter 6, Article 3, Section 2 of the Village Code that Governs Park Hours, Extending the Closing of Proesel Park to 11:30 pm on the Friday and Saturday of the 2012 Lincolnwood Fest

Mark Bloom of 7002 North Keeler Avenue indicated opposition to the proposed Ordinance as he lives across the street from Proesel Park and he did not want the Lincolnwood Fest to be going until 11:30 P.M. Ms. Hincapie responded by stating that extending the hours in Proesel Park for the Fest has been the Village's practice for several years and that the main purpose was to allow staff and public safety to prepare the Fest for closing. There was no discussion from the Village Board.

Trustee Swanson moved to approve the Ordinance. Trustee Elster seconded the motion.
Upon Roll Call by Acting Village Clerk Petroshius the results were:
AYES: Trustees Patel, Heidtke, Leftakes, Elster, Sprogis-Marohn, Swanson
NAYS: None The motion passed.
The Ordinance was approved.

Manager's Report
Mr. Wiberg reported that due to the insect known as the Emerald Ash Borer, the Public Works staff will be removing 900 Ash Trees located on the public right-of-way. These trees have been rendered dead or unsafe due to the Emerald Ash Borer. Mr. Wiberg indicated that although 900 trees will be removed the Village has approximately 7,000 trees in the public right-of-way.
Mr. Wiberg reported that several years ago the Village and School District 74 received a "Safe Route to Schools" grant which is being fully implemented this year. Roadway improvements are currently underway at the intersections of Pratt Avenue and East Prairie Road and Morse Avenue and East Prairie Road near the School District's campus. Sign and roadway markings will be improved around the general perimeter of all three schools. Mr. Wiberg also reported on temporary lane closures during construction. President Turry thanked Mr. Wiberg for his report.

Board and Commissions Report
None.

IIII. PUBLIC HEARING: 6950 Central Park Avenue – Text Amendment, Special Use, and Variations
Request: 1) Text Amendment to the Zoning Code to Add "Firearms Dealers" as a Special Use in the MB District; 2) Special Use Approval for a "Firearms Dealer" at the Subject Property; and 3) Consideration of Front and Side Yard Setback Variations to Permit an Addition to the Existing Building

Development Manager Cook began with a PowerPoint presentation. The first matter for Plan Commission consideration is the necessary Text Amendment to the Zoning Code. The Zoning Code will need to be amended to even consider the requested Special Use and Variations. Shore Galleries has been operating in the Village since the 1950's at 3318 Devon Avenue. They sell Firearms and have been limited to a non-public shooting area. They desire to relocate to 6950 Central Park Avenue. A change in the Zoning Code is sought to allow relocation of their business. To authorize Firearms/Gun Shop/Shooting Range in the underlying zoning district, Staff suggests that the Code be amended to allow these uses only upon issuance of a Special Use Permit. Currently, the Village Code requires Firearms dealers to possess a Federal Firearms Dealer License. Also, the license cannot be issued for a location within ½ mile of a school or public park unless the business is operating at a located that was licensed on September 1, 1994. The Park/School restriction effectively prohibits new firearms dealers, and Shore Galleries is grandfathered, but only at its current location.

The subject property that Shore Galleries seeks to move to is 6950 Central Park Avenue which is now occupied by Resillo Press Pads. The property is located in the Lincolnwood Business Park and is zoned M-B Light Manufacturing-Business. The property is within ½ mile from a school and a park. Further, the current Zoning Code does not contain a Zoning Classification authorizing firearms dealers/shooting ranges/or gun shops. The use is prohibited. To authorize the relocation, a Zoning Code Text Amendment is needed. Staff recommends that the appropriate land use category be added as a Special Use in the M-B district only. Staff also recommends that a definition of "Firearms Dealer" be added to the definitions section of the Zoning Code, and that Off-Street Parking Requirements for "Firearms Dealer" be added to the off-street parking table.

Staff further recommends that the Text Amendments for "Firearms Dealer" as a Special Use in the MB District set forth the following additional criteria: 1) Any Firearms Dealer must be a minimum of 800 feet from any property zoned Public Space/Park (P) or Residentially (R) zoned property; 2) Any Firearms Dealer must be a minimum of 800 feet from any other operating firearms dealer in the Village; and 3) Firearms Dealers are not permitted on any property with frontage on a State of Illinois highway. With these requirements it makes it almost impossible for another firearms dealer to come into Lincolnwood.

Village Attorney Passman stated this is a set of suggested text changes. This does not guarantee that another firearms dealer will not try to apply to open and operate in Lincolnwood.

Commissioner Goldfein stated that this proposed relocation should be rejected due to the proximity of the proposed bike path and within ½ mile of three parks, and those rules should be supported and protected.

Development Manager Cook continued with the presentation that the definition of "Firearms Dealer" be defined as: "Any person licensed to deal firearms pursuant to 18 U.S.C *§* 923 (a)(3)(B), as may be amended, and excluding any person licensed as a collector pursuant to 18 U.S.C *§* 923(b), as may be amended." As to the appropriate off-street parking requirements for "Firearms Dealer", Manager Cook stated that many communities do not incorporate such uses in their land use table or specifically state off-street parking for "Firearms Dealers". There currently is no standard in the region for applying this use. Staff suggested an off-street parking requirement as follows: Two spaces per shooting range station, plus three spaces per 1,000 square feet of floor space not devoted to indoor shooting range.

If a Text Amendment is deemed appropriate and recommended, Shore Galleries requests consideration of a Special Use Permit for 6950 Central Park Avenue. The proposed use would comply with the suggested Text Amendment for "Firearms Dealers". Additionally, there are no objections from the Chief of Police, but the Chief does recommend a security plan be presented to the Police Department and approved prior to occupancy.

Lastly, there are several variations requested for Shore Galleries to move in and occupy the space: (1) to permit an addition to the front of the existing building, which will encroach into Required Front and Side Setbacks within the M-B District; and (2) to reduce the required minimum off-street parking for Shore Galleries at the proposed new location.

Chairman Eisterhold swore in petitioners Scott Krone, Chris Hart, Steve Siegel, and Mitch Shore. Mr. Krone gave a brief introduction about Shore Galleries. The business has been operating from the 1950's without incident. Mitch Shore is certified as a range master with the FBI and does various certification and training throughout the county with various police departments. His business needs this extra space to continue operating, as a result 6950 Central Park is the only viable option. Many other properties have been looked at throughout the Chicagoland area and Mr. Shore would like to stay in Lincolnwood. The property is isolated with respect to traffic and would not draw any attention to the business. The M-B district allows for retail as an additional use, and this is the easternmost location in the M-B district away from Residential. The other sites have been eliminated, and Shore feels that this is the best site. The construction technique is good, the structure is solid and extremely well built. Additionally, the original property did extend all the way out to Central Park Avenue but at some point some property along Central Park was obtained by the Village and the property line was moved back. That is what created the front yard setback hardship. That is also why the parking was taken away from the property. The plan is to have 13 parking spaces along the street and 9 additional parking spaces on the site. The relocation is required because the business cannot survive at the current location. With regard to the zoning variations, Shore is only

looking to extend the building to its natural front yard setback; all the other buildings are closer or in line with the proposed plan.

Chairman Eisterhold questioned the petitioner if they will add parking spaces along Central Park Avenue. The petitioner responded that there are currently nine spaces, that they are proposing 13 spaces, and will incur the expense to construct the additional spaces. Commissioner Jakubowski suggested as an approval condition that the existing building on Devon must close and the Applicant will only be allowed to have the proposed 6950 Central Park Avenue location.

Chairman Eisterhold stated the current location on Devon does not have a full shooting range, and asked if the petitioner could give an idea of the percentage of police officer clients as opposed to non-police customers. Mr. Krone responded that it is between 80-90% law enforcement. The new shooting range will be open to the public but everyone must have a certified license to operate and fire a firearm.

Mr. Hart testified that he is responsible for designing the technical aspects of the range. The building has steel columns with thickened 18 inch slabs even on the second floor. The entire permitted has block and face brick with the steel columns to support it. Commissioner Sampen questioned the noise factor in the range. Mr. Hart responded that the noise will be minimized and will be no louder than a car passing outside. To the neighbor of the south, the petitioner will add a CMU block wall with a cavity that will buffer the noise as much as possible. The noise will be hard to hear from the property line. Several sound studies have been conducted from other buildings that are not as substantial as this one. Typically, the passing traffic will be louder than the gun shots inside the building. There are two ranges with two separate bays and different lengths with the same equipment on both. With the double wythe wall and the air gaps it will help curtail the sound leaving the building. Mr. Hart has designed hundreds of these ranges a year. They have been built in high rise buildings and share walls with gyms and things of that nature, the noise has been curtailed without complaint.

Commissioner Jakubowski does not want any shots heard when riding bikes on the bike path with families. Mr. Krone stated that it will be almost impossible to hear noise past the property line. Chairman Eisterhold reminded the Commission that there is a certain amount of noise that is allowed in the M-B district.

Commissioner Goldfein questioned the number of shooting booths. Mr. Krone stated there will be eight booths in each. Chairman Eisterhold questioned if they had spoken to neighbors about the proposed business. Mr. Shore stated that he had gone to speak with the neighbors and introduced himself, sat down and addressed any questions they might have.

Mr. Krone added that they will not request any signage that is not allowed, and that signage with only the business' name and address will suffice. The hours of operation would also not be outrageous either. There may be up to twelve employees, they will not be there all at the same times. All the employees have adequate training. There will

always be a range master present and the petitioner will have very high tech security systems.

Commissioner Touras questioned sales tax revenue on the business. The Village would benefit from the sales of merchandise, not from renting the range. Mr. Clarke noted that Mr. Shore was open to charging some sort of amusement tax.

Mr. Michael Shapiro, owner of 6900 Central Park Avenue, expressed two concerns. First concern is about parking. The parking along the side of the building will remain, although, the proposed amendment for parking would require 70 spots and the property is not adequate for that amount of parking. Second concern is the noise. A wall is shared between the two businesses. Where the loading dock is located now is where the offices are located for Ravenswood Studio at 6900 Central Park Avenue. A barrier wall is in the plan; Mr. Shapiro questioned whether that wall runs the entire length of the wall. In the back of the building is where the heavy concrete slab is; Mr. Shapiro questioned whether that is where the person shooting would be standing toward the east by the loading dock. Mr. Krone responded that the wythe wall will go the entire length of the wall, and the trap where the bullet is received will be west, shooting from where the loading dock is.

Mr. Shapiro is concerned about the proximity of where the guns will be shot and the noise. Mr. Krone responded that not all sixteen booths are right there. The ranges are spread out. Mr. Shapiro questioned if there would be any recourse after the addition is built? Village Attorney Passman stated there is legal recourse about noise when it becomes a public or private nuisance. Any property owner has the right to right for a private nuisance action with a neighboring owner who is interfering with the use or enjoyment of their property. It is a right that a property owner may have to any neighboring property.

Commissioner Jakubowski stated that it sounds like there will be significantly less noise than before from the press pad business.

Mr. Krone stated there are two things that allow sound transmission to occur, a very thin mass or holes in the mass. This wall is a solid brick wall with a thickened mass that is enhancing the sound retention capability of the building.

Chairman Eisterhold noted that the petitioner did address all the standards in the application for the Special Use and the Variations, and they are accepted as provided.

Commissioner Yohanna made a motion to approve the Text Amendment to the Zoning Code to add "Firearms Dealers" as a Special Use in the MB district. Including the three criteria that Firearms Dealers in the MB Zoning District be abided by any firearms dealer must be a minimum of 800 feet from any property zoned Public Space/Park (P) or Residentially (R) zoned property, any firearms dealer must be a minimum of 800 feet from any other operating fire arms dealer in the Village, and firearms dealers are not permitted on any property with frontage on a State of Illinois highway. The parking standard. To approve the definition of a "Firearms Dealer" as any person licensed to deal

firearms pursuant to 18 U.S.C §923 (a)(3)(B), as may be amended, and excluding any person licensed as a collector pursuant to 18 U.S.C § 923 (b), as may be amended. Lastly, the recommended two spaces per shooting range station plus three spaces per 1,000 square feet of floor space not devoted to indoor shooting range. Also, the indoor shooting range be ancillary use to a firearms dealer, and the classroom space would be considered part of the retail space in the calculations. Seconded by Commissioner Jakubowski. Motion carries 5-1.

Commissioner Yohanna made a motion to approve the Special Use for a Firearms Dealer in the MB Zoning District and to relocate the "Firearms Dealer" to 6950 Central Park Avenue. Subject to the conditions set forth that a security plan must be submitted and approved by the Police Chief, Shore Galleries will close at current location at 3318 Devon Avenue, and will take the necessary steps for the double wythe walls to eliminate noise and will be well maintained. Will need to also submit a proposal of hours of operation to Staff for the Village Board. Commissioner Jakubowski seconded. Motion carries 5-1.

Commissioner Yohanna made a motion to approve the variations for the proposed additions to the building to align with the existing building location loading berth, which is located closer than the required 25 foot setback, a side yard setback variation, and the off-street parking variation conditioned upon the following; the petitioner will have to rebuild the 13 parking spaces on the public right-of-way in the front of the building, the curbs be re-built to Village standards, and the north side of the building will be rehabilitated. Commissioner Jakubowski seconded. Motion carries 5-1.

Chairman Eisterhold noted that this case is scheduled to be heard by the Village Board on July 17, 2012.

V. PUBLIC HEARING: Restaurant Parking – Zoning Code Text Amendment (Continued from May 2, 2012)
Request: Text Amendment to Modify the Minimum Off-Street Parking Requirements for Eating & Drinking Establishments

Commissioner Yohanna made a motion to continue this Public Hearing to a date certain of July 11, 2012 at 7:00 PM and seconded by Commissioner Sampen. Motion passes 6-0.

VI. PUBLIC COMMENT: None.

VII. ADOURNMENT:
Chairman Eisterhold will be present at the next Village Board meeting on behalf of the Plan Commission. The next Plan Commission meeting is scheduled for July 11, 2012 at 7:00 PM. Hearing no further business, Motion to adjourn made by Commissioner Yohanna. Seconded by Commissioner Goldfein. Motion approved unanimously 6-0. Meeting adjourned at 9:54 P.M.

Respectfully submitted,

Lauren Wolf
Community Development Department Coordinator

VILLAGE PRESIDENT
Gerald C. Turry

VILLAGE CLERK
Beryl Herman

VILLAGE MANAGER
Timothy C. Wiberg

TRUSTEES
Lawrence A. Elster
John Swanson
Thomas Heidtke
Nicholas Leftakes
Jesal B. Patel, Sr.
Renee Sprogis-Marohn

August 17, 2012

Scott L. Anderson, Board President
Lincolnwood School District 74
6950 N. East Prairie Road
Lincolnwood, IL 60712

RE: Supplemental Notice: Shore Galleries Meeting

Dear President Anderson:

This is a supplemental notice to clarify and advise that the Plan Commission meeting scheduled for August 22, 2012 at 7PM in Village Hall concerning Shore Galleries is not a public hearing as indicated to you in correspondence dated July 27th but rather it is a public meeting.

Specifically before the Plan Commission at this meeting is a request to amend the text of the Village Zoning Code to authorize Firearms Dealers as Special Uses in portions of the Village's MB (Light Manufacturing/Business) Zoning District, as well as a request for Special Use and certain variations for the subject property at 6950 Central Park Avenue. Shore Galleries request on these matters is on file with the Village and may be inspected in the Community Development Department.

The Plan Commission proceedings scheduled for the August 22, 2012 meeting are scheduled to be televised and may be attended by any interested person. The right to provide comment during the proceedings however will be at the discretion of the Chairman.

Should you have any questions regarding this matter, feel free to contact me at 847-745-4710.

Sincerely,

Timothy M. Clarke, AICP
Community Development Director
Cc: Plan Commission Members

VILLAGE PRESIDENT
Gerald C. Turry

VILLAGE CLERK
Beryl Herman

VILLAGE MANAGER
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July 27, 2012

Scott L. Anderson, Board President
Lincolnwood School District 74
6950 N. East Prairie Road
Lincolnwood, IL 60712

RE: Public Hearing: Shore Galleries

Dear President Anderson:

This is a courtesy notice to advise you of a continuing public hearing scheduled by the Village of Lincolnwood that may be of interest to your taxing district. This public hearing concerns the proposed relocation of Shore Galleries, a firearms dealer, currently located in the Village on Devon Avenue, to the proposed location of 6950 Central Park Avenue. In addition to relocation of this business, which has been in the Village since 1956, Shore Galleries proposes to add indoor shooting ranges to the proposed 6950 Central Park location.

This continuing public hearing is scheduled **for Wednesday August 22, 2012 at 7PM** before the Plan Commission. This meeting will be held in the Council Chambers room of Village Hall which is located at 6900 Lincoln Avenue.

Specifically before the Plan Commission is a request to amend the text of the Village Zoning Code to authorize Firearms Dealers as Special Uses in portions of the Village's MB (Light Manufacturing/Business) Zoning District, as well as a request for Special Use and certain variations for the subject property at 6950 Central Park Avenue. Shore Galleries request on these matters is on file with the Village and may be inspected in the Community Development Department.

At the August 22nd public hearing, oral comments or testimony may be made directly to the Plan Commission. Written comments are welcome in advance of the meeting by submitting such written comments to the Community Development Department no later than 5PM on August 17th. All written comments received will be forwarded to the Plan Commission for their consideration.

Should you have any questions regarding this matter, feel free to contact me at 847-745-4710.

Sincerely,

Timothy M. Clarke, AICP
Community Development Director

Cc: Plan Commission Members

VILLAGE PRESIDENT
Gerald C. Turry

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July 27, 2012

Kendra Beard, Board President
Lincolnwood Public Library District
4000 W Pratt Avenue
Lincolnwood, IL 60712

RE: Public Hearing: Shore Galleries

Dear President Beard:

This is a courtesy notice to advise you of a continuing public hearing scheduled by the Village of Lincolnwood that may be of interest to your taxing district. This public hearing concerns the proposed relocation of Shore Galleries, a firearms dealer, currently located in the Village on Devon Avenue, to the proposed location of 6950 Central Park Avenue. In addition to relocation of this business, which has been in the Village since 1956, Shore Galleries proposes to add indoor shooting ranges to the proposed 6950 Central Park location.

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At the August 22nd public hearing, oral comments or testimony may be made directly to the Plan Commission. Written comments are welcome in advance of the meeting by submitting

VILLAGE PRESIDENT
Gerald C. Turry

VILLAGE CLERK
Beryl Herman

VILLAGE MANAGER
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August 17, 2012

Kendra Beard, Board President
Lincolnwood Public Library District
4000 W. Pratt Avenue
Lincolnwood, IL 60712

RE: Supplemental Notice: Shore Galleries Meeting

Dear President Beard:

This is a supplemental notice to clarify and advise that the Plan Commission meeting scheduled for August 22, 2012 at 7PM in Village Hall concerning Shore Galleries is not a public hearing as indicated to you in correspondence dated July 27th but rather it is a public meeting.

Specifically before the Plan Commission at this meeting is a request to amend the text of the Village Zoning Code to authorize Firearms Dealers as Special Uses in portions of the Village's MB (Light Manufacturing/Business) Zoning District, as well as a request for Special Use and certain variations for the subject property at 6950 Central Park Avenue. Shore Galleries request on these matters is on file with the Village and may be inspected in the Community Development Department.

The Plan Commission proceedings scheduled for the August 22, 2012 meeting are scheduled to be televised and may be attended by any interested person. The right to provide comment during the proceedings however will be at the discretion of the Chairman.

Should you have any questions regarding this matter, feel free to contact me at 847-745-4710.

Sincerely,

Timothy M. Clarke, AICP
Community Development Director
Cc: Plan Commission Members

such written comments to the Community Development Department no later than 5PM on August 17th. All written comments received will be forwarded to the Plan Commission for their consideration.

Should you have any questions regarding this matter, feel free to contact me at 847-745-4710.

Sincerely,

Timothy M. Clarke, AICP
Community Development Director

Cc: Plan Commission Members

VILLAGE PRESIDENT
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Renee Sprogis-Marohn

July 25, 2012

Dear Property Owner:

Previously you received notice of a public hearing to consider an application made by Shore Galleries concerning a Zoning Code Text Amendment as well as a request for Special Use and variations concerning property located at 6950 Central Park Avenue. The purpose of these requests by Shore, is to allow Shore Galleries to relocate their Firearms business from their current location on Devon Avenue to the proposed 6950 Central Park property and to add to this proposed location shooting ranges.

This is a courtesy notice to advise you that the Village Board considered this matter and has remanded the matter back to the Plan Commission for further consideration. The Plan Commission will now reconsider this matter on Wednesday August 22, 2012 at 7PM. This meeting will be held in the Council Chambers room of Village Hall which is located at 6900 Lincoln Avenue.

At this August 22nd meeting, you may provide oral comments or testimony directly to the Plan Commission. You may also provide written comments in advance of the meeting by submitting such written comments to the Community Development Department no later than 5PM on August 17th. All written comments will be forwarded to the Plan Commission for their consideration.

Do know that Shore Galleries request is on file with the Village and may be inspected by you in the Community Development Department. Should you have any questions regarding this matter, you may call the Community Development Department at 847-673-7402.

Sincerely,

Lauren Wolf

Lauren Wolf
Development Coordinator

VILLAGE PRESIDENT
Gerald C. Turry

VILLAGE CLERK
Beryl Herman

VILLAGE MANAGER
Timothy C. Wiberg

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Jesal B. Patel, Sr.
Renee Sprogis-Marohn

July 25, 2012

Dear Property Owner:

Previously you received notice of a public hearing to consider an application made by Misericordia Home for Reasonable Accommodation to establish a Community Residence at property located at 6501 Longmeadow Avenue. This letter is intended as a courtesy notice to advise you that this matter is still before the Plan Commission and will be discussed by the Plan Commission at a meeting scheduled for Wednesday August 1, 2012 at 7 P.M. This meeting will be held in the Council Chambers room of Village Hall which is located at 6900 Lincoln Avenue.

Misericordia's request for Reasonable Accommodation is on file with the Village and may be inspected by you in the Community Development Department. Do know that once the Plan Commission has formulated its recommendation, this recommendation will be forwarded and considered by the Village Board whose decision is final on this matter.

Should you have any questions regarding this matter, you may call the Community Development Department at 847-673-7402.

Sincerely,

Lauren Wolf
Development Coordinator

TERRY G. HILLARD

Mayor Gerald Turry
Village of Lincolnwood
6900 N Lincoln Ave.
Lincolnwood, IL 60712

Dear Mayor Turry:

My name is Terry G. Hillard. I am writing this letter to express my support for the relocation of Shore Galleries and the construction of a State of the Art Law Enforcement and citizens Firearms Safety Training Center in Lincolnwood, Illinois

I have known Mitch Shore for over twenty years. I knew his father Sig when I was a young Patrolman working the streets for the Chicago Police Department. I became very close to Mitch Shore as I rose through the Command Staff of the Chicago Police Department, and have bought firearms from Shore Galleries after I became Superintendent. Shore Galleries is a trusted and major provider of police equipment to officers and agents from a broad variety of city, county, state and federal law enforcement agencies. Mitch is a highly regarded police and civilian firearms and firearms safety instructor and range master. I am highly confident that the relocation of Shore Galleries will be both a public safety and an economic benefit to Lincolnwood in general, and will be a very good thing for those who use Lincolnwood's proposed nearby bike path.

Mayor Turry, thank you for your time and consideration on this issue.

Sincerely,

Terry G. Hillard
Superintendent (Ret.)
Chicago Police Department

Gerald T. Brandt & Associates, Inc.
IL License 115-001389 / 119-000846
37710 N. Fairfield Rd. Lake Villa, IL 60046
847 644-8410 gbrandt123 @ aol.com
http://geraldtbrandtassociates.com

May 31, 2012

The Honorable Gerald Turry
Mayor of the Village of Lincolnwood
6900 North Lincoln Avenue
Lincolnwood, IL 60712

Dear Mayor Turry,

I have known and have done business with Mitchell Shore of Shore Galleries for over thirty years. I have found him to be honest and forthright in his business dealings and a good friend to the Law Enforcement community.

I support and wish him well regarding his new venture. I am sure you will find his business to be an asset to the community both financially and architecturally. As a former Police Commander I understand the value of training. Cost containment by Police Departments is a reality of the difficult economic environment we live in. By having a state of the art training center locally available will permit area Police Departments to train their Officers without incurring a major cost to their community. Paying a reasonable fee for range time could be more economically acceptable to communities than building out a training facility.

Having this facility in Lincolnwood will attract Law Enforcement Officers as well as citizens to Lincolnwood looking for professional training and a great retail outlet.

Respectfully,

Gerald T. Brandt
Commander (Retired)
Evanston Police Department

JEREMY D. MARGOLIS
Partner

321 North Clark Street
Suite 2300
Chicago, IL 60610

Direct 312.464 3167
Main 312 464 3100
Fax 312 277-8957
jmargolis@loeb.com

June 1, 2012

Gerald Turry
Mayor
Village of Lincolnwood
6900 North Lincoln Avenue
Lincolnwood, IL 60712

Re: Shore Galleries

Dear Mayor Turry:

I am a long time Lincolnwood resident. I write on behalf of Shore Galleries' efforts to establish an enhanced and expanded retail operation and a state of the art law enforcement training center in Lincolnwood's industrial corridor.

My dealings with and knowledge of this Village of Lincolnwood icon and the two generations of responsible Lincolnwood corporate citizens who have owned and operated it is both personal and professional. From 1973 to 1984 I served as an Assistant United States Attorney. From 1984 through 1991 I served as Illinois Inspector General and Director of State Police. During those years, I met and grew to deeply respect founders Sig and Charlene Shore and their son Mitch, a police officer and also now owner. I was and I am a customer. The Illinois State Police that I proudly served was and is a customer. I became dear personal friends with Sig (of blessed memory), Charlene (who I hug as my first priority whenever I visit the store) and Mitch.

Because of Mitch's credibility as a working police officer and because of his extraordinary ability and dedication of a police firearms and tactics instructor, Shore Galleries holds a unique place in Illinois law enforcement. Shore's record of honesty, reliability and professionalism has earned it the loyalty and respect of both the leaders and the street officers of our Lincolnwood PD, Chicago PD, the Illinois State Police, the Cook County Sheriff's Police, the FBI, the U.S. Secret Service, the Drug Enforcement Administration and a host of other federal agencies and innumerable local police departments.

The expansion of this Lincolnwood business will add tax dollars to our village, and it will continue to bring trained law enforcement personnel (both on and off duty) to our community.

Respectfully submitted,

Jeremy D. Margolis

RECEIVED
AUG - 6 2012
LINCOLNWOOD
COMMUNITY DEVELOPMENT

RECEIVED
AUG 2012
LINCOLNWOOD
COMMUNITY DEVELOPMENT

August 3, 2012

Village of Lincolnwood
Plan Commission
6900 North Lincoln Avenue
Lincolnwood, Illinois 60712

Dear Village Officials:

As a veteran law enforcement officer in the State of Illinois (38+ years) I am writing to express my support for Shore Galleries' expansion in your jurisdiction.

I have known Mitch Shore for more than 20 years, during which time I have come to appreciate that he conducts his business with the utmost integrity, scrupulously adhering to state and federal laws that regulate the buying, selling, and transferring of firearms.

Know that I wholeheartedly support Mr. Shore's business plan and proposed expansion. I believe his impeccable business record at his current location speaks for itself, and I am confident he will manage the expanded business in exactly the same way.

Thank you for taking the time to review this letter.

Sincerely,

Richard Eddington
807 Davis Street
Evanston, Illinois 60201

kmt

RECEIVED
AUG - 8 2012
LINCOLNWOOD
COMMUNITY DEVELOPMENT

August 7, 2012

Village of Lincolnwood
Planning Commission
6900 North Lincoln Avenue
Lincolnwood, Illinois 60712

Dear Village Planning Board:

I have been a law enforcement officer for the past 24 years in the State of Illinois. I am writing this letter to support the proposed expansion of Shore Galleries in your Village.

I have known the owner of Shore Galleries, Mitch Shore for the past 20 years. Not only do I know him personally but I have known him professionally as well. My agency has done business with Shore Galleries for many, many years. I commend the way Shore Galleries does business with its customers. Mitch is an honest business owner who is very serious about the way he conducts business. The business of selling firearms is heavily regulated by federal and state laws and Shore Galleries keeps scrupulous records of all sales and transactions.

I support Mitch and his proposed business plan. I believe that if his expansion is allowed he will continue to run his business impeccably as he currently does.

Sincerely,

Claude M. Casaletto
350 Walnut Ave.
Northfield, IL. 60093

I apologize for my questions coming so late...I struggled with identifying my concerns and separating them from my personal opinions with regard to guns. Nonetheless, I sincerely hope that these concerns have already been identified by others who are empowered to make these significant decisions on behalf of our community and, if not, will at least be considered in your decision-making process.

I feel very strongly that government endorsement of such a project sends the wrong message to our 'world'. We have always been a family community and the thought of us being the town that wants what no one else does is not something that sits well with me. What has changed since the last decision was made that would cause you to change your position with regard to safety? (Please refer to the attached .pdfs of reporting from the last go-round to refresh your memory.) Just because this business existed before is no reason to give them special consideration. I feel this decision should be approached no differently than a new business. Is this what we want for Lincolnwood?

Setting aside my foregoing statement of personal opinion, I have the following questions/concerns with regard to any such location:

Will there be adequate sound barriers that will buffer all sound from the surrounding vicinity? Or will we allow basic compliance as required of surrounding industry?

What type of systems will be put in place to eliminate all lead emissions into the air? What type of monitoring will be done? By who and how frequently?

How will lead waste be disposed? What type of system will be put in place to eliminate flow into our sewers? What type of monitoring will be done? By who and how frequently?

A few other general questions I have are:

Shore is listed as a part owner of the LLC; what percentage does he own and who are the other owners?

A discrepancy exists between the estimated tax revenue reported in the Chicago Tribune when compared to the Village Board packet posted on the website. Please explain this discrepancy.

Because of my busy work schedule right now and the short time frame in which this has all transpired, I haven't done very much homework on other aspects of this. However, at this point, my biggest complaint is the lack of communication and transparency with regard to the most recent issues raised in our community. We are a small community and I feel as if the voice of the community is not being heard, nor is their opinion even being sought. I feel the minimum is being done in this regard.

Then, there is the question of why now, why in this way - on issues that were visited not that long ago. Add to that the fact that other communities do not want this. It all causes me to say that we need to slow down, look at things more carefully and be sure that this is in the best interests of all in our community. This has nothing to do with my personal opposition to certain type of guns that have no use in private hands, but deals more with the quality of life issues and perception our community takes on when opening its doors to a business no one else wants. I do feel that people in our community do need to know what is going on around them and should be given the opportunity, if desired, to have their voices, questions and concerns heard.

Jean Moy

July 30, 2012

To Village Trustees and Members of the Plan Commission,

For just a moment, I hoped that recent gun massacre in Colorado would mean the end to the proposed gun megaplex and I wouldn't need to write this letter or agonize further over this latest threat to my community. I wish the trustees voted this down at their last meeting. I respect their decision to return this to the Plan Commission because of the long standing business that Shore has had, and in response to pro-gun opinions voiced at that meeting. The Plan Commission, however, clearly failed in their responsibility to thoroughly and carefully vet the proposal and address all of the various concerns, yet rushed to recommend this controversial plan. Why?

Regarding the proposed gun megaplex site being 'in the middle of nowhere' – I take exception! That middle of nowhere is right down the street from my home of 20 + years, where I live, work, play, go to school, shop, drink coffee, walk and drive. Take a look around that middle of nowhere, and you will see progress and improvements to an area that once was a desolate, unsafe area. Thanks to the EDC, the TIF, current businesses, Beautification and Sculpture Committees, and the Parks and Recreation Department, the area has already undergone significant improvements and I hope will continue to be an area of appropriate development. "Guns R Us" is not appropriate for this site or this community. I found it surprising that Mayor Turry quickly brought up the 'notorious' connotations of historic Tessville as a negative, yet supports the idea of Lincolnwood being home to this gun megaplex. History repeats itself – alcohol wasn't allowed in Chicago, so they came here. Gun megaplexes are not allowed in Skokie or Chicago, so they want to come here. I'd rather have a drink than a gun, and I sure don't want to be grabbing a coffee or loading up my groceries at Dominicks near vehicles and people with guns and ammunition just purchased down the block. Chicago and Skokie 'would never consider' such a proposal, and the state of Illinois outlaws its location on its state roads, yet we are willing to drastically change our longstanding codes and ordinances to accommodate GUNS?

The only member of the Plan Commission to stand against the proposal and to consider the bike path was Commissioner Goldfien; I appreciate her consideration and support. Her background on Sculpture and Beautification gave her the knowledge of the strategic plan for the area. I was embarrassed for the Parks and Recreation Board when our absence and lack of input was questioned. (June Plan mtg) Does the plan commission have a mission statement or strategic plan as a basis for its work? I would be interested to learn more, but couldn't find it on the web page.

The Plan Commission and village staff are quick to defend their "'processes" as the correct policy and procedures that ensure fairness to residents. ***Here are my concerns:***

- The Park Board never received proper notification (before our open public hearing about the bike paths June) of the proposed gun megaplex, which was located well within 250 feet of our Bike Path (Bikeway Plan 2006). We would not expect to halt a legitimate proposal, but we deserve to participate in the process, mitigate our positions and concerns, and help make sound proposals work in the best interests of everyone.
- Incomplete, inaccurate and biased maps and charts from staff failed to provide ALL the necessary information. (Ex. Bike path NOT on maps and charts presented at Plan Mtg June; worse, they were not updated for the Village Board meeting in July, despite the request of the Park Board. (Director Hincapie did give her prompt attention to the Park Board's stated concern (PKBD July) about the proposal's impact on our grants for the Bike Path. (State law prohibits this type of establishment on state roads.) Her inquiries and report to the Park Board was responsive in a timely fashion and fortunately, indicated no threat to our grants at this time from this proposal.)
- Notifying everyone within 250 feet of the proposal may be compliant with the law, but is in effect, inadequate and unfair to the community, since the vast majority of people affected, in a potentially negative way, are outside the 250 ft perimeter. Everyone that is LOSING the ½ mile zone of gun free protection should have been fully informed of this significant change to their village and safety.

- It is unfair to keep saying business neighbors of the proposed gun megaplex should expect noise because they are zoned a 'light manufacturing district'. Well, that's what they have been doing – quietly, successfully, and in that 'upscale, niche fashion' that Lincolnwood so aspires to – for quite some time now. The new gun megaplex is not 'manufacturing' anything - but trouble!
- Every time you extoll the virtues of Mr. Shore and his business as such as wonderful business resident, you demean every business and home owners who have been just as much model citizens and taxpayers and have remained in compliance with all of our village ordinances. We could fill the room with Lincolnwood residents and business owners who have struggled with the village over INCHES in their nonconforming proposals for their business or homes, and who received no special consideration to such extent that this petitioner got from the Plan Commission. Why? Standards for parking may in fact need revisiting, but the current requirements are still binding precedent in law and should be fairly enforced.
- Clear, specific standards for any unusual use should be identified and stringently required, commensurate with the gravity of the proposal (noise, pollution, construction requirements, safety, operations, ownership, parking etc.). Don't refer the parking problem back to the EDC – refer it back to Shore's architects! Maybe some of those gun lanes will have to be parking – in fact, maybe garage parking is part of a solution! Straightforward, clear and responsive answers must be required of the petitioner and staff. This proposal was originally presented as a 'discreet move' of an 'existing individual business' when in fact that has been proven to be far from the truth. The proposed business is a corporation looking for a large variety of concessions from our community in order to allow a public gun megaplex with a large retail space and a 16 lane gun range – a dubious, controversial proposal at best that was inadequately researched and studied by staff and the Plan Commission.
- Similar concerns about the Plan Commission process are being raised in regards to the group home/Misercordia/zoning change issue.

At the July Village Board meeting, the petitioner was allowed to turn what should have been a community meeting and important village-wide discussion to become a forum for political gun advocates and the NRA. The petitioner purposely rallied supporters on Facebook and filled our Meeting Chambers, so that residents, respected village elders, members of various village commissions and boards, and residents with agenda items could not even enter the room, no less sit and actively participate in the meeting. Mr. Shore then told the board that he *does not advertise*. No matter how desperate Lincolnwood's economic situation may be, we do NOT need to bring such a controversial issue to our village, especially in light of the current violent climate here in Chicagoland and nationwide.

Personally, it was a frightening experience to attend that meeting; thank goodness they were only waving their cards, not their weapons. What's next, metal and weapon detectors at village meetings? Thank you for your consideration; please *just say no!* to guns in Lincolnwood.

Judith Snyder
7267 N. East Prairie Road
Lincolnwood, IL 60712
847-910-5537
2jude13@gmail.com

chicagotribune.com

Des Plaines gun shop, firing range gets OK for move, expansion

Move will more than triple business' space

By Jon Davis, Special to the Tribune

July 19, 2012

A Des Plaines gun store and indoor firing range has won unanimous approval for its plan to relocate and expand in the city.

Aldermen voted 7-0 Monday to approve a conditional-use permit allowing Maxon Shooter Supply and Indoor Range, of 1226 Rand Road, to relocate to 75 Bradrock Drive, in an industrial/manufacturing zone. Aldermen also agreed to grant preliminary and final approval on the same night rather than wait to take the final vote at the next City Council meeting in three weeks.

Their votes clear the way for Maxon to expand from its current 4,000-square-foot space to 14,670 square feet — enough to accommodate two 75-by-30-foot shooting ranges, 2,340 square feet of retail space, two classrooms, storage space and a gunsmith shop.

Maxon owner Barry Levin said he plans to open the new store and range in February.

"There's a complete build-out. It's going to be a building within a building … for the ranges. There's a lot of work to be done," said Levin, a master gunsmith and firearms instructor.

No one spoke out against the gun range plan.

City planners supported the Maxon move, although they required Levin to improve the parking lot, add sidewalks and landscaping, submit a security plan and ensure that police and fire radios will work properly inside the building.

"This is a business that has been in town for years and years and years," Ald. Mark Walsten said. "I'd just like to see them get open and bring in tax money and serve their customers."

Marc Albertario, of Prospect Heights, said he represented the National Rifle Association, which he said strongly supported the gun range proposal.

Ald. James Brookman told Albertario: "You don't have a hostile council here."

The Bradrock Drive site was Levin's second choice for a new location. In September, the store planned to lease space at 461 N. Third Ave., but that deal fell through. Levin said that prompted him to buy the Bradrock Drive building rather than seek another rental deal.

Levin said firearms dealers should have indoor ranges as a matter of safety training.

"If people are going to sell guns, it should be mandatory that they should have a range so they can train people in the safety of firing these guns," he said. "It's like buying an airplane without knowing how to fly. It's asking for a world of troubles."

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Proposal For Bus Shelter Relocation Pushed To August

Delay Will Serve As 'Cool Off Period'

By TODD WESSELL
Journal & Topics Editor

Following lengthy discus-on Monday night on a pro-sal to relocate a downtown es Plaines bus shelter closer a condominium complex, al-rmen opted to wait until Aug. to revisit e issue.

MayorMar- Moylan, ho urged e delay, id yester-y (Tuesday) at it will serve as a "cooling period" to allow aldermen ne to consider public opinion at was expressed Monday ght and at a public meeting o weeks ago.

City council members are nsidering moving a Pace s shelter from the north side Miner Street between Lee d Pearson streets, about a ock and a half to the east at arson and Miner. Proponents el the relocation is necessary open up six parking spots ng Miner and to improve e appearance and use of lewalk area.

Many, primarily condo-nium residents near Pearson d Miner, are upset that the ocation of the shelter will harm their quality of life with the staging of noisy, smoke-belching buses at the corner.

At Monday night's meeting, several concerns and questions raised two weeks ago were addressed by City Engineer Tim Oakley and city-hired consultants. Their reports said that a proposal to move the shelter to the south side of Miner next to the Metra station was impractical and that noise and emission effects with the move to Pearson and Miner would be minimal. Oakley said the city staff's recommendation to move the shelter to Miner and Pearson remains.

"A lot of valid points were made tonight. We're listening to you," Ald. Dick Sayad (4th) said.

Numerous residents told aldermen of their strong opposition to the proposed move saying it will greatly harm their quality of life. Irene Rozansky, president of the River Point Condominium Assn., suggested moving the shelter to the center area of Metropolitan Square. She also asked that a 30-day continuance be ordered by aldermen in order to reevaluate the entire matter.

"A lot of valid points were made tonight," said Ald. Dick Sayad (4th), who added that as chairman he will soon call a meeting of the city's engineering committee to discuss the issue. "We're listening to you," said Sayad.

Shooting Range Cleared To Move

A Des Plaines shooting range will move forward with plans to expand at a new location in the city.

Maxon Shooters Supply was given approval by the city Monday night to relocate from their building at 1226 Rand Rd. to a new store at 75 Bradrock Dr. near Oakton Street and Mt. Prospect Road.

Hours of operation will run from Tuesday through Friday between 10 a.m. and 9 p.m. and 9 a.m. to 5 p.m. on weekends. The store will also be open from 6 to 10 p.m. on some Mondays for special events.

The plan calls for two 75-foot by 30-foot shooting ranges with nine positions each, a 2,340 sq. ft. sales area, two classrooms, and areas for storage and gun smithing.

The one-story building will be 14,670 sq. ft., larger than Maxon's existing 4,000 sq. ft. location.

The city council approved a Conditional Use permit for the store Monday, allowing them to begin the move.

The city previously approved a conditional use permit for Maxon to move to 461 N. Third Ave., but they chose not to proceed with that location.

Rivers Celebrates First Anniversary In Des Plaines

Special promotions and events are being held at Rivers Casino, 3000 S. River Rd., yesterday and today (July 17 and 18) in celebration of its one-year anniversary.

The casino is the latest destination to be opened in the state and features nearly 1,050 slots and 50 table games.

On Tuesday, the casino hosted both The Drive (97.1 FM) from 12 to 2 p.m. and The Mix (101.9) from 5 to 7 p.m. Stations broadcasted live at the casino and callers took part in live appearances and won special prizes and tickets.

All guests entering the casino before 10 a.m. today (Wednesday) are guaranteed a gift. The first 100 guests will receive special anniversary prizes.

Later today, two invite-only performances by Jim Belushi and the Sacred Hearts will be hosted for VIP guests.

The celebration will continue for the rest of the month with the $1 million One Year Anniversary Wall of Cash giveaway every Sunday and Wednesday in July.

Each finalist and five wild card winners will be invited to participate in the Grand Finale at 9 p.m. on Sunday, July 29 in the Cube, where each is guaranteed $1,000 and someone is guaranteed $100,000.

Call 847-299-5511 to subscribe to the Journal!

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CHARCOAL DELIGHTS
1090 E. Oakton St. Des Plaines
FEATURED MENU SPECIALS
CHARCOAL BROILED CHICKEN SANDWICH

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Zoning panel recommends gun shop move

Lincolnwood Review (IL) - Thursday, June 12, 1997

Author: *MIKE ISAACS, STAFF WRITER*

The Lincolnwood Zoning Board of Appeals unanimously has recommended a longtime village gun store be allowed to relocate to a larger building close to Springfield Park.

Shore Galleries Inc., 3318 Devon Ave., a 41-year Lincolnwood business, has already bought a larger building at 3910 Devon Ave. next to Myron and Phil's Restaurant. But in order to sell firearms and ammunition from that location, the owner needs a special use permit for retail because the area is zoned for manufacturing.

The Village Board is scheduled to vote on the recommendation at next Thursday's regular meeting.

But there are two additional obstacles beyond the special use permit that stand in the gun shop owner's way.

The new building is located in one of three of the village's designated "protected areas." Special use permits are not allowed in such areas.

Another problem is an ordinance on the books that prohibits the Lincolnwood police chief from issuing a firearms dealer's license to any business within a half-mile from the grounds of a school or a public park.

The back of the new building sits directly across from Springfield Park.

The current location of Shore Galleries is within a half-mile of Channel Runne Park, but the ordinance makes an allowance for that. It states the business owner is exempt if he was "operating the business on Sept. 1, 1994 at this location."

But because Shore Galleries would no longer be "at this location" after its move, and because it would be well within a half-mile of Springfield Park, the ordinance would have to be changed, officials said.

Additional space

Shore Galleries currently occupies 12,000 square feet. In its new building, it would occupy 19,500 square feet.

Lawyer Jeremy Margolis, representing owner Mitchell Shore, said the move is being made for additional office, training and warehouse space.

"We're simply asking to move down the street a half-mile because we've outgrown a 41-year-old building," he said. "We're not moving because the business is mushrooming or exploding. I'm really not sure what all the fuss is about."

But some residents at last week's zoning board hearing raised concerns that Shore wants to use some of the space for a shooting range. Margolis said the owner has no such plans at this time.

Another concern for some residents is the property's proximity to a park that has children playing on playground equipment. The business sells 85 percent of its products to police departments, but it is the other 15 percent that apparently bothers some residents.

Zoning Board Chairman Zave Gussin said that while that concern is understandable, there has never been any evidence of trouble due to the store's civilian customers.

"If this hidden 15 percent tended to be troublemakers or place the community in jeopardy, then we would have known about that," he said. "But most of these people are professionals, and there has not been a complaint or an incident concerning them in 41 years in Lincolnwood."

Gussin said the current building is located closer to residents than the new building and that gun shop customers have been parking on neighborhood streets for years now. The new building will have parking, he said.

Margolis also questioned the difference between having the Lincolnwood Police Department located next to Proesel Park and Shore Galleries next to Springfield Park.

"We primarily service police departments and the other 15 percent are mostly residents of Lincolnwood - lawyers and doctors and other professional people. I'm one of those 15 percent."

Recommended

The zoning board not only recommended the special use permit for Shore Galleries but also a change in the boundaries of the protected area to get around that problem.

The protected area presently includes Lincoln Avenue on the north, Devon Avenue on the south, Proesel Avenue on the west and railroad tracks on the east.

Under the recommended change, the area would no longer extend to Devon but to Schreiber Avenue leaving Shore Galleries just to the south of the boundaries.

Gussin said the Lincolnwood ordinance concerning the sale of firearms near a park is not a zoning matter and did not figure into the board's recommendation.

"The Village Board felt it was appropriate and fair to grant a grandfather exclusion to Shore Galleries at one time because it was within one-half mile of Channel Runne Park," Gussin said.

"The owner's objective will have to be to convince the board that he is entitled to the same kind of exemption because he is at a similar location in that he would be near a park again."

If village trustees are convinced about changing that ordinance, a further complication emerges. Lincolnwood does not have home rule powers and it is unclear whether the board has the authority to make such a change to the ordinance, officials said.

Not pleased

Not everyone was pleased with the zoning board's recommendation including Village Administrator Robert Bocwinski.

"Their decision was quite a surprise to me," Bocwinski said.

Bocwinski said his objections to the recommendation have nothing to do with the applicant but with the process. He is concerned about allowing a retail business into a protected zone in the village.

"If (the zoning board) is to recommend that the boundaries of the protected zone are to change, then I think it's appropriate that there be a public hearing on that issue," he said. "There wasn't one and that concerns me."

Gussin said this objection was never raised at the meeting but that he believes the public hearing regarding the special use application itself was adequate.

Like some residents, Bocwinski said he believes the owner will eventually want some of the additional space for a shooting range.

"It is just my opinion but I'm convinced the same applicant will come back and the next thing on the agenda will be a request for a shooting range there," he said.

If the owner wants a range, he would have to go through the same process all over again and receive final approval from the village board, Gussin said.

Bocwinski said the owner should not have bought the building until he knew he would be allowed to sell his product there.

But Gussin called that concern "a non-issue."

"That has no effect on the board unless the owner makes a case on the grounds of hardship and appeals to the board for sympathy," Gussin said. "But that was not the case. It was a risk the owner has taken and I do not know why he did that but it doesn't affect us one way or the other."

Margolis said there were other people competing for the building and time was a factor.

"In buying the building, there was never any attempt to put any pressure on the board," he said.

If trustees turn down the application, Shore will have to lease or sell the building, Margolis said.

Bocwinski also wanted the recommendation to include a mandate that a sprinkler system be installed in the building but the board decided that was not a matter for the zoning board.

"My intention is not to criticize the zoning board of appeals as a body," Bocwinski said.

"But I do feel too much weight was given to the fact that this is a longtime existing business in town and not enough attention was paid to the land use issues."

Residents

Several residents appeared at the hearing to raise concerns over safety issues.

"If there's a law on the books about selling firearms near a park, they should abide by the law," said Eugene Mitofsky. "There are many reasons why selling firearms should not take place near a park."

Mitofsky said kids playing in the park who know about the business could question whether parked cars in the area have firearms inside.

"This isn't about gun control," he said. "It's one thing to sell it and another to openly sell it in the sight of kids. If kids see people coming in and out, it gives them the impression that everyone is carrying guns. That's not good."

But Gussin and Margolis said there has never been any safety complaint about the business in 41 years and that people coming in and out of the store are not likely to have contact with kids in the park.

"Their concern is legitimate and understandable and we looked at it very seriously," Gussin said. "But I think we reached a proper conclusion based on the real evidence that is out there." Copyright ©1997 Lincolnwood Review

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Gun shop relocation shot down

Lincolnwood Review (IL) - Thursday, June 26, 1997

Author: *BY KATHY ROUTLIFFE, STAFF WRITER*

Longtime gun shop owners Mitchell Shore and his mother Charlene Shore are good business residents of Lincolnwood, village trustees agreed last week.

But the Shores still won't be able to move Shore Galleries Inc. from its current 3318 Devon Ave. location to the 19,000-square-foot building they purchased at 3910 Devon Ave.

After a long and occasionally heated night of testimony from almost two dozen residents and interested spectators, trustees unanimously agreed to turn down a request by Shore Galleries for a special use permit to move into the building, next to Myron and Phil's Restaurant.

That request had been endorsed June 4 by the Lincolnwood Plan Commission.

The commission decision came even though the proposed location is in an industrial zone and within a "protected zone" in which special use permits are prohibited. The reason, commission members said at the time, was because the use of the building was a reasonable one and would relieve parking problems at Shore Galleries' current location.

Trustees also unanimously turned down a motion to amend their existing gun shop and assault weapons ordinance, which would have allowed Shore Galleries - now grandfathered at its current location under gun shop regulations - to make the move.

In doing so, they agreed with opponents of the gun shop move, many of them residents who coalesced under the banner of Citizens for a Safer Lincolnwood.

That group mounted a vigorous public relations campaign against the Shore Galleries request in the days prior to last Thursday's meeting, including a rally June 18.

Opponents said putting the shop directly across from Springfield Park would expose children not only to guns and the people who buy them, but desensitize them to a major source of modern violence.

"This is not really about whether we think guns are good or bad," resident Jane Klein told trustees. "It's about the appropriateness of putting a store across from one of our highly used parks."

"Kids see people coming in and out of gun shops and they will inevitably get the idea that everyone deals with guns. That's not a message we want to send them. After all, Lincolnwood schools don't even allow toy guns in school because they send the wrong message."

They reminded village board members time after time that the village in 1994 passed ordinances preventing gun shops from within a half-mile of schools or parks and that the back of the new building is directly across from Springfield Park.

The only reason Shore Galleries can even operate where it is now - within a half-mile of Channel Runne park - is because it predates the park and the ordinance.

Jeremy Margolis, the Shore's attorney, gave an impassioned speech to trustees at the outset of Thursday's debate, asking them for approval.

Margolis, a former head of the Illinois State Police and a customer of the store, said the Shore's business has operated

safely and without incident in Lincolnwood for 41 years and 85 percent of current customers are law enforcement officers.

The new building would not only give a cramped business room to breathe rather than room to expand, he said, but it would be even more secure from the public than it is now, with off-street parking the current location lacks and an enclosed loading dock. The customer entrance would be at least 200 feet from Springfield Park, he said.

There were and are no plans for a gun range he said, "no secret plans to explode the business into some huge size.

"I am second to none in backing safety for children," he said, detailing the safety programs and legislation he backed while head of the State Police. "But I think the kids in this room and this village have heard more about guns, seen more pictures about guns and had more ideas on guns in the past two days than kids in Lincolnwood have heard about from Shore Galleries in the past 41 years."

He admitted the Shores bought their new building before getting zoning approval. That wasn't part of a plan to railroad the village board, he said, merely a necessity sparked by a firm buyer.

The board's two-part rejection "saddened and disappointed" him and his clients, he said.

"I respect the board's right to vote as they did. I also respect the rights of everyone who held and gave their opinion tonight. That's the American way," he said after the meeting.

"But there was a great deal of misinformation provided here, a great deal of emotion, a lot of which was stirred up by people from outside the community."

Margolis referred to representatives with the Illinois Council Against Handgun Violence, Illinois Democratic House Rep. Janice Schakowsky, and others who spoke against the proposed move.

One of them, former Chicago Police Officer Michael A. Robbins, referred to his own history of being shot on duty. He pleaded with Lincolnwood officials to uphold their zoning regulations without change and suggested, even after Margolis' speech, that Shore Galleries eventually plans to become even larger.

Margolis later repeated his contention that the store will not expand it's businesses and said "I don't know where these reports come from, and I would like to know where your information originates."

Parent Andrea Smolsky disputed Margolis' suggestion of overly-emotional reactions, saying "This isn't merely hysterical housewives afraid of guns. Please uphold our ordinances. Regardless of the 85 percent of customers who are law enforcement officers, anyone can walk into Shore Galleries. We don't know how the 15 percent are going to be."

Shore Galleries did have supporters among the capacity audience last Thursday. Police Officer Walter Klinger said "as a homeowner and a taxpayer who also utilizes the parks I am 100 percent in favor of this plan. As a veteran police officer I can see no adverse impact on the neighborhood."

Klinger and Lincolnwood resident Seymour Abrams also championed the request because to deny it, they said, would send the wrong message to businesses which the village is trying to coax inside its borders.

"People fight change," Abrams said. "If people tried to put a religious institution (in the building at 3910 Devon Ave.) I guarantee some of the people here would be against it."

Even before audience members got their chance to testify, village trustees had to decide whether the zoning request should be sent back to the Plan Commission. Commission Chairman Zave Gussin said that might be necessary, on the advice of Village Attorney Joan Cherry, because of language technicalities. Trustees ultimately decided against taking that route.

At least one trustee, Robert Abelson, voted to turn down both requests, but admitted much of the opposition to Shore Galleries' request "including, perhaps my own" was emotionally based.

Mitchell and Charlene Shore refused to comment about any future moves, including the fate of their newly-acquired building. Margolis said "we have a lot of options. It could be rented, leased, sold, used as warehouse. We have to talk about it." Copyright ©1997 Lincolnwood Review

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Staff Report
Plan Commission
June 6, 2012

Subject Property:
6950 Central Park Avenue

Zoning District: M-B Light Manufacturing/Business District

Petitioner: Shore Galleries, Tenant & Platform I, LLC. - Property Owner

Nature of Request: The petitioner seeks text amendments, special use approval and variations to permit the relocation of "Firearms Dealer" to the subject property.



Requested Action:

1) **Zoning Code Text Amendments to Add:**
   A) "Firearms Dealer" as a Special Use in the MB District (Section 4.05 Table 4.01.1)
   B) Definition of "Firearms Dealer" (Section 2.02)
   C) Off-Street Parking Requirements for "Firearms Dealer" (Section 7.10 Table 7.10.01)
2) **Special Use** approval for a "Firearms Dealer" as per Amended Section 4.05 Table 4.01.1;
3) **Variations to Permit:**
   A) An Addition to Encroach into the Required Front & Side Yard Setback (Section 4.14)
   B) A "Firearms Dealer" to operate with fewer than the required Minimum Off-Street Parking Spaces (Section 7.10/Table 7.10.01)

Notification: Consistent with Village requirements, notice of this scheduled public hearing was made in the Lincolnwood Review dated May 17, 2012, by Public Hearing Sign Installed at 6950 Central Park Avenue, and by regular US Mail to Properties within 250 Feet of the subject property.

Summary of Request

Shore Galleries, a firearms dealer currently located in the Village at 3318 West Devon Avenue, seeks approval of: 1) Zoning Code Text Amendment; 2) Special Use; and, 3) Certain Variations in order to permit the firearms dealer to relocate to the existing building at 6950 Central Park Avenue.

In addition to these zoning matters identified above, in order for Shore Galleries to relocate, an amendment to the Municipal Code is also required. Currently the Municipal Code prevents any firearms dealer to be located within a ½ mile of any school or public park, unless that

firearms business was operating at their licensed location on September 1, 1994. Since there is no property in the Village that is not farther than a ½ mile from a public park or school, this current Municipal Code restriction prevents any Firearms Dealer to locate in the Village, except Shore and only then at their current grandfathered Devon Avenue location.

Earlier this year, Shore approached the Village Board to ascertain whether support existed for the needed changes to the Municipal Code and Zoning Code to allow for relocation of their business within the Village. Acknowledging that Shore has been a longtime business in the Village (since the 1950's) Village Board members indicated support for necessary changes that would allow for the relocation of Shore, yet continue to highly restrict the location and number of firearms dealer locations in the Village.

Currently the Zoning Code does not authorize firearms dealers in the Village. The action before the Plan Commission is a request for a text amendment to the Zoning Code that would authorize Firearms Dealers as a Special Use. The subsequent related request is to obtain special use approval for a firearms dealer at 6950 Central Park and also certain variations in order to operate at this location.

The subject property has been the site of Resillo Press Pad Co. for many years. Based on Village records, the building was constructed in 1956. There was a permit issued in 1966 for a rear addition which extended the building to the rear lot line.

Text Amendments - Currently, the Zoning Code does not include "Firearms Dealer" or any similar land use as a permitted or special use in any district within the Village. Shore Galleries in its current location is considered to be a legal existing non-conforming use as it has existed at this location since 1956. In order to relocate their business, Shore Galleries seeks to add as a Special Use "Firearms Dealer" to Section 4.05/Table 4.01.1 "Permitted and Special Uses in All Districts".

Consistent with direction given by the Village Board to provide for Shore Galleries relocation, but to otherwise highly restrict Firearms Dealer Uses in the Village, staff recommends the following additional text amendment criteria in establishing Firearms Dealers as a Special Use in the MB Zoning District:

1) Any Firearms Dealer must be a minimum of 800 feet from any property zoned Public Space/Park (P) or Residentially (R) zoned property;
2) Any Firearms Dealer must be a minimum of 800 feet from any other operating firearms dealer in the Village;
3) Firearms Dealers are not permitted on any property with frontage on a State of Illinois highway.

Several companion text amendments are also necessary to fully regulate this "new" land use in the Zoning Code. The first of the companion requests is to add the definition of the new use. The Village's Municipal Code contains a definition of "Firearms Dealer" and for consistency purposes, staff recommends that the definition for Firearms Dealer found in the Municipal Code be duplicated for the Zoning Code. The definition in the Municipal Code is:

> **Firearms Dealer** - Any person licensed to deal firearms pursuant to 18 U.S.C. § 923(a)(3)(B), as may be amended, and excluding any person licensed as a collector pursuant to 18 U.S.C. § 923(b), as may be amended.

The final text amendment for consideration is establishing the appropriate minimum off-street parking requirement for Firearms Dealer uses. New land uses can be subject to parking standards that are already incorporated into Zoning Code Section 7.10/Table 7.10.01 if the uses are similar. The Plan Commission may consider "Firearms Dealer" as a retail use (3.3 spaces per 1,000SF) however such a standard may result in a much higher parking requirement than such a use would need.

Staff researched surrounding communities to determine the adopted parking requirements for "Firearms Dealer" and/or similar uses. Few communities in the area have established parking requirements specific to "Firearms Dealer". Below is a list of communities that do include parking standards for "Firearms Dealer" and "Indoor Shooting Range" (from APA Parking Standards & Village Staff Research):

Firearms Dealer Off-Street Parking Minimum

- 1 per 300 S.F. of GFA in floor area greater than 4000 SF. (Minneapolis MN)
- 4 per 1000 SF of GFA (Hickory NC)

Indoor Shooting Range Off-Street Parking Minimum

- 1 per firing lane, plus 1 per employee on maximum shift (Las Cruces, NM)
- 1 per 200 SF of GFA (Fort Lauderdale, FL)
- 2 spaces per shooting point (Holladay, UT)
- 2 spaces per shooting range station (Michigan City, IN)

Based on the data available, staff recommends that a parking standard be established that is based on both floor space devoted to the office/retail component and space devoted to shooting ranges. Accordingly, staff recommends the following standard:

> *2 spaces per shooting range station plus 3 spaces per 1,000 square feet of floor space not devoted to indoor shooting range.*

Since this is a text amendment to the Zoning Code, while Shore Galleries is the petitioner, any resulting action would be applicable to any "Firearms Dealers" application within the M-B District.

Special Use – Subject to and presuming a favorable recommendation for a text amendment allowing consideration of a Special Use for a Firearms Dealer in the MB Zoning District, Shore Galleries, also seeks Special Use approval to relocate the "Firearms Dealer" to 6950 Central Park Avenue. The subject property is eligible for Special Use consideration under the additional proposed restrictions as recommended by Staff. The attached map indicates that 6950 Central Park Avenue is not closer than 800 feet to from any property zoned Public Space/Park (P) or Residentially (R) zoned property. The subject property does not have frontage on any State of Illinois highway.

Attached is a memorandum from the Police Chief indicating he has no objections or concerns with the relocation of Shore Galleries to the subject property. The Chief does recommend however that any approval be subject to the approval by the Chief prior to occupancy, of a security plan for the premises.

Shore Galleries proposes to modify the existing building, including an addition, in order to create interior retail and display, indoor shooting range, office space, classroom, bathrooms, and locker room. The floor plan is primarily devoted to the retail and display area (7,449SF) and the short range gallery (3,570SF) and long range gallery (7,177SF). Access into the business will be from the east elevation (fronting Central Park Avenue) into a lobby.

Variations – As indicated, Shore Galleries proposes an addition to the existing building at the location of the current loading berth. This addition is proposed in order to gain the appropriate length needed for the proposed long range shooting gallery. The proposed addition would be built to align with the existing front of the building which is located closer than the required minimum 25 foot setback. Shore Galleries seeks a variation to permit the existing building and the proposed addition to encroach into this required front yard setback. This proposed addition is also located within the required five foot side yard setback, thus also requiring a side yard setback variation. Both the existing building and the proposed addition are at a zero side yard setback.

Finally, Shore Galleries seeks a variation to permit fewer than the required minimum off-street parking spaces. While there is no current minimum off-street parking standard adopted yet for this type of land use, the existing property has no legal off-street parking spaces. While there is a hard-surfaced area on the property to the north of the existing building, and some parking may occur, the dimensions of this area are insufficient for minimum access aisle width and minimum parking space dimensions (width and length).

Staff notes that there is existing parkway parking spaces located immediately to the front of the existing building but since these are located entirely within the public right-of-way, they cannot be counted as off-street parking. As a result, there are technically zero off-street parking spaces and therefore, regardless of the appropriate parking standard for "Firearms Dealer", Shore Galleries must obtain a parking variation to occupy the premises at 6950 Central Park.

Conclusion

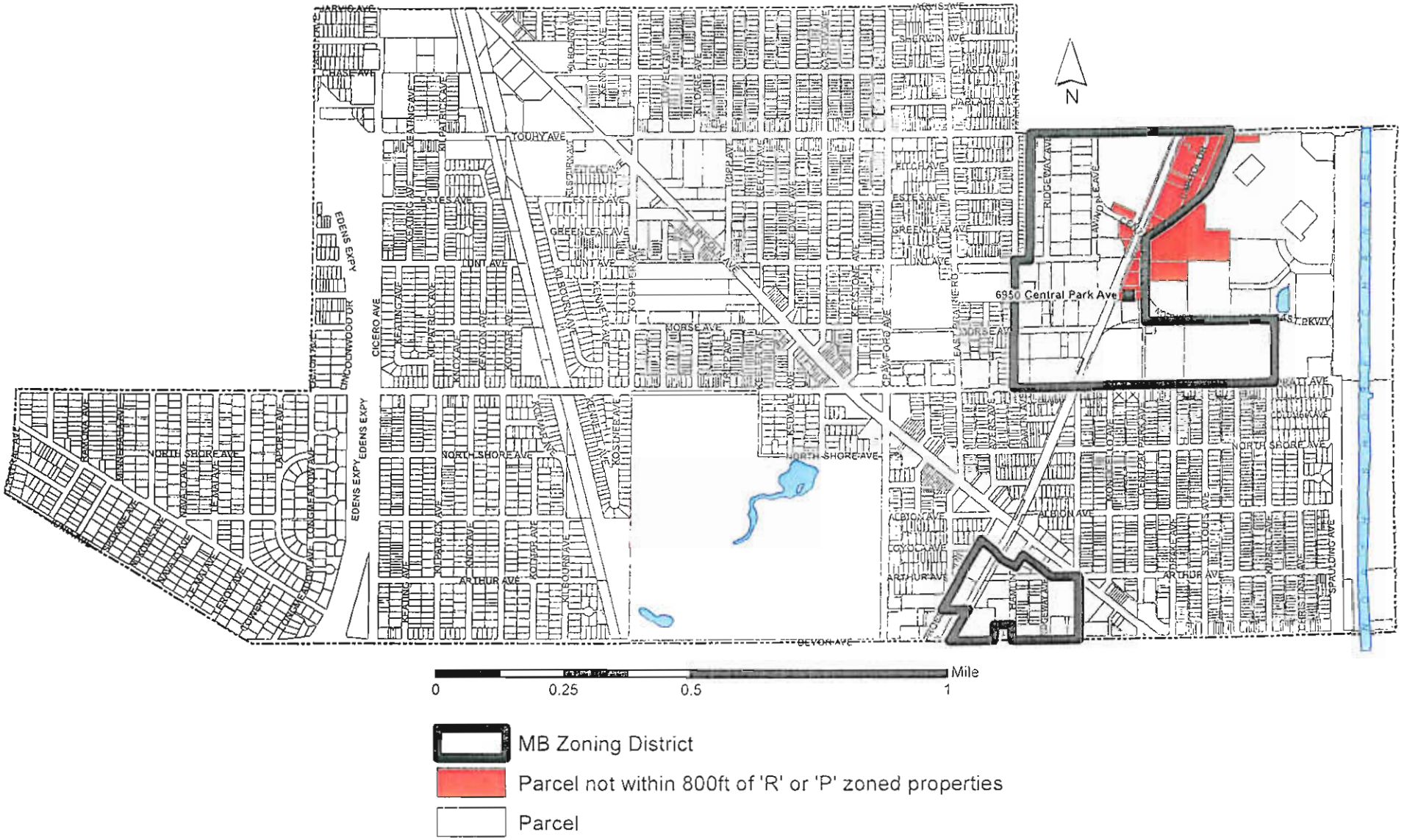
The petitioner is seeking text amendments, special use approval and variations in order to relocate the business to 6950 Central Park Avenue. The text amendments requested are necessary to add "Firearms Dealer" as a special use in the MB District, add a definition of "Firearms Dealer" in the Zoning Code, and add minimum off-street parking requirements for "Firearms Dealers". If favorable consideration is received on the text amendments, Shore Galleries seeks Special Use approval per the amended Zoning Code to operate a "Firearms Dealer" in the MB District at 6950 Central Park Avenue. Shore Galleries also seeks approval of front and side yard variations to permit an addition to the existing building while also seeking a parking variation.

Documents Attached

1. Map - Firearms Ordinance Review
2. Shore Galleries Application Binder (Text Amendment Application, Special Use Application, Boundary & Topographic Survey, Site Plan, Proof of Ownership, Floor Plan, Building Elevations, Commercial Variation Application)
3. Police Chief Memorandum
4. Committee of the Whole Memorandum Dated March 26, 2012

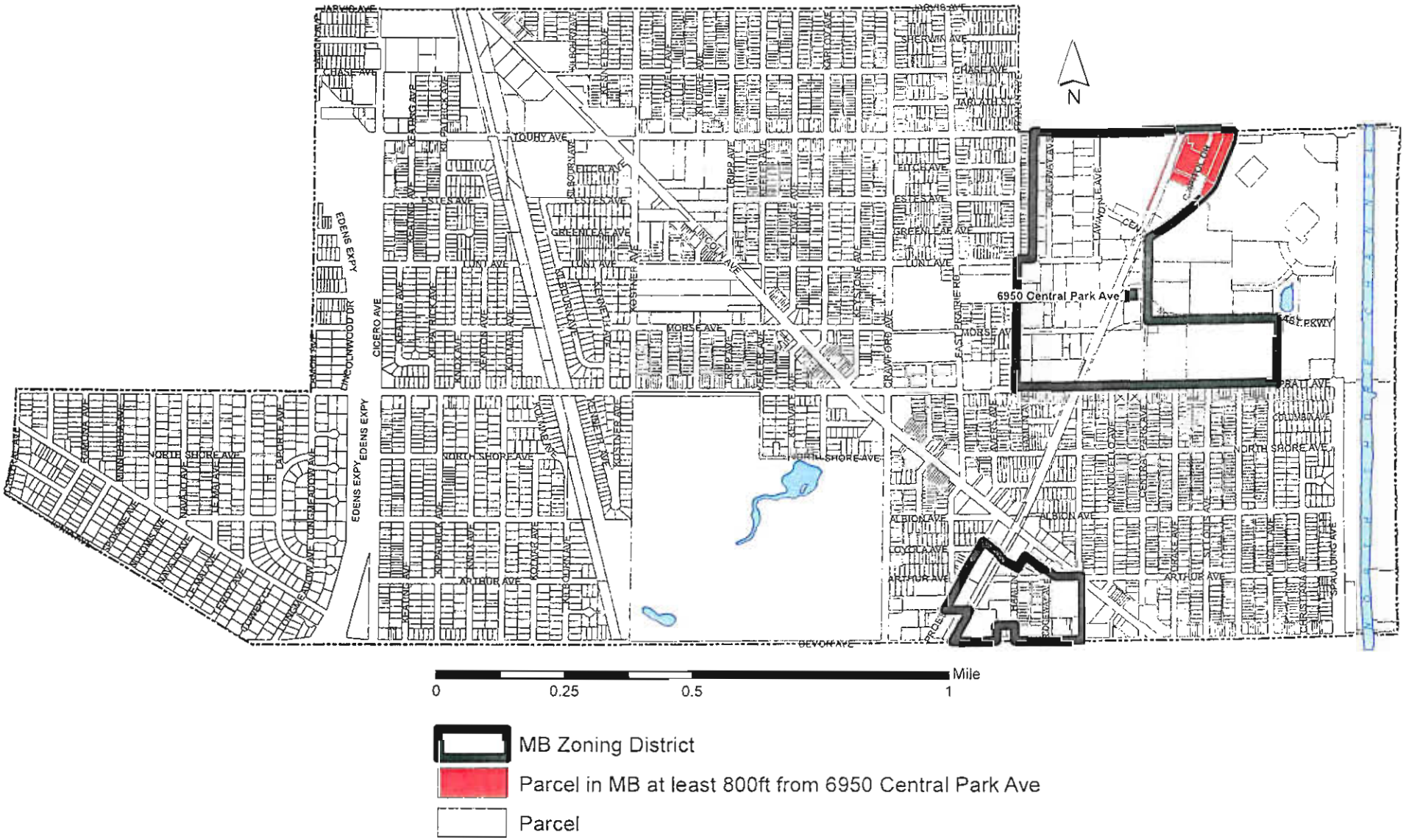
Firearms Ordinance Review

Parcels Not Within 800ft of 'R' or 'P' Zoned Properties



Firearms Ordinance Review

Parcel in MB at least 800ft from 6950 Central Park Ave



VILLAGE OF LINCOLNWOOD Public Hearing Application
Community Development Department Text Amendment

PETITIONER INFORMATION

Name: SHORE GALLERIES

Address: 6950 CENTRAL PARK

Telephone: (847) 676.2900 Fax: (847) 675.6660 E-mail Address: MITCH@SHOREGALLERIES.COM

COST REIMBURSEMENT REQUIREMENT

The Village requires reimbursement of certain out-of-pocket costs incurred by the Village in connection with applications for zoning approvals and relief. These costs include, but are not limited to, mailing costs, attorney and engineer costs, and other out-of-pocket costs incurred by the Village in connection with this application. In accordance with Section 5.02 of the Village of Lincolnwood Zoning Ordinance, both the petitioner and the property owner shall be jointly and severely liable for the payment of such out-of-pocket costs. Out-of pocket costs incurred shall be first applied against any hearing deposit held by the Village, with any additional sums incurred, to be billed at the conclusion of the hearing process.

Invoices in connection with this application shall be directed to:

Name: PLATFORM I c/o STEVE SIEGEL
Address: 825 S. WAUKEGAN RD AB #106
City, State: LAKE FOREST, IL 60045

ATTESTMENT AND SIGNATURE

I hereby state that I have read and understand the Village cost reimbursement requirement, as well as the requirements and procedures outlined in Article V of the Village Zoning Ordinance, and I agree to reimburse the Village within 30 days after receipt of an invoice therefor. I further attest that all statements and information provided in this application are true and correct to the best of my knowledge and that I have vested in me the authority to execute this application.

PROPERTY OWNER
PLATFORM I. SHORE, LLC

Signature Date 4/14/12

STEVE SIEGEL
Print Name

PETITIONER *(If different than property owner)*
SHORE GALLERIES

Signature Date 4/14/12

MITCH SHORE
Print Name

REQUIRED ATTACHMENTS *

Check all documents that are attached:

Proposed Text Amendment Language ✓

**The above documents are required for all applications. The Zoning Officer may release an applicant from specific required documents or may require additional documents as deemed necessary.*

For Office Use Only

Fee: _____ Deposit: _____

Date Received: _____

Checked By: _____

The article(s), section(s) and paragraph(s) of the Village of Lincolnwood Zoning Ordinance from which the Action is being sought:

TEXT AMENDMENT STANDARDS

To be approved, the requested text amendment must meet certain specific standards. These standards are listed below. After each listed standard, explain how the text amendment the listed standard. Use additional paper if necessary.

1. **Nature of Request**: Explain below why you are seeking a text amendment to the zoning code. What is it that you would like to do that requires a change in the text of the zoning code?

SEE ATTACHED FOR ALL RESPONSES

2. **What zoning district(s) would be affected by the proposed text amendment?** Categorize the type of properties or area of the Village that likely would be affected by the proposed change?

3. **Cite the specific section(s) of the code proposed to be amended.**

4. **Provide the proposed text amendment.** Provide below or attach the exact section code language, as it is currently written, then use strikeouts for proposed deletion of existing language and insert/add the proposed new language using highlighting (bolding) so that the language is shown exactly as you propose (with all deletions and additions indicated).

5. **Indicate why you believe this text change is needed and why it would benefit the Village.**

VILLAGE OF LINCOLNWOOD Public Hearing Application

Community Development Department Text Amendment

1. **Nature of Request:** Explain below why you are seeking a text amendment to the zoning code. What is it that you would like to do that requires a change in the text of the zoning code.

Municipal Code 9-15-2-4 (c) permits Shore Galleries to operate its business within the Village of Lincolnwood. However, the Municipal Code only permits Shore Galleries from operating at its current location. In order to continue to service their customers, Shore Galleries is seeking a text amendment to allow them to move within the Village to the proposed location of 6950 Central Park located in the M-B zoning district. The proposed location grants Shore Galleries the ability to offer its clients the services and amenities they are seeking.

2. **What zoning district(s) would be affected by the proposed text amendment?** Categorize the type of properties or area of the Village that likely would be affected by the proposed change?

The proposed zoning district for amendment is the M-B Light Manufacturing/Business District. The proposed use is most consistent with the desired type and uses of business. The proposed use has a combination of light retail and space allocated for training and educational use. Shore Galleries is currently located in a high profile (on Devon) Retail district. The new proposed location is a discrete site isolated from either retail or residential districts. The proposed building is a 1950's light warehouse type construction consistent with all the other buildings along the block. There will be simple signage indicating the store. The traffic pattern and use will be consistent with the other business in the neighborhood. Currently, Shore Galleries has no on site parking, and only two off site spaces. The proposed plan will accommodate (9) on site parking and (13) off site spaces along the easement. With respect to use and parking the M-B zoning is the most appropriate for Shore Galleries.

3. **Cite the specific section(s) of the code proposed to be amended.**

Municipal Code 9-15-2-4 (c) as well as Zoning Code 4.01 (9), table 4.01.1, and the definition for the use.

4. **Provide the proposed text amendment.** Provide below or attach the exact section code language, as it is currently written, then use strikeouts for proposed deletion of existing language and insert/add the proposed new language using highlighting (bolding) so that the language is shown exactly as you propose (with all deletions and additions indicated).

unless the licensee was operating the business on September 1, 1994, ~~at this location~~ **in the Village**.

5. **Indicate why you believe this text change is needed and why it would benefit the Village.**

Shore Galleries has been serving the Village, local police departments, and its clients since 1956. It has conducted its business solely at the Devon location without incident since it was first opened. As it's clients needs have grown and developed, Shore Galleries has attempted to grow within their existing storefront.

The current demands exceed the capacity of their current space. The size of the building prohibits them from installing the ranges their customers seek. The proposed location offers them a similar size retail space, improved office space, and length of building necessary for the range installations.

Without the ability to relocate, Shore Galleries will need to pursue other locations outside the Village to accommodate their business. Nevertheless, Shore Galleries desires for its business to remain in Lincolnwood, and continue to strength the business district within the community. Shore Galleries is a solid reputable business which generates a significant sales tax for the Village.

VILLAGE OF LINCOLNWOOD Public Hearing Application
Community Development Department Special Use & PUD

Property Address: 6950 CENTRAL PARK

Permanent Real Estate Index Number(s): 10-35-107-002 & 10-35-135-008

Zoning District MB Lot Area: 31,393 SF

List all existing structures on the property. Include fencing, sheds, garages, pools, etc.

MASONRY WAREHOUSE STRUCTURE

Are there existing development restrictions affecting the property? ☐ Yes ☑ No
(*Examples: previous variations, conditions, easements, covenants*)

If yes, describe:

☑ Special Use - Non-Residential
☐ Special Use - Residential
☐ Planned Unit Development (PUD)
☐ Other

Describe the Request and Project: TO RELOCATE SHORE GALLERIES FROM A RETAIL DISTRICT TO THE M-B DISTRICT, TO CREATE DEFINITION AND DETERMINE APPROPRIATE PARKING.

Property Owner(s):

Name: (List all beneficiaries if Trust): PLATFORM I - SHORE, LLC

Address: C/O STEVE SIEGEL · 825 S. WAUKEGAN RD. #B106 · LAKE FOREST 60045

Telephone: (773) 851.5700 Fax: ( ) / E-mail Address: SSSSDEVELOPC@GMAIL.COM

Petitioner (*if different from owner*):

Name: SHORE GALLERIES Relationship to Property: TENANT

Address: 3318 W. DEVON

Telephone: (847) 676.2900 Fax: (847) 675.6660 E-mail Address: MITCH@SHOREGALLERIES.COM

REQUIRED ATTACHMENTS *

Check all documents that are attached:

Plat of Survey	✓
Site Plan	✓
Proof of Ownership	✓
Floor Plans	✓
Elevations	✓
Applicable Zoning Worksheet	NA
Photos of the property	✓
PDF files of all drawings	✓

For Office Use Only

Fee: _____ Deposit: _____

Date Received: _____

Checked By: _____

The article(s), section(s) and paragraph(s) of the Village of Lincolnwood Zoning Ordinance from which the Action is being sought:

_____

_____

_____

_____

_____

**The above documents are required for all applications. The Zoning Officer may release an applicant from specific required documents or may require additional documents as deemed necessary.*

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Address: 825 S. WAUKEGAN RD AB #106
City, State: LAKE FOREST, IL 60045

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I hereby state that I have read and understand the Village cost reimbursement requirement, as well as the requirements and procedures outlined in Article V of the Village Zoning Ordinance, and I agree to reimburse the Village within 30 days after receipt of an invoice therefor. I further attest that all statements and information provided in this application are true and correct to the best of my knowledge and that I have vested in me the authority to execute this application.

PROPERTY OWNER
PLATFORM I - STONE, LLC

_____ 4/14/12
Signature Date

STEVE SIEGEL
PRINT NAME

PETITIONER *(If different than property owner)*
STONE GATE HOMES

_____ 4/14/12
Signature Date

MITCH CHOPE
PRINT NAME

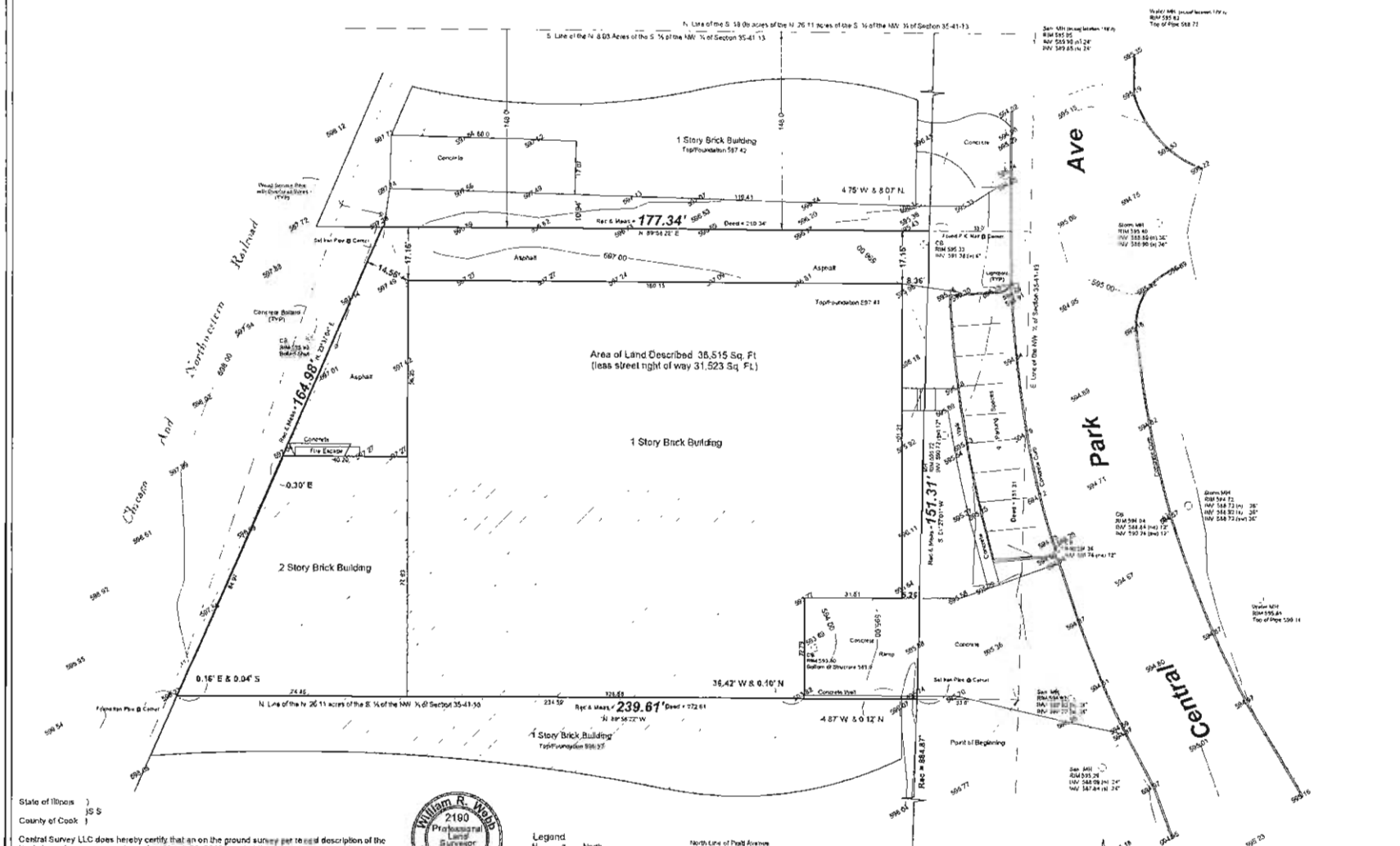
Boundary & Topographic Survey by

Central Survey, LLC 6415 N Caldwell Ave , Chicago, Illinois 60646-2713
Phone (773) 631-5285 www.Centralsurvey.com Fax (773) 775-2071

Legal Description

That part lying East of the right of way of Junction Railway Company, of the 18 06 acres South of and adjoining the North 8 03 acres of the South ½ of the Northwest ¼ of Section 35, Township 41 North, Range 13 East of the Third Principal Meridian, more fully described as follows beginning at the intersection of the South line of the North 26 11 acres of the South ½ of the Northwest ¼ of said Section 35, with the East line of the Northwest ¼ of said Section 35 thence North along said East line of the Northwest ¼ of Section 35, a distance of 151 31 feet to an intersection with a line drawn parallel with and 148 0 feet South of the South line of the North 8 03 acres of said South ½ of the Northwest ¼ of Section 35, thence West along the last described parallel line, a distance of 210 34 feet to the Easterly right of way line of Chicago and Northwestern Railroad, thence Southwesterly along said Easterly right of way line, a distance of 164 98 feet to the intersection with the South line of the North 26 11 acres of the South ½ of the Northwest ¼ of said Section 35, thence East along said South line of the North 26 11 acres of the South ½ of the Northwest ¼ of said Section 35, a distance of 272 61 feet to the point of beginning in Cook County, Illinois

Commonly Known as 6950 N Central Park Avenue, Lincolnwood, Illinois



State of Illinois)
)S S
County of Cook)

Central Survey LLC does hereby certify that an on the ground survey per to said description of the land shown hereon was performed on March 30, 2012 and that the map of plat hereon drawn is a correct representation of said survey When bearings are shown the bearing base is assumed Dimensions are shown in feet and hundredths and are correct at a temperature of 68° Fahrenheit. This professional service also conforms to the Illinois minimum standards for topographic surveys

Dated this 30th day of March 2012 William R. Webb

William R Webb P.L.S #2190 (exp 11/30/2012) Professional Design Firm Land Surveying LLC (#184-004113)

William R. Webb 2190 Professional Land Surveyor State of Illinois Chicago Illinois

This professional service conforms to current Illinois minimum standards for a boundary survey

Legend

N.	=	North
S	=	South
E	=	East
W	=	West
(TYP)	=	Typical
Rec	=	Record
Meas	=	Measure
SI	=	Street
Ave	=	Avenue

Decimal/Inch Conversions		
0.01' = 1/8"	0.08' = 1"	0.58' = 7"
0.02' = 1/4"	0.17' = 2"	0.67' = 8"
0.03' = 3/8"	0.25' = 3"	0.75' = 9"
0.04' = 1/2"	0.33' = 4"	0.83' = 10"
0.05' = 5/8"	0.42' = 5"	0.92' = 11"
0.06' = 3/4"	0.50' = 6"	1.00' = 12"
0.07' = 7/8"		

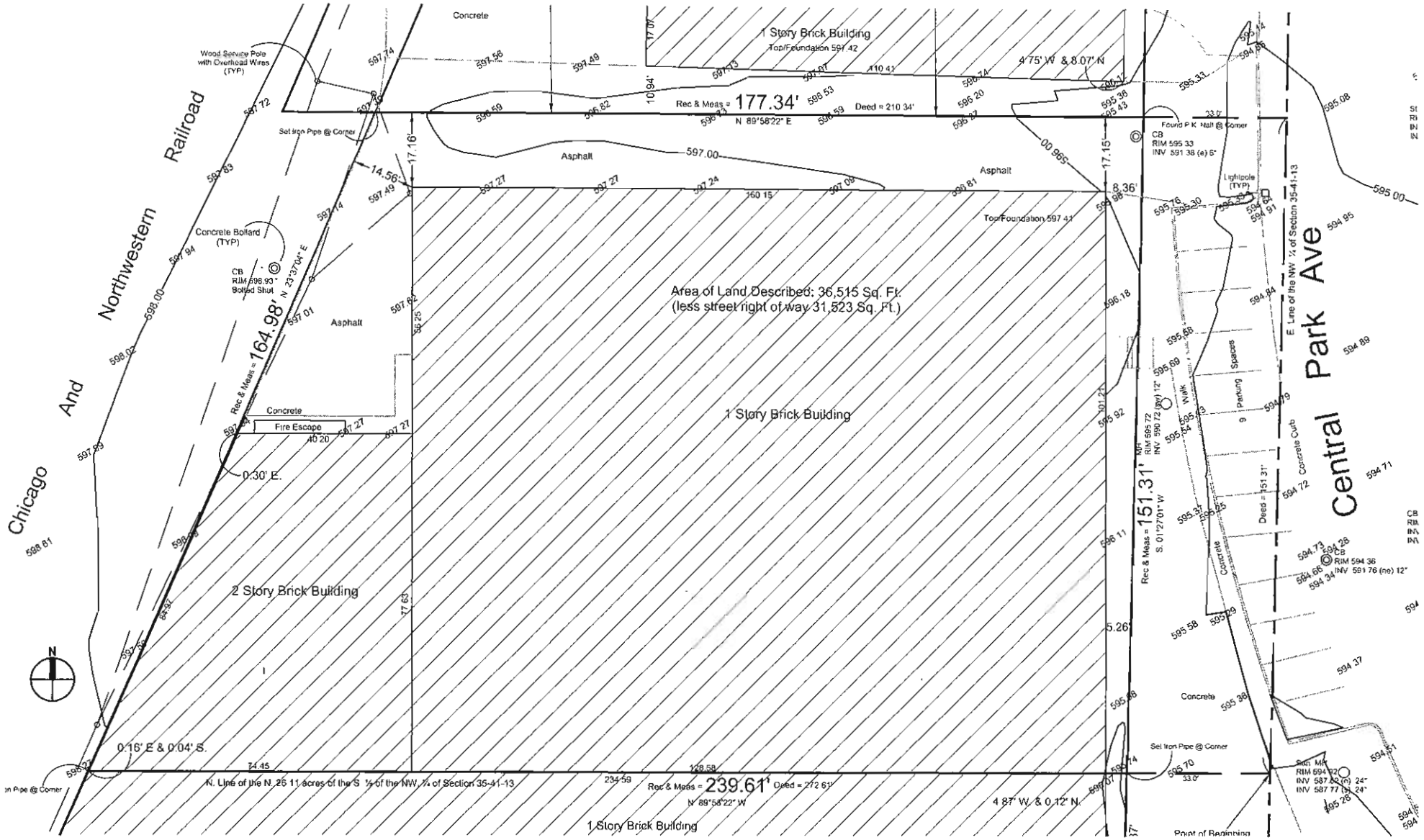
NOTE Elevations shown hereon derived from Village of Lincolnwood bench mark #123 located at the Southwest corner of Pratt & Lawndale (Elevation = 601 594' NGVD)

Scale, 1 inch equals 20 Feet

Ordered By Coda LLC

Order Number 69508

Assume no dimension from scaling upon this plat. Compare all points before building and report any difference at once. For building restrictions refer to your abstract, deed, contract and local ordinances



Shore Galleries

SITE PLAN

4.9.2012

CODA LLC.

6950 N. CENTRAL PARK AVE.,
LINCOLNWOOD, IL

1" = 20'-0"

A101

REAL ESTATE SALE AGREEMENT

THIS REAL ESTATE SALE AGREEMENT (this "Agreement") is made as of the 8TH day of APRIL, 2012 (the "Effective Date") by and between Chicago Title Land Trust Company, successor to LaSalle National Bank, T/U/T 101866608 dated 12-22-1971 ("Seller"), , and Platform I, LLC, an Illinois limited liability company ("Purchaser").

RECITALS

A. Seller is the owner of a certain parcel of real estate (the "Real Property") in the Village of Lincolnwood, County of Cook, State of Illinois, which parcel is more particularly described in attached Exhibit A, and upon which is located an industrial office building. For purposes of this agreement "Seller" shall also include the beneficiaries of the above-described land trust.

B. Seller desires to sell to Purchaser, and Purchaser desires to purchase from Seller, the Property (as such term is hereinafter defined), in accordance with and subject to the terms and conditions set forth in this Agreement.

THEREFORE, in consideration of the above Recitals, the mutual covenants and agreements herein set forth and the benefits to be derived therefrom, and other good and valuable consideration, the receipt and sufficiency of which are hereby acknowledged, Purchaser and Seller agree as follows:

1. PURCHASE AND SALE.

Subject to and in accordance with the terms and conditions set forth in this Agreement, Purchaser shall purchase from Seller and Seller shall sell to Purchaser the Real Property, together with: (i) all buildings and improvements owned by Seller (the "Improvements") and any and all of Seller's rights, easements, licenses and privileges presently thereon or appertaining thereto; (ii) all furniture, furnishings, fixtures, equipment, tools and other tangible property (collectively, the "Personal Property") owned by Seller, located on the Real Property and used solely in connection therewith, excluding the specific items of personal property a list of which is attached hereto as Exhibit B (collectively, the "Excluded Items"); and (iii) all right, title and interest of Seller under any and all of the maintenance and service and other like contracts and agreements with respect to the ownership and operation of the Property which may be canceled on not more than 30 days prior notice without payment of penalty (collectively, the "Service Contracts"), a list of which is attached hereto as Exhibit C, all to the extent applicable to the period from and after the Closing (as such term is hereinafter defined); (items (i) through (iii) above, together with the Real Property, are collectively referred to in this Agreement as the "Property").

2. PURCHASE PRICE.

13.13 Facsimile Signatures. Signatures to this Agreement transmitted by telecopy shall be valid and effective to bind the party so signing. Each party hereto agrees to promptly deliver to the other party an executed original to this Agreement with its actual signature, but a failure to do so shall not affect the enforceability of this Agreement, it being expressly agreed that each party to this Agreement shall be bound by its own telecopied signature and shall accept the telecopied signature of the other party to this Agreement.

13.14 Prevailing Party Attorney Fees. If either Seller or Purchaser files suit to enforce the obligations of the other party under this Agreement, the prevailing party shall be entitled to recover the reasonable fees and expenses of its attorneys from the non-prevailing party.

IN WITNESS WHEREOF, Seller and Purchaser have executed and delivered this Agreement as of the date first above written.

SELLER:

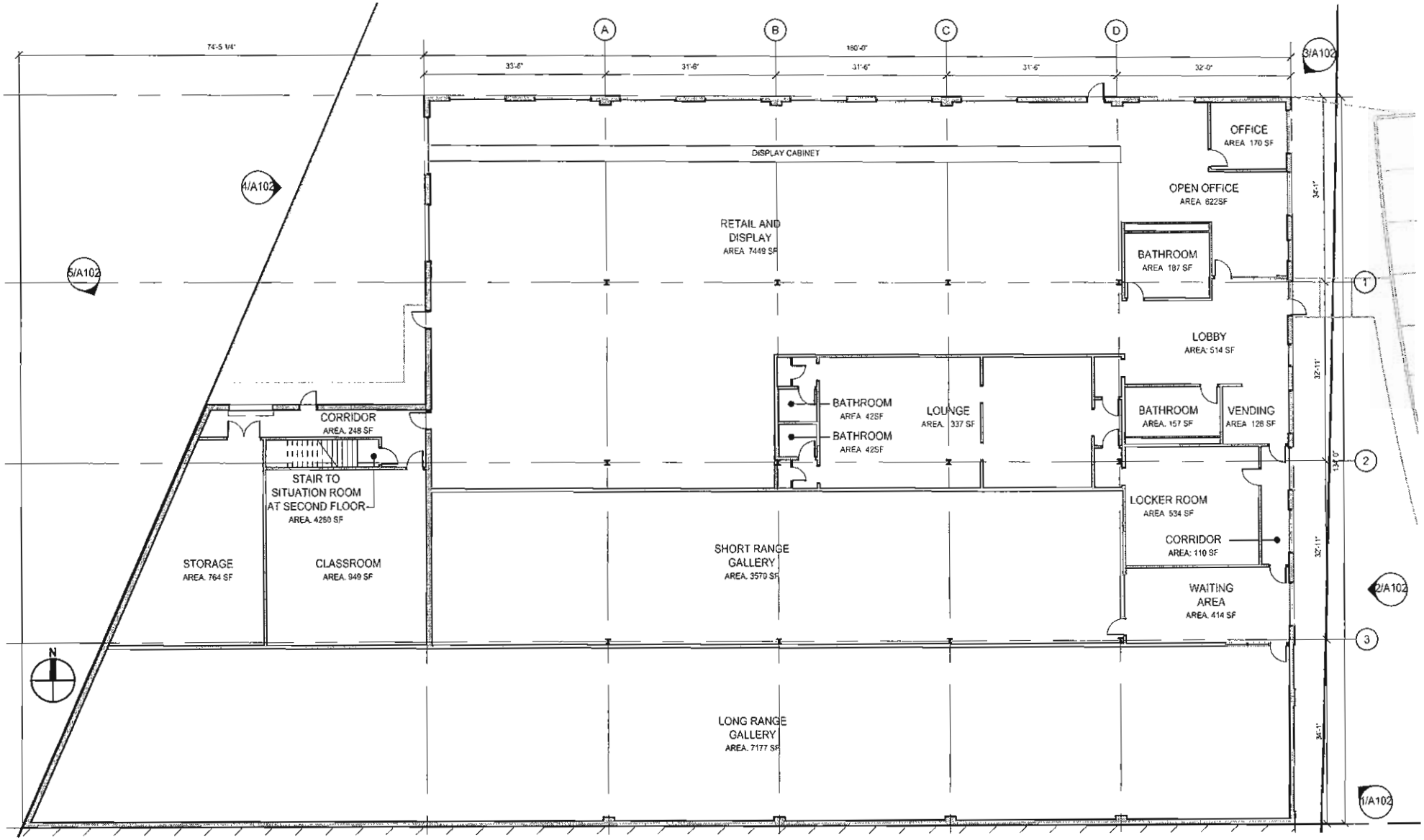
Chicago Title Land Trust Company, successor to LaSalle National Bank, T/U/T 101866608 dated 12-22-1971

By: _____
Name: Leo Pearl
Duly authorized agent for all beneficiaries

PURCHASER:

Platform I, LLC, an Illinois limited liability company

By: _____
Name:
Its: Manager



Shore Galleries

CODA LLC.

FIRST FLOOR PLAN

6950 N. CENTRAL PARK AVE.,
LINCOLNWOOD, IL

4.9.2012

1/16" = 1'-0"

A101



1. PROPOSED SOUTHEAST CORNER ELEVATION



2. PROPOSED EAST ELEVATION



3. EXISTING NORTHEAST CORNER ELEVATION



4. PARTIAL PROPOSED WEST ELEVATION



5. PROPOSED NORTHWEST CORNER ELEVATION

SHORE GALLERIES

CODA LLC.

ELEVATIONS

6950 N. CENTRAL PARK AVE.,
LINCOLNWOOD, IL

4.9.2012

NOT TO SCALE

A102

VILLAGE OF LINCOLNWOOD
COMMUNITY DEVELOPMENT DEPARTMENT

SPECIAL USE STANDARDS

To be approved, each special use request must meet certain specific standards. These three standards are listed below. After each listed standard, explain how the special use request satisfies the listed standard. Use additional paper if necessary.

1. Please explain how the use is necessary for the public convenience at this location, and the subject property is deemed suitable for the use. (Please explain in detail)

SEE ATTACHED FOR ALL RESPONSES.

2. Please explain how the use is so designed, located and proposed to be operated that the public health, safety and welfare will be protected.

3. Please explain how this use would not cause substantial injury to the value of other property in the neighborhood in which it is located.

4. The special use would not cause substantial injury to the value of other property in the neighborhood in which it is located.

5. The special use is consistent with the goals and policies of the Comprehensive Plan.

6. Please explain how the special use is so designed to provide adequate utilities, access roads, drainage, or necessary facilities.

7. Please explain how the special use is so designed to provide ingress and egress to minimize traffic congestion on public streets.

1. Please explain how the use is necessary for the public convenience at this location, and the subject property is deemed suitable for the use. (Please explain in detail).

Municipal Code 9-15-2-4 (c) permits Shore Galleries to operate its business within the Village of Lincolnwood. However, the Municipal Code only permits Shore Galleries from operating in its current location. In order to continue to service their customers, Shore Galleries is seeking the text amendment to allow them to move within the Village to the proposed location of 6950 Central Park located in the M-B zoning district. The proposed location grants Shore Galleries the ability to offer its clients the services and amenities they are seeking without having to move their business outside of Lincolnwood.

Numerous police departments and officers purchase their equipment and supplies from Shore Gallery. By permitting Shore Galleries to relocate, they will also be able to offer those officers, and the public, the ability to train for certification.

Currently, Shore Galleries is located in a high traffic retail location. The M-B district is more suitable due to the volume of traffic. Shore Galleries is not seeking a high traffic location. They operate a discrete business, and the M-B district offers them a low profile. Furthermore, the property is located in the center of the M-B, so the remaining portion of the M-B district buffers the property from residential, schools or parks.

2. Please explain how the use is so designed, located and proposed to be operated that the public health, safety, and welfare will be protected.

First and foremost, the selection of the site was given the utmost priority with respect to public health, safety, and welfare. Other sites were reviewed and considered, but due to their proximity to residential neighborhoods, they were removed from consideration. Second, the site is located in the center of the M-B district as reviewed above. The use and traffic of the district is most consistent with the proposed use by Shore Gallery. Furthermore, all aspects of the interior layout were designed specifically for life safety. All special use rooms have secure interior locations. There is no visible access from the street. Upon entering Shore Galleries, a customer first must walk past the receptionist to either enter the retail or the training areas. Access to the training areas is further limited by secured door entryways. A corridor and waiting area separate the exterior from any training or locker areas. As found at the current location, the latest and most secure security system shall be installed throughout the building. Equally important, the location and access to the ranges has been designed to accommodate numerous check points for the highest level of public safety.

3. Please explain how his use would not cause substantial injury to the value of other property in the neighborhood in which it is located.

Shore Galleries has been a successfully operating business in the Village since 1956 all at its current location. There is no evidence to suggest, that the presence of Shore Galleries has diminished or cause substantial injury to the value of the properties in the neighborhood. Since 1956, the value of property in the immediate neighborhood as grown in a manner consistent with the Village. The relocation of Shore Galleries will improve the value of the immediate surrounding properties, due to the fact a healthy, successful business is relocating there. Within the immediate area, there is a vacant lot, a building in foreclosure and others for sale. Relocating a strong community asset will only help the surrounding property values.

4. The special use would not cause substantial injury to the value of other property in the neighborhood in which it is located.

As stated above, the business on the property granted by the special use will be conducted in a discrete and professional manner as Shore Galleries has since 1956.

5. The special use is consistent with the goals and policies of the Comprehensive Plan.

Shore Galleries has been serving the Village, local police departments, and its clients since 1956. Due to its reputation, the Comprehensive Plan and Municipal Code "grandfathered" Shore Galleries as an allowable use. The intent of the Plan or Code are not being altered. The special use allows Shore Gallery to continue to operate in the Village.

6. Please explain how the special use is so designed to provide adequate utilities, access roads, drainage, or necessary facilities.

The intensity of use for the proposed plan does not increase the loads for utilities, roads, drainage or other necessary facilities. The previous use was a manufacturing plant and warehouse. As such, the gas, electrical and water requirements were far in excess of the projected retail and training utility requirements. The retail is a limited retail due to the nature of the speciality products. Standard lighting and mechanical loads are required for the retail, educational, and storage areas. With respect to the training areas, the mechanical systems are more specialized compared to normal units, but only with respect to the air filtration systems. The load uses are consistent with a building of this use and size.

7. Please explain how the special use is so designed to provide ingress and egress to minimize traffic congestion on public streets.

As previously stated, the use of the building will be a manner consistent with the previous ownership. No additional loads are anticipated for the retail or training compared to the loads of the manufacturing company. Currently, Shore Gallery is serviced by (2) off site parking spaces. The new site shall have (9) on site spaces, and (13) off site spaces in the public easement. The parking is more than sufficient

compared to the use and Shore Galleries existing parking. Furthermore, the configuration and access to the parking for the property is not proposed to be altered.

VILLAGE OF LINCOLNWOOD Public Hearing Application
Community Development Department — Variations

SUBJECT PROPERTY

Property Address: 6950 CENTRAL PARK

Permanent Real Estate Index Number(s): 10-35-107-002 & 10-35-135-008

Zoning District M-B Lot Area: 31,393

List all existing structures on the property. Include fencing, sheds, garages, pools, etc.

Are there existing development restrictions affecting the property? ___ Yes ✓ No
(*Examples: previous variations, conditions, easements, covenants*)

If yes, describe: ___

REQUESTED ACTION

- ☐ Variation – Residential
- ☑ Variation – Non-Residential
- ☑ Variation – Off-Street Parking
- ☐ Variation – Design Standards
- ☐ Variation – Signs/Special Signs
- ☐ Minor Variation
- ☐ Other

PROJECT DESCRIPTION

Describe the Request and Project: RELOCATE SHORE GALLERIES TO THE SITE, AND BUILD OUT THE SOUTHEAST CORNER OF THE BUILDING. A FRONT YARD SET BACK & PARKING VARIATIONS ARE SOUGHT.

PROPERTY OWNER/PETITIONER INFORMATION

Property Owner(s):

Name: (List all beneficiaries if Trust): PLATFORM I - SHORE, LLC

Address: c/o STEVE SIEGEL - 825 S WAUKEGAN RD. #106 LAKE FOREST 60045

Telephone: (773) 851.5700 Fax: (___) ___ E-mail Address: SSSDEVELOP@GMAIL.COM

Petitioner (*if different from owner*):

Name: SHORE GALLERIES Relationship to Property: TENANT

Address: 3318 W DEVON

Telephone: (847) 676.2900 Fax: (847) 675.6060 E-mail Address: MITCH@SHOREGALLERIES.COM

REQUIRED ATTACHMENTS *

Check all documents that are attached:

Plat of Survey	✓
Site Plan	✓
Proof of Ownership	✓
Floor Plans	✓
Elevations	✓
Applicable Zoning Worksheet	N/A
Photos of the property	✓
PDF files of all drawings	✓

For Office Use Only

Fee: _____ Deposit: _____

Date Received: _____

Checked By: _____

The article(s), section(s) and paragraph(s) of the Village of Lincolnwood Zoning Ordinance from which the Action is being sought:

_____

_____

_____

_____

_____

**The above documents are required for all applications. The Zoning Officer may release an applicant from specific required documents or may require additional documents as deemed necessary.*

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City, State: LAKE FOREST, IL 60045

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PROPERTY OWNER

PLATFORM I · SHORE, LLC

Signature _____ Date 4/14/12

PRINT NAME

PETITIONER *(If different than property owner)*

SHORE ENTITIES

Signature _____ Date 4/14/12

Mitchell Shore

PRINT NAME

VILLAGE OF LINCOLNWOOD
COMMUNITY DEVELOPMENT DEPARTMENT

VARIATION STANDARDS

To be approved, each variation request must meet certain specific standards. These eight standards are listed below. After each listed standard, explain how your variation request satisfies the listed standard. Use additional paper if necessary.

1. The requested variation is consistent with the stated intent and purposes of the Zoning Ordinance and the Comprehensive Plan.

SEE ATTACHED FOR RESPONSES.

2. The particular physical surroundings, shape or topographical conditions of the subject property would bring a particular hardship upon the owner, as distinguished from a mere inconvenience, if the strict letter of this Zoning Ordinance is enforced.

3. The conditions upon which the petition for the variation is based would not be applicable generally to other property within the same Zoning District.

4. The variation is not solely and exclusively for the purpose of enhancing the value of or increasing the revenue from the property.

VARIATION STANDARDS (continued)

5. The alleged difficulty or hardship has not been created by any person presently having an interest in the property.

6. The granting of the variation will not be detrimental to the public welfare or injurious to other property or improvements in the neighborhood in which the property is located.

7. The variation granted is the minimum change to the Zoning Ordinance standards necessary to alleviate the practical hardship on the subject property.

8. The proposed variation will not impair an adequate supply of light and air to adjacent property, or substantially increase the danger of fire, or otherwise endanger the public safety, or substantially diminish or impair property values within the neighborhood.

SIGN VARIATION STANDARDS

For all Sign Variation and/or Special Sign requests the Applicant shall also complete Questions 9-12.

9. The proposed variation is consistent with the statement of purpose set forth in Section 11.01 of the Zoning Ordinance.

10. The proposed sign complies with any additional standards or conditions set forth in Article XI of the Zoning Ordinance.

11. The proposed sign will substantially enhance the architectural integrity of the building or other structure to which it will be attached, if any.

12. The proposed sign conforms with the design and appearance of nearby structures and signs.

1. The requested variation is consistent with the stated intent and purposes of the Zoning Ordinance and the Comprehensive Plan.

The proposed Special Use adoption shall allow the use to be a conforming use within the M-B district. Shore Galleries is an allowable use within the Municipal Code and Comprehensive Plan pursuant to 9-15-2-4 (c). The two requested variations pertain to front/side yard set back, and on site parking. Neither item alters the intent or purpose as defined within the Zoning Ordinance as will be shown hereinafter.

2. The particular physical surroundings, shape or topographical conditions of the subject property would bring a particular hardship upon the owner, as distinguished from a mere inconvenience, if the strict letter of the Zoning Ordinance is enforced.

When the building was originally built, the front yard setback were consistent with the current zoning code. We can only presume at the time of construction, the side yard set back was in conformance with the Zoning Code. Subsequently at some time there in after, the Village of Lincolnwood acquired a substantial portion of the front yard to accommodate the improvements for Central Park Avenue. As a result, the front yard was reduced from 38.75' to 5.26', and the front yard parking was converted to off site parking.

In addition, the Zoning Ordinance, presumably, was altered requiring a side yard set back. The current structure is built on the south property line adjacent to its neighbor. The neighbors building shares the same relationship to the lot line. As a result, the existing building, due to no hardship incurred by the owner is not in compliance with the Zoning Ordinance. The modification to the Zoning Ordinance and the acquisition of the front yard by the Village have caused the hardship to the property.

3. The conditions upon which the petition for the variation is based would not be applicable generally to other property within the same Zoning District.

Generally speaking, the stated hardships are generally not applicable to other properties within the district due to the two conditions outline in response (2). It is highly unlikely that other buildings in the M-B district were built prior to the change in the Zoning Ordinance as well has having the Village acquire 86.42% of the front yard, and parking spaces.

4. The variation is not solely and exclusively for the purpose of enhancing the value of or increasing the revenue from the property.

The main reason for the variation is due to the hardship created by the Village acquiring the front yard for a public easement, and modifications to the Zoning Code. The

proposed addition will "square off" the Southeast corner of the building in a manner consistent with the existing buildings and street front.

5. The alleged difficulty or hardship has not been created by any person presently having an interest in the property.

No modifications have been performed by the owner of the building to cause this hardship. The conditions are the result of actions taken by others beyond the control of the property owner.

6. The granting of the variation will not be detrimental to the public welfare or injurious to other property or improvements in the neighborhood in which the property is located.

The proposed improvements are consistent with the street frontage along Central Parkway. 75% of the front yard elevation is currently non-conforming. The remaining 25% of the front elevation shall be built in a similar manner as the existing non-conforming portion of the building. 86.38% of the existing building is non-conforming with respect to the side yard setback. The immediate adjacent neighboring buildings is 100% non-conforming with respect to the side and front yard setbacks. As both buildings abut the side yard setback, the proposed change will not impact the neighboring properties. Rather, the proposed addition is a natural extension of the existing building.

7. The variation granted is the minimum change to the Zoning Ordinance standards necessary to alleviate the practical hardship on the subject property.

The proposed change maintains the building well below the allowable FAR, and represents 3.1% of the total size of the building. Further, by enclosing the loading docks, the building creates a more consistent street frontage along Central Park.

8. The proposed variation will not impair an adequate supply of light and air to the adjacent property, or substantially increase the danger of fire, or otherwise endanger the public safety, or substantially diminish or impair property values within the neighborhood.

Neither 6950 or its immediate neighbor to the south have any access to light or vent from the south property line. The proposed change does not modify either building's ability to obtain light or vent. As the existing buildings are in non-conformance along the entire property line, there is no increase danger to fire or other public safety matters.

LINCOLNWOOD POLICE DEPARTMENT

INTER-OFFICE MEMO

Robert LaMantia
Chief of Police

To: Mr. Timothy Clarke, Director of Community Development

From: Robert LaMantia, Chief of Police

Date: June 1, 2012

Subject: Shore Galleries Public Hearing Application (Text Amendment)

Staff has reviewed the Public Hearing Application Text Amendment Relocation Plan submitted by Shore Galleries for the property located at in the MB Zoning District at 6950 Central Park, Lincolnwood, IL.

Staff has no objection to the petitioner's request. However, it is recommended that the petitioner's security plan reviewed and approved by the Chief of Police prior to occupancy.

Thank you for your consideration in this matter. Please let me know if you have any questions or concerns.

Memorandum

To: Timothy C. Wiberg
Village Manager

From: Timothy M. Clarke, AICP
Community Development director

Date: March 26, 2012

Subject: Shore Gallery
Request to Amend Code

Shore Gallery, located at 3318 Devon Avenue is desirous of relocating and expanding in the community. Shore has identified a property at 6950 Central Park Avenue as their desired replacement location. Shore, which operates a gun shop and shooting range, has been in the Village since the 1950's.

Two basic Code changes are required in order for Shore to relocate its business within the Village:

1) Change in the Municipal Code; and
2) Change in the Zoning Code

At the April 3, 2012 Committee of the Whole meeting, Shore will be present to gauge Trustee support for these basic changes which are necessary for their desired relocation.

Municipal Code

Currently the Municipal Code is written to both 1) prohibit any additional firearms dealers from operating in the Village; and, 2) to only allow Shore Gallery to operate at its present Devon Avenue location and at no other location in the Village.

The existing Village Code does this in two ways: 1) by preventing the issuance of a Village firearm license to an entity that has not already obtained a Village firearms license by October 15, 1994; and, 2) by preventing the issuance of a Village firearms license to any firearms business located within ½ mile of any school or public park, unless that business was operating and licensed as a firearms dealer at its present location on September 1, 1994. Shore was operating and licensed at their present location on September 1, 1994, thereby allowing them to operate within a ½ mile of a school or public park at their current location, but at no other location. The restriction that firearms dealers must have obtained a Village firearms license by October 15, 1994 and be more than a ½ mile from a school or public park, effectively prevents any firearms dealer from operating in the community, except for the current grandfathering of Shore at their current location. The relevant existing Code language is as follows:

> It shall be unlawful for any person licensed as a firearms dealer pursuant to federal law to engage in the business of dealing in firearms at an address within the corporate limits of the village without having applied for or obtained a village firearms license pursuant to this article by October 15, 1994.
>
> *And*
>
> The Chief shall not issue a Village firearms license to any person who is engaged in the business of dealing in firearms or any other activity requiring a federal firearms dealer's license, or indicates an intention to do so, within 1/2 mile of the grounds of a school or public park measured from the property lines of the respective properties, unless the licensee was operating the business on September 1, 1994, at this location

In discussing this matter with Shore, Shore is supportive of modifying the language of the Code sections so that it only allows for their relocation within the Village and which would still retain the current restriction/prohibition on any other firearms dealers from operating in the Village.

Zoning Code

In addition to a change in the Municipal Code, a text amendment to the Zoning Code would also be needed to allow for Shore to relocate. The Zoning Code does not currently contain a land use classification related to firearms dealers, gun shops or shooting ranges and therefore this use is not currently allowed by the Zoning Code in the Village (Shore Gallery is considered a legal nonconforming use at its present location). To allow for this use, a text amendment to the Zoning Code would be required along with the establishment of a parking requirement for this use.

If the Village Board is favorable to allowing for the relocation of Shore Gallery, staff would recommend that this use be added to the Zoning Code as a Special Use within the Village's M-B Light Manufacturing Business District. A minimum parking standard would also be needed as well. Shore's desired relocation to 6950 Central Park is within the M-B zone and Shore supports the use being classified as a Special Use. Requests for Special Uses require notice and a public hearing before the Plan Commission.

Attached is a rough sketch of how Shore Gallery contemplates utilizing the 30,000 square foot building located at 6950 Central Park. A zoning analysis has not yet occurred and it is possible that certain zoning variations may also be needed, such as for parking.

Direction Sought

The threshold question on this matter for the Village Board is whether the Village Board is supportive of modifying the Municipal Code to allow at minimum for the relocation of Shore Gallery. If the Village Board is not interested in such a change in the Municipal Code concerning firearms dealers, then Shore Gallery can not relocate within Lincolnwood and a text amendment to the Zoning Code becomes moot.

If the Village Board is supportive of a change in the Municipal Code that would allow for Shore to relocate; then a text amendment to the Zoning Code would be needed and

direction is desired on whether the Village Board desires the use to be a Special Use only in the MB Zoning District.

Should the Village Board be supportive of needed changes for Shore, a referral by the Village Board of a Zoning Code text amendment would be placed on the Village Board's April 16 agenda and a change to the Municipal Code would be considered, consistent with any direction given, at the time the Plan Commission recommendation on the text amendment is scheduled for Village Board consideration.

Representatives of Shore Gallery are expected to be present for this discussion at the Committee of the Whole.

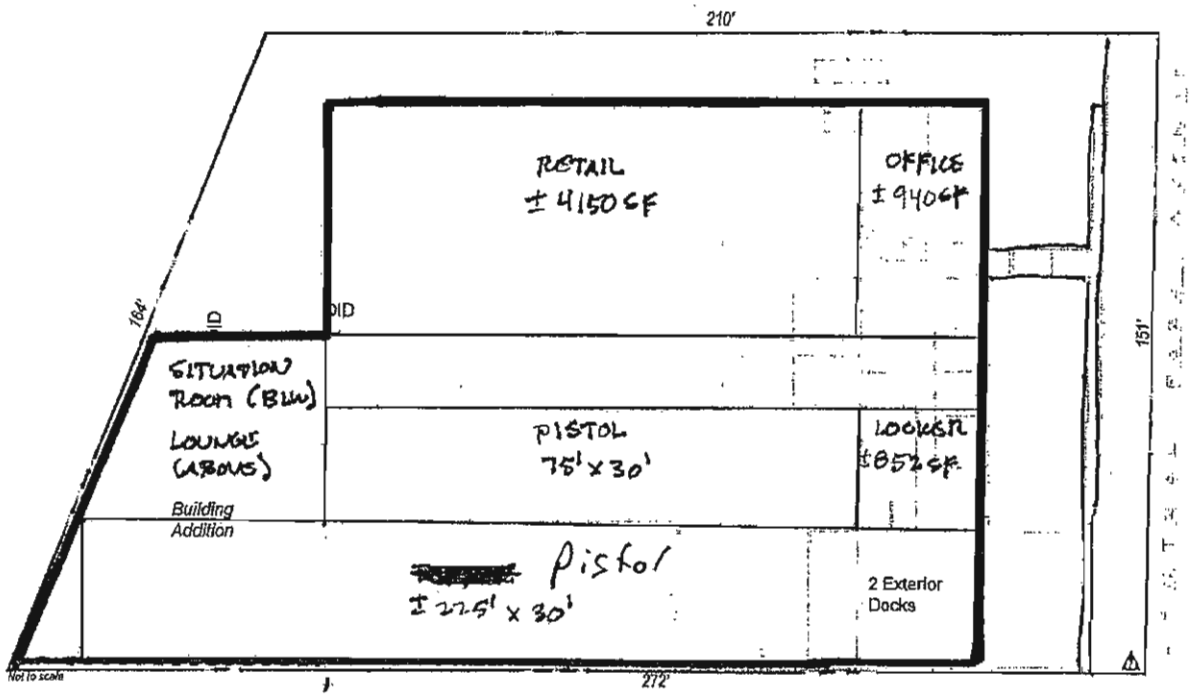
Attachment

6950 Central Park Sketch

6950 N. Central Park

Lincolnwood, Illinois

30,000 SF Available for Sale or Lease





NORTH





Newmark Knight Frank

Epic

Denise Stein Chalmovitz 847.588.5683 denise@newmarkkfe.com

VILLAGE OF LINCOLNWOOD Public Hearing Application

Community Development Department Application Supplement

On behalf of the applicant, we would like to submit the following supplemental documentation in response to the following:

1. Questions forwarded to us by Village Staff
2. Questions raised by our neighbor
3. Questions raised by concerned residents of Lincolnwood

We certainly appreciate the thoughts and questions raised by each group. We have considered each of these prior to and subsequently to insure that we are looking and evaluating all aspects of the proposed project. In summary, we believe there are four prevailing items that we can provide further insight and clarification. They are:

1. Level of noise produced by the ranges
2. Safety
3. Parking
4. Economic Impact

With regard to each of the items, we have retained expert consultants, studied various ranges from around Cook County, as well as Lake County, compiled further data, and sought the feedback from our neighbors as well as residents in the community.

First and foremost, per the request of the Trustees, we have included Mitch Shore's curriculum vitae. Please note his extensive qualifications as an authority in his field which leads credence to Shore Galleries impeccable track record within the community since 1956.

For each of the above mentioned items, we shall briefly convey the documents to be found in the attached addendums.

1. Sound - Spinnaker, a nationally recognized acoustical engineering firm, was retained to model the proposed construction of the ranges. The attached report confirms the range's construction technique will out perform the Village's LM District's noise regulations. In summary, eight simultaneously shots will produce the equivalent of a quiet whisper in a library from 6'-0" in our neighbor's space. On the roof the construction technique will transmit the equivalent of less than a normal conversation at 3'-0". In summary, the construction technique of the building is outstanding, and it will be extremely difficult to hear any noise from the building.

2. Safety - Action Target has been retained to fabricate and install the range. They have performed their work all over the world and throughout the Chicagoland area. Their reputation and craftsmanship is of the highest quality. They have had no reported incidents of bullets exiting their ranges. The ranges are being built in accordance with the highest standards of safety and in full compliance with all codes with respect to building and ventilation. The air will be cleaner exiting the filtration system than the air we breathe. The LM district is a more ideal location for this use compared to the existing retail. The proposed site is further away from community parks, homes, and retail. In the 1980's, the Village

of Lincolnwood approved Shore Galleries to install a range at their existing location. In 1997, Lincolnwood residents requested Shore Galleries to re-located to the to the commercial district.

The proposed bike path along the rear property line will be a wonderful improvement to the community. Nevertheless, the proposed use of 6950 N. Central Park will not create an unsafe environment for the bicycle commuters. Consider Bass Pro Shop in Gurnee. They have a range in their store. The store is a part of the Gurnee Mills Mall. On average, the Mall has over 23,000,000 shoppers annually in direct vicinity of their range. There has been zero incidents at that location. The operators of their range do not have the credentials of Mitch Shore. Last, The Village of Lincolnwood Police Chief endorses the proposed use.

3. Parking - The Village Staff has made a positive recommendation to the Plan Commission regarding the use and proposed parking plan based upon the facts and the existing conditions. The Plan Commission made a 5-1 positive recommendation for the plan. At Shore Gallery's existing location there are only 2 spaces on the public easement for all of their customers and four employees. If all 16 range positions are being utilized at the exact same time, and assuming they all drive separately, the site will have enough parking spaces to accommodate all of the users, all of Shore's employees (including the new position of range master), and 4 retail consumers. During normal consumer hours, having 4 customers at the same time is incredibly rare. The proposed plan is more than adequate for normal daily operation.

4. Economic Impact - Approving the proposed plan preserves a long established relationship between Shore Galleries and the Village. It also maintains a business in the LM district which currently has (1) REO property, (2) vacant parcels, and (3) properties for sale. Most significantly, it provides the Village with a new source of income and revenue based upon licenses and use.

In summary, we appreciate the Trustees review and consideration of the facts provided hereinafter. As we previously stated, we understand and welcome all questions that have been brought forth. The enclosed facts are vital to understanding the answers to the questions.

Sincerely,

Platform I - Shore, LLC

Steve Siegel
Manager

Shore Gallery

Mitch Shore
President

3318 West Devon Avenue
Lincolnwood, IL. 60712

Phone 847-676-2900
Fax 847-675-6060
E-mail mitch@shoregalleries.com

Mitchell H. Shore

- **Occupation**
  - President. Shore Galleries, Inc.
  - Auctioneer and Appraiser, Shore Galleries, Inc., since 1976
  - Police Officer/Range Master Village of Riverwoods since 2002
- **Organization Memberships**
  - Appraisers Association of America, Inc.
  - National Auctioneers Association
  - National Rifle Association, Certified Basic Firearms Education Instructor in Home Firearms Safety, Personal Protection, Rifle, Pistol, Shotgun and Law Enforcement
  - Ohio Gun Collectors Association, Life Member
  - Midwest Gang Investigators
  - Illinois Tactical Officers Association
  - Association of SWAT Personnel of Wisconsin
  - International Association of Law Enforcement Firearms Instructors
  - Scottish Rite Mason 32°
  - Medinah Shrine
  - International Law Enforcement Education Training Association Member
- **Associated Training**
  - Attended over 100 hours of basic and advanced firearms training and other associated classes sponsored by the FBI and NEMRT
  - Competes in IDPA and IPSC pistol competitions
  - Range Officer for Illinois Tactical Officer's Association pistol and carbine FTX training exercises
  - Member of North Suburban Police Pistol League
- **Training Certifications**
  - FBI Firearms Instructor; Basic and Advanced
  - FBI Tactical Shotgun
  - Illinois Department of Professional Regulation Instructor for 20 hour Firearm Training Course
  - Sigarms Advanced Shooting Techniques

- State of Illinois Rifle/Carbine Instructor
- Monadnock Expandable Baton Instructor
- MSI. Instructor; Aerosol Instructor
- NEMRT Firearms Instructor

I have been active in Shore Galleries, Inc. since 1976. For the past 25 years. have been responsible for supervising its retail and wholesale operation and developed a large police and law enforcement supply business.

I am a Certified Armorer for Beretta Firearms, Mossberg Firearms, Ruger Firearms. Remington Firearms and Sig Sauer Firearms.

Completed appraisals on arms and armor for estates, courts, individuals and organizations. Appraisals are fully accepted by Insurance Agencies & Courts

Conducted auction sales for estates, courts, individuals and organizations.

Firearms consultant for local police agencies.

Expert witness. Testified in Federal and State Courts for various government agencies.

- Education
  - Northern Illinois University, BS Business Administration

VILLAGE OF LINCOLNWOOD
Community Development Department

Public Hearing Application
Application Supplement

Time Line

Cook County Ranges

VILLAGE OF LINCOLNWOOD
SHORE GALLERY TIME LINE

Date	Event
3.21.12	Steve Siegel and Scott Krone meet with the Village to discuss the concept of Shore Galleries relocating, and what the expected procedures would be.
4.3.12	Village of Lincolnwood Trustee Committee of the Whole Meeting - Discussed the proposed concept with the Trustees, and mechanics of the application with Staff.
4.13.12	Submitted to Staff application for Special Use, Text Amendment, and Zoning application.
4.17.12	Village Council Meeting to approve the application to commence - approved on the consent agenda.
5.15.12	Village of Lincolnwood installs notification sign at 6950 N. Central Park for a Public Hearing.
5.16.12	Village of Lincolnwood mails public notices*.
5.17.12	Mitch Shore begins contacting neighbors to introduce himself and explain his business.
6.6.12	Village of Lincolnwood Plan Commission Hearing to review Special Use, Text Amendment, and Zoning. Plan Commission votes in favor 5-1 for positive recommendation to Village Council.
7.17.12	Village of Lincolnwood Village Trustee to review project and Plan Commission's findings.

*Notification List provided by Village Staff

6950 Central Park Ave	10-35-107-002-0000	Resillo Press Pad Co
3700 Morse Ave	10-35-126-042-0000	Highland Baking
3665 Lunt Ave	10-35-126-041-0000	Highland Baking
3708 Morse Ave	10-35-126-042-0000	Highland Baking
3659 Lunt Ave	10-35-126-041-0000	Highland Baking
6994 Central Park Ave	10-35-135-002-0000	Econocare
3550 Pratt Ave	10-35-203-007-0000	Surbco Limited Partner
6950 Central Park Ave	10-35-135-008-0000	Leo Pearl
6900 Central Park Ave	10-35-135-006-0000	Michael J Shapino
6980 Central Park Ave	10-35-135-007-0000	Mpm Enterprises LLC
6970 Central Park Ave	10-35-135-007-0000	Mpm Enterprises LLC
6990 Central Park Ave	10-35-135-002-0000	Econocare
3701 Lunt Ave	10-35-126-035-0000	Larry Bowman

VILLAGE OF LINCOLNWOOD
Community Development Department

Public Hearing Application
Application Supplement

Acoustical Study and Report

Acoustical Feasibility Study:

Shore Galleries
6950 N. Central Park Avenue
Lincolnwood, IL

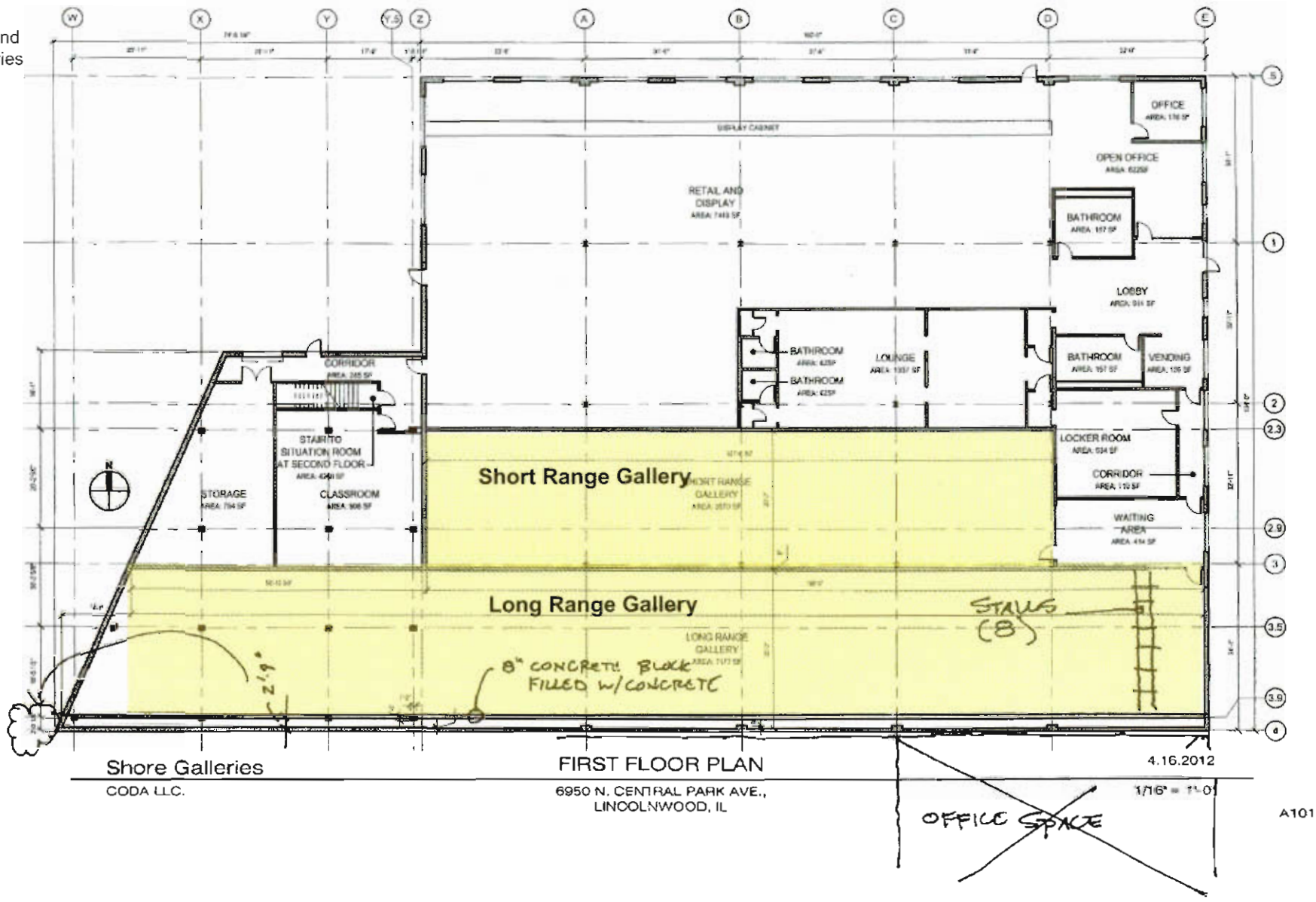
Prepared by:
Spinnaker

Software:
AFMG – Sound Flow
Sound Absorption and Transmission Loss Simulator

July 7, 2012

Background: Shore Galleries is proposing a shooting range at 6950 N. Central Park Avenue consisting of (2) firing galleries: (1) long and (1) short range, Fig. 1. This evaluation simulated sound generated from within the range, through walls and ceiling, and its impact on an adjacent office/workshop and on other property.

Fig. 1 – Long and short range galleries



Neighbor: An adjacent office/workshop is occupied by Ravenswood Studio, Fig. 2. Shore Galleries and Ravenswood Studio will share a wall of approximately 160' (— · —). This study evaluates noise impact to Ravenswood Studio through the adjoining wall and ceiling.

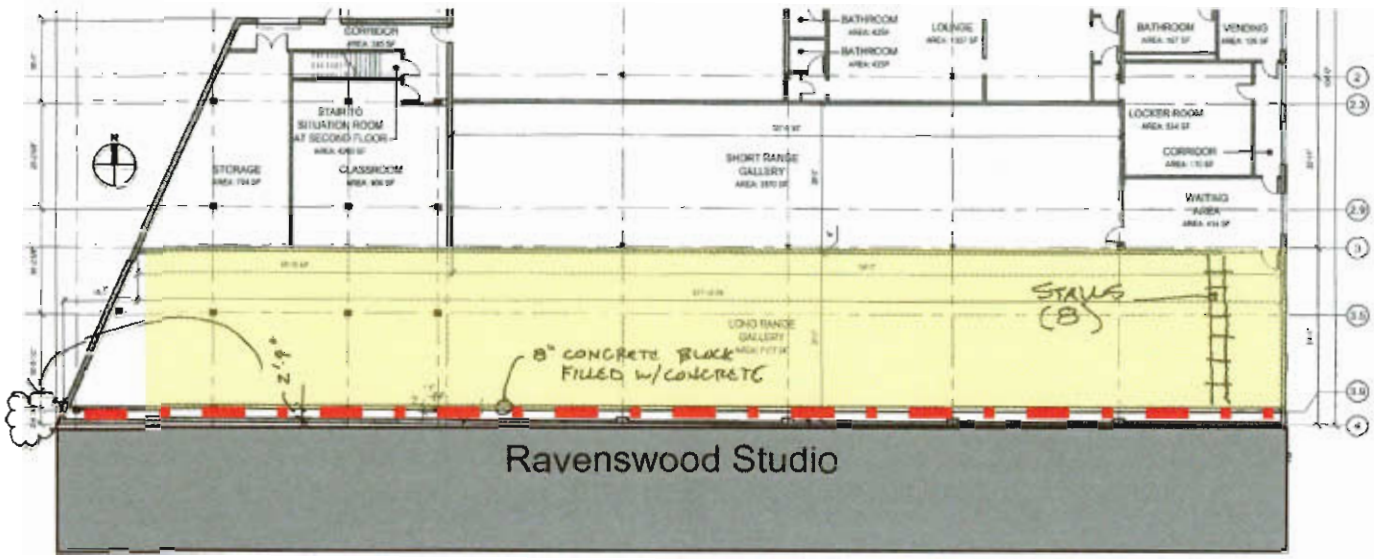


Fig. 2 - Ravenswood office/workshop





Code Sound Level Limits: For the Village of Lincolnwood, sound level limits are set for in Chapter 15. Zoning, Article VI Site Development Standards, Part E. Environmental and Performance Standards, 6.20. Noise and Vibration states:

(1) No land use or other activity within the Village shall be conducted in such a manner that it generates a level of sound on another property greater than that allowed under the Noise Regulations of the State of Illinois, adopted by the State Pollution Control Board pursuant to the Environmental Protection Act, 415 ILCS 5/1 et seq., as amended, and appearing in Title 35, Subtitle H, of the Illinois Administrative Code, as amended.

(2) In addition to the standards set forth above, no land use or other activity within the Village, other than those specified in Subsection 6.20(3) below, shall be conducted in such a manner that it generates a level of sound on another property which is greater than the sound level set forth in Table 6.20.01.

(3) Sound levels shall be measured with a sound level meter manufactured according to the standards prescribed by the American National Standards Institute or its successor body.

Table 6.20.01

A-Weighted Sound Level Limits

District Classification	Time of Day	Maximum A-Weighted Sound Level db(A)
Monday to Friday		
Residential districts	7:00 a.m. to 6:00 p.m.	50
	6:00 p.m. to 7:00 a.m.	45
All others	7:00 a.m. to 11:00 p.m.	60
	11:00 p.m. to 7:00 a.m.	55
Saturday to Sunday		
Residential districts	7:00 a.m. to 12:00 p.m.	50
All others	7:00 a.m. to 11:00 p.m.	60

Source Noise – Reference noise data for (1) weapon was obtained from an acoustical evaluation at Misawa Air Base, report attached. This study simulated a worst case scenario; (8) M4 semi-automatic firing (3) round bursts using 5.63mm rounds. Given a semi-automatic weapon creates noise in rapid succession compared to a single shot weapon, the data represents a longer more sustained noise level than expected at Shore Galleries. A margin of error is allowed by calculating the total SPL expected based on (8) firearms being discharged simultaneously in 3 round bursts.

(1) Weapon Noise Data = 140dB SPL (A)

Frequency	Source dB LIN (Example)	Source dB (A)
125	117	100.8101489
160	123	109.7554755
200	125	114.1527483
250	127	118.3249777
315	130	123.3560378
400	132	127.2259196
500	133	129.7520082
630	133	131.0913719
800	132	131.2052314
1000	132	132
1250	132	132.5761762
1600	130	130.9930921
2000	129	130.2016993
4000	126	126.9642292
	dB SPL (LIN)	dB SPL (A)
Single Number Reference	141.6404317	140.2511776

(5) Weapons Noise Data = 147dB SPL (A)

	Source dB LIN (Example)	Source dB (A)
125	123.98	107.7901489
160	129.98	116.7354755
200	131.98	121.1327483
250	133.98	125.3049777
315	136.532	129.8880378
400	138.98	134.2059196
500	139.98	136.7320082
630	139.98	138.0713719
800	138.98	138.1852314
1000	138.98	138.98
1250	138.98	139.5561762
1600	136.98	137.9730921
2000	135.98	137.1816993
4000	132.98	133.9442292
	dB SPL (LIN)	dB SPL (A)
Single Number Reference	148.5911571	147.2224681

(8) Weapons Noise Data = 149dB SPL (A)

Frequency	Source dB LIN (Example)	Source dB (A)
125	126.0308999	109.8410488
160	132.0308999	118.7863753
200	134.0308999	123.1836482
250	136.0308999	127.3558776
315	139.0308999	132.3869376
400	141.0308999	136.2568194
500	142.0308999	138.7829081
630	142.0308999	140.1222718
800	141.0308999	140.2361313
1000	141.0308999	141.0308999
1250	141.0308999	141.6070761
1600	139.0308999	140.023992
2000	138.0308999	139.2325992
4000	135.0308999	135.995129
	dB SPL (LIN)	dB SPL (A)
Single Number Reference	150.6713316	149.2820774

Evaluation of Proposed Wall adjoining Ravenswood Studio and Shore Galleries

The proposed wall construction method shown in Fig. 3 spans approximately 160'.

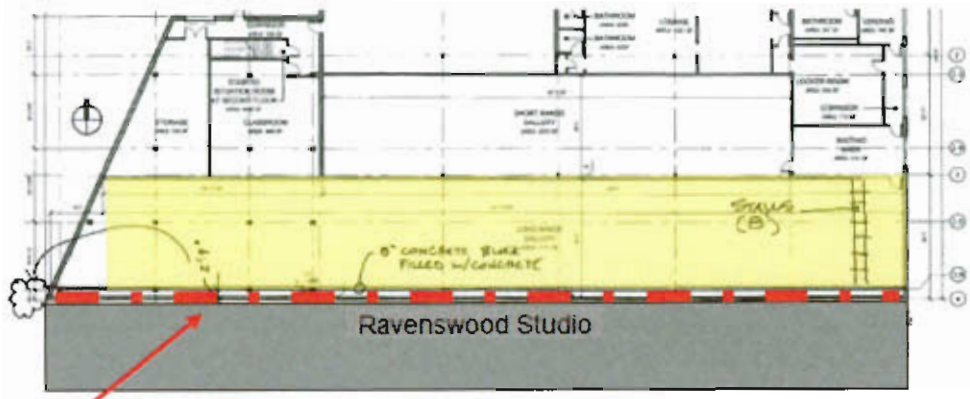
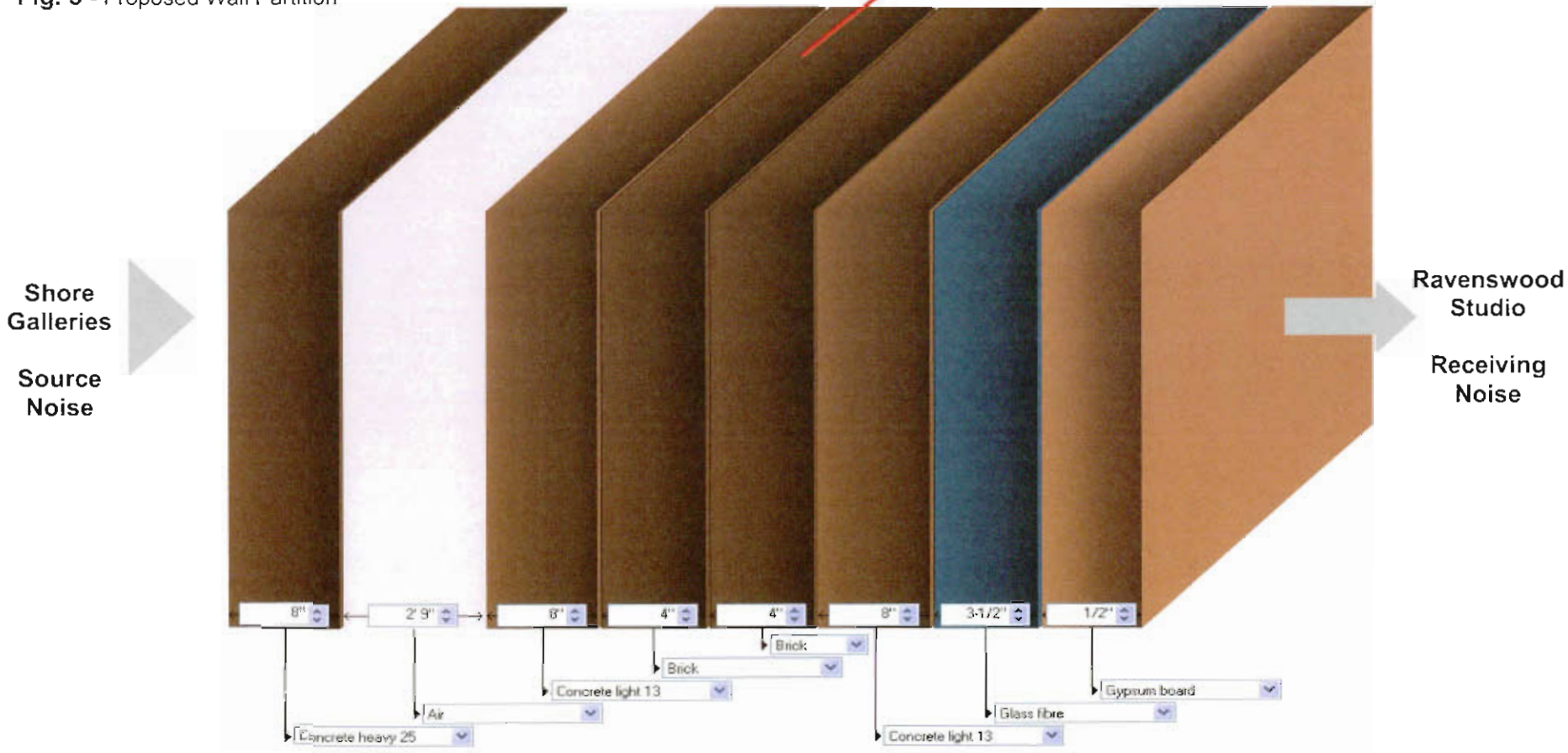


Fig. 3 - Proposed Wall Partition



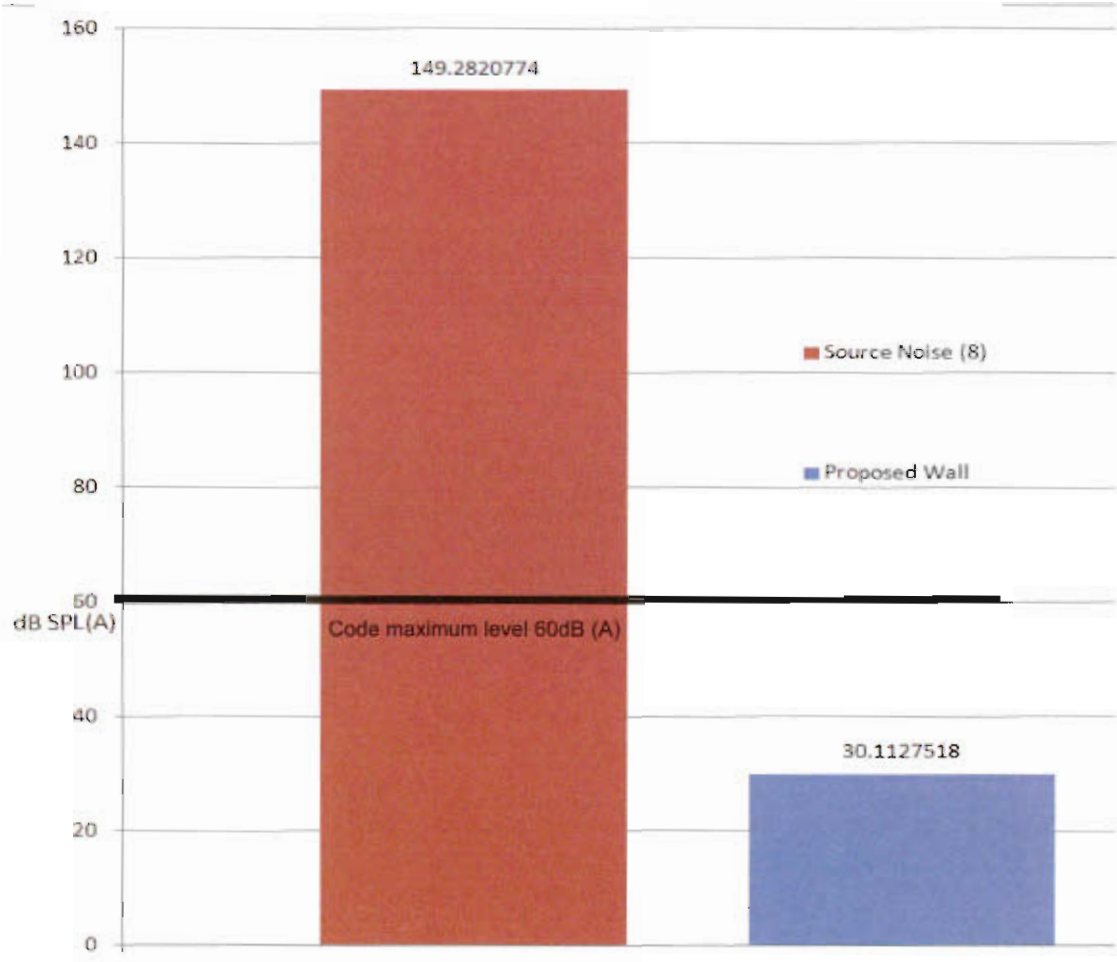
Evaluation of Proposed Wall adjoining Ravenswood Studio and Shore Galleries (continued)

Fig. 4 estimates the proposed wall Sound Transmission Class at 105. Fig. 5 charts the source noise of (8) weapons at 149dB SPL (A) and the estimated noise through the proposed wall at **30dB SPL (A).** ***The proposed wall passes the Code maximum noise level of 60dB SPL (A)***

Fig. 4 - Proposed Wall Partition STC 105

Octave band	Transmission Loss (TL)	Reference Contour (E413-04)	Adjusted Reference Contour
125	81	-16	89
160	98	-13	92
200	117	-10	95
250	99	-7	98
315	137	-4	101
400	148	-1	104
500	136	0	105
630	161	1	106
800	180	2	107
1000	191	3	108
1250	186	4	109
1600	206	4	109
2000	220	4	109
4000	234	4	109
	Sound Transmission Class		
	105		

Fig. 5 – Estimated Noise level through the proposed wall



Evaluation of Proposed Wall adjoining Ravenswood Studio and Shore Galleries (continued)

Fig. 6 calculations estimate the proposed wall Sound Transmission Class at 105, and the estimated noise level of (8) weapons through the proposed wall at **30dB SPL (A).** ***The proposed wall passes the Code maximum noise level of 60dB SPL (A)***

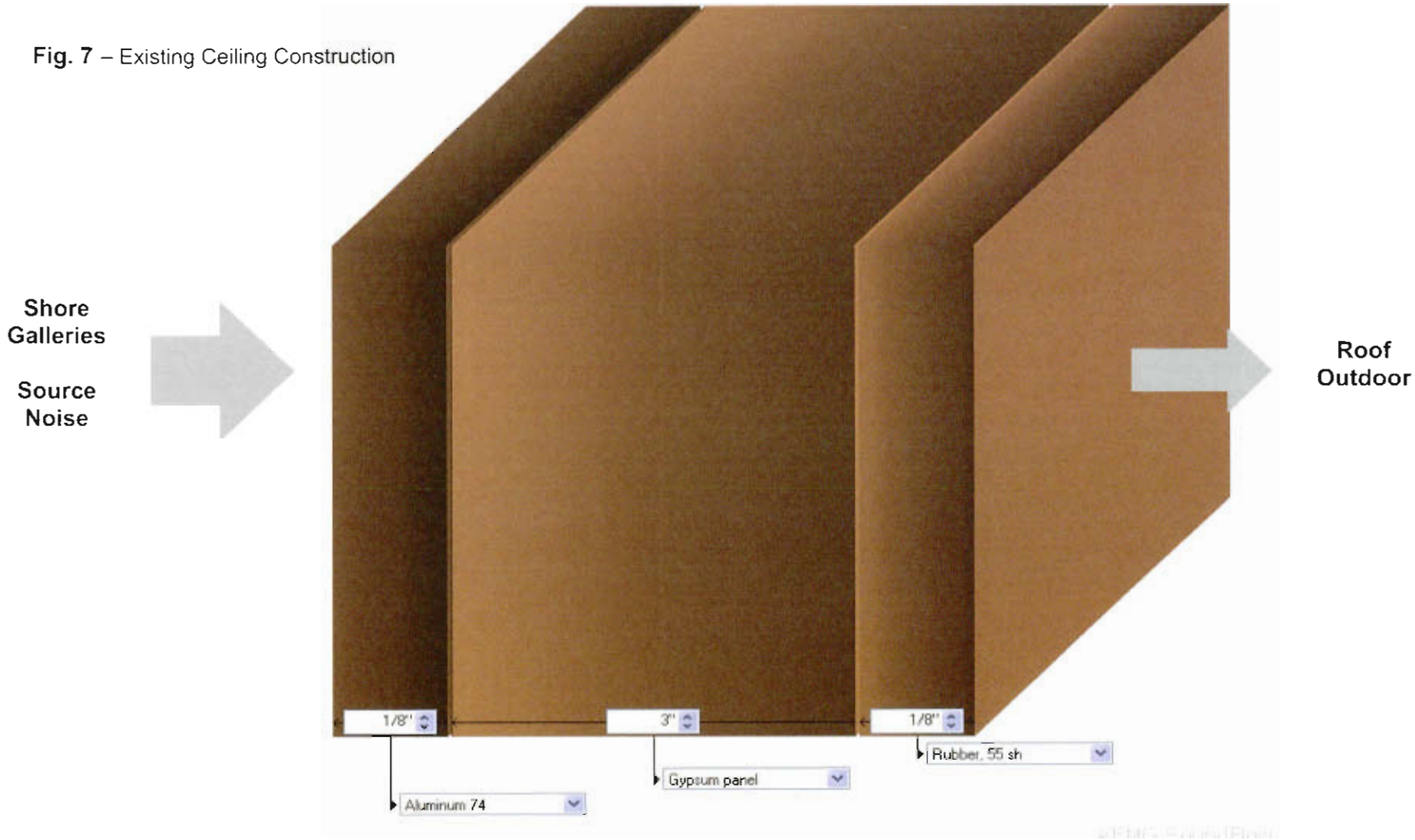
Fig. 6 – Sound Level at adjoining wall 30db (A)

Octave band	Transmission Loss (TL)	Reference Contour (E413-04)	Adjusted Reference Contour	Contour Adjust	Difference	Difference	SPL Result (LIN) (LIN - TL = LIN)	SPL Result (A)
125	81	-16	89	105	-8	-8	45	29.28304881
160	98	-13	92		6	0	34	17.80104881
200	117	-10	95		22	0	17	0.891048808
250	99	-7	98		1	0	37	20.67604881
315	137	-4	101		36	0	2	-13.94895119
400	148	-1	104		44	0	-7	-22.71895119
500	136	0	105		31	0	6	-10.36895119
630	161	1	106		55	0	-19	-35.21895119
800	180	2	107		73	0	-39	-55.58195119
1000	191	3	108		83	0	-50	-66.09895119
1250	186	4	109		77	0	-45	-61.09695119
1600	206	4	109		97	0	-67	-83.29295119
2000	220	4	109		111	0	-81	-97.68895119
4000	234	4	109		125	0	-99	-115.0879512
	Sound Transmission Class						Estimated dB SPL (LIN) at receiving location	Estimated dB SPL (A) at receiving location
	105					-8	46.30260286	30.1127518

Evaluation of Existing Ceiling Structure in Shore Galleries

Fig. 7, a sample of the existing roof structure was evaluated as 1/8" Steel Roof Deck, 3" gyp-crete and 1/8" rubber membrane. Rooftop noise levels were evaluated to assess the impact on other property.

Fig. 7 – Existing Ceiling Construction



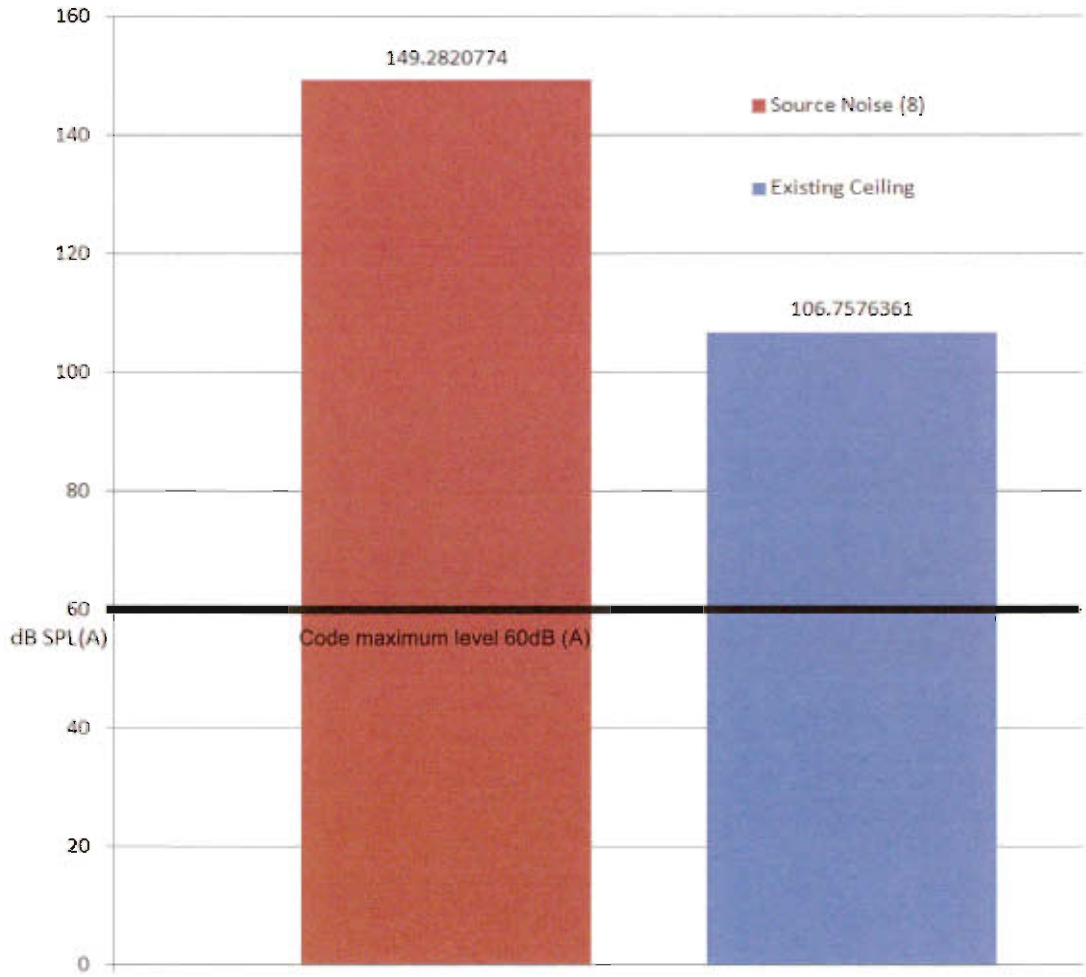
Evaluation of Existing Ceiling Structure in Shore Galleries (continued)

Fig. 8 estimates the Sound Transmission Class for the existing ceiling structure at 29. Fig. 9 charts the noise level of (8) weapons at 149db SPL (A) and the estimated noise level on the rooftop at **106dB SPL (A).** ***The existing ceiling fails the Code maximum noise level of 60db SPL (A).***

Fig. 8 – Existing Ceiling STC 29

Octave band	Transmission Loss (TL) Existing Ceiling	Reference Contour (E413-04)	Adjusted Reference Contour
125	31	-16	13
160	33	-13	16
200	34	-10	19
250	35	-7	22
315	35	-4	25
400	31	-1	28
500	21	0	29
630	28	1	30
800	27	2	31
1000	40	3	32
1250	40	4	33
1600	46	4	33
2000	38	4	33
4000	63	4	33
	Sound Transmission Class		
	29		

Fig. 9 – Estimated Noise level through existing ceiling **106 dB SPL (A)**



Evaluation of Existing Ceiling Structure in Shore Galleries (continued)

Fig. 10 calculations estimate the existing ceilings Sound Transmission Class at 29, and the estimated noise level noise level of (8) weapons on the rooftop at **106dB SPL (A).** ***The existing ceiling fails the Code maximum noise level of 60db SPL (A).***

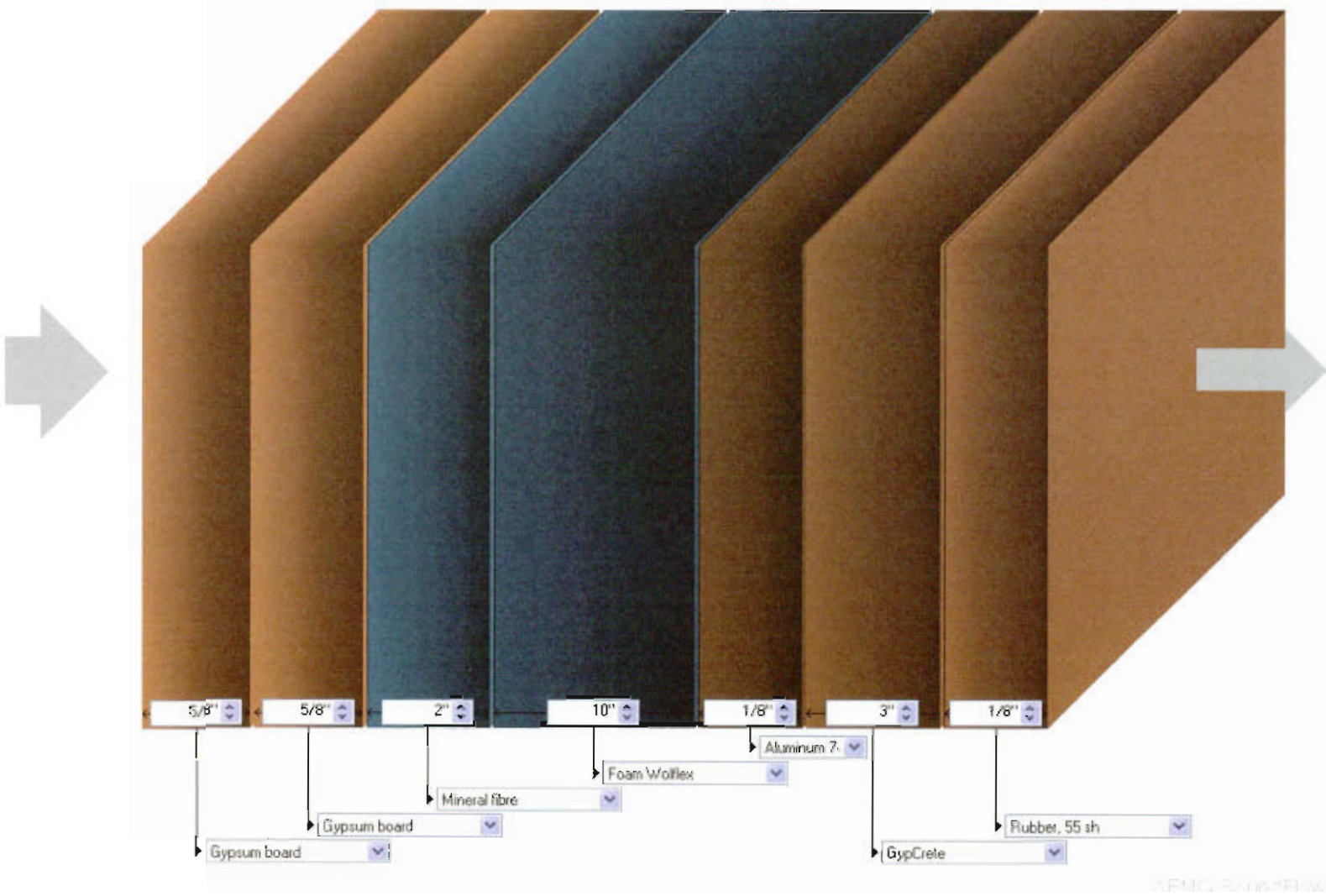
Fig. 10 – Estimated Noise level through existing ceiling **106 db (A)**

Octave band	Transmission Loss (TL) Existing Ceiling	Reference Contour (E413-04)	Adjusted Reference Contour	Contour Adjust	Difference	Difference	SPL Result (LIN)	SPL Result (A)
125	31	-16	13	29	18	0	95	78.84104881
160	33	-13	16		17	0	99	82.84104881
200	34	-10	19		15	0	100	83.84104881
250	35	-7	22		13	0	101	84.84104881
315	35	-4	25		10	0	104	87.84104881
400	31	-1	28		3	0	110	93.84104881
500	21	0	29		-8	-8	121	104.8410488
630	28	1	30		-2	-2	114	97.84104881
800	27	2	31		-4	-4	114	97.84104881
1000	40	3	32		8	0	101	84.84104881
1250	40	4	33		7	0	101	84.84104881
1600	46	4	33		13	0	93	76.84104881
2000	38	4	33		5	0	100	83.84104881
4000	63	4	33		30	0	72	55.84104881
	Sound Transmission Class						Estimated dB SPL (LIN) at receiving location	Estimated dB SPL (A) at receiving location
	29					-14	122.9474871	106.7576361

Evaluation of Proposed Ceiling Structure in Shore Galleries

Fig. 11, a sample of the proposed ceiling was evaluated as (2) 5/8" gypsum boards, 2" Mineral Fiber, 10" Foam Wolfex, 1/8" Steel Roof Deck, 3" GypCrete, and 1/8" Rubber Roof.

Fig. 11 – Proposed Ceiling Construction



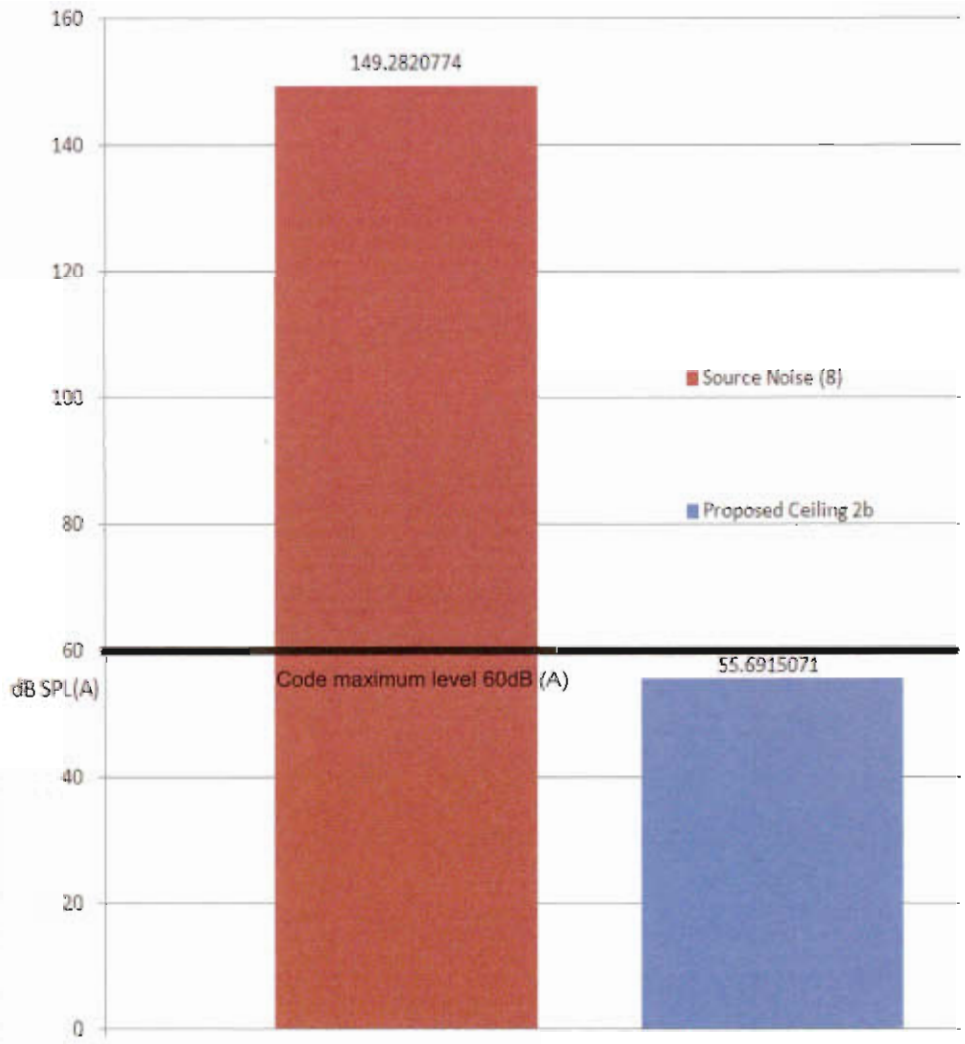
Evaluation of Proposed Ceiling Structure in Shore Galleries (continued)

Fig. 12 estimates the proposed ceilings Sound Transmission Class at 80. Fig. 13 charts the source noise level of (8) weapons at 149dB (A) and the estimated noise level on the rooftop at **55db (A).** ***The proposed ceiling passes the Code maximum noise level of 60dB (A).***

Fig.12 – Proposed Ceiling STC 80

Octave band	Transmission Loss (TL) Ceiling 2b	Reference Contour (E413-04)	Adjusted Reference Contour
125	56	-16	64
160	65	-13	67
200	74	-10	70
250	83	-7	73
315	92	-4	76
400	100	-1	79
500	104	0	80
630	102	1	81
800	120	2	82
1000	134	3	83
1250	138	4	84
1600	159	4	84
2000	172	4	84
4000	212	4	84
	Sound Transmission Class		
	80		

Fig.13 – Estimated Noise level through Proposed Ceiling **55db** (A)



Evaluation of Proposed Ceiling Structure in Shore Galleries (continued)

Fig. 14 calculations estimate the existing ceilings Sound Transmission Class at 80 and the estimated noise level of (8) weapons on the rooftop at **55dB (A).** ***The proposed ceiling passes the Code maximum noise level of 60dB (A).***

Fig.14 – Estimated Noise level through Proposed Ceiling **55db** (A)

Octave band	Transmission Loss (TL) Ceiling 2b	Reference Contour (E413-04)	Adjusted Reference Contour	Contour Adjust	Difference	Difference	SPL Result (LIN) (LIN - TL = LIN)	SPL Result (A)
125	56	-16	64	80	-8	-8	70	53.39404881
160	65	-13	67		-2	-2	67	50.84104881
200	74	-10	70		4	0	60	43.84104881
250	83	-7	73		10	0	53	36.84104881
315	92	-4	76		16	0	47	30.84104881
400	100	-1	79		21	0	41	24.84104881
500	104	0	80		24	0	38	21.84104881
630	102	1	81		21	0	40	23.84104881
800	120	2	82		38	0	21	4.841048808
1000	134	3	83		51	0	7	-9.158951192
1250	138	4	84		54	0	3	-13.15895119
1600	159	4	84		75	0	-20	-36.15895119
2000	172	4	84		88	0	-34	-50.15895119
4000	212	4	84		128	0	-77	-93.15895119
	Sound Transmission Class						Estimated dBSPL (LIN) at receiving location	Estimated dBSPL (A) at receiving location
	80					-10	71.88135816	55.6915071

CODA / Shore Galleries Shooting Range
Proposed Wall Estimates

Noise Data - M4 Semi Automatic/ 3 Round Burst / 5.64mm Round

NR of Proposed Wall 1 - STC=105 (1 Source)

Frequency	Source dB LIN (Example)	Source dB (A)	Octave band	Transmission Loss (TL)	Reference Contour (E413-04)	Adjusted Reference Contour	Contour Adjust	Difference	Difference	SPL Result (LIN) (LIN - TL = LIN)	SPL Result (A)
125	117	100.8101489	125	81	-16	89	105	-8	-8	36	20.25214894
160	123	109.7554755	160	98	-13	92		6	0	25	8.770148938
200	125	114.1527483	200	117	-10	95		22	0	8	-8.139851062
250	127	118.3249777	250	99	-7	98		1	0	28	11.64514894
315	130	123.3560378	315	137	-4	101		36	0	-7	-22.97985106
400	132	127.2259196	400	148	-1	104		44	0	-16	-31.74985106
500	133	129.7520082	500	136	0	105		31	0	-3	-19.39985106
630	133	131.0913719	630	161	1	106		55	0	-28	-44.24985106
800	132	131.2052314	800	180	2	107		73	0	-48	-64.61285106
1000	132	132	1000	191	3	108		83	0	-59	-75.12985106
1250	132	132.5761762	1250	186	4	109		77	0	-54	-70.12785106
1600	130	130.9930921	1600	206	4	109		97	0	-76	-92.32385106
2000	129	130.2016993	2000	220	4	109		111	0	-91	-106.7198511
4000	126	126.9642292	4000	234	4	109		125	0	-108	-124.1188511
	dB SPL (LIN)	dB SPL (A)		Sound Transmission Class						Estimated dB SPL (LIN) at receiving location	Estimated dB SPL (A) at receiving location
Single Number Reference	141.6404317	140.2511776		105					-8	37.27170299	21.08185193

NR of Proposed Wall 1 - STC=105 (5 Sources)

Frequency	Source dB LIN (Example)	Source dB (A)	Octave band	Transmission Loss (TL)	Reference Contour (E413-04)	Adjusted Reference Contour	Contour Adjust	Difference	Difference	SPL Result (LIN) (LIN - TL = LIN)	SPL Result (A)
125	123.98	107.7901489	125	81	-16	89	105	-8	-8	43	27.23214894
160	129.98	116.7354755	160	98	-13	92		6	0	32	15.75014894
200	131.98	121.1327483	200	117	-10	95		22	0	15	4.160851062
250	133.98	125.3049777	250	99	-7	98		1	0	35	18.62514894
315	136.532	129.8880378	315	137	-4	101		36	0	0	-16.44785106
400	138.98	134.2059196	400	148	-1	104		44	0	-9	-24.76985106
500	139.98	136.7320082	500	136	0	105		31	0	4	-12.41985106
630	139.98	138.0713719	630	161	1	106		55	0	-21	-37.26985106
800	138.98	138.1852314	800	180	2	107		73	0	-41	-57.63285106
1000	138.98	138.98	1000	191	3	108		83	0	-52	-68.14985106
1250	138.98	139.5561762	1250	186	4	109		77	0	-47	-63.14785106
1600	136.98	137.9730921	1600	206	4	109		97	0	-69	-85.34385106
2000	135.98	137.1816993	2000	220	4	109		111	0	-84	-99.73985106
4000	132.98	133.9442292	4000	234	4	109		125	0	-101	-117.1388511
	dB SPL (LIN)	dB SPL (A)		Sound Transmission Class						Estimated dB SPL (LIN) at receiving location	Estimated dB SPL (A) at receiving location
Single Number Reference	148.5911571	147.2224681		105					-8	44.25168629	28.06183522

NR of Proposed Wall 1 - STC=105 (8 Sources)

Frequency	Source dB LIN (Example)	Source dB (A)	Octave band	Transmission Loss (TL)	Reference Contour (E413-04)	Adjusted Reference Contour	Contour Adjust	Difference	Difference	SPL Result (LIN) (LIN - TL = LIN)	SPL Result (A)
125	126.0308999	109.8410488	125	81	-16	89	105	-8	-8	45	29.28304881
160	132.0308999	118.7863753	160	98	-13	92		6	0	34	17.80104881
200	134.0308999	123.1836482	200	117	-10	95		22	0	17	0.891048808
250	136.0308999	127.3558776	250	99	-7	98		1	0	37	20.67604881
315	139.0308999	132.3869376	315	137	-4	101		36	0	2	-13.94895119
400	141.0308999	136.2568194	400	148	-1	104		44	0	-7	-22.71895119
500	142.0308999	138.7829081	500	136	0	105		31	0	6	-10.36895119
630	142.0308999	140.1222718	630	161	1	106		55	0	-19	-35.21895119
800	141.0308999	140.2361313	800	180	2	107		73	0	-39	-55.58195119
1000	141.0308999	141.0308999	1000	191	3	108		83	0	-50	-66.09895119
1250	141.0308999	141.6070761	1250	186	4	109		77	0	-45	-61.09695119
1600	139.0308999	140.023992	1600	206	4	109		97	0	-67	-83.29295119
2000	138.0308999	139.2325993	2000	220	4	109		111	0	-81	-97.68895119
4000	135.0308999	135.995129	4000	234	4	109		125	0	-99	-115.0879512
	dB SPL (LIN)	dB SPL (A)		Sound Transmission Class						Estimated dB SPL (LIN) at receiving location	Estimated dB SPL (A) at receiving location

Noise Data - M4 Semi Automatic/ 3 Round Burst / 5.64mm Round

NR of Existing Ceiling 1 - STC=29 (1 Source)

	Source dB LIN (Example)	Source dB (A)	Octave band	Transmission Loss (TL) Existing Ceiling	Reference Contour (E413-04)	Adjusted Reference Contour	Contour Adjust	Difference	Difference	SPL Result (LIN)	SPL Result (A)
125	117	100.8101489	125	31	-16	13	29	18	0	86	69.81014894
160	123	109.7554755	160	33	-13	16		17	0	90	73.81014894
200	125	114.1527483	200	34	-10	19		15	0	91	74.81014894
250	127	118.3249777	250	35	-7	22		13	0	92	75.81014894
315	130	123.3560378	315	35	-4	25		10	0	95	78.81014894
400	132	127.2259196	400	31	-1	28		3	0	101	84.81014894
500	133	129.7520082	500	21	0	29		-8	-8	112	95.81014894
630	133	131.0913719	630	28	1	30		-2	-2	105	88.81014894
800	132	131.2052314	800	27	2	31		-4	-4	105	88.81014894
1000	132	132	1000	40	3	32		8	0	92	75.81014894
1250	132	132.5761762	1250	40	4	33		7	0	92	75.81014894
1600	130	130.9930921	1600	46	4	33		13	0	84	67.81014894
2000	129	130.2016993	2000	38	4	33		5	0	91	74.81014894
4000	126	126.9642292	4000	63	4	33		30	0	63	46.81014894
	dB SPL (LIN)	dB SPL (A)		Sound Transmission Class						Estimated dB SPL (LIN) at receiving location	Estimated dB SPL (A) at receiving location
Single Number Reference	141.6404317	140.2511776		29					-14	113.9165873	97.7267362

NR of Existing Ceiling 1 - STC=29 (5 Sources)

	Source dB LIN (Example)	Source dB (A)	Octave band	Transmission Loss (TL) Existing Ceiling	Reference Contour (E413-04)	Adjusted Reference Contour	Contour Adjust	Difference	Difference	SPL Result (LIN)	SPL Result (A)
125	123.98	107.7901489	125	31	-16	13	29	18	0	93	76.79014894
160	129.98	116.7354755	160	33	-13	16		17	0	97	80.79014894
200	131.98	121.1327483	200	34	-10	19		15	0	98	81.79014894
250	133.98	125.3049777	250	35	-7	22		13	0	99	82.79014894
315	136.532	129.8880378	315	35	-4	25		10	0	102	85.34214894
400	138.98	134.2059196	400	31	-1	28		3	0	108	91.79014894
500	139.98	136.7320082	500	21	0	29		-8	-8	119	102.7901489
630	139.98	138.0713719	630	28	1	30		-2	-2	112	95.79014894
800	138.98	138.1852314	800	27	2	31		-4	-4	112	95.79014894
1000	138.98	138.98	1000	40	3	32		8	0	99	82.79014894
1250	138.98	139.5561762	1250	40	4	33		7	0	99	82.79014894
1600	136.98	137.9730921	1600	46	4	33		13	0	91	74.79014894
2000	135.98	137.1816993	2000	38	4	33		5	0	98	81.79014894
4000	132.98	133.9442292	4000	63	4	33		30	0	70	53.79014894
	dB SPL (LIN)	dB SPL (A)		Sound Transmission Class						Estimated dB SPL (LIN) at receiving location	Estimated dB SPL (A) at receiving location
Single Number Reference	148.5911571	147.2224681		29					-14	120.8911211	104.70127

NR of Existing Ceiling 1 - STC=29 (8 Sources)

	Source dB LIN (Example)	Source dB (A)	Octave band	Transmission Loss (TL) Existing Ceiling	Reference Contour (E413-04)	Adjusted Reference Contour	Contour Adjust	Difference	Difference	SPL Result (LIN)	SPL Result (A)
125	126.0308999	109.8410488	125	31	-16	13	29	18	0	95	78.84104881
160	132.0308999	118.7863753	160	33	-13	16		17	0	99	82.84104881
200	134.0308999	123.1836482	200	34	-10	19		15	0	100	83.84104881
250	136.0308999	127.3558776	250	35	-7	22		13	0	101	84.84104881
315	139.0308999	132.3869376	315	35	-4	25		10	0	104	87.84104881
400	141.0308999	136.2568194	400	31	-1	28		3	0	110	93.84104881
500	142.0308999	138.7829081	500	21	0	29		-8	-8	121	104.8410488
630	142.0308999	140.1222718	630	28	1	30		-2	-2	114	97.84104881
800	141.0308999	140.2361313	800	27	2	31		-4	-4	114	97.84104881
1000	141.0308999	141.0308999	1000	40	3	32		8	0	101	84.84104881
1250	141.0308999	141.6070751	1250	40	4	33		7	0	101	84.84104881
1600	139.0308999	140.023992	1600	46	4	33		13	0	93	76.84104881
2000	138.0308999	139.2325992	2000	38	4	33		5	0	100	83.84104881
4000	135.0308999	135.995129	4000	63	4	33		30	0	72	55.84104881
	dB SPL (LIN)	dB SPL (A)		Sound Transmission Class						Estimated dB SPL (LIN) at receiving location	Estimated dB SPL (A) at receiving location
Single Number Reference	150.6713316	149.2820774		29					-14	122.9474871	106.7576361

NR of Proposed Ceiling 2b - STC=79 (1 Sources) 2x 5/8 GYP, 2" Min Fiber, 10" Open Cell Foam, Steel Roof Deck, 3" GypCrete, Rubber Roof

	Source dB LIN (Example)	Source dB (A)	Octave band	Transmission Loss (TL) Ceiling 2b	Reference Contour (E413-04)	Adjusted Reference Contour	Contour Adjust	Difference	Difference	SPL Result (LIN) (LIN - TL = LIN)	SPL Result (A)
125	117	100.8101489	125	56	-16	64	80	-8	-8	61	44.36314894
160	123	109.7554755	160	65	-13	67		-2	-2	58	41.81014894
200	125	114.1527483	200	74	-10	70		4	0	51	34.81014894
250	127	118.3249777	250	83	-7	73		10	0	44	27.81014894
315	130	123.3560378	315	92	-4	76		16	0	38	21.81014894
400	132	127.2259196	400	100	-1	79		21	0	32	15.81014894
500	133	129.7520082	500	104	0	80		24	0	29	12.81014894
630	133	131.0913719	630	102	1	81		21	0	31	14.81014894
800	132	131.2052314	800	120	2	82		38	0	12	-4.189851062
1000	132	132	1000	134	3	83		51	0	-2	-18.18985106
1250	132	132.5761762	1250	138	4	84		54	0	-6	-22.18985106
1600	130	130.9930921	1600	159	4	84		75	0	-29	-45.18985106
2000	129	130.2016993	2000	172	4	84		88	0	-43	-59.18985106
4000	126	126.9642292	4000	212	4	84		128	0	-86	-102.1898511
	dB SPL (LIN)	dB SPL (A)		Sound Transmission Class						Estimated dBSPL (LIN) at receiving location	Estimated dBSPL (A) at receiving location
Single Number Reference	141.6404317	140.2511776		80					-10	62.85045829	46.66060723

NR of Proposed Ceiling 2b - STC=79 (5 Sources) 2x 5/8 GYP, 2" Min Fiber, 10" Open Cell Foam, Steel Roof Deck, 3" GypCrete, Rubber Roof

	Source dB LIN (Example)	Source dB (A)	Octave band	Transmission Loss (TL) Ceiling 2b	Reference Contour (E413-04)	Adjusted Reference Contour	Contour Adjust	Difference	Difference	SPL Result (LIN) (LIN - TL = LIN)	SPL Result (A)
125	123.98	107.7901489	125	56	-16	64	80	-8	-8	68	51.34314894
160	129.98	116.7354755	160	65	-13	67		-2	-2	65	48.79014894
200	131.98	121.1327483	200	74	-10	70		4	0	58	41.79014894
250	133.98	125.3049777	250	83	-7	73		10	0	51	34.79014894
315	136.532	129.8880378	315	92	-4	76		16	0	45	28.34214894
400	138.98	134.2059196	400	100	-1	79		21	0	39	22.79014894
500	139.98	136.7320082	500	104	0	80		24	0	36	19.79014894
630	139.98	138.0713719	630	102	1	81		21	0	38	21.79014894
800	138.98	138.1852314	800	120	2	82		38	0	19	2.790148938
1000	138.98	138.98	1000	134	3	83		51	0	5	-11.20985106
1250	138.98	139.5561762	1250	138	4	84		54	0	1	-15.20985106
1600	136.98	137.9730921	1600	159	4	84		75	0	-22	-38.20985106
2000	135.98	137.1816993	2000	172	4	84		88	0	-36	-52.20985106
4000	132.98	133.9442292	4000	212	4	84		128	0	-79	-95.20985106
	dB SPL (LIN)	dB SPL (A)		Sound Transmission Class						Estimated dBSPL (LIN) at receiving location	Estimated dBSPL (A) at receiving location
Single Number Reference	148.5911571	147.2224681		80					-10	69.82906483	53.63921377

NR of Proposed Ceiling 2b - STC=79 (8 Sources) 2x 5/8 GYP, 2" Min Fiber, 10" Open Cell Foam, Steel Roof Deck, 3" GypCrete, Rubber Roof

	Source dB LIN (Example)	Source dB (A)	Octave band	Transmission Loss (TL) Ceiling 2b	Reference Contour (E413-04)	Adjusted Reference Contour	Contour Adjust	Difference	Difference	SPL Result (LIN) (LIN - TL = LIN)	SPL Result (A)
125	126.0308999	109.8410488	125	56	-16	64	80	-8	-8	70	53.39404881
160	132.0308999	118.7863753	160	65	-13	67		-2	-2	67	50.84104881
200	134.0308999	123.1836482	200	74	-10	70		4	0	60	43.84104881
250	136.0308999	127.3558776	250	83	-7	73		10	0	53	36.84104881
315	139.0308999	132.3869376	315	92	-4	76		16	0	47	30.84104881
400	141.0308999	136.2568194	400	100	-1	79		21	0	41	24.84104881
500	142.0308999	138.7829081	500	104	0	80		24	0	38	21.84104881
630	142.0308999	140.1222718	630	102	1	81		21	0	40	23.84104881
800	141.0308999	140.2361313	800	120	2	82		38	0	21	4.841048808
1000	141.0308999	141.0308999	1000	134	3	83		51	0	7	-9.158951192
1250	141.0308999	141.6070761	1250	138	4	84		54	0	3	-13.15895119
1600	139.0308999	140.023992	1600	159	4	84		75	0	-20	-36.15895119
2000	138.0308999	139.2325992	2000	172	4	84		88	0	-34	-50.15895119
4000	135.0308999	135.995129	4000	212	4	84		128	0	-77	-93.15895119
	dB SPL (LIN)	dB SPL (A)		Sound Transmission Class						Estimated dBSPL (LIN) at receiving location	Estimated dBSPL (A) at receiving location
Single Number Reference	150.6713316	149.2820774		80					-10	71.88135816	55.6915071

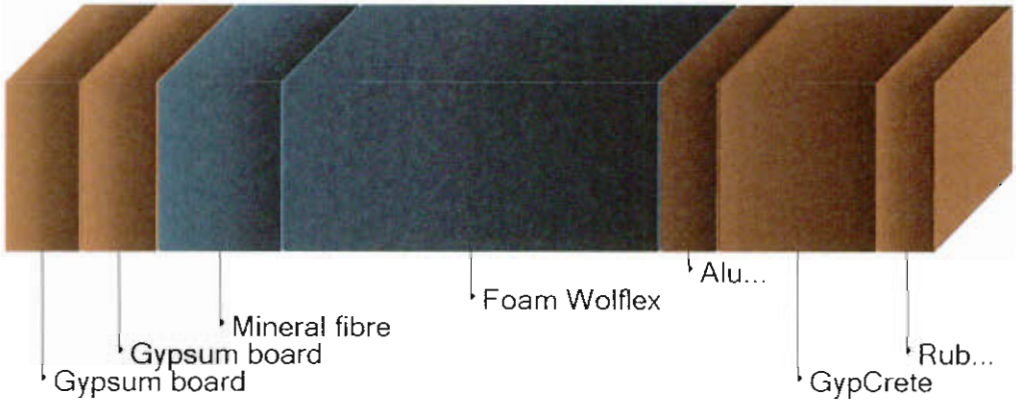
AFMG SoundFlow Report



Creation date: 7/5/2012
AFMG SoundFlow Version: 1.0.9

1. Model

1.1 Ceiling Structure Proposed 2b



Ceiling Structure Proposed 2b

Dimension	**Infinite**
Backing	**Air**
Absorber Model	**Absorber**
Filename	**Z:\Project Business\Clients\CODA\3011 Platform I - Acoustic Evaluation\Workfiles\SoundFlow\Program Files\Ceiling Structure Proposed 2aa.sfstr**

1.1.1 Layers

Overview

Layer No.	Material	Thickness	Material Type
1	Gypsum board	5/8"	Plate
2	Gypsum board	5/8"	Plate
3	Mineral fibre	2"	Absorber
4	Foam Wolflex	10"	Absorber
5	Aluminum 74	1/8"	Plate
6	GypCrete	3"	Plate
7	Rubber, 55 sh	1/8"	Plate

Layer 1: Gypsum board

D.A.Bies&C.H.Hansen, Engineering Noise Control, Spon 2003, p609
Loss Factor: 0.006 - 0.03

Thickness	**5/8"**
Material Type	**Plate**
Density [pcf]	**47.45**
Young's Modulus [psi]	**290075**
Poisson's Ratio	**0**
Bending Loss Factor	**0.03**

Layer 2: Gypsum board

D.A.Bies&C.H.Hansen, Engineering Noise Control, Spon 2003, p609
Loss Factor: 0.006 - 0.03

Thickness	**5/8"**
Material Type	**Plate**
Density [pcf]	**47.45**
Young's Modulus [psi]	**290075**
Poisson's Ratio	**0**
Bending Loss Factor	**0.03**

Layer 3: Mineral fibre

loose, synthetic-resin bond

W.Fasold,E.Sonntag,H.Winkler,"Bau- und Raumakustik" Bauwesen Berlin 1987, p391
Flow Resistivity: 5 - 120 kPa*s/m²
Density: 20 - 300 kg/m³
Fibre Radius: 1 - 5 µm

Thickness	**2"**
Material Type	**Absorber**
Flow Resistivity [kPa*s/m²]	**10.0**
Density [pcf]	**2.00**

Layer 4: Foam Wolflex

acetone-formaldehyde-resin foam
Wolflex
open-cell foam

W.Fasold,E.Sonntag,H.Winkler,"Bau- und Raumakustik" Bauwesen Berlin 1987, p391
Flow Resistivity: 30 - 50 kPa*s/m²
Density: 25 kg/m³

Thickness	**10"**
Material Type	**Absorber**
Flow Resistivity [kPa*s/m²]	**30.0**
Density [pcf]	**1.56**

Layer 5: Aluminum 74

F.P.Mechel, "Formulas of Acoustics" Springer 2002, p459

Thickness	**1/8"**
Material Type	**Plate**
Density [pcf]	**168.56**
Young's Modulus [psi]	**10732793**
Poisson's Ratio	**0.34**
Bending Loss Factor	**7E-05**

Layer 6: GypCrete

F.P.Mechel, "Formulas of Acoustics" Springer 2002, p458
bulk density: 1000 - 1200 kg/m^3
E modulus: 3.5 - 7 GPa

Thickness	**3"**
Material Type	**Plate**
Density [pcf]	**100.00**
Young's Modulus [psi]	**638166**
Poisson's Ratio	**0**
Bending Loss Factor	**0.004**

Layer 7: Rubber, 55 sh

W.Fasold,E.Sonntag,H.Winkler,"Bau- und Raumakustik" Bauwesen Berlin 1987, p390

Thickness	**1/8"**
Material Type	**Plate**
Density [pcf]	**87.40**
Young's Modulus [psi]	**435**
Poisson's Ratio	**0.001**
Bending Loss Factor	**0.3**

2. Results

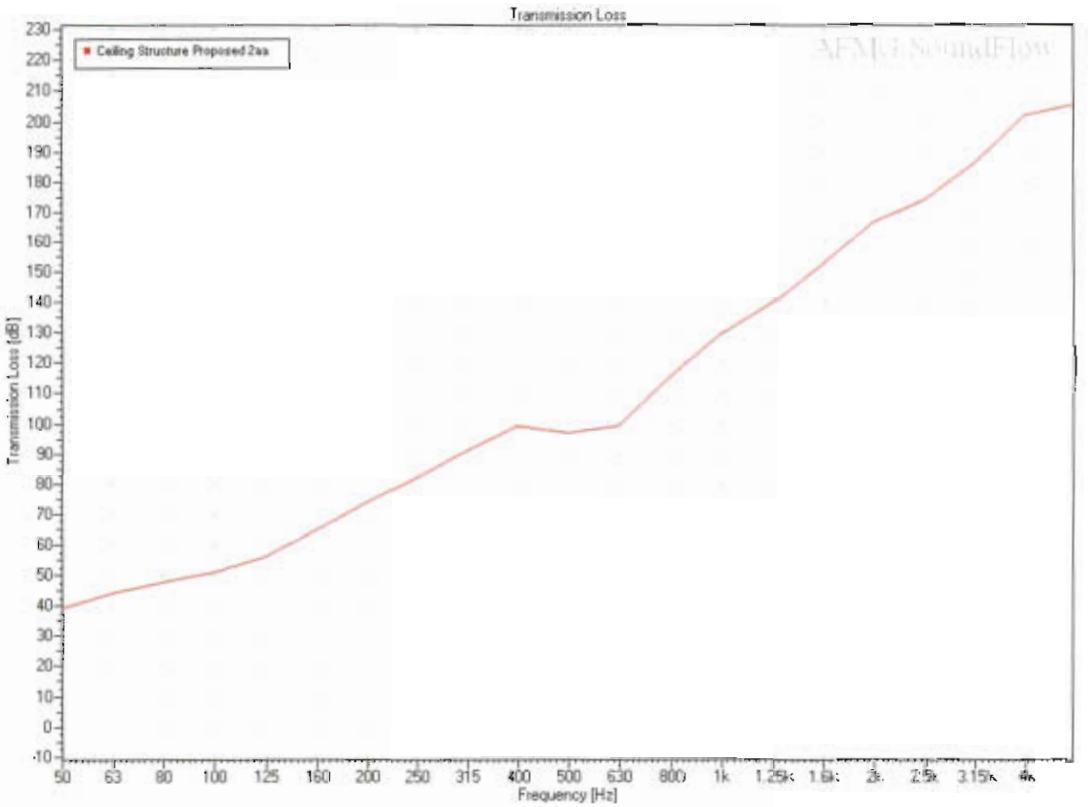
2.1 Broadband Quantities

Diffuse field incidence: 0° - 85°

Structure	ALPHAw	NRC	Rw	C	Ctr	C 50-5000	Ctr 50-5000	STC
Ceiling Structure Proposed 2aa	0.00	0.00	83	-6	-14	-9	-22	88

2.2 Transmission Loss

Direction of incidence	**Diffuse field (0° - 85°)**
Frequency resolution [Octave]	**1/24**
Frequency smoothing [Octave]	**1/3**



Transmission Loss

1/3 Octave Band Data	
Frequency [Hz]	**Ceiling Structure Proposed 2aa**
50	39.10
63	43.96
80	47.72
100	50.78
125	56.01
160	64.60
200	73.52
250	82.26
315	91.16
400	99.51
500	97.13
630	99.33
800	115.33

1000	129.21
1250	139.69
1600	152.59
2000	166.66
2500	173.87
3150	186.02
4000	202.26
5000	205.64

AFIOH
Air Force Institute for Operational Health

Acoustical Evaluation of 35 SFS Indoor Firing Range, Misawa Air Base, Japan

June 24-25, 2004



Consultative Letter # AFIOH-DO-BR-CL-2004-0046

Prepared by:

Detachment 3, AFIOH/CD
Kadena AB, Okinawa, Japan

10 August 2004

Distribution Statement: Approved for public release; distribution unlimited

DEPARTMENT OF THE AIR FORCE
DETACHMENT 3, AIR FORCE INSTITUTE FOR OPERATIONAL HEALTH
(AFIOH) (AFMC)
APO AP 96368-5213

10 August 2004

MEMORANDUM FOR 35 AMDS/SGPB
Attention: Capt Belser

FROM: Detachment 3, AFIOH/CD
Unit 5213
APO AP 96368-5213

SUBJECT: Consultative Letter, IOH-DO-BR-CL-2004-0046, Acoustical Evaluation of 35 SFS Indoor Firing Range, Misawa Air Base, Japan

1. Scope: At the request of your office, Detachment 3, of the Air Force Institute for Operational Health (AFIOH) completed an acoustical study at the 35 SFS Indoor Firing Range. The purpose of this study was to identify noise contours that could be utilized to select appropriate dampening materials and pinpoint dampening installation locations.

2. Background: The Security Forces indoor small arms range is located in the Security Hill sector of Misawa AB at building 1549. This recently opened range complex is poured concrete construction with a roughly finished interior. Much of the range, including all of the ceiling and most of the walls (see attachment 1) has been left as natural concrete. This creates significant reverberation inside the range during weapons firing. Couple this with a lack of noise dampening in the range and there are significant hazardous noise issues.

3. Personnel Contacted:
Capt William Belser, Bioenvironmental Engineering Flight Commander
TSgt Anthony Harris, 35 SFS Firing Range
SrA Nekia Mbaye, Bioenvironmental Engineering Technician
Ms. Christina Lane, Bioenvironmental Engineering Assistant

4. Process Description: The firing range was evaluated over a two day period. The initial visit involved a complete physical assessment of the range and development of an accurate facility drawing (see attachment 2). The facility is 8' 11½" tall from front to back. It has two entry doors in the walls behind the firing line. There is a control booth in one of the corners behind the firing line. The control booth is not enclosed. The back wall of the range is peg-hole wallboard. Besides functioning as a rear wall for the range, it also allows supply air from a ventilation system behind the wall to be blown into the firing area. This system captures lead dust created

during weapon firing and carries it down range. The ceiling is natural concrete with fluorescent lighting shielded by wooden bullet deflectors. The down range portion tapers 15'4" to a funnel where spent rounds are collected. They are captured on a tray behind the range where an auger operates to pull the rounds down the tray and into a 55-gallon drum. This area of the range also has a large exhaust system to capture airborne lead dust. There is no existing noise dampening in the range.

The noise assessment was completed on the second day. In order to accomplish this, a Quest Model 2900 Sound Level Meter with a Quest Model OB-300 Octave Filter was utilized. This instrument was calibrated with a Quest Model QC-10 Calibrator immediately prior to the start of the survey and the calibration was verified several times during the survey. Measurements were taken at two locations inside of the range under a variety of scenarios. The first measurement location was at ear level of the seated position in the operator's booth. The microphone was positioned downrange at an angle according to manufacturer recommendations. The second measurement location was at ear level for the weapon's operator. The weapon's operator fired a M4 in three round bursts using 5.56-mm ammunition. The M4 is the most common weapon used on the range. The weapon's operator was situated in the prone firing position in lane seven of the firing range. This lane was chosen due to its proximity to the operator's booth and to a range wall. This would maximize reverberation and thereby sound levels.

Four sets of measurements were collected at both measurement locations. These four sets included (1) background noise, (2) background noise + lead capture auger, (3) background noise + ventilation system, and (4) background noise + lead capture auger + ventilation system + weapons firing. In each case, the sound level meter captured linear decibel readings at all of the primary center frequencies (16Hz, 31.5Hz, 63Hz, 125Hz, 250Hz, 500Hz, 1000Hz, 2000Hz, 4000Hz, 8000Hz, and 16000Hz). For the first three sets, the meter was set to fast response and the highest stable reading was recorded. Due to the staccato nature of weapons firing, the meter was set to impact for the final measurement set and the highest reading was recorded.

5. Findings & Observations:

The results for the background sound level measurements inside the firing range are listed in Table 1. These levels are normal for this type of building construction.

Table 1: Background Sound Levels (dB_{LIN})

	Frequency (Hz)										
	16	**31.5**	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**	**16000**
Operator's Booth	48	53	55	47	43	34	30	30	30	30	30
Shooter	49	51	57	54	50	38	30	30	30	30	30

*Note that 30dB was the lower limit of the machine.

The sound levels listed in Table 2 were measured when the lead capture auger was turned on. The table also indicates the difference between these values and the background level. When examining these values, it is important to realize that the decibel scale is logarithmic, not linear. Therefore a one decibel increase in sound level equates roughly to a 20% increase in noise exposure.

Table 2: Background + Lead Capture Auger Sound Levels (dB_{LIN})

	Frequency (Hz)										
	16	**31.5**	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**	**16000**
Operator's Booth	76	80	68	66	58	53	54	62	64	64	47
Difference from Background	+28	+27	+13	+19	+15	+19	+24	+32	+34	+34	+17
Shooter	69	78	71	71	66	56	56	62	66	66	49
Difference from Background	+20	+27	+14	+17	+16	+18	+26	+32	+36	+36	+19

The lead capture auger adds a significant sound burden to the room, but none of the values approach levels of regulatory or occupational health concern. The sound seems to be spread evenly across the entire spectrum, but with the highest levels still concentrated in the lower frequencies. Table 3 illustrates the change to the background level when the ventilation fan was turned on.

Table 3: Background + Ventilation Sound Levels (dB_{LIN})

	Frequency (Hz)										
	16	**31.5**	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**	**16000**
Operator's Booth	46	51	62	69	67	65	65	62	58	52	43
Difference from Background	-2	-2	+7	+22	+24	+31	+35	+32	+28	+22	+13
Shooter	47	52	63	69	66	66	67	63	57	49	44
Difference from Background	-2	-1	+6	+15	+16	+28	+37	+33	+27	+19	+14

As with the lead capture auger, the ventilation system adds a significant sound burden to the firing range, but the resulting levels are not considered significant with regard to regulatory or occupational health concerns. This sound seems to be concentrated more in the mid-frequency area, with a slight tendency toward the high frequencies. The small negative numbers on the low frequency end of the spectrum can be considered within the normal variability associated with the instrument be utilized. They should not be interpreted to indicate that it was quieter with the ventilation turned on than with it off.

It is also interesting to note that levels for both the operator's booth and the shooter are nearly identical, even though the supply ventilation is entering the range directly behind the operator's booth. This can most likely be attributed to the reverberation acoustics of the room which tend to even out the sound levels throughout. The final chart (Table 4) shows the measurements during weapons firing with all other sound sources operating.

Table 4: Background + Lead Auger + Ventilation + Weapons Sound Levels (dB_{LIN})

	Frequency (Hz)										
	16	**31.5**	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**	**16000**
Operator's Booth	84	88	91	115	126	129	132	131	127	120	108
Difference from Background	+36	+35	+36	+68	+83	+85	+102	+101	+97	+90	+78
Shooter	98	104	107	117	127	133	132	129	126	119	107
Difference from Background	+49	+53	+50	+63	+77	+95	+102	+99	+96	+89	+77

It is readily apparent from Table 4 that the sound level associated with the weapon completely dominates all other sources. Although this is true across all frequencies, the highest increases in sound pressure are between 250-4000 Hertz. Another note of interest is the apparent lack of significant sound level difference between the two measurement locations. This can likely be attributed to reverberation in the firing range. All of this information is valuable in determining the proper control of noise in this environment.

6. Discussion:

It is clear from the measurements above that the sound pressure levels being generated by gunfire in the firing range need to be reduced. Since it is unacceptable to replace the current weapons or modify the training classes, the most feasible solution is to dampen the sound. There are two sources to the sound (direct and reverberation), so an effective solution will address both. Based upon this, there are a couple of options available when considering dampening.

1. Quilted Fiberglass: A reliable method used at many indoor firing ranges is quilted fiberglass panels. Typically, these 1" thick panels, with a 1" air gap, are mounted to the range walls and ceiling behind the firing line. The panels must be covered on both sides to facilitate cleaning and prevent lead impregnation. These panels are an excellent choice for reducing reverberation, but provide minimal direct sound absorption.

2. Foam Panels: A variety of manufacturers produce panels composed of noise-absorbent foam. The primary advantage of these panels is their ability to limit reverberation and absorb sound energy. A typical panel can absorb between 70-90% of the acoustical energy for the 500 Hz and 1000 Hz frequencies. These panels also have the advantage of easy cleaning to prevent lead dust build-up. Finally, these panels can be manufactured with fire retardant materials making them significantly less flammable than the quilted fiberglass.

7. Recommendation:

Based upon the above discussion, the most appropriate method to control sound levels in the indoor firing range is through the use of foam panels. The following items should be considered when purchasing the appropriate panels.

- Panels should be 2" thick and have a Class I fire rating.

- Based upon the size of the range, 3800ft^2 of foam will be necessary to properly dampen the range. Foam should be split with 2/3 applied to the ceiling and 1/3 applied to the walls. The ceiling foam should be applied starting at 6' behind the firing line and moving forward down the range. The foam should cover the ceiling from side wall to side wall. The wall foam should start at the firing line and extend down range. Foam should be applied to each side evenly with a 1' gap left between the bottom of the foam and the floor.

- Panels should be cut as little as possible. It will be necessary to modify the panels to avoid lights and deflectors, but the more intact the panels remain, the better they will function.

- Panels should have a Hypalon® coating to facilitate cleaning.

- Panels should be attached directly to the concrete walls -- no air gap is necessary. Special adhesives are unnecessary; a standard water-based or spray adhesive will work fine.

8. If you have any questions concerning this survey, please contact me at DSN 634-2638 or e-mail me at gregory.frick@kadena.af.mil. I appreciate the opportunity to provide assistance on this project and would like to extend my gratitude to all of the professionals in your shop for their cooperation and support.

GREGORY A. FRICK, Maj, USAF, BSC, CIH
Chief, Occupational Health Division

2 Attachments:
1. Firing Range Photos
2. Firing Range Drawing



Figure 1: Firing Line -- Stations 1-3

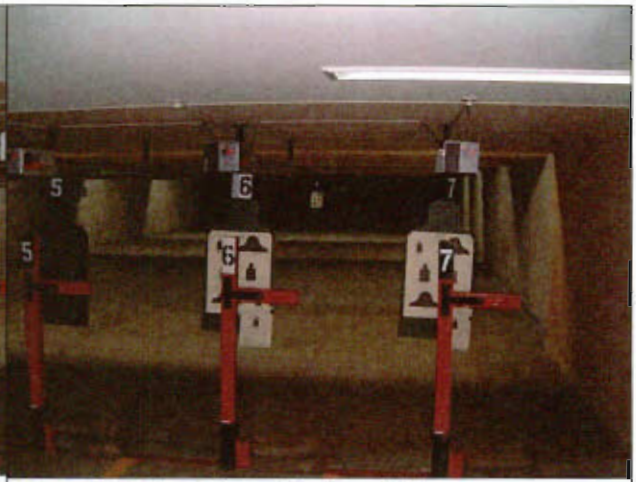


Figure 2: Firing Line -- Stations 5-7



Figure 3: Control Booth -- Measurement Location #1

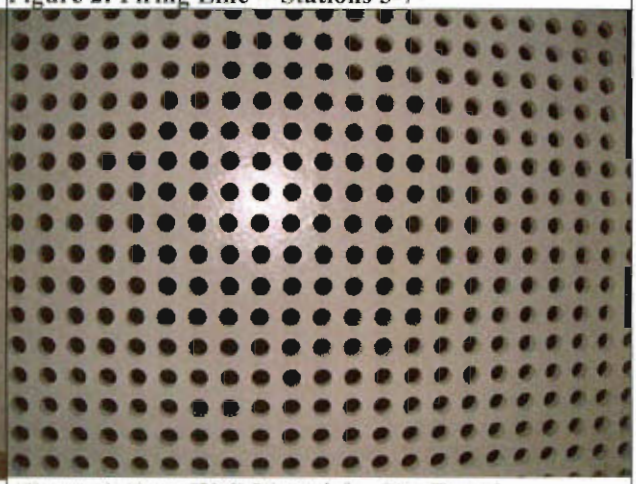


Figure 4: Rear Wall Material -- Peg Board

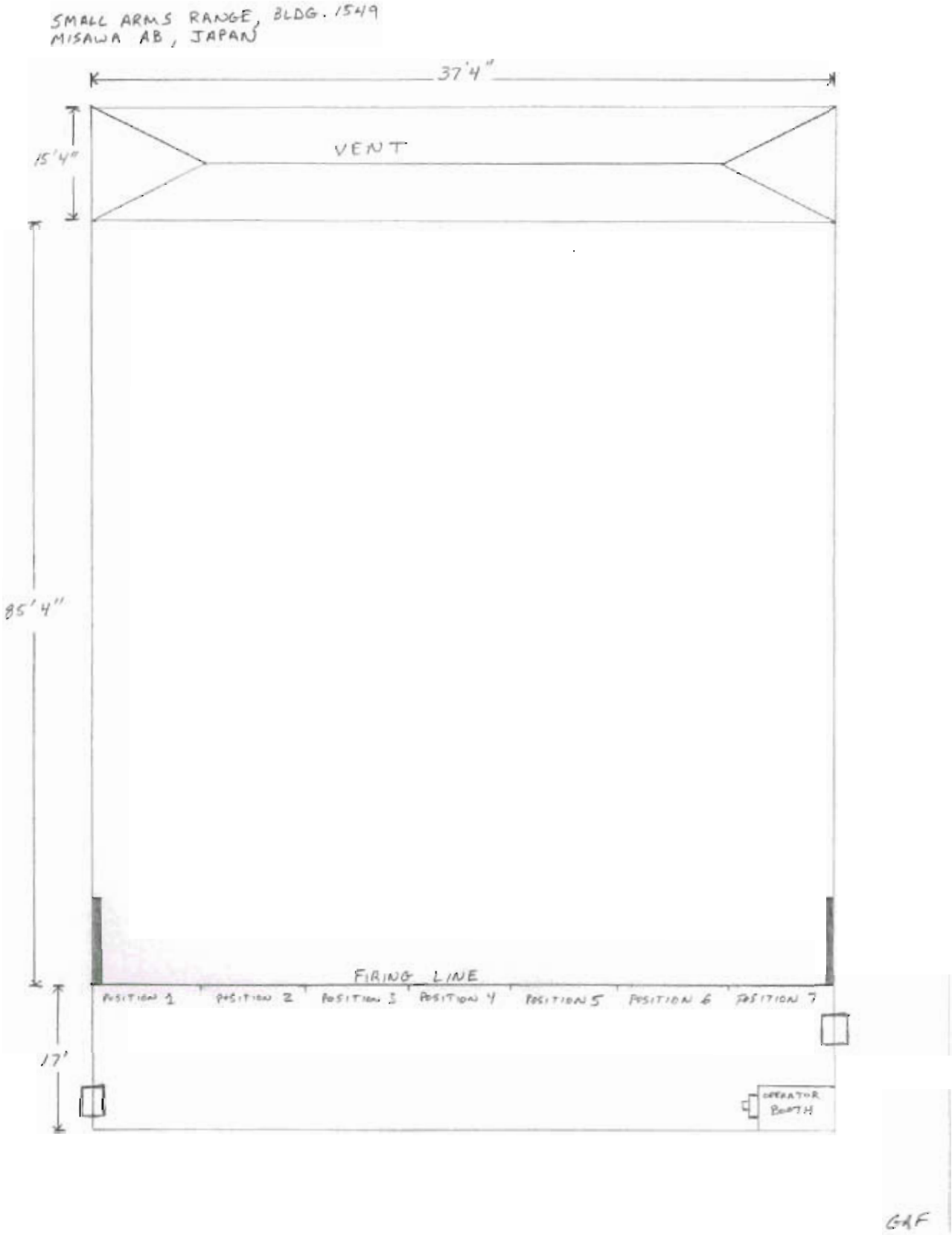


Figure 5: Firing Range Side Wall



Figure 6: Firing Position #7 -- Measurement Location #2

Attachment 1
Firing Range Photos
1-1



Attachment 2
Firing Range Drawing
2-1

Google

Directions to W Devon Ave
308 ft – about **1 min**

Walking directions are in beta.
Use caution – This route may be missing sidewalks or pedestrian paths.

A 3318 W Devon Ave, Lincolnwood, IL 60712

1. Head **east** on **W Devon Ave** toward **N McCormick Blvd**
   About 1 min

go 308 ft
total 308 ft

B W Devon Ave NOTLTH SHORE CHANNEL TRAIL

These directions are for planning purposes only. You may find that construction projects, traffic, weather, or other events may cause conditions to differ from the map results, and you should plan your route accordingly. You must obey all signs or notices regarding your route.

Map data ©2012 Google

Directions weren't right? Please find your route on maps.google.com and click "Report a problem" at the bottom left.

Google

Directions to Drake Ave
0.3 mi – about **6 mins**

Walking directions are in beta.
Use caution – This route may be missing sidewalks or pedestrian paths.

A 3318 W Devon Ave, Lincolnwood, IL 60712

1.	Head **west** on **W Devon Ave** toward **Christiana Ave** About 4 mins	go 0.2 mi total 0.2 mi
2.	Slight right to stay on **W Devon Ave** About 1 min	go 305 ft total 0.3 mi
3.	Turn right onto **Drake Ave** About 53 secs	go 220 ft total 0.3 mi

B Drake Ave PARK ON DRAKE

These directions are for planning purposes only. You may find that construction projects, traffic, weather, or other events may cause conditions to differ from the map results, and you should plan your route accordingly. You must obey all signs or notices regarding your route.

Map data ©2012 Google

Directions weren't right? Please find your route on maps.google.com and click "Report a problem" at the bottom left.

Google

Directions to 6950 Central Park Ave, Lincolnwood, IL 60712
0.5 mi – about **10 mins**

Walking directions are in beta.
Use caution – This route may be missing sidewalks or pedestrian paths.

A Todd Hall School, 3925 West Lunt Avenue, Lincolnwood, IL 60712

1. Head **east** on **W Lunt Ave** toward **E Prairie Rd** About 9 mins	go 0.5 mi total 0.5 mi
2. Turn right onto **Central Park Ave** About 1 min	go 285 ft total 0.5 mi

B 6950 Central Park Ave, Lincolnwood, IL 60712

These directions are for planning purposes only. You may find that construction projects, traffic, weather, or other events may cause conditions to differ from the map results, and you should plan your route accordingly. You must obey all signs or notices regarding your route.

Map data ©2012 Google

Directions weren't right? Please find your route on maps.google.com and click "Report a problem" at the bottom left.

VILLAGE OF LINCOLNWOOD
Community Development Department

Public Hearing Application
Application Supplement

Range at Gurnee Mills Mall

Crystal Lake Range Planning

City of Chicago Adoption of Ranges

Newsletters | Mobile

America's Most-Visited Shopping Malls

No. 9 Gurnee Mills, Gurnee, IL

Annual Visitors: 23 million

Year Opened: 1991

Size: 1.8 million square feet

Another of Chicagoland's mega-malls, Gurnee Mills was also a pioneer of mixing retail and entertainment. Ice-skating, laser tag, miniature golf, and a 20-theater Cineplex count among its many nonshopping attractions. There's even an indoor zoo called Serpent Safari, where various snakes, lizards, turtles, and crocodiles can be viewed and sometimes handled. Get ready to have a photo snapped with a Burmese python draped around your neck.

simon.com

Source: Chicago Tribune



Courtesy Gurnee Mills

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Best Travel Gifts 2009



America's Most and Least Attractive People



Found: The Perfect Travel Dress



World's Most Beautiful Airports

Comments (5)

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Add a Comment

JSP — POSTED DEC. 15, 2011 7:33PM EST report

I'm baffled as to why Galleria Dallas with over 19 million annual visitors and 1.9 million square feet of space failed to make the list. It should be No. 17 on this list.. This list was compiled with, quite frankly, an embarrassing level of research.

ibjoecouture — POSTED DEC. 9, 2011 1:54PM EST report

The Yorktown Center is fortunate to have a top notch Operations Manager. Keep up the great work!!

Luis32789 — POSTED DEC. 5, 2011 5:22PM EST report

The Walden Gallery (which is Cheektowaga - NOT Buffalo) and The Florida Mall in Orlando, Florida should also be on this list. The Florida Mall is swamped with tourists from the Disney Parks area looking for deals. Also, Short Hills Mall in New Jersey should also be considered.

pyrexmaniac — POSTED DEC. 5, 2011 9:29AM EST report

The Walden Galleria in Buffalo, NY is conspicuous by it's absence.....18 million shoppers in 2010

#2012-39
Straight Shooter Gallery LLC - 560 Beechcraft
Project Review for Planning and Zoning Commission

Meeting Dates: June 6, 2012

Requests: Special Use Permit Amendment to amend the conditions of Ordinance No. 6618 granting a SUP to allow a commercial recreation use for a shooting range located at the subject property and a variation from Article 4-700 C 7, Rooftop Appurtenances, of the UDO from the requirement that all non-residential uses are required to screen rooftop appurtenances from view.

Location: 560 Beechcraft Lane

Acreage: 1.99 acres

Existing Zoning: "M" Manufacturing

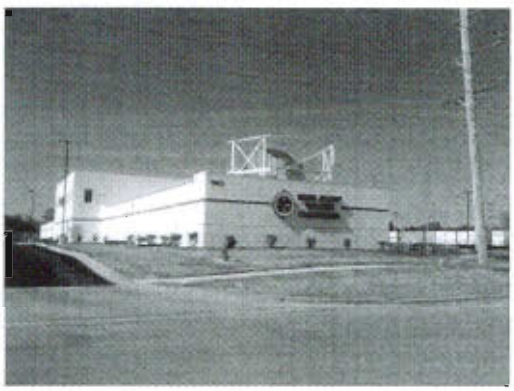
Surrounding Properties:

North:	ComEd ROW
South:	"M" Manufacturing
East:	"M" Manufacturing
West:	"M" Manufacturing

Staff Contact: Latika Bhide (815-356-3615)

Background:

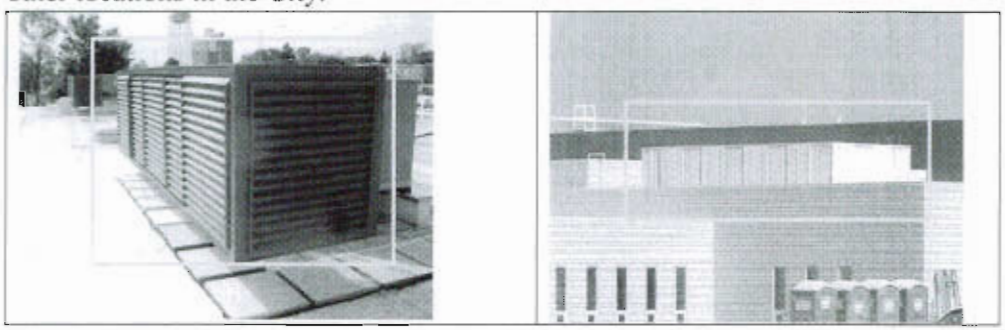
- Location: 560 Beechcraft Lane
- Zoning: "M" Manufacturing
- Development: Terra Cotta Tech Subdivision Unit 2, platted 2007
- Request: Special Use Permit Amendment from the conditions of Ordinance #6618 and Variation from the requirement that rooftop appurtenances be screened from view



Land Use Analysis:

- History: In 2010, a Special Use Permit to allow a commercial recreation use for a shooting range was approved for this property. A temporary occupancy for this facility was granted in May 2012. One of the conditions of the SUP approval as that 'All mechanical equipment whether on ground or on the roof, must be screened per the UDO'.

- UDO requirements: Per the requirements of the UDO, rooftop appurtenances (such as cooling towers, elevator or mechanical equipment, vents, intakes or stacks or other rooftop structures) for non-residential uses must be screened from view by employing the following methods:
  (i) The rooftop appurtenances shall be located in the center of the building (or tenant space) or as far from the street side façade as possible; and/or
  (ii) The rooftop appurtenances shall be painted and maintained in the same color as the roof or top portion of the building; and/or
  (iii) If more than 50% of the rooftop appurtenances are still visible after providing both (i) and (ii) above, then the rooftop appurtenances shall be screened by a parapet wall, solid metal sight screening or similar systems designed for use as screening of these types of devices.
  Compliance with these screening standards shall be computed within a 150-foot buffer from the property lines, excepting the side abutting a right-of-way, where it shall be computed across the right-of-way
- Site Conditions: The nature of this use dictates the location of the mechanical equipment for this building. Therefore the units cannot be located in the center of the building or far from the street side façade as possible. The petitioner had previously proposed screening for the unit along Beechcraft lane (south side) using TREX decking material. At this time, the framing for this screening is in place, but the petitioner has requested that a SUP amendment and variation be granted to not install the screening. The north side (far end) mechanical equipment must be painted to match the color of the building. The mechanical equipment on the second floor of this building meets the UDO requirements for screening. The building is not visible from Nunda Trail located north of the ComEd right-of-way.
- Examples: Included below are some examples of the various types of screening utilized at other locations in the City.



Screening requirements are fairly typical and are generally complied with. It should be noted that this property backs up to the ComEd right-of-way and is located within an industrial park and not visible from Route 176.

- Other Issues: It has been brought to staff's attention that several types of screening systems, if not installed simultaneously with the installation of the roof, void the roof warranty. Previously, petitioners have installed screening that is attached to the mechanical equipment to avoid the roof warranty issues. However, lately it has been pointed out that this method voids the warranty for the mechanical equipment.

Findings of Fact:

UNIFIED DEVELOPMENT ORDINANCE VARIATION

The granting of a Variation rests upon the applicant proving practical difficulty or hardship caused by the UDO requirements as they relate to the property. It is the responsibility of the petitioner to prove hardship at the Planning and Zoning Commission public hearing. Before recommending any Variation, the Planning and Zoning Commission and City Council shall first determine and record its findings that the evidence justifies the conclusions that:

1. The plight of the property owner is due to unique circumstances, such as, unusual surroundings or conditions of the property involved, or by reason of exceptional narrowness, shallowness or shape of a zoning lot, or because of unique topography, or underground conditions.
   ☐ True ☐ False

2. Also, that the variation, if granted, will not alter the essential character of the locality.
   ☐ True ☐ False

The Commission may take into consideration the extent to which the following facts favorable to the application have been established by the evidence presented at the public hearing:

1. That the conditions upon which the application for variation is based would not be applicable generally to other property within the same zoning classification;
   ☐ True ☐ False

2. That the alleged difficulty or hardship has not been created by any person presently having interest in the property;
   ☐ True ☐ False

3. That the granting of the variation will not be detrimental to the public welfare or injurious to other property or improvements in the neighborhood in which the property is located; or
   ☐ True ☐ False

4. That the proposed variation will not impair an adequate supply of light or air to adjacent property, will not unreasonably diminish or impair the property values of adjacent property, will not unreasonably increase congestion in the public streets, substantially increase the danger of fire or otherwise endanger public safety.
   ☐ True ☐ False

Where the evidence is not found to justify such conditions, that fact shall be reported to the City Council with a recommendation that the variation be denied.

SPECIAL USE PERMIT

The petitioner is also requesting a Special Use Permit amendment. Special Uses require separate review because of their potential to impact surrounding properties and the orderly development of the City.

Section 2-400 of the Unified Development Ordinance establishes the general standard for all Special Uses in Crystal Lake. The criteria are as follows:

1. That the proposed use is necessary or desirable, at the location involved, to provide a service or facility which will further the public convenience and contribute to the general welfare of the neighborhood or community.
   ☐ Meets ☐ Does not meet

2. That the proposed use will not be detrimental to the value of other properties or improvements in the vicinity.
   ☐ Meets ☐ Does not meet

3. That the proposed use will comply with the regulations of the zoning district in which it is located and this Ordinance generally, including, but not limited to, all applicable yard and bulk regulations, parking and loading regulations, sign control regulations, watershed, wetlands, and flood plain regulations, Building and Fire Codes and all other applicable City Ordinances.
   ☐ Meets ☐ Does not meet

4. That the proposed use will not negatively impact the existing off-site traffic circulation; will adequately address on-site traffic circulation; will provide adequate on-site parking facilities; and, if required, will contribute financially, in proportion to its impact, to upgrading roadway and parking systems.
   ☐ Meets ☐ Does not meet

5. That the proposed use will not negatively impact existing public utilities and municipal service delivery systems and, if required, will contribute financially, in proportion to its impact, to the upgrading of public utility systems and municipal service delivery systems.
   ☐ Meets ☐ Does not meet

6. That the proposed use will not impact negatively on the environment by creating air, noise, or water pollution; ground contamination; or unsightly views.
   ☐ Meets ☐ Does not meet

7. That the proposed use will maintain, where possible, existing mature vegetation; provide adequate screening to residential properties; provide landscaping in forms of ground covers, trees and shrubs; and provide architecture, which is aesthetically appealing, compatible or complementary to surrounding properties and acceptable by community standards, as further detailed in Article 4, Development and Design Standards.
   ☐ Meets ☐ Does not meet

8. That the proposed use will meet standards and requirements established by jurisdictions other than the City such as Federal, State or County statutes requiring licensing procedures or health/safety inspections, and submit written evidence thereof.
   ☐ Meets ☐ Does not meet

9. That the proposed use shall conform to any stipulations or conditions approved as part of a Special Use Permit issued for such use.
   ☐ Meets ☐ Does not meet

10. That the proposed use shall conform to the standards established for specific special uses as provided in this section.
    ☐ Meets ☐ Does not meet

Recommended Conditions:

If a motion is made to approve the petitioner's request, the following are recommended as conditions of approval:

1. Approved plans, reflecting staff and advisory board recommendations, as approved by the City Council:
   A. Application, received 5-16-12

2. A Special Use Amendment and variation are hereby granted for the shooting range at 560 Beechcraft Lane, allowing the petitioner not to screen the existing rooftop appurtenances from view.

3. The mechanical equipment on the first floor roof, on all sides shall be painted white to match the building.

4. Any additional rooftop appurtenances that are added, either by this tenant or other future tenants at this location, will be required to be screened per the provisions of the UDO.

5. The petitioner shall address any comments and requirements from the Engineering and Building, Fire Rescue, Police, Public Works, and Planning and Economic Development Departments.

PUBLIC NOTICE

BEFORE THE PLANNING AND ZONING COMMISSION OF THE CITY OF CRYSTAL LAKE, MCHENRY COUNTY, ILLINOIS

IN THE MATTER OF THE APPLICATION OF STRAIGHT SHOOTER GALLERY, LLC

LEGAL NOTICE

Notice is hereby given in compliance with the Unified Development Ordinance (UDO) of the City of Crystal Lake, Illinois, that a public hearing will be held before the Planning and Zoning Commission of the City of Crystal Lake upon the application of Straight Shooter Gallery, LLC, relating to the following described real estate commonly known as 560 Beechcraft Lane, Crystal Lake, Illinois 60012 PIN: 14-33-226-014 (the "Subject Property").

This application is filed for the purposes of seeking a Special Use Permit (SUP) Amendment and Variation. The SUP amendment is to amend the conditions of Ordinance No. 6618 granting a SUP to allow a commercial recreation use for a shooting range located at the subject property. The SUP Amendment and variation from Article 4-700 C 7, Rooftop Appurtenances, of the UDO is from the requirement that all non-residential uses are required to screen rooftop appurtenances from view, to allow not requiring screening; as well as any other variations that may be necessary to allow the plans as presented. Plans for this project can be viewed at the City of Crystal Lake Planning and Economic Development Department at City Hall.

A public hearing before the Planning and Zoning Commission on the request will be held at 7:30 p.m. on Wednesday, June 6, 2012, at the Crystal Lake City Hall, 100 West Woodstock Street, at which time and place any person determining to be heard may be present.

Tom Hayden, Chairperson
Planning and Zoning Commission
City of Crystal Lake
(Published in the Northwest Herald May 22, 2012)

City of Crystal Lake
Development Application

Office Use Only 3 9 2012
File # _____

Project Title: STRAIGHT SHOOTER GALLERY LLC

RECEIVED
MAY 16 2012
BY:

Action Requested

__ Annexation	__ Preliminary PUD
__ Comprehensive Plan Amendment	__ Preliminary Plat of Subdivision
__ Conceptual PUD Review	__ Rezoning
__ Final PUD	__ Special Use Permit
__ Final PUD Amendment	X Variation
__ Final Plat of Subdivision	__ Other

Petitioner Information → SAME

Name: _____

Address: _____

_____

Phone: _____

Fax: _____

E-mail: _____

Owner Information (if different)

Name: STRAIGHT SHOOTER GALLERY LLC

Address: 560 DAKOTA ST
CRYSTAL LAKE, IL 60012

Phone: 815-477-3123

Fax: 815-477-4923

E-mail: BOSTROMCHAS@IVDEV.COM

Property Information

Project Description: INDOOR SHOOTING RANGE

Project Address/Location: 560 ~~DAKOTA ST.~~ BEECHCRAFT

PIN Number(s): _____

Development Team

Please include address, phone, fax and e-mail

Developer: CHARLES RIVER DEVELOPMENT GROUP INC.

Architect: DAVID GILLESPIE

Attorney: JOSEPH GOTTHOLLER

Engineer: NORTHWESTERN ENG

Landscape Architect: _____

Planner: _____

Surveyor: VANDERSTAPPEN

Other: _____

Signatures

_____

PETITIONER: Print and Sign name (*if different from owner*) **Date**

As owner of the property in question, I hereby authorize the seeking of the above requested action.

BO STROM 4-20-12

OWNER: Print and Sign name **Date**

NOTE: If the property is held in trust, the trust officer must sign this petition as owner. In addition, the trust officer must provide a letter that names all beneficiaries of the trust.

OFFICE OF THE MAYOR
CITY OF CHICAGO

FOR IMMEDIATE RELEASE
July 6, 2011

Mayor's Press Office
(312) 744-3334
press@cityofchicago.org

Law Department
Jenny Hoyle
(312) 744-1575

CITY COUNCIL APPROVES ORDINANCE ALLOWING SHOOTING RANGES IN CHICAGO

The City Council today approved an ordinance that creates a comprehensive licensing and regulatory framework that allows for shooting ranges to be located in the City of Chicago.

"Swift and decisive action from the City Council was essential to preserve the gun control and safety elements of the ordinance," said Mayor Emanuel. "The action taken by the Council today ensured that the gun ranges in Chicago will be regulated as part of a thoughtful plan that is focused on the safety of all Chicagoans."

The City's Responsible Gun Ownership Ordinance, which was passed in July of 2010, banned shooting ranges in the City of Chicago. At the time, no shooting ranges were located in the City and there was no regulatory or licensing framework addressing shooting ranges. Shortly after the passage of the Responsible Gun Ownership Ordinance, two lawsuits were filed in federal court challenging the constitutionality of the ban.

Today, as the Council approved the ordinance that allows for shooting ranges to be located in Chicago, the 7th Circuit Court of Appeals at virtually the same time issued a ruling in one of the pending cases against the city. The 7th Circuit ordered the district court to issue a preliminary injunction against the prohibition on gun ranges. The City's attorneys are conducting a thorough legal review of the decision made by the 7th Circuit, and will provide recommendations for how the City will proceed relative to this court case.

Today's ordinance in City Council protects residents of Chicago in a number of ways. It ensures that there is no enforcement gap between the time the existing ban is unenforceable and the new ordinance is enacted. It additionally lays out a licensing and regulatory framework for the gun ranges. Further, the ordinance ensures that the shooting ranges are enclosed and located at a safe distance from residential districts, parks, schools, day care centers, and churches. These frameworks allow the City to comply with the law while maintaining its focus on the safety and security of the general public.

Specifically, the ordinance addresses:

Licensing:

- The ordinance creates a new business license for shooting range facilities.
- Shooting ranges can only be located in completely enclosed buildings.
- Mobile shooting ranges and open air shooting ranges are prohibited.
- Licensees must be at least 21 years of age and possess a valid Chicago Firearm Permit, Illinois FOID card and any necessary federal firearms, licenses.
- Licensees must also maintain liability insurance in the aggregate amount of $1 million.

Zoning:

- Gun ranges can only be located in districts zoned for manufacturing, and they will be considered "special uses" in these districts.
- Special uses require a hearing before the Zoning Board of Appeals during which community input can be considered.
- Within manufacturing districts, shooting ranges cannot be located within 1,000 feet of the following: another shooting range facility; a district zoned for residential use; any school, day-care facility, park, place of worship, children's activities facility, library, museum and hospital; and any establishment licensed for the retail sale of liquor.

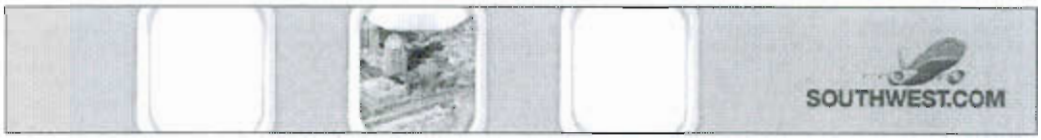
Health and Safety:

- Every application for a shooting range license must be accompanied by a safety plan approved by the Police Superintendent.

- The safety plan must include exterior lighting; interior and exterior surveillance cameras; an alarm system; protocols for the safe display and storage of firearms and ammunition; and adequately trained personnel and range masters.

- The ordinance also includes changes to the environmental, building and fire codes to address concerns specific to firing ranges, such as air quality, noise pollution, building structure and storage of flammable materials.

# # #



City Council tweaks Chicago gun range restrictions

September 06, 2011 | By Hal Dardick Clout Street

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The Chicago City Council isn't done tinkering with gun-control measures it hastily approved last summer after the U.S. Supreme Court struck down a decades-old handgun ban.

The council's Public Safety Committee on Tuesday recommended approval of a tweak that would cut in half the licensing fee to open up a shooting range. The cost would be $2,000 for two years.

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The city also would reduce the minimum distance a gun range would have to be located from homes, parks and houses of worship to 500 feet from 1,000 feet.

The changes would make it easier to put a gun range in Chicago, but another provision of the ordinance would complicate record keeping at such facilities.

It would require gun range owners keep records of everyone who used their facilities after ensuring each patron had a state firearm owner's identification card and city firearm permit.

Aldermen are retooling the gun-control ordinance they approved a year ago under Mayor Richard Daley. The measure outlawed shooting ranges within city limits, even as it required firearm training for people before they could get a gun permit.

In July, the council approved Mayor Rahm Emanuel's proposal to allow the gun ranges as the city tried to get out front of an anticipated federal appellate court ruling striking down ban on such facilities. Gun ranges had to be confined to manufacturing areas and meet a slew of other restrictions.

But the appellate court ruling forced further changes, said M. Rose Kelly, senior counsel at the city Law Department.

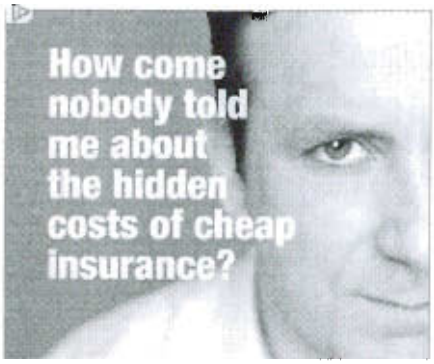
"We were trying to anticipate how the court would rule," Kelly said. "But now that we have been able to review the ruling and the court's decision, we've looked at the shooting range ordinance and feel that it needs some tweaking in some areas to come into compliance."

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July 27, 1990

Elected Women Urge Gun Control
July 30, 1993

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Attorney Walter Maksym, who sued the city on behalf of people who want to sell guns in Chicago, said he believed even the revised shooting range restrictions would be too onerous to pass court muster.

Shooting Range
Gun Range

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VILLAGE OF LINCOLNWOOD
Community Development Department

Public Hearing Application
Application Supplement

Construction Safety

SAFETY BAFFLES

Action Target has multiple offerings of safety ceilings and ballistic baffles. We know bullet containment is essential and non-negotiable for any firing range. The safety ceilings and ballistic baffles we install are not just overhead plates. They are systems specifically engineered, designed, manufactured and installed for each range project.







We combine steel, rubber, wood, and acoustic tile to provide ballistic protection with a polished, professional appearance, and noise reduction. Action Target safety ceilings and ballistic baffles provide an impenetrable barrier that can be configured for a fixed firing line or to support a tactical training environment. Action Target uses steel with ballistic properties ranging from 10 gauge to heavy armor in our safety ceilings and baffles that withstand rounds from handguns to high-power rifles.



Action Target not only manufactures the highest-quality range equipment, we also provide full delivery and install service as well. Our team will work with you from start to finish to ensure the best outcome for your project, including the complete superstructure for your indoor or outdoor range.

Purple Heart Official



PROTECTION

Our relentless dedication to R&D means you train safely.

RANGE VENTILATION

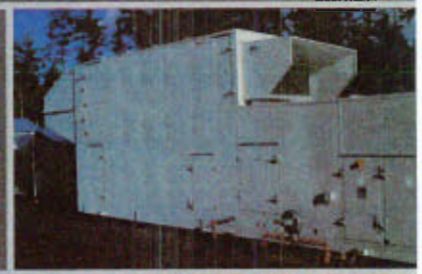
The primary purpose of range ventilation is to remove airborne contaminants from the respiratory zone of the range participant. Action Target uses patented technology to assure safe air quality that exceeds even the strictest standards.



Action Target ventilation designs have consistently provided compliance within the established federal standards for airborne inorganic lead concentration limits, including those of the Environmental Protection Agency (EPA) and the Occupational Safety and Health Administration (OSHA). Our ventilation systems have undergone the rigourous testing and approval process to meet the highest possible standards set by the US Navy for their firearm training facilities.



Action Target and Carey's partnered years ago to offer the best small arms range ventilation systems on the market. These systems have been repeatedly tested by the U.S. Government with results showing zero airborne contaminants in the shooters respiratory zone. For the safest training conditions possible at your range, Action Target consistently delivers proven solutions.



PRODUCT DATA
FILTER-LINE™
SERIES FLH
PD-FLFLH-03A
JANUARY 2003

AIR FILTERS

FILTER-LINE™

SERIES FLH — 95/12, 97/12, 99/12

HEPA FILTERS

95%, 99.97% AND 99.99% DOP EFFICIENT — 6" OR 12" DEEP

Description



The FILTER-LINE™ Series FLH — Filter-Line HEPA (High Efficiency Particulate Air) Filters are designed to provide the highest levels of air filtration. Filter-Line HEPA Filters may be used in a wide variety of critical applications, including: hospitals, pharmaceutical/electronic manufacturing, food processing, reseach laboratories, etc. Filter-Line HEPA Filters are available in 3 efficiency ranges (95%, 99.97% and 99.99%) and 2 air flow capacity levels: **Standard Capacity** HEPA filters are available for normal operating conditions and **High Capacity** HEPA Filters are available for higher air flow applications. Filter-Line HEPA Filters are available in (5) standard face sizes and (2) filter depths.

Construction

MICRO GLASS FIBER PAPER MEDIA

Filter-Line HEPA Filters are manufactured from micro glass fiber wet laid paper media. Media is water resistant and spacing is maintained by the use of corrugated aluminum separators.

16 GAUGE GALVANIZED STEEL CELL SIDE

Filter-Line HEPA Filters are constructed of 16 gauge galvanized steel. The cell side provides for a very rigid filter and all interior surfaces of the air filter media are sealed to the enclosing frame.

MEDIA PACK/CELL SIDE SEALANT BOND

Filter-Line HEPA Filters are manufactured to provide a leak-free seal between the media pack and the cell side. All sides of the media pack are sealed with an adhesive to ensure filter integrity.

DOVE TAIL NEOPRENE DOWNSTREAM GASKET

Filter-Line HEPA Filters are supplied with a standard downstream sealing gasket. The gasket is an interlocking dove tail design constructed of neoprene which is attached to the HEPA cell side.

INDIVIDUALLY TESTED AND LABELLED FILTERS

Filter-Line HEPA Filters are tested and labelled for minimum DOP efficiency on 0.3 micron (uM) particles, in accordance with *The Edgewood Arsenal Instruction Manual 136-300-175.*

WIDE VARIETY OF FILTER SIZES AND DEPTHS

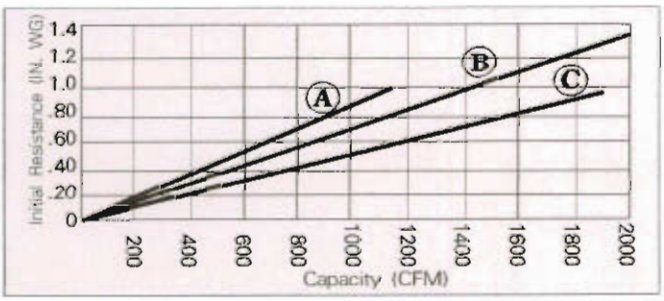
Filter-Line HEPA Filters are offered in (5) standard face sizes and (2) filter depths for 6" and 12" HEPA Filters. All Filter-Line HEPA Filters conform to industry standards for fit and performance.

Dimensional Data

SERIES FLH - HEPA FILTERS		STANDARD CAPACITY @		HIGH CAPACITY @
		.95"	1.00"	1.35"
MODEL NUMBER	ACTUAL SIZE	95% DOP	99.97% 99.99%	99.97% 99.99%
FLH**/121123*MD	11 3/8 x 23 3/8 x 11 1/2	865	485	830
FLH**/121224*MD	12 x 24 x 11 1/2	910	525	900
FLH**/122323*MD	23 3/8 x 23 3/8 x 11 1/2	1900	1090	1900
FLH**/122424*MD	24 x 24 x 11 1/2	2000	1150	2000
FLH**/122430*MD	24 x 30 x 11 1/2	2550	1450	2540

**Insert "95" for 95%, "97" for 99.97% and "99" for 99.99% DOP highly efficient HEPA Filters.

*Insert "S" for Standard Capacity or "H" for High Capacity. "M" stands for Metal Cell Side, "D" for Downstream Gasket.



MODEL NUMBER KEY

FLH97/12**2424**SMD

Insert model number extension to complete model number.

FLH-	FILTER-LINE™ HEPA Filter
97/12-	99.97% Efficiency - 12" Depth
24-	Unit Width
24-	Unit Height
SMD-	Standard Capacity, Metal Cell Side, Downstream Gasket

Notes:

1. Performance data is based on:
   (A) - Standard Capacity HEPA Filter: 24 x 24 x 11 1/2
   (B) - High Capacity HEPA Filter: 24 x 24 x 11 1/2
   (C) - 95% Efficient HEPA Filter: 23 3/8 x 23 3/8 x 11 1/2
2. 6" deep and special HEPAs are available, please contact factory.

Corporate Headquarters
P.O. Box 14187,
Louisville, Kentucky 40214
Phone: (502) 366-6002
Fax: (502) 366-6255

E-Mail: askus@blcind.com

BLC-West
Phone: (480) 839-5333
Fax: (480) 839-1584

www.blcind.com

We reserve the right to make changes in product design and product specifications without prior notice or obligation.

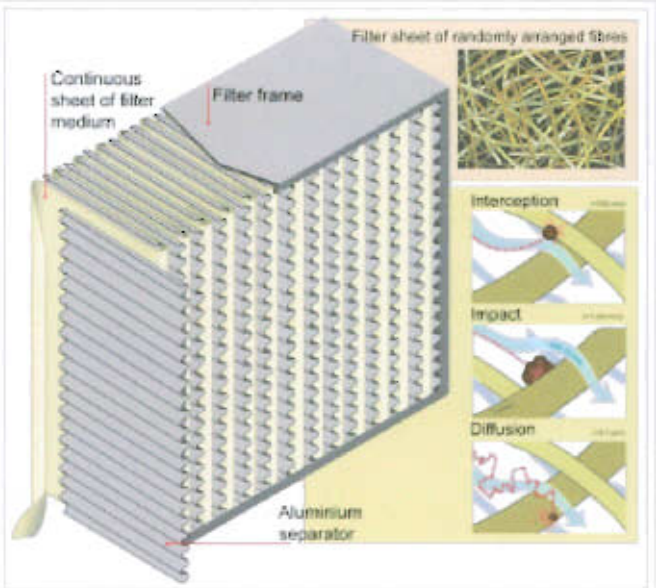
BLC INDUSTRIES INC.

Breathe Easy. We Have The Line On Air Filtration.

HEPA

From Wikipedia, the free encyclopedia

High-Efficiency Particulate Arresting or **HEPA**[1][2] is a type of air filter. Filters meeting the HEPA standard have many applications, including use in medical facilities, automobiles, aircraft, and homes. The filter must satisfy certain standards of efficiency such as those set by the United States Department of Energy (DOE). To qualify as HEPA by US government standards, an air filter must remove 99.97% of all particles greater than 0.3 micrometer from the air that passes through. A filter that is qualified as HEPA is also subject to interior classifications.



HEPA-Filter with functional description

Contents

- 1 Function
- 2 Specifications
- 3 Biomedical applications
- 4 Vacuum cleaners
- 5 Vehicle use
  - 5.1 Cars
  - 5.2 Airlines
- 6 See also
- 7 References
  - 7.1 Footnotes
  - 7.2 General references
- 8 External links

Function

HEPA filters are composed of a mat of randomly arranged fibres. The fibres are typically composed of fiberglass and possess diameters between 0.5 and 2.0 micrometers. Key factors affecting function are fibre diameter, filter thickness, and face velocity. The air space between HEPA filter fibres is much greater than 0.3 μm. The common assumption that a HEPA filter acts like a sieve where particles smaller than the largest opening can pass through is incorrect. Unlike membrane filters at this pore size, where particles as wide as the largest opening or distance between fibres cannot pass in between them at all, HEPA filters are designed to target much smaller pollutants and particles. These particles are trapped (they stick to a fibre) through a combination of the following three mechanisms:

1. *Interception*, where particles following a line of flow in the air stream come within one radius of a fibre and adhere to it.
2. *Impaction*, where larger particles are unable to avoid fibres by following the curving contours of the air

stream and are forced to embed in one of them directly; this effect increases with diminishing fibre separation and higher air flow velocity.

3. *Diffusion*, an enhancing mechanism that is a result of the collision with gas molecules by the smallest particles, especially those below 0.1 µm in diameter, which are thereby impeded and delayed in their path through the filter; this behaviour is similar to Brownian motion and raises the probability that a particle will be stopped by either of the two mechanisms above; it becomes dominant at lower air flow velocities.

Diffusion predominates below the 0.1 µm diameter particle size. Impaction and interception predominate above 0.4 µm. In between, near the Most Penetrating Particle Size (MPPS) 0.3 µm, both diffusion and interception are comparatively inefficient. Because this is the weakest point in the filter's performance, the HEPA specifications use the retention of these particles to classify the filter.

Lastly, it is important to note that HEPA filters are designed to arrest very fine particles effectively, but they do not filter out gasses and odor molecules. Circumstances requiring filtration of volatile organic compounds, chemical vapors, cigarette, pet, and/or flatulence odors call for the use of an activated carbon (charcoal) filter instead of or in addition to a HEPA filter.

Specifications

HEPA filters, as defined by the DOE standard adopted by most American industries, remove at least 99.97% of airborne particles 0.3 micrometers (µm) in diameter. The filter's minimimal resistance to airflow, or pressure drop, is usually specified around 300 Pa at its nominal flow rate.

The specification usually used in the European Union is the European Norm EN 1822:2009. It defines several classes of HEPA filters by their retention at the given Most Penetrating Particle Size (MPPS):

HEPA class	retention (total)	retention (local)
E10	> 85 %	---
E11	> 95 %	---
E12	> 99.5 %	---
H13	> 99.95 %	> 99.75 %
H14	> 99.995 %	> 99.975 %
U15	> 99.9995 %	> 99.9975 %
U16	> 99.99995 %	> 99.99975 %
U17	> 99.999995 %	> 99.9999 %

The original HEPA filter was designed in the 1940s and was used in the Manhattan Project to prevent the spread of airborne radioactive contaminants. It was commercialized in the 1950s, and the original term became a registered trademark and a generic term for highly efficient filters. Over the decades filters have evolved to satisfy the higher and higher demands for air quality in various high technology industries, such as aerospace, pharmaceutical processing, hospitals, health care, nuclear fuels, nuclear power, and electronic microcircuitry (computer chips).

Today, a HEPA filter rating is applicable to any highly efficient air filter that can attain the same filter efficiency performance standards as a minimum and is equivalent to the more recent NIOSH N100 rating for respirator filters.

The United States Department of Energy (DOE) has specific requirements for HEPA filters in DOE regulated applications. In addition, companies have begun using a marketing term known as "True HEPA" to give consumers assurance that their air filters are indeed certified to meet the HEPA standard. [3]

Products that claim to be "HEPA-type", "HEPA-like", "HEPA-style" or "99% HEPA" do not satisfy these requirements and may not have been tested in independent laboratories. Some of these sub-par quality filters may come reasonably close to HEPA filtration, while others will fall significantly short, making them truly inferior.[4]

Biomedical applications

HEPA filters are critical in the prevention of the spread of airborne bacterial and viral organisms and, therefore, infection. Typically, medical-use HEPA filtration systems also incorporate high-energy ultra-violet light units to kill off the live bacteria and viruses trapped by the filter media. Some of the best-rated HEPA units have an efficiency rating of 99.995%, which assures a very high level of protection against airborne disease transmission.



Hospital staff modelling a HEPA filter, which can be used if a patient has active tuberculosis.

Vacuum cleaners



HEPA original filter for Philips FC87xx-series vacuum cleaners

Many vacuum cleaners also use HEPA filters as part of their filtration systems. This is beneficial for asthma and allergy sufferers, because the HEPA filter traps the fine particles (such as pollen and dust mite feces) which trigger allergy and asthma symptoms. For a HEPA filter in a vacuum cleaner to be effective, the vacuum cleaner must be designed so that all the air drawn into the machine is expelled through the filter, with none of the air leaking past it. This is often referred to as "Sealed HEPA" or sometimes the more vague "True HEPA." Vacuum cleaners simply labeled HEPA have a HEPA filter, but not all air necessarily passes through it. Finally, vacuum cleaner filters marketed as "HEPA-like" will typically use a filter of a similar construction to HEPA, but without the filtering efficiency. Because of the extra density of a HEPA filter, HEPA vacuum cleaners require more powerful motors to provide adequate cleaning power.

Newer models claim to be better than the first models because of being "washable". Generally washable filters are expensive. Some manufacturers claim filter standards such as "HEPA 4", without explaining the meaning behind them. It refers to their Minimum Efficiency Reporting Value (MERV) rating. These ratings are used to rate the ability of an air cleaner filter to remove dust from the air as it passes through the filter. MERV is a standard used to measure the overall efficiency of a filter. The MERV scale ranges from 1 to 20, and measures a filter's ability to remove particles from 10 to 0.3 micrometre in size. Filters with higher ratings not only remove more particles from the air, they also remove smaller particles.

Vehicle use

Cars

Some new model cars have cabin air filters that look like HEPA filters, but are not. The confusion is perpetuated by guides on how to change your car's air filter, misnaming it as a HEPA filter. The performance of these filters is obscured by manufacturers and difficult to evaluate, as they are not rated with the MERV system. They are typically close to MERV 8 performance.

Airlines

Modern airliners use HEPA filters to reduce the spread of airborne pathogens in recirculated air. [5]

See also

- Air purifier
- Clean Air Delivery Rate
- Electrostatic precipitator - trap particles with high voltage
- HEGA - carbon cloth filter developed by the British military against chemical warfare
- Hypoallergenic vacuum cleaner - vacuum cleaner with high efficiency air filter
- Respirator
- ULPA - Removes 99.999% of dust, pollen, mold, bacteria and particles larger than 120 nm

References

Footnotes

1. ^ HEPA Company glossary of terms (http://www.hepa.com/about_glossary.asp)
2. ^ Originally 'High Efficiency Particulate Arrestment - see thefreedictionary.com (http://www.thefreedictionary.com/HEPA)
3. ^ http://www.home-air-purifier-guide.com/true-hepa-filter.html
4. ^ http://www.air-purifier-power.com/hepatypefilter.html
5. ^ Boeing Facts on Cabin Air Systems in Commercial Airplanes (http://www.boeing.com/commercial/cabinair/facts.html)

General references

- TSI Application Note ITI-041: Mechanisms of Filtration for High Efficiency Fibrous Filters (http://www.tsi.com/documents/ITI-041.pdf)

External links

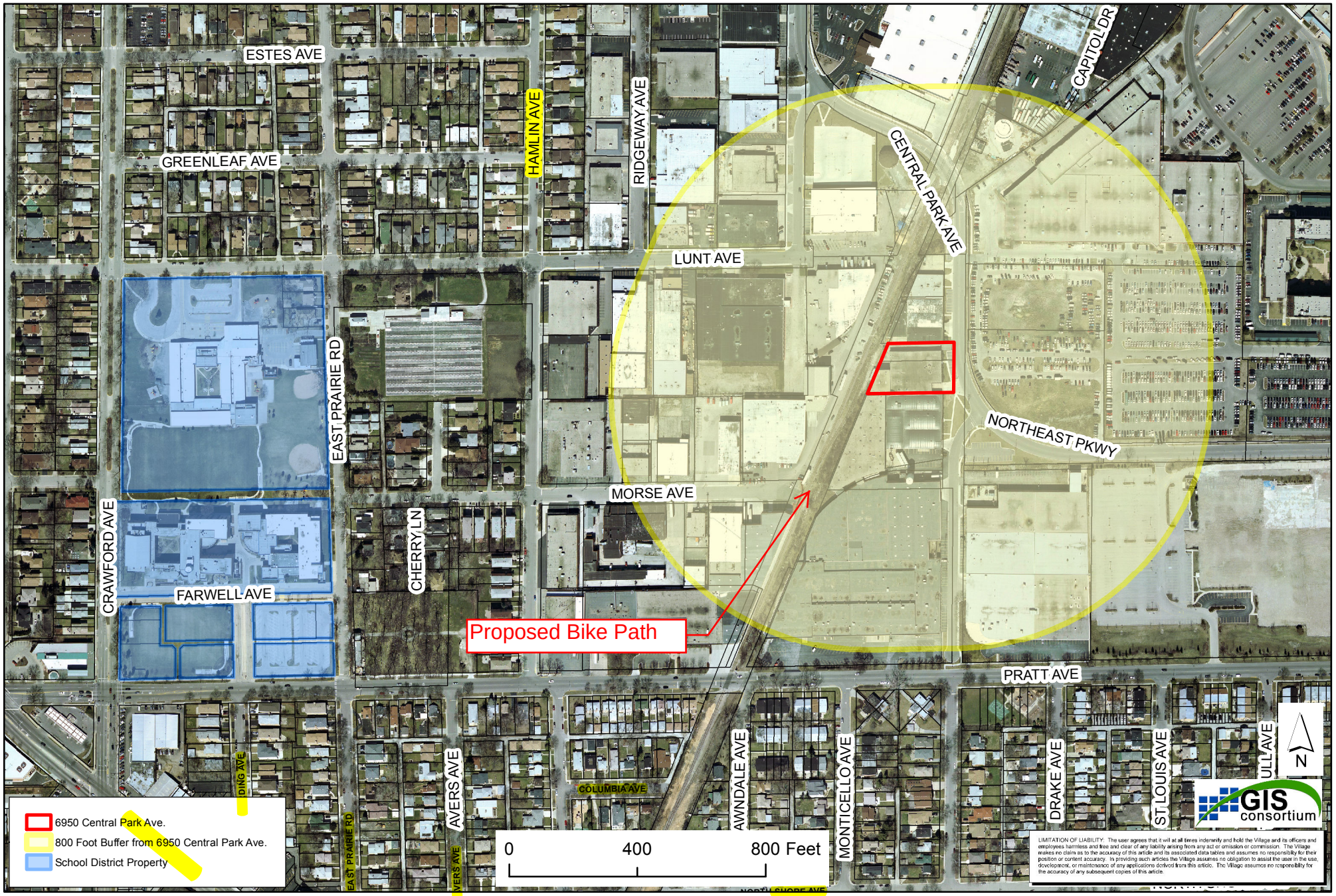
- US Department of Energy HEPA website (http://www.hss.doe.gov/nuclearsafety/qa/hepa/index.html)
- US DOE-STD-3020 HEPA Filters Used by DOE Contractors, 2005 Edition (http://www.hss.doe.gov/nuclearsafety/techstds/docs/standard/doe-std-3020-2005.pdf) *Warning: 100k PDF*
- DOE HDBK-1169-2003; DOE Handbook Nuclear Air Cleaning Handbook (http://www.hss.doe.gov/nuclearsafety/techstds/docs/handbook/index_hdbk1169.html)

- Nuclear Air Cleaning Conference Proceedings (http://www.hss.doe.gov/nuclearsafety/qa/hepa/conference.html)
- ASME AG-1, Section FK, Special HEPA Filters (http://cstools.asme.org/csconnect/pdf/CommitteeFiles/16990.pdf)
- American Society of Heating, Refrigerating and Air-Conditioning Engineers (http://www.ashrae.org/)
- Recommended Practice on HEPA and ULPA Filters (http://www.iest.org/StandardsRPs/RecommendedPractices/IESTRPCC001/tabid/10894/Default.aspx)
- How HEPA filters work (http://www.airfiltersandpurifiers.com/HEPA-filters)
- Understanding HEPA Filters and the 0.3 Micron Standard (http://www.amorwares.com/post/understanding-hepa-filters-and-the-03-micron-standard)

Retrieved from "http://en.wikipedia.org/w/index.php?title=HEPA&oldid=495883828"
Categories: Building biology | Filters

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Village of Lincolnwood
800 Ft. Buffer from 6950 Central Park Ave.



2012.07.11_MGPDRM

Village of Lincolnwood
800 Ft. Buffer from 3318 W. Devon Ave.



800 Foot Buffer from 3318 W. Devon Ave.
3318 W. Devon Ave.
Village Boundary

0 400 800 Feet

N

GIS consortium

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20120711_MGPDRM

Ravenswood Studio, Inc.

July 6, 2012

Village of Lincolnwood
Board of Trustees

6950 Central Park Avenue – Text Amendment, Special Use, and Variations

Dear Village Board Members and Mayor Turry,

I am the founder and owner of Ravenswood Studio, Inc. We are located at 6900 N Central Park Avenue, adjacent to 6950 N Central Park Avenue. Some background information: we are a twenty year old privately held company. We do highly specialized design and fabrication work for corporate and cultural institutions around the country. We are a unique company with an extremely diverse client base. Here's an abbreviated list: Microsoft Corporation, John Deere, Houston Grand Opera, MacArthur Foundation, Western Union, Florida Grand Opera, New York City Opera, Mythbusters, Field Museum, Shedd Aquarium, Six Flags, Blue Man Group, Museum of Science and Industry and many more.

Executives from these companies come to Ravenswood Studio for everything from concept and preplanning to design, fabrication and installation. Client meetings and charrettes in our conference room and offices can last for several days. This type of work requires focused attention in a relatively quiet, normal, office environment. Our offices and the proposed shooting range will share a demising wall. Gunfire noise will be audible within our office. The highly annoying, percussive nature of gunfire noise will render our offices unusable. See the attached report from the acoustic engineering firm Kirkegaard Associates.

The other concerning issue is parking. At the June 6th Plan Commission meeting village staff recommended 74 off street parking spots for this size and type of facility, the variance would be for zero. The public lot across the street has 24 spots and is mostly full. The weeks we tracked it there were between 17 and 24 cars parked during normal business hours. Introducing a facility of this size with no parking will cause serious problems for the existing businesses.

I am no expert on the impact of economic activity and we are a small company, but here are some Ravenswood Studio statistics for the twelve month period ending June 30, 2012.

Full time employees	46
Annual Payroll	$2,252,837.00
Average Hourly Wage	$23.33
2011 Property Taxes	$131,222.00

The type of jobs we offer are increasingly rare these days with more and more people forced to accept low paying, low skill retail positions. Wal-Mart average wage is $11.75! In our 5 1/2 years in Lincolnwood I have no doubt we've exceeded Shore Galleries 50 year payroll and employment record. I am not claiming that I'm a 'big guy' or that the 'little guy' doesn't matter. But does it make sense to drive me and my employees from the community?

To reiterate, our 6,000 sq ft office will become unusable sharing a wall with a shooting range. We will not be able to operate in our current location. Moving is expensive and risky in this economy. My life's work and that of many of my long time employees is at risk. Please consider not allowing the proposed zoning changes or at the very least send this back to the Plan Commission for further study.

Sincerely,



Michael Shapiro
President
Ravenswood Studio, Inc.

Kirkegaard ASSOCIATES

MEMORANDUM

Date: 15 June 2012

To: Mr. Michael Shapiro, President
Ravenswood Studios, Inc.

Copy: Project file

From: Louie Sunga/Hans Michel

Re: **Proposed Firing Range Adjacent to Ravenswood Studios**
Lincolnwood, IL
KA Project N° 122495

Dear Michael,

It was a pleasure to meet with you and your staff to discuss the potential acoustic problem with the proposed firing range adjacent to your office and a conference room. This memorandum will document our discussions in yesterday's meeting and attempt to describe the issues in simpler terms that will allow you to make an informed decision.

As we discussed in Tuesdays meeting, Shore Galleries is a gun shop and is proposing to purchase the building adjacent to Ravenswood Studios. The attached floor plan provided by the Architect shows a long range and short range shooting gallery located opposite the shared demising wall of Ravenswood Studios. The noise from the firing ranges has the potential to disrupt the functions within your offices and conference room which are located on the shared wall. The first floor plan is attached for reference at the end of this memo.

GENERAL DISCUSSION ON SOUND

Sound as we experience it is a disturbance of the pressure in the air around us. As a noise source moves, it excites the air particles around it and creates a wave that travels outward in all directions. When in enclosed spaces, a certain portion of these waves are reflected, a certain portion are absorbed (converted into heat), while a third group is transmitted through the enclosure as vibration and reradiated on the other side. When designing the appropriate acoustic isolation between spaces it is important to look at the allowable noise level within the space adjacent to the noise source, the level and character of the noise source, the transmission loss of the construction between the spaces.

The maximum allowable noise levels from surrounding noise sources are defined per the Lincolnwood zoning code, Part E, item 6.20 Noise and Vibration. The table in this location

identifies a maximum allowable noise levels on adjacent non-residential properties to be 60 dB(A) between 7:00AM and 11:00PM. dB(A) is a single number simplification of the measured sound spectrum of a noise source, weighted to emphasize the middle of the range of human hearing. This value of 60 dB(A) is equivalent to the level of normal conversation at three feet. We interpret the noise ordinance will restrict the noise levels at the property line to be at 60 dB(A). The property line is located in the middle of the shared demising partition. It can be reasonably inferred that the noise within the Ravenswood Studios must be less than 60 dB(A) due to the existing exterior wall construction. We estimate that the existing exterior wall construction to reduce the noise levels to approximately 50-52 dB(A) inside the offices and conference room. While not offensively loud, this level would be clearly audible in the conference rooms and offices adjacent to the shooting range.

Noise sources are defined by their sound pressure level, their frequency content, and whether they are steady state or impulsive sources. Steady state sources stay at the measured levels continuously, with little variation as time passes. Impulsive noise sources reach a peak level quickly, and decay just as quickly.

Because gunshots would qualify as impulsive noise there are additional psychological aspects of acoustics that must be taken into consideration. In a quiet office environment such as your office and conference room, some people might find the impulsive "pops" of gunshot to be tolerable while others may find it extremely disturbing. In our meeting, we suggested an unscientific experiment to determine for yourself if this noise level will be disruptive to your work environment. The experiment involves placing a loudspeaker source in an adjacent room and play music with heavy percussive bass to simulate gunshots. The loudspeaker can be turned on at a level that is 60 dBA in the receiver room. The people can then go into the receiver room and experience this type of noise and determine how disruptive it will be to their work. This experiment will not replicate the sporadic and unpredictable sounds from gunshots which some people find extremely disturbing.

The frequency content of gunshots is typically fairly constant from low to high frequencies. The maximum levels of noise will typically be in the mid frequencies, with a slight roll off at low and high frequencies depending on the size of the gun. As a general rule the larger the caliber of gun the more low frequency noise created. Given that the range is anticipated for use with a 50 caliber weapon, this low frequency noise has the potential to be very disruptive.

The last issue associated with the noise source is the sound pressure level. In order for a bullet to fire from a gun a tremendous amount of pressure must be created. While most of this power is used to propel the bullet, the noise levels created by this reaction are impressive. Indoor shooting ranges can be particularly challenging, as the portion of the sound waves reflected by interior surfaces capture the sound energy. This will increase the length of time it takes for the noise to dissipate, increasing the noticeability of the noise. The addition of sound absorbing materials can help, though is not an assurance of performance by itself. Gunshots by themselves can reach impulse levels upwards of 170+ dBA. As a point of reference, a Jet engine at 100' is continuous at140 dBA, and the maximum possible level of sound under normal atmospheric conditions (due to physical changes within the medium of air) is 194 dB.

Kirkegaard
ASSOCIATES

ANALYSIS OF PROPOSED WALL AND ROOF CONSTRUCTION

The construction needed to achieve a reduction of 110+ dBA is quite impressive. Given the critical adjacencies necessitated by the site conditions a great deal of care will be needed in design and construction to ensure acoustic performance. The most direct path for sound to travel in this condition is through the shared demising partition. Though not impossible, the 110 dBA reduction requires incredibly heavy and massive construction, and will mandate extreme attention to detail during construction to avoid flanking paths for sound.

A secondary path for sound to travel from one space to another is for the sound to be transmitted through a different partition common to the noise source, radiate from that partition to another partition common to the receiver room, and finally be transmitted through that partition into the receiver room. The ceiling and roof construction of the firing range is the most likely culprit for a weakness in this path, and will need to be accounted for during design and construction. Given the lightweight roof systems of both buildings a heavy ceiling system will be needed to attenuate sound through this path. This type of system may weigh 70+ pounds per square foot, and should be studied by a structural engineer to determine the feasibility of such construction.

The roof/ceiling construction can best be described as ballistic ceiling panels (1/4" thick steel plates) hung from the roof structure. The product data that we received shows gaps between panels and slots for lighting which will prevent an airtight ceiling construction. Further research has indicated that the firing range will need a lot of air circulation to remove the lead dust and smoke when the range is in use. We are assuming that the ductwork serving the firing range will need to penetrate the ceiling or wall assembly, thus reducing the sound isolation efficiency. Above the roof structure, metal deck with 1" thick gypcrete, roofing insulation, roof membrane and stone ballast comprise the remainder of the roof assembly.

Another path for sound to travel is as vibration through structure, reradiating sound as it travels. The exterior walls of these structures are continuous around the entire perimeter of the buildings, and almost certainly touch at the property line. As the walls at the ends of the firing range appear to be the exterior wall systems, there is ample opportunity for vibration to translate along these surfaces and reradiate in Ravenswood Studios. A complete structural separation of the shooting range from the surrounding structure will be necessary to ensure proper acoustic performance. This requires that inner walls and ceilings be supported by vibration isolating elements, while the slab could be isolated via a slab cut or an isolated slab system.

All weaknesses in the isolation created by mechanical and electrical and plumbing penetrations must be carefully accounted for. If compromises in the construction exist sound can travel through these paths either directly through gaps via the air, or secondarily through vibration of penetrating elements. Airtight closure of the space with resilient connection to surrounding structure will be required to maintain the acoustic integrity of the enclosure. When dealing with such extreme levels the margin for error is considerably smaller.

Kirkegaard
ASSOCIATES

It is our assessment that the proposed design of the firing ranges will not meet the noise ordinance. The roof/ceiling design is insufficient to attenuate the sound of gunshots and will be audible within Ravenswood Studios.

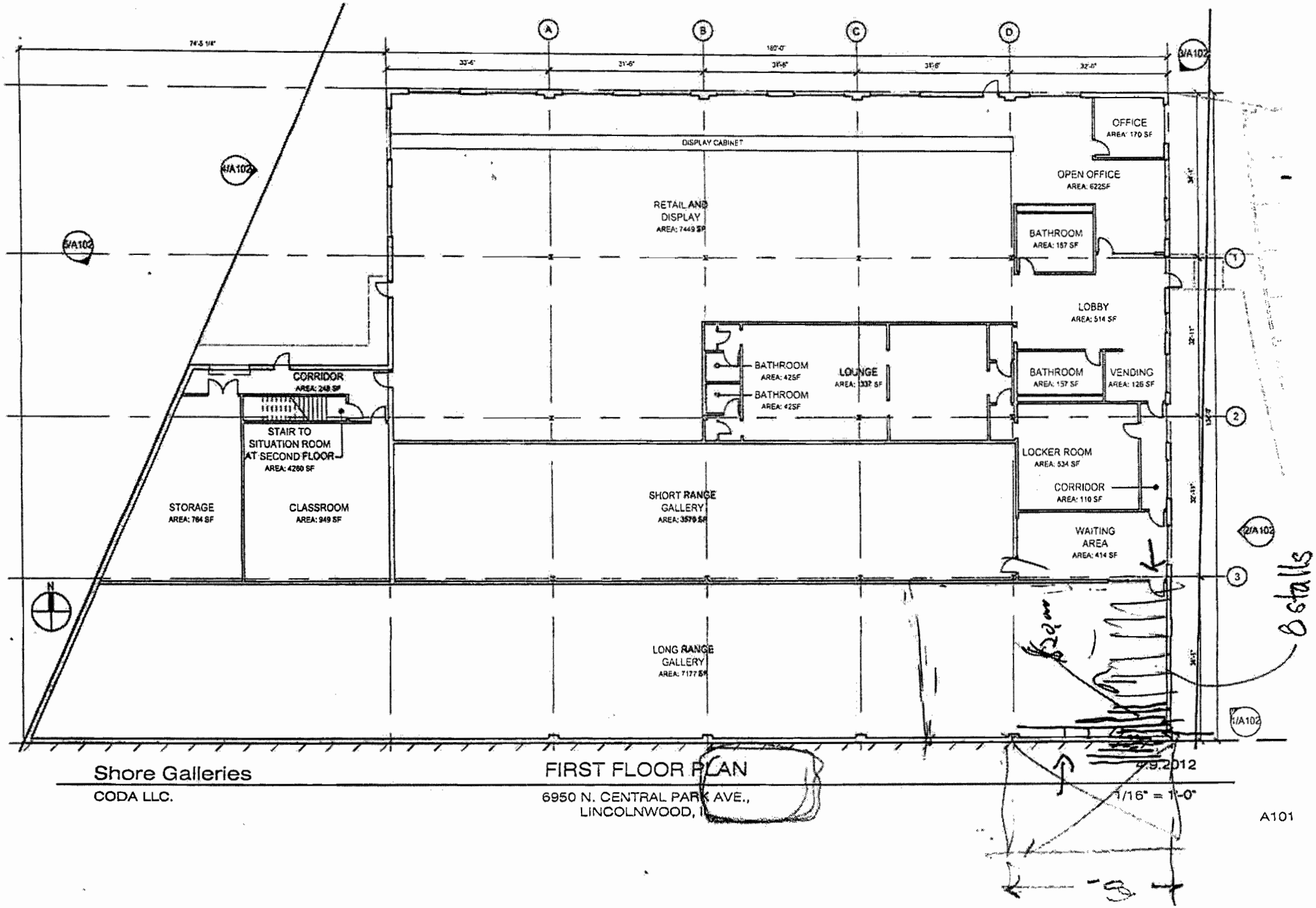
Please don't hesitate to contact us with additional questions or comments.

With kind regards,

Louie Sunga, AIA and Hans Michel

attachments:

- First floor plan
- Demising detail
- Safety Baffles product data



Shore Galleries

CODA LLC.

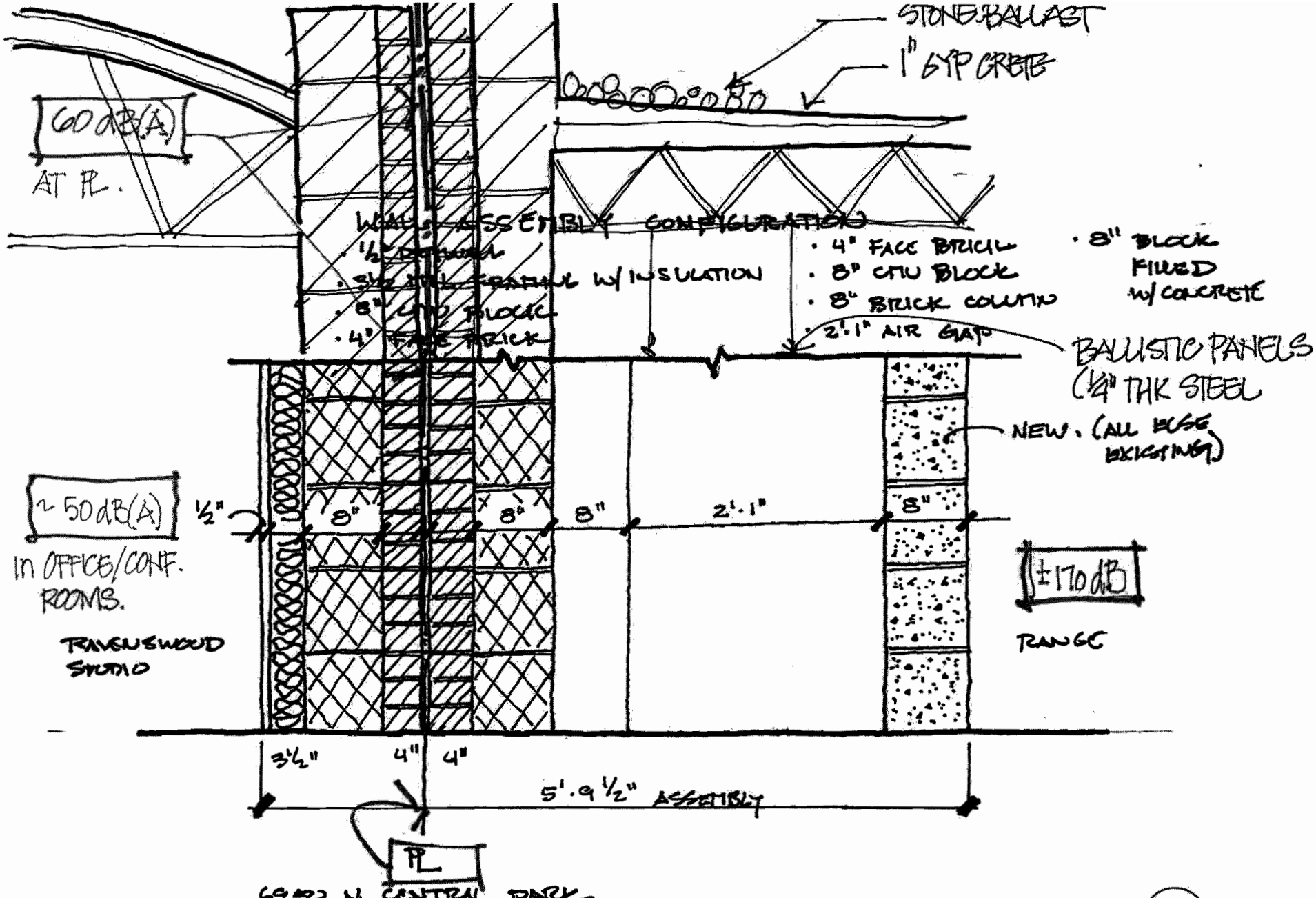
FIRST FLOOR PLAN

6950 N. CENTRAL PARK AVE.,
LINCOLNWOOD, I

9.9.2012

1/16" = 1'-0"

A101



CODA

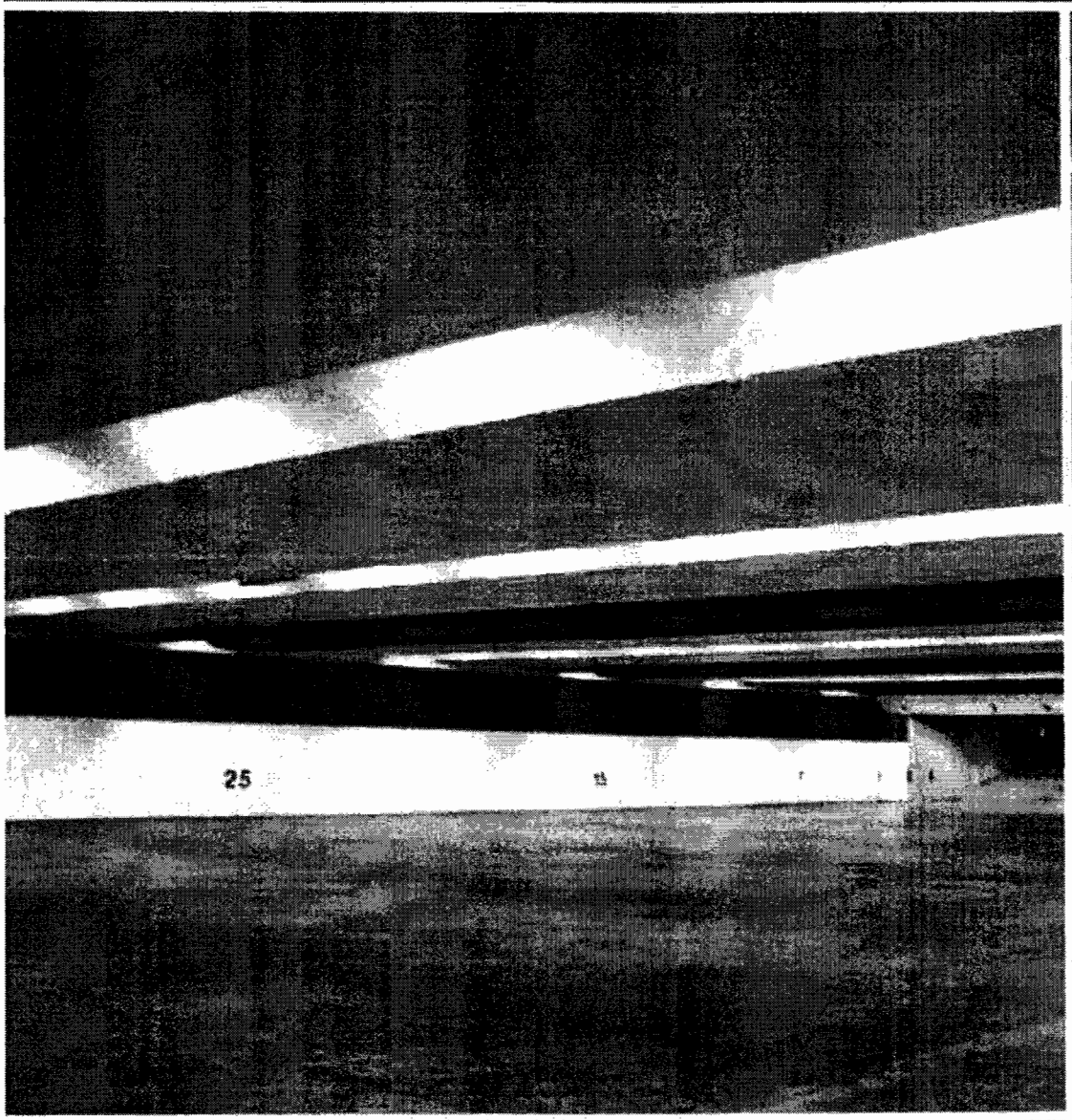
Corporate Office
631 Lake Avenue
Wilmette, IL 60091

INDOOR RANGES

U.S. PATENT # 5822936

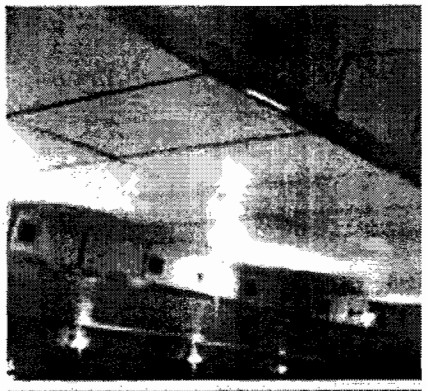
SAFETY BAFFLES™

In addition to keeping fired bullets from exiting the range, baffles offer protection for overhead lights, pipes, ventilation ducts, and other structures.









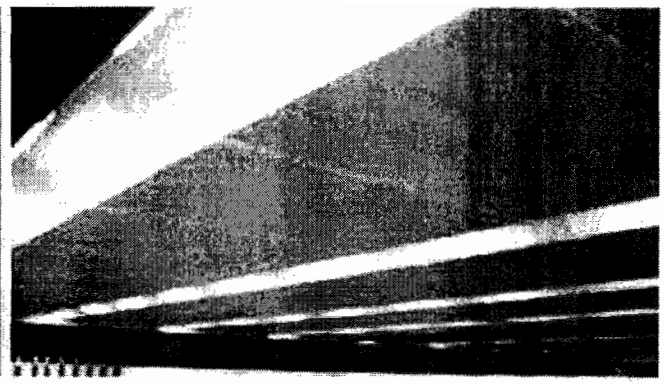
A critical safety concern on any indoor range is making sure bullets can't escape to the outside. Using an innovative combination of steel, wood, and acoustical tile, Action Target Baffles provide ballistic protection, sound abatement, and a polished, professional appearance.

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To ensure you get exactly what you need for your specific range requirements, Action Target Safety Baffles come in 4 levels of protection.

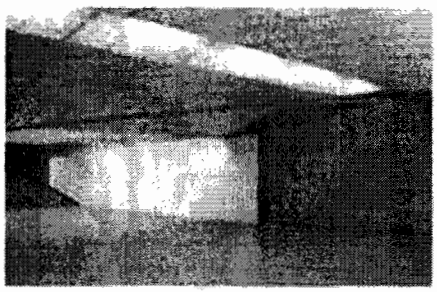


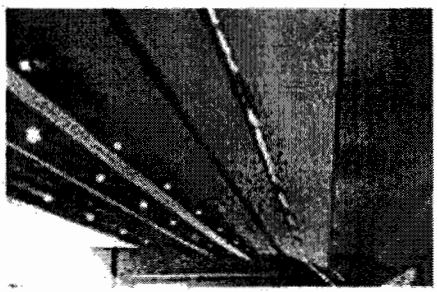
LEVEL 1: Baffles are made of 10-gauge steel, and will deflect and contain most standard handgun rounds fired at an angle of at least 45 degrees from perpendicular, some damage to the steel plate may occur. Repeated rounds impacting in the same area may breach the baffle.

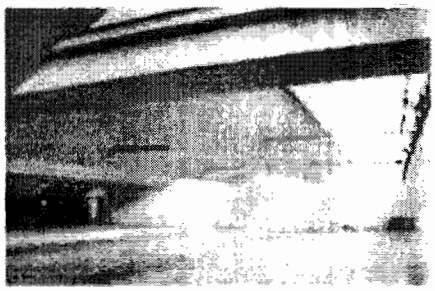
LEVEL 2: Baffles are made of 1/4" mild steel and will deflect and contain standard handgun rounds fired at an angle of at least 45 degrees from perpendicular with little or no damage to the steel plate. Baffle will also deflect and contain standard handgun rounds fired at a perpendicular angle with some potential damage to the steel plate.

LEVEL 3: Baffles are made of 1/4" AR steel and will deflect and contain standard handgun rounds fired at a perpendicular angle with no damage to the steel plate. Baffle will also deflect and contain high power rounds (5.62 and .308) fired at an angle of at least 45 degrees from perpendicular. Some damage to the steel plate may occur.

LEVEL 4: Baffles are made of 3/8" AR steel and will deflect and contain standard handgun rounds fired at a perpendicular angle with no damage to the steel plate. Baffle will also deflect and contain high power rounds (5.62 and .308) fired at a perpendicular angle. High power rounds fired at a perpendicular angle will cause damage to the steel plate. Repeated high power rounds fired at a perpendicular angle impacting in the same area may breach the baffle.







Performance Characteristics	• Impenetrable barrier • Protect lighting, ventilation, and other utilities & equipment • Help control acoustics and other sound issues • Match the grade of baffles to the scope of the range: Handguns? Rifles? • Choosing line Baffles: Calculate line of sight from standing, kneeling, and prone positions • Tactical movement baffles: Entire range must be completely protected — not just certain areas Baffles are different than deflectors

RECEIVED
JUL 9 2012



From: Marvin Cooper <m-cooper@northwestern.edu>
Subject: **Zoning Law Change Vote,scheduled for July 17, 2012**
Date: July 8, 2012 8:37:07 PM CDT
To: John Swanson <jswanson@lwd.ord>, Lawrence Ester <lelster@lwd.org>, Renee Sprogis-Marohn <rsprogismarohn@lwd.org>, Gerald Turry <jturry@lwd.org>, Jesal Patel <jpatel@lwd.org>, Thomas Heidtke <heidtke@lwd.org>, bherman@lwd.org, Nicholas Leftakes <nleftakes@lwd.org>

Sunday, July 08, 2012

To: Honorable Gerald Turry, President, Village of Lincolnwood, and all members of the Village Board, Lincolnwood Illinois;

My name is Marvin E. Cooper, M.D.
My wife Marcia and I have lived in Lincolnwood (62 years). We raised our family and I have also had the honor of serving many years ago as the Medical Consultant to the Police Department, plus being a member of the Human Relations commission until my resignation last year.

Because of a previous committment on July 17, 2012, we wil be unable to attend the open meeting of the Village Board when a Zoning Law Change vote is to be taken relating to a Gun Range and Store. Because this information first was brought to my attention yesterday, I have made some inquiries of individuals whom I felt might have some knowledge of this proposal. What I learned was that 'Shore Gallery' wishes to move from it's present location to a new and larger facility.

I am not anti business, nor anti business wanting to expand, but I am and always will be anti guns which have an uncanny way of ending up in wrong hands. There are enough parcels of land available that are more than 800 feet from our schools and should be considered as appropriate sites for this establishment. It is my hope that this will be a factor prior to voting.

Please! Please! think of yours and all of our children before casting your vote, which I hope will be against changing the zoning laws.

Marvin E. Cooper, M.D.
4400 W. Pratt Ave.
Lincolnwood, Il 60712-3318
m-cooper@northwestern.edu

Walter J. Klinger
6518 N. Navajo
Lincolnwood, Illinois 60712



20 June 2012

The Village of Lincolnwood Illinois
The Honorable Mayor Gerald Turry
6900 N. Lincoln Avenue
Lincolnwood, Illinois. 60712

Dear Mayor Turry:

The purpose of this letter is as a resident to voice my support for Shore Galleries to be able to move from their current location on Devon Avenue to their new facility at 6950 Central Park Avenue here in Lincolnwood. It is my understanding that this move would be affirmed under a zoning variation as granted by the Village. This absolutely should be voted in the affirmative by the Board immediately. The rationale that backs up my support is as follows:

Shore Galleries has been a corporate citizen since 1956; and was founded by Mr. Sig Shore (of blessed memory) and his wife Mrs. Charlene Shore. The Shore family has been wonderful neighbors and supporters of all things Lincolnwood for many decades; longer than many if not most of our residents have lived in the Village. There is no way that you can replace this act of dedication shown to our Village by one of its corporate citizens for as long as the Shore family has done this.

Let's talk about Mr. Shore's project for a moment. Mr. Shore continues to run his family business here in the Village for more than 57 years. Mr. Shore is a highly successful proprietor of Police Equipment and Law Enforcement Supplies. He like his father is no stranger to running a highly successful operation that pays more than its share of taxes to the Village; and employs many fine people who also in turn contribute their share of tax revenue to the coffers. Mr. Shore has developed a solid business plan that will grow his business; continue to employ people with good jobs and should ultimately generate even more revenue for the Village that we desperately need. This proposal is a no-brainer in every aspect.

As a resident of the Village, I firmly believe that the Village Fathers need to stand squarely behind each and every one of the businesses that support our community with sales tax, property tax and licensing/fee based revenues. As I drive around the Village that I have grown to love, I am deeply disturbed that so many of our retail, manufacturing, service, and industrial neighbors have left the Village. I drive down parts of Touhy and Lincoln Avenues and I see nothing but empty stores and businesses. It does not take a rocket scientist to realize that when these corporate neighbors are gone, someone needs to take up the tax burden that is left behind. This means that I along with my neighbors (you, and single homeowner in the Village) has to dig deeper into our declining pockets to support the necessary Village services.

Mayor Proesel saw the Village grow to almost 12,000 residents and to sport more businesses and industries that anyone could imagine. The current Village Fathers simply must support this

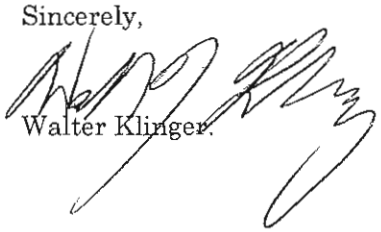
business in the very same manner that Mayor Proesel most certainly would have if we even hope for a chance of better financial stability.

Furthermore, I am a Police Sergeant, employed by a large Police Department. I depend on Shore Galleries for the equipment that I need and use daily in the performance of my sworn duties. I will be able to do a better job of protecting our citizens if there were to be a practice range near my house to practice my shooting skills at(as was the case with Gabby Hartnett's, also formerly a Village business). If Shore Galleries were to close, I would be forced to take my business not only out of Lincolnwood, but also out of Cook County. The closest comparable business to Shore's is in DuPage County. This cannot be acceptable to anyone in the Village.

In closing, I ask that you and the Village Board grant Mr. Shore this variation, and any other relief that he might reasonably need so that we can keep this cherished business; specifically his family business right here in the Village for many more years to come.

I am told that Lincolnwood once used to be a reasonably inexpensive place to live. If the Village Board were to develop, encourage and support the enterprising and forward thinking people like Mr. Shore, we might well again be able to live up to that standard once again.

Sincerely,



Walter Klinger

SUGGESTION/ISSUE: ...

Describe your question or comment below.
Greetings , I am writing the President , trustees, and clerk, of Lincolnwood to voice my support of Shore galleries' request for a permit to open a gun store and practice range in the new light manufacturing district in Lincolnwood . I applaud the boards consideration of allowing this longtime business the opportunity to expand . For those who have reservations and would vote against Please allow me to bring up these points of interest for your consideration. I have been a resident of Lincolnwood since 1983, and prior to that a resident along the North Shore since 1960 , , when I became interested in the shooting sports it was a very convenient thing to go to Gabby Hartnets on Lincoln avenue in Lincolnwood to purchase sporting goods and to practice my marksmanship in their indoor , below ground ,range . Gabby's also had a bowling alley on the first floor . Things have changed over the years in the shooting sports and in the laws governing fire arm ownership over the years . Today , A person isnt let on any range that I know of in the Chicago area , without the direct supervision of a Fire Arm Owners Identification card Holder ,issued by the State of Illinois . This process of ownership approval vets the unstable , or criminal, and prevents their purchase of firearms or ammunition in our state . In short , the process of FOID card issuance assures responsible law abiding individuals are in legal possession of firearms . I am sure that the Policy of FOID possession will be observed at the new Shore facility . I was heartened by the Skokie Police departments decision to provide a fire arms training facility to their officers at the new headquarters on Niles center and Touhy . But I was disheartened to hear that they instituted a program using Lazer firing practice devices for marksmanship practices . I am of the opinion that a person should practice with the sevice weapon they must carry on the job . The Shore facility holds out the promise that our peace officers will be able to stay proficient with the tools they sometimes regrettably need to use . Shore galleries present facility is rather cramped and small . They have had to tailor their offerings towards the bread and butter customers mostly peace officers due to a lack of room . I hope the expanded location will allow a greater display of more sporting oriented fire arms that opens up the perception that the firearm isn't only used as a deadly force weapon but also a sport. I am a great financial supporter of the United States Olympic shooting sports teams efforts at winning medals at the Olympic events . It is rather unfortunate that the majority of teen age and young adult competitors seem to be out of the western part of the United States . I put this down to little opportunity afforded to Our own youth in developing a good working knowledge and healthy respect for these sporting arms. Finally let me observe that at my location on the northwestern edge of Lincolnwood , I can not only hear the sound of the CTA's swift train whistle as it crosses the streets along Howard street , but on most Sunday mornings , I can also hear the sound of shotguns further North at a range which I believe also has a golf course on it . In short there are fire arms ranges and venues already in existance around Us , the addition of one run by as responsible an indivdual and long time Lincolnwood proprietor , like Mr Mitch Shore shouldnt raise any legitimate objection . Please Vote Yes Thank You .

SERVICE REQUESTS REQUESTER CONTACT INFORMATION
NAME: Stan Wilk
BUSINESS:
EMAIL:
PHONE
FAX:
ADDRESS: 4830 CHASE AVE
Lincolnwood IL
60712

Lincolnwood Park and Recreation Board Meeting

Lincolnwood Village Hall – Council Chambers
July 10, 2012
Draft Minutes

CALL TO ORDER

The meeting was called to order at 7:32 P.M.

PRESENT AT MEETING

Park Board Members: Demerise Gratch, Gail Ito, Barry Bass, Judy Snyder
Parks and Recreation Department Staff: Jan Hincapie, Jan Springer, Andrew Thurman
Village Staff: Tim Wiberg, Gerald Turry
Village Board Liaison: John Swanson
Audience: Scott Krone, CODA, LLC, 631 Lake, Wilmette, Jeremy Margolis, 6400 N. Cicero, Lincolnwood, Mark Kristoff, 6608 N. Knox, Lincolnwood

APPROVAL OF MINUTES

On motion Ito/Bass to approve the regular meeting minutes as amended of June 12, 2012 meeting. 4-0, motion passed.

On motion Ito/Bass to approve minutes as amended of June 12, 2012 bike path public hearing. 4-0, motion passed.

AUDIENCE PARTICIPATION/LETTERS TO THE DEPARTMENT

OLD BUSINESS

A. Turkey Trot Donations

Hincapie – In the past, charitable donations have been $500-$2000. Advertising the charity can make the race more appealing for participants. In 2011, we had participants bring in non-perishable food items for the Niles Township Food Pantry. Staff is looking for direction for the 2012 charity/charities.
Snyder – Did we also donate money to the food pantry in 2011 or just food?
Hincapie – No money, just food donations in 2011.
Snyder – I like the idea of continuing with support for the food pantry, monetarily or food donations and the Parks and Recreation scholarship program.
Hincapie – Thursday, August 2 is Celebrate Lincolnwood Night at the fest with a portion of the proceeds benefiting the scholarship program fund.
Ito – In the past we've done a local and national charity. Are we continuing with that? How do you feel we would do from a fundraising position with a local charity only? I'm in support of the food pantry. An email should be sent to absent board members to get their input.

On motion, Ito/Bass to recommend 2012 Turkey Trot charitable proceeds, monetary or food donations, to benefit the Niles Township Food Pantry. 4-0, motion passed.

NEW BUSINESS

A. Consideration of Ordinance Extending Park Hours For Exit Lighting

Hincapie – Police Department would like the Park Board to consider extending park hours on Friday, August 3 and Saturday, August 4, 2012 during Lincolnwood Fest. The fest ends at 11pm and the park closes at 11pm. By extending park hours, lights can be left on and the Police Department will be better able to clear the park.

On motion, Bass/Ito to recommend the approval of an ordinance waiving Chapter 6, Article 3, Section 2 of the Village Code that governs the park hours, extending the closing of the park to 11:30pm on the Friday and Saturday of the 2012 Lincolnwood Fest. 4-0, motion passed.

B. Shore Galleries Gun Range in Relation to Parks and Proposed Bike Path

Gratch – Welcome discussion pertaining to how the proposed new Shore Galleries site relates to parks. Visited the site and would like to clarify that the parking lot does not require people to cross over the proposed bike path as was previously stated.
Hincapie – Feel it's important due to the timing of the bike path and the proposed Shore Galleries projects to discuss the issues. Staff did not make the connection prior to the public hearing that the proposed site was adjacent to the proposed bike path since learning Hincapie has. Met with Tim Clarke, Community Development Director, to become better educated on the requirements of the Zoning and Municipal codes. Tim Wiberg, Village Manager, will discuss the public process.
Wiberg – Purpose of attending this meeting is to establish the facts on the process followed by the Village with respect to Shore Galleries. Shore Galleries has operated on Devon Avenue in Lincolnwood for the past 56 years complaint-free. Their primary clientele is law enforcement agencies. The current site is approximately 400 feet from Lincolnwood Centennial Park; the proposed site would be 900 feet from the nearest park. The public meeting process for this project is as follows:

- April 3 COTW – Village Board did not object to Shore Galleries pursuing a new site
- April 17 – Village Board meeting – formally referred proposed zoning code text amendment to Plan Commission
- Notice required for public hearing
    - May 14 – letters mailed to property owners within 250 feet of subject property
    - May 17 – notice published in Lincolnwood Review
    - June 1 – agenda posted in Village Hall
- June 6 – Plan Commission conducts public hearing
- July 17 – Village Board begins formal consideration

Snyder – No trustee mentioned the bike path at the April 3 meeting.
Wiberg – No, and I take responsibility for that. There was no connection made to the bike path and Shore Galleries.
Wiberg – I take responsibility for not notifying the Park Board. Moving forward, we need to be more proactive in identifying global issues. Staff will forward meeting packets to each respective commission member:

- Village Board
- Plan Commission
- Zoning Board of Appeals
- Economic Development Commission
- Beautification

Snyder – The Plan Commission slide says "staff recommends" so how can you say you are not presenting sides? Shore Galleries now is not the same as what the new Shore Galleries wants to be. Saying it is 400 feet from their current location to Lincolnwood Centennial Park is the dump site at the far end of the park, not a well-used area of the park.
Wiberg – I measured beyond the dump site when figuring the distance of 400 feet.
Gratch – There is a transparency issue. When we as board members hear about a situation like this outside of our own village, it makes us as Park Board members look like we don't know what's going on. I think as a village, we need to ask the question, "Are we really asking people for input?" For the bike path public meeting, two different attempts were made to reach people. The ordinance states ½ mile radius, so why were property owners within 250 feet only notified and not within ½ mile?
Snyder – A public hearing was held in good faith for the bike paths without all of the information.
Margolis – Former Assistant U.S. States Attorney for 11 years, Illinois Inspector General for three years, Director of Illinois State Police for four years – when I looked at the location for the bike path and saw weeds and overgrowth, I immediately thought it would be a good thing for safety to have this area developed for a bike path. Of the Shore Galleries' users, 90% will be from the state, federal and local law enforcement community, bringing security to the bike path. I have no agenda. I live in Lincolnwood and feel from a public safety standpoint this will be a good thing. I want to make Lincolnwood an extraordinary place to live, work, raise a family.
Gratch – Park Board has a right to have a voice with the Village Trustees.
Bass – I would like more information on how the site will differ from the existing site.
Krone – I am the architect for the project. The retail space will be very similar in size; additional classroom, training area and two ranges. There are no ranges in the existing space. Village approved a range in the 80s but never built it out.
Ito – Will there be a range at the new site?
Krone – Yes, two ranges open to the public.
Bass – I am familiar with shooting ranges. Have there been any accidents at Shore?
Krone – No, expanded our search to all of Cook and Lake Counties. There is a range in Bass Pro Shop at Vernon Hills Mall.
Bass – The police presence at a gun range makes it a safe environment. You would be foolish to cause trouble there.

Ito – Is it sound-proof?
Krone – We've developed an acoustic model that is in compliance.
Snyder – Would like to see a correct map with the bike path included.
Gratch – You can go to the Plan Commission on the website – very specific and easy to get to.
Snyder – Are buffers being looked at?
Gratch – Would like the Village Board to look at the following items:

- Valid map of the site with bike path, parking area(s)
- Revisit the minutes of the 1994 ordinance that required the ½ mile radius notice; clarify the reason for the change to 250 feet
- Confirm this development does not jeopardize grant funding

Ito – Need to look at things more globally in the future to make sure things are addressed through all commissions/boards.
Gratch – It's more meaningful to have information sent to you than to be told where to go and find it.
Ito – There is a change in the way society is communicating. We see it with advertising for Market and Music. People will say they didn't know about it because they didn't open their email. I appreciate the comments from the speakers this evening.
Bass – I feel a large part of the issue is that some people are morally opposed to firearms. That issue is not the issue we are here to discuss. I have no opposition to this. Many people are excited, and many are not. We need to rely on the professionals in other departments.
Snyder – I have a problem when information is not clear. I want to know all of the details, want all of the facts when holding a public meeting. This is not about guns. The process has a flaw in it. I'm concerned about grant funding for the bike paths. The state would not allow a gun range on Touhy.
Hincapie – Will check on any conflicts pertaining to grant funding.
Gratch – The Village Board will discuss this at the July 17 meeting. Attend the meeting following the promenade ceremony to voice your opinion.

C. Metra Edgebrook Shelter Use

Hincapie – Resident Mark Kristoff, a rail enthusiast, contacted Mayor Turry (letter enclosed in packet) in support of the Village purchasing the Metra Edgebrook shelter once Metra removes it from its current location during a renovation project.
Kristoff – On a mission to preserve the Edgebrook train station shelter and to move the structure to a Lincolnwood park. Sent a letter and follow up email to Mayor Turry, noting the shelter would make a fine picnic area, highlighting the character and craftsmanship of the shelter. The structure could be moved in one piece by removing the bottom part, which is not original. Have contacted a company familiar with this sort of move and received an estimate of $14,600 for the job. Public Works would be required to dig the holes and reinstall the shelter in a new location, perhaps at Flowers or Proesel Park. Willing to personally contribute finances to see this project through.
Gratch – The proposed location is in Flowers Park?
Kristoff – Measured areas in both Flowers and Proesel.
Hincapie – Asking for direction on the concept. Further analysis is needed if we go further with this.
Kristoff – The location in Flowers Park would allow for the structure to be moved in without trashing the park and would not interfere with any living trees. It could also provide a second entry point into the park from the bike path.
Ito – I think this is a fine idea if it is economical for the Village.
Hincapie – This has not been budgeted for so it would require a reallocation of funds. What is Metra's timeframe for this project?
Kristoff – Metra has stated possession would need to be taken in two weeks. If the Village would need more time to secure funding, I could make a no interest one-year loan.
Ito – We need to take into consideration the financial impact. Flowers Park has areas with nothing in it. You could put historical information under the shelter, which would be great information to have.
Bass – What are the dimensions of the shelter?
Kristoff – 11ft. x 45 ft.
Snyder – Reallocating funds means other projects that also require funding would be bumped, which is my only concern. Also, would need to see this done safely.
Gratch – I am a fan of reusing things. I have no issue with the concept. The initial price quoted was $30,000. There are a lot of things in our budget that have financial implications. This is more of a timing issue, not a lack of interest. With the tight timeframe there is no way for this to come back to the Park Board.
Mayor Turry – It is difficult to ask Metra to work around our schedule.
Gratch – This is a great idea, and you've provided incredible information.
Ito – The interest is there but we can't trump another project to do this.
Mayor Turry – Metra would need to wait until next spring to move it.
Bass – Economically out of the question. If we were to put the shelter on the bike path it would require two moves since we do not have access to the land at this time.

Kristoff – The Village engineer's quote of $30,000 included disassembling the structure and reassembling it.
Hincapie – Park Patrol could inspect the shelter.
Trustee Swanson – We have other projects on waiting lists. This would need to go through the budget cycle. The timeframe of the project is not helpful. It would be hard to find money to fund this.
Kristoff – I am offering the Village a no interest loan.
Trustee Swanson – I think it's a great idea, but it needs to go through the proper budget process.
Gratch – We are not in a position to decide how much is OK to spend. The idea is beautiful but we are not able to move on something in two weeks. We can direct staff to further discuss this.
Trustee Swanson – It costs money to direct staff to further discuss this.
Kristoff – Trustee Swanson, would you think it would be a fine shelter in Flowers Park?
Trustee Swanson – I would not feel comfortable. Metra is getting rid of the shelter for a reason. I would be more comfortable putting up our own shade structure.
Snyder – We couldn't afford to put up a shade structure in O'Brien Park.

On motion, Gratch/Snyder to recommend not moving forward at this time due to financial and time constraints with the purchase and relocation of the Metra Edgebrook shelter. 4.0, motion passed.

D. Intra-Village Communication

As discussed earlier, in an effort to think more globally, staff will forward meeting packets to each respective commission member:

- Village Board
- Plan Commission
- Zoning Board of Appeals
- Economic Development Commission
- Beautification
- Park Board

DIRECTOR'S REPORT

Thank staff for doing a nice job with summer programs and facilities. NorthShore Health System donated $5000 for healthy camp snacks. Jody Temkin turned in her resignation effective August 31. We appreciate her efforts.
Ito – Typo in report – should read "inclusion" not "conclusion"

RECREATION STAFF REPORTS

A. SUPERINTENDENT OF RECREATION – JAN SPRINGER
As noted in report.

B. SUPERINTENDENT OF PARKS AND FACILITIES – ANDY THURMAN
No closures at the pool. Pulled numbers this morning and we are up from last year in every area – swim lessons, daily admissions, concession sales.

C. COMMUNITY CENTER PROGRAM SUPERVISOR, KATIE SMITH
As noted in report.

D. COMMUNITY OUTREACH COORDINATOR, GENELLE IOCCA
As noted in report.

E. YOUTH PROGRAMS COORDINATOR, MELANIE UNTERFRANZ
As noted in report.

Hincapie – There was an incident outside of the pool. A male was reported behaving indecently. The man got away. Any suspicious activity should be report to 911.
Bass – Neighbors mentioned there was a situation they witnessed at the pool that took a lifeguard away from his/her position. Citizens were concerned with the way it was handled.
Thurman – The area should be cleared so staff can manage the situation safely. Talked to staff about clearing the pool and crowd control during emergencies.
Snyder – Witnessed a similar situation and it was handled properly. Reminder – Synchronized swimming show on July 27.
Ito – Watched situation with Judy. Staff cleared the pool, focused on the lady, and then allowed swimmers back in.
Gratch – Thank you to everyone for tonight. Appreciate your respectfulness and thoughtfulness.

ADJOURNMENT

On motion, Ito/Snyder to adjourn the meeting at 9:18 P.M.
Park Board Minutes prepared by: Jan Springer, Superintendent of Recreation

Parks and Recreation Board President: _____ _____

Signature Date