# ANECHOIC CHAMBERS

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## 1.0 SCOPE

This data sheet provides loss prevention and control recommendations for fire and associated perils in radio frequency (RF) and electromagnetic interference/electromagnetic compatibility (EMI/EMC) anechoic chambers. The data sheet assumes that the microwave absorber liner material used in the chamber meets criteria established by the Naval Research Laboratories (NRL) Report 8093, Tests 1, 2 and 3 for reduced ignition.

This data sheet does **not** cover acoustic anechoic chambers using non-NRL 8093 absorber material; refer to Data Sheet 1-57, *Plastics in Construction*, for plastic building material recommendations that can be applied. (See Appendix A – Glossary of Terms, **Acoustic**)

### 1.1 Hazard

The two main hazards in anechoic chambers are fire and water damage (the latter caused by accidental deployment of water-based fire protection systems).

Anechoic chambers are subject to deep-seated fires that, if uncontrolled, can bring testing activity to a halt for extensive periods of time, as well as cause extensive damage to the chamber structure, liner material, and contents. Because of the nature of foam liner material, fires in anechoic chambers produce substantial amounts of smoke that can migrate out of the chambers and cause nonthermal damage in areas surrounding the chamber.

The use of fire-hardened (retardant) microwave foam absorber material (NRL foam) contributes to a reduction in both the likelihood and severity of fires in anechoic chambers. However, in most cases, the use of foam meeting the NRL criteria alone is not enough protection. Loss history shows that severe fires can still develop in such chambers if electromagnetic energy exceeding the absorbing capacity concentrates on the foam material, or from other possible ignition sources.

Anechoic chambers and their contents are also subject to damage caused by accidental deployment of water-based fire protection systems. Water can result in damage requiring replacement of the liner material and cleaning of metal walls exposed to water. The use of halocarbon and inert gas (clean agent) fire extinguishing systems eliminates this problem; however, scale and other debris from a dirty gas pipe can still cause limited damage that necessitates chamber cleanup after an accidental discharge.

A particular hazard exists when contents undergoing tests include complete satellites or other high-value equipment. In such cases, fires and related perils inside anechoic chambers can potentially result in total loss of the contents and can severely disrupt mission progress.

### 1.2 Changes

**April 2025.** Interim revision. Significant changes were made to the following:

A. Revised the Scope, 1.0, to clarify the intent is for Radio Frequency (RF) anechoic chambers and not acoustic anechoic chambers.

B. Revised Section 2.3.3, Sole Protection of Chamber, to clarify the installation of sprinklers at the ceiling if the ceiling height exceeds 25 ft (7.6 m).

C. Revised Section 2.3.4, Halocarbon or Inert Gas (Clean Agents) Fire Extinguishing Systems, including the following:

1. Identified the use of a halocarbon or inert gas extinguishing agent listed in the FM *Approval Guide* for the specific application of anechoic chambers.

2. Provided guidance on the Test Plan for existing situations with a halocarbon or inert gas extinguishing fire extinguishing system using concealed nozzles.

3. Revised Table 2.3.4.3, Design Extinguishment Concentrations for Gaseous Suppression Systems, to:

a. Revised title

b. Removed Note 1

c. Included FK-5-1-12

## 2.0 LOSS PREVENTION RECOMMENDATIONS

### 2.1 Introduction

Because of the variety of characteristics, value, contents, and operating conditions of anechoic chambers, there are two distinct protection goals for anechoic chambers:

1. Protection of the chamber and/or its contents
2. Protection of the surrounding occupancy from a fire within the chamber

Certain recommendations included in this section are aimed at these specific protection goals; hence, a protection goal needs to be established before selecting the applicable loss prevention and control recommendations to be applied in each case. The protection goal is established in Section 3.0, Support for Recommendations. Section 3.0 also presents discussions about issues to be considered when selecting the protection goal for a given location.

In determining the applicable active fire protection for a given protection goal, use the guidelines in Section 2.3 Protection. Use Section 2.3.2 or 2.3.3 when the selected protection goal is the chamber and/or its contents; use Section 2.3.1 when the goal is to solely safeguard the surrounding occupancy or building where a chamber may be installed.

### 2.2 Construction and Location

#### 2.2.1 Use of NRL Foam

2.2.1.1 Use microwave foam absorber material that meets NRL 8093 test numbers 1, 2, and 3.

2.2.1.2 Post a sign outside the chamber clearly indicating the absorbing capacity of the liner material in W/in.$^2$ (W/m$^2$) and the maximum energy density tests that can be conducted inside the chamber and are still compatible with the energy absorbing capacity of the liner material.

#### 2.2.2 Chamber Construction

2.2.2.1 Locate anechoic chambers at or above grade, with no occupancy below grade, except for utility trenches.

2.2.2.1.1 Where anechoic chambers are needed to be located in stories above other occupancies, use watertight floors built with curbs to protect against any water penetration at the walls.

2.2.2.1.2 Provide floor drains to remove water accumulated as a result of automatic sprinkler operation and use of fire hoses during a fire.

2.2.2.1.2.1 Arrange floor drainage as follows:

A. Provide drain outlets arranged to discharge to safe locations, i.e., where other property will not be exposed to water damage.

B. Design the drainage system with sufficient capacity to safely handle the flow rates expected from the sprinkler and hose stream water discharge during a fire. (See Data Sheet 1-24, *Protection Against Liquid Damage*.) In some cases, the drains will require RF shielding. In these cases, consult the chamber designer for guidance.

C. Plastic materials for the piping and drain covers are acceptable.

2.2.2.2 Design with bolted type construction for anechoic chambers and shielded rooms where levels of attenuation are 100 dB or lower.

2.2.2.2.1 For levels of attenuation greater than 100 dB, design with welded construction to achieve higher attenuation levels. Welded construction presents difficult maintenance and retrofit conditions because of the need for hot work (cutting and welding) to be performed on site.

2.2.2.3 Use only noncombustible materials for structure, wall, floor and ceiling panels.

#### 2.2.3 Smoke Control

2.2.3.1 Provide means of smoke removal where needed to support the protection goal.

Smoke control systems are used to limit smoke damage within the chamber and to prevent smoke from exposing nearby smoke-sensitive occupancies, such as cleanrooms. Whenever smoke control systems are used, care is needed to ensure that they will not interfere with the primary protection systems. Since the improved ventilation may enhance burning, they are appropriate only where water supplies are strong or where compartmentalization is reliable.

2.2.3.2 If used in conjunction with halocarbon or inert (clean agent) fire extinguishing systems identified in Section 2.3.4, set smoke exhaust systems to operate solely by manual actuation.

2.2.3.2.1 Train employees to actuate the exhaust as follows:

A. On anechoic chambers protected with halocarbon or inert (clean agent) fire extinguishing systems provided with connected gas reserve, actuate the smoke control system only if the extinguishing agent and any connected extinguishing agent reserve has clearly failed to suppress the fire.

B. On anechoic chambers protected with halocarbon or inert (clean agent) fire extinguishing systems provided with sprinkler system back up, actuate smoke control only in the sprinkler operation phase of a fire.

2.2.3.2.2 Verify that premature operation of the exhaust system will not affect the required soaking period for the available halocarbon or inert (clean agent) fire extinguishing system.

2.2.3.3 If used with automatic sprinkler systems, arrange the smoke exhaust to operate only after the sprinkler system has operated.

2.2.3.3.1 Actuation of the smoke control system may be manual, with an interlock to ensure that ventilation begins only after the sprinklers fuse (water flow alarm).

2.2.3.4 Design the smoke control exhaust system to handle the volumetric smoke flow rate created by fire size expected inside the anechoic chamber.

2.2.3.4.1 Size the smoke control system so that all areas surrounding the anechoic chamber are kept clear of smoke, but not less than 10 air changes per hour.

2.2.3.5 Provide automatic closing, smoke-tight doors leading out of the chamber and into other plant areas. This will help provide a barrier to smoke propagation from the chamber into staging areas.

2.2.3.5.1 Provide smoke barriers in the form of smoke tight doors, smoke curtains or other forms of barriers, in the room housing the anechoic chamber. This will help prevent migration of smoke from staging areas to other parts of the building.

2.2.3.6 Locate air intakes near the floor level to minimize the risk of smoke being drawn back into the system.

2.2.3.6.1 Locate the exhaust outlet above roof level, at the opposite side of the fresh air intake and away from exposed property.

2.2.3.6.2 In some cases, the air intake and exhaust outlet will require RF shielding. In these cases, consult the chamber designer for guidance.

2.2.3.7 Use FM Approved smoke removal duct systems or noncombustible duct systems.

2.2.3.7.1 Do not use fire dampers or interrupters in smoke control ductwork.

2.2.3.8 If there is concern that smoke from a fire in a nearby area may enter the chamber and expose particularly susceptible contents, the chamber may be pressurized, rather than exhausted.

2.2.3.8.1 Determine the required pressure differential so smoke is kept out of the chamber for the projected exposing fire size, but not less than 0.10 in. water gauge (25 Pa).

### 2.2.4 Liquid Damage

2.2.4.1 Do not locate liquid filled domestic piping within or above the anechoic chambers.

2.2.4.2 When liquid piping is located within or above the anechoic chamber, provide protection against liquid damage for high value equipment in accordance with Data Sheet 1-24, *Protection Against Liquid Damage*.

## 2.3 Protection

### 2.3.1 General

Provide protection for the hazards and occupancy outside of the anechoic chamber in accordance with the relevant hazard- or occupancy-specific data sheet.

### 2.3.2 Protection of Chamber and its Contents

2.3.2.1 Use halocarbon or inert (clean agent) fire extinguishing systems as the primary form of protection where the protection goal is to safeguard the chamber and its contents.

2.3.2.1.1 Design systems to be actuated by air-aspirated very early warning fire detection (VEWFD) systems, and to meet the recommendations in Section 2.3.5.

2.3.2.2 Protect all areas of the chamber, including the space created under raised floors and inside utility trenches.

2.3.2.3 Institute a pre-incident plan in accordance with Section 2.7.

2.3.2.4 For anechoic chambers other than acoustic and EMC chambers, provide means for effective manual detection and suppression of hot spots within microwave-absorbing cone material as follows:

A. Provide means for incipient hot spot detection using hand-held infrared cameras. IR cameras should be available at all times at the control room and used to identify possible formation of hot spots within liner material cones upon smoke detection (see Section 2.3.5).

B. Provide means of manual hot spot quenching, using either hose stations or manual lances, in accordance with Section 2.3.7.

2.3.2.5 Provide an equally sized, manually activated, connected supply of halocarbon or inert gas extinguishing agent as backup or reserve.

2.3.2.5.1 Alternatively, install a standard preaction sprinkler system as back-up to the primary halocarbon or inert gas (clean agent) extinguishing system as follows:

A. Design in accordance with Sections 2.3.3.1 and 2.3.3.2.

B. Provide air-aspirated, very early warning fire detection (VEWFD), arranged per Section 2.3.5.

### 2.3.3 Sole Protection of Chamber

Provide automatic sprinklers based on Data Sheet 2-0, *Installation Guidelines for Automatic Sprinklers*, in conjunction with the recommendations in this section.

2.3.3.1 Use automatic sprinklers on a wet system as follows:

A. Install FM Approved quick-response, 160°F (70°C) nominally rated minimum K11.2 (K160) upright Storage sprinklers at ceiling level, installed in the pendent position, on linear spacing that does not exceed 9 ft (2.7 m).

B. Arrange sprinkler drops into the anechoic chamber as follows:

1.The sprinkler deflector extends at least 6 in. (150 mm) beyond the tip of the anechoic material for pyramids up to 1 ft (300 mm) long, and 12 in. (300 mm) for pyramids exceeding 2 ft (0.6 m) (see Appendix C, Figure C.1.1-1).

a. The extension may be interpolated for intermediate pyramid lengths.

b.The sprinklers may be installed permanently in this position using rigid metallic sprinkler piping or FM Approved plastic sprinkler piping, permanently protected with at least 1/2 in. (13 mm) thick mineral wool or other noncombustible insulation.

2. Sprinklers may be arranged to telescope into the desired position upon waterflow using FM Approved telescoping sprinkler assemblies. (See Appendix C for a discussion of telescoping sprinkler assemblies.)

C. When providing FM Approved telescoping assemblies for ceiling protection, install “vertical” telescoping sprinkler assemblies specifically FM Approved for use in anechoic chambers using center-strut automatic sprinklers FM Approved as an integral component of the assembly.

Bulb-type automatic sprinklers may be used with an FM Approved telescoping assembly if the assembly is specifically listed for use with this type of sprinkler.

D. When providing FM Approved telescoping assemblies for wall protection, install “horizontal” telescoping sprinkler assemblies specifically FM Approved for use in anechoic chambers with center-strut, automatic FM Approved sprinklers as an integral component of the assembly.

Bulb-type automatic sprinklers may be used with an FM Approved telescoping assembly if the assembly is specifically listed for use with this type of sprinkler.

E. Install fire protection piping so the room RF shielding is preserved. If fire protection piping penetrates RF shielding, there may be a need to install special penetrations with “waveguides.”

2.3.3.1.1 If the ceiling height of the chamber is 15 ft (4.6 m) or less, design the ceiling sprinkler system to provide a minimum flow of 48 gpm (180 L/min) from the most remote ceiling sprinkler while all sprinklers within the **lesser** of the following areas are flowing:

A. The most remote 2000 $ft^2$ (186 $m^2$) of floor area, or

B. The entire chamber floor area

2.3.3.1.2 If the ceiling height of the chamber exceeds 15 ft (4.6 m) but is less than 25 ft (7.6 m), provide the following protection for walls (in addition to the ceiling protection recommended in 2.3.3.1.B):

A. Install one level of supplemental wall sprinklers positioned along the wall between one-half to two-thirds of the overall ceiling height.

B. Design the single line of supplemental wall sprinklers to provide a minimum flow of 45 gpm (170 L/min) from the most remote 8 sprinklers.

C. Provide the supplemental wall sprinklers at the same spacing as the ceiling sprinklers to be installed.

2.3.3.1.3 If the ceiling height of the chamber exceeds 25 ft (7.6 m), provide protection as follows:

A. Install one level of supplemental wall sprinklers at the 15 ft (4.6 m) height and an additional level of supplemental sprinklers every 10 ft (3.0 m) vertically.

B. Design the wall sprinklers to provide a minimum flow of 45 gpm (170 L/min) from the most remote 14 sprinklers (7 on the top 2 levels).

C.Install the same sprinklers used at ceiling level as the supplemental wall sprinklers and arrange them to direct the water spray back toward the wall.

1. Position the sprinklers so they extend past the anechoic material tips in the same manner as the ceiling sprinklers in accordance with Section 2.3.3.1.B.

2. Alternatively provide “horizontal” telescoping sprinkler assemblies specifically FM Approved for use in anechoic chambers using center-strut automatic sprinklers Approved as an integral component of the assembly.

Bulb type automatic sprinklers may be utilized with an Approved telescoping assembly if the assembly is specifically listed for use with this type of sprinkler.

3. Provide the supplemental wall sprinklers at the same spacing as the ceiling sprinklers to be installed.

2.3.3.1.4 In all cases, hydraulically balance the wall sprinkler system with the ceiling sprinkler system at their point of connection.

2.3.3.2 If a wet sprinkler system is not a viable option, protect the anechoic chamber using either a dry or preaction system (non-interlock or single-interlock) in accordance with Section 2.3.3.1 and the following:

A. Design systems with minimal air capacity to minimize the time delay necessary for water to reach the automatic sprinklers.

B. Provide OS&Y valves both upstream and downstream of the dry valve to accommodate safe tripping for annual tests.

C. For preaction systems, use only smoke detectors (air-aspirated, spot-type or linear beam detectors) for system actuation.

D. Do not use pilot type sprinklers or spot type heat detectors because of the associated time delay in system deployment that they introduce.

E. Pressurize the system with reliably dry compressed air or with nitrogen having a maximum supervisory pressure of 10 psi (69 kPa). This is particularly important to prevent water from condensing inside the pipe and forming regions of preferential corrosion. Use regenerative air dryers for supplying air to sprinkler systems; alternatively, use drying canisters where frequent checks can be conducted to ensure the drying medium is not saturated.

F. Use galvanized pipe in accordance with Data Sheet 2-0, *Installation Guidelines for Automatic Sprinklers*.

G. Refer to Data Sheet 2-1, *Corrosion in Automatic Sprinkler Systems*, if corrosion prevention is warranted due to local water conditions.

H. Do not use double interlock systems for protection of anechoic chambers, especially if automatic sprinklers are to be hidden or embedded within the anechoic liner material.

Double interlock systems require actuation of both a detector and a sprinkler for the system to deploy, and sprinkler actuation may be delayed, or even prevented, when the sprinklers are embedded within the anechoic liner material.

### 2.3.4 Halocarbon or Inert Gas (Clean Agent) Fire Extinguishing Systems

Provide clean agent fire extinguishing systems based on Data Sheet 4-9, *Halocarbon and Inert Gas (Clean Agent) Fire Extinguishing Systems*, in conjunction with the recommendations in this section.

2.3.4.1 Use FM Approved clean agent fire extinguishing systems listed only for the application of anechoic chambers equipped with the halocarbon or inert gas (clean agents) extinguishing agents identified in Table 2.3.4.3.

2.3.4.2 Design and install clean agent fire extinguishing systems in accordance with Data Sheet 4-9, *Halocarbon and Inert Gas (Clean Agent) Fire Extinguishing Systems*, and the recommendations in this section.

2.3.4.2.1 Install fire protection piping so the room RF shielding is preserved. If fire protection piping penetrates RF shielding, there may be a need to install special penetrations with “waveguides.”

2.3.4.3 Use the minimum extinguishing design concentrations recommended in Table 2.3.4.3.

*Table 2.3.4.3. Design Concentrations for Halocarbon and Inert Gas (Clean Agent) Suppression Systems*

| *Agent Name* | *Minimum Design Concentration* |
|---|---|
| Inergen or PROINERT | 49% |
| FM-200 | 9% |
| FK-5-1-12 | 6.8% |

2.3.4.4 Keep all doors and other openings to the chamber in the normally closed position and interlocked to close automatically on fire alarm if temporarily held open.

### 2.3.5 Detection

2.3.5.1 Use FM Approved air-aspirated very early warning fire detection (VEWFD) for pre-fire alarm and actuation of primary protection systems, where the goal is protection of chamber and contents.

2.3.5.2 Provide a fire detection and fire alarm control system designed and installed so that equipment or asset testing conducted inside the anechoic chamber will not interfere with proper fire detection, monitoring and alarm operations. No false alarms or other types of interference should result from testing inside the chamber.

2.3.5.3 Conduct acceptance testing of the detection and fire alarm control system including validation tests to demonstrate that the fire detection and alarm system will not go into alarm due to product testing operations inside the chamber.

2.3.5.4 Provide a fire detection and fire alarm control system designed and installed to preserve the chamber shielding. Where fire alarm system wiring and components penetrate shielding, specialty filters and “waveguides” may need to be installed to eliminate interaction with the alarm circuitry and preserve room shielding.

2.3.5.5 Install air aspirated very early warning fire detection (VEWFD) with sampling ports arranged in a manner to allow for early warning of products of combustion resulting from a “hot spot” within the foam absorbing material anywhere in the chamber.

2.3.5.5.1 At a minimum, install detectors at the ceiling with sampling ports at the tip level of microwave absorbing pyramids and spaced not more than 14 ft (4.3 m) and with a coverage no greater than 200 $ft^2$ (18.6 $m^2$) per sampling port.

2.3.5.5.2 In anechoic chambers with unlined floor to ceiling clearances of 15 ft (4.6 m) and higher, install additional sampling ports at midpoints along walls following the same minimum prescribed coverage area and detector spacing used for the ceiling layout.

2.3.5.6 Arrange the fire detection and fire alarm control system to provide two levels of alarm, and at least one level of fire alarm as follows:

A. First pre-alarm: Arrange the system to pre-alarm at a threshold of obscuration (smoke density, as explained below) no greater than 0.0125% obscuration/ft (0.0410% obscuration/m) and to alert the chamber operator to stop all testing activity and initiate IR scanning of microwave absorber material, and manual suppression efforts, if necessary.

B. Fire alarm: Arrange the system to alarm at the minimum threshold corresponding to the breakout of a flaming fire involving the anechoic liner material (or any of the contents within the chamber) and to initiate the following activities:

1. Automatically notify chamber evacuation.

2. Shut down all electrical power to the chamber and its contents, except for emergency lights.

3. Immediately actuate door closing devices, dampers, fan shut down control, and any other devices needed to close off the chamber.

4. Immediately actuate the gaseous systems and deploy the preaction system, if available.

2.3.5.6.1 Use a minimum threshold of 0.030% obscuration/ft (0.0984% obscuration/m) if information about the minimum threshold for flame breakout is not provided.

2.3.5.6.2 Use higher percent obscuration thresholds for the fire alarm, where the excess smoke required to reach the higher fire alarm threshold will not result in foreseeable damage to chamber contents or to surrounding occupancies. A higher fire alarm threshold can be achieved by providing a second level of fire alarm in certain air-aspirated VEWFD systems at a % obscuration threshold not exceeding 1.5% obs/ft (4.92% obs/m).

2.3.5.6.3 Alternatively, a higher fire alarm threshold can be achieved by cross-zoning the fire alarm from an air-aspirated VEWFD detector at a 0.030% obs/ft (0.0984% obs/m) threshold with the actuation of spot-type or linear beam smoke detectors installed at the ceiling.

2.3.5.6.4 Do not use spot-type heat detectors for this function.

2.3.5.7 Provide a non-recycling time delay in the actuation of the active protection system for up to 30 seconds to accommodate evacuation of the chamber.

2.3.5.8 When abort switches are provided, use devices that require constant manual pressure (i.e., “deadman” switches) to interrupt the discharge, in addition to a non-recycling time delay.

2.3.5.8.1 Locate the abort switch in the path of egress where the interior of the chamber can be observed to ensure that the operator is completely aware of any changes in chamber conditions.

2.3.5.9 Use conventional Spot-Type Smoke Detectors or Linear Beam Detectors for actuation of protection systems only where the goal is the protection of surrounding occupancies.

2.3.5.9.1 Where the protection goal is the chamber and contents, these detectors can be used only when allowed by Section 2.3.5.6 and the detectors are cross-zoned with air-aspirated very early warning smoke detection (VEWFD) systems.

2.3.5.10 Arrange linear beam detectors at the ceiling with photoelectric beams spaced at not more than 10 ft (3 m) apart when linear beam detectors are used.

2.3.5.10.1 Provide a second level of linear beam detectors at an unobstructed height above the test object or equipment to enhance reaction time in chambers 30 ft (9.1 m) or higher.

2.3.5.11. Locate detectors at the ceiling, so that each covers an area no greater than 1/2 of their maximum listed spacing or 125 $ft^2$ (12 $m^2$), whichever is less when spot type smoke detectors are used.

2.3.5.11.1 Conduct on-site evaluations of smoke movement to ensure that chamber air flow patterns are satisfactorily accommodated.

2.3.5.12 Install detectors in a single zone system and as close to the pyramid tips as feasible.

2.3.5.12.1 Recess detectors by up to one-third of the pyramid height where necessary.

2.3.5.12.2 Do not embed or countersink detectors in the microwave absorbing material liner base.

### 2.3.6 Control Rooms and Concealed Areas

2.3.6.1 Protect areas such as control rooms, concealed ceiling spaces, sub-floor areas, and below pedestal areas with a protection system consistent with the protection of the chamber.

### 2.3.7 Hose Stations

2.3.7.1 Provide hose stations equipped with 1 1/2 in. (38 mm) hose outlets.

2.3.7.1.1 Include a hose demand allowance of 500 gpm (1,900 L/min) and a system duration of 60 minutes.

2.3.7.1.2 Locate hose stations just outside the doors of the chamber.

2.3.7.2 Where recommended in Section 2.3.2.4, provide hose stations with manual lances of sufficient length to readily penetrate the entire depth of the foam liner.

2.3.7.3 Where the goal is to protect the surrounding occupancy, recommendation 2.3.7.2 applies but at a minimum provide hose stations with a combination of spray/stream nozzles so that all points within the chamber are within reach of a hose stream. While the length of the stream may vary for different nozzles, typically all points within the chamber should be within reach of the hose length plus 10 ft (3 m) for the hose stream.

2.3.7.4 Where lances for this application are not readily available, they may be fabricated out of the following suggested specifications (see Figure 2.3.7.4-1).

2.3.7.4.1 Make lances light and of sufficient mechanical strength to penetrate foam material without breaking or being damaged.

2.3.7.4.1.1 Suggested Specification for Manual Lances:

- Lance material: schedule 10 or lighter stainless-steel pipe or tube stock
- Discharge flow rate: 1.3 to 2.6 gpm (5 to 10 l/min)
- Diameter: 1/2 in. (13 mm)
- Nozzle type: “shower”, “needle” type nozzles, welded to the lance body
- Nozzle material: 24-gauge sheet metal or stronger material
- Nozzle length: approximately 3 to 4 inches (76 to 100 mm)
- Diameter of “shower” orifices: approximately 1/8 in. (3 mm) or less
- Spacing of orifices: 1/2 in. (13 mm) o.c.

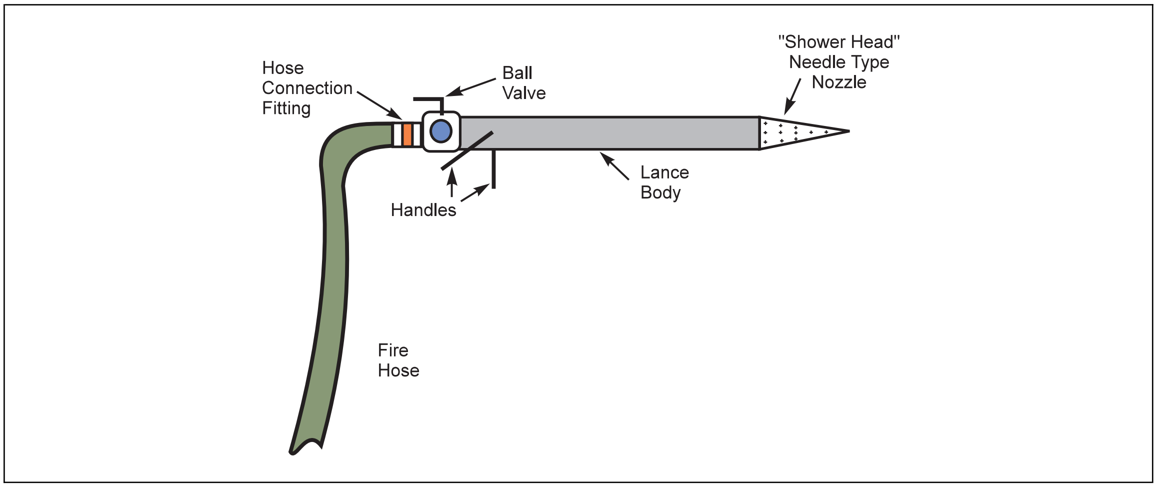


*Fig. 2.3.7.4-1. Example of manual lance for hot spot suppression within anechoic foam material — Not to scale*

- Water control valve: quick opening “ball” type valve.
- Hose connection: compatible with the fire hose connection available on site

2.3.7.5 Test any prototype lances as follows:

A. Verify penetration in actual spare cones of anechoic foam material.

B. Ensure that lances can be easily inserted in the material.

C. Verify that nozzles are not deformed by insertion or become obstructed by displaced foam material, preventing water discharge.

D. Verify that water distribution is uniform and not excessive.

E. If necessary, make adjustments in orifice sizes to avoid clogging or add orifice plate immediately upstream or downstream of ball valve to limit water discharge.

### 2.3.8 Fire Extinguishers

Install fire extinguishers of the proper type and capacity at or near the access door for the anechoic chamber.

## 2.4 Electrical

2.4.1 Arrange electrical equipment in the chamber as follows:

A. Provide conduits for power cables and weather-tight covers for outlets. Install weather-tight outlet covers so that the spring-loaded cover is on the top side when the outlet is in use.

B. Use electric/electronic control cables with abrasion-resistant, nonflammable insulation and screw-on (or bayonet) twist-lock connectors.

C. Do not permit open frame equipment inside chambers. Provide covers to all equipment.

D. Install shields and screens in all equipment with cooling air fans to ensure free flow of inlet and outlet air.

E. Do not permit exposed electrical terminals of any kind on any equipment.

F. Obtain written certification from chamber designer that heat build-up from any fixed lighting installed within the chamber will not expose microwave absorbing liner material, or chamber contents, to within 50% of their piloted auto ignition temperature. Utilize safety lamps (Model MP type) with enclosed fixtures for any high intensity discharge lighting installed within the chamber.

G. Limit the energy density of any equipment operated in the anechoic chamber to 0.5 Watt/in.$^2$ (650 Watt/m$^2$) or to the energy density absorbing capacity of the absorber material, whichever is greater. Where higher energy densities are expected, use high-power microwave absorbers or high-power composite materials capable of handling the expected incident energy density.

H. Limit the difference in electrical potential between the chamber ground and equipment chassis to 0.5 volts. Establish that such electrical potential difference is not exceeded prior to the use of any electrical equipment in the chamber (including temporary flexible wiring or exposed power supply terminals).

I. Use only continuous electrical wiring without splices. Where splicing becomes necessary for repairs, place splices in appropriate enclosures.

### 2.5 Operation and Maintenance

2.5.1 Do not leave equipment operating in the chamber while the control room is unattended. For example, do not leave batteries being charged inside a chamber overnight. At the close of business each day, close all exterior doors to the chamber, and shut down the main power to the chamber.

2.5.2 Do not use, dry, store or handle ignitable liquids inside the chamber. Replace alcohol, commonly used to clean electrical contacts, with a nonignitable or high flash point cleaning fluid. Use less hazardous hydraulic fluids for hydraulically actuated pedestals and other equipment.

2.5.3 Post signs near all entrances outlining restrictions affecting fire safety.

2.5.4 Inspect and maintain fire protection equipment as recommended in the appropriate section(s) of FM Data Sheet 2-81, *Fire Protection System Inspection, Testing and Maintenance* and the manufacturer's inspection and maintenance manual. Give particular attention to the following:

A. Evaluate the system activating devices (detectors) to determine they are functional. Allow only adequately trained personnel to inspect and test heat and smoke detector systems. Follow manufacturer's or installer's recommendations in maintaining, inspecting, and testing the equipment. Pay particular attention to detecting and removing carbon dust from the detectors. This is particularly true of air-aspirated detectors that continually draw air through their filters.

B. Arrange the fire protection equipment and systems to allow adequate testing every six months by simulating emergency mode conditions.

C. Make all equipment requiring servicing and testing readily accessible. Provide a practical means for adequate cleaning.

D. Conduct acceptance and annual testing of telescoping sprinkler assemblies in accordance with the procedure outlined below in Section 2.5.5, where protection systems use telescoping assemblies.

1. Conduct tests by allowing the assemblies to be moved through their full travel distance.

2. Automatic sprinkler systems should be operated via introduction of air pressure simulating the minimum operating pressure of the devices.

2.5.5 Test procedure for telescoping sprinkler assemblies:

1. Test all telescopic sprinkler assemblies in accordance with this procedure at new system acceptance and annually thereafter.

2. When hydrostatic testing is performed, completely empty the anechoic chamber of assets and equipment; and cover all walls, floor and ceiling (except for the locations where telescopic assemblies are installed) with plastic sheeting to prevent contamination of liner material by any debris originated from testing.

3. Ensure that all sprinkler assemblies are held in the static (up) position prior to applying air pressure to the assemblies. Verify that the enclosure is not in use at the time of the test, and that there are no personnel or equipment beneath the telescopic assemblies being tested that could be injured or damaged by these testing operations. Close the sprinkler control valve and use the FM Red Tag system to prevent accidental water damage to the chamber.

4. Install an accurate pressure gauge that is properly rated for the pressure to be applied (e.g., 0 to 100 psi [0 to 690 kPa]). Install the pressure gauge in conjunction with a properly sized air pressure regulator fitted with 1/4 in. (6 mm) NPT or larger with greater than 40 CFM (m3/min) capacity. The air regulator maintains a consistent air pressure in the manifold of the sprinkler systems as the telescoping sprinklers deploy.

5. Gradually increase the air pressure in the fire protection manifold. The increase in air pressure should be made in 10 psi (69 kPa) increments starting at 10 psi (69 kPa) with the air pressure allowed to stabilize at each setting for 10 minutes. The maximum air pressure measured in the manifold shall be 50 psi (345 kPa). Should all sprinkler assemblies deploy prior to reaching 50 psi (345 kPa), the test is complete. Deployment of all sprinkler assemblies shall be completed within 10 minutes after the manifold pressure has stabilized at 50 psi (345 kPa). Contact the manufacturer's authorized distributor to service or replace any telescopic assembly that fails to deploy properly.

6. Check all telescoping assemblies for burrs, rust, loose debris, deformation, dents, leaks, signs of corrosion or any other condition that could inhibit the ability to operate as intended.

7. Replace the O-rings in telescoping sprinkler assemblies as part of the initial test and maintenance should a leak be detected, and replace every 5 years thereafter. Use only manufacturer's replacement O-rings of the same specification as the original O-ring.

8. After completion of the deployment test procedure, evacuate the air pressure from the manifold, remove the plugs from sprinklers (if used) and reset the sprinkler assemblies into the up position by returning the sprinklers to the static position.

9. Re-open the sprinkler control valve.

10. Document the test and provide schematic plans indicating Pass/Fail on initial and subsequent testing of all telescoping assemblies, and document steps taken to correct failed assemblies.

2.5.6 Establish and enforce the following procedures prior to any scheduled or emergency maintenance inside anechoic chambers:

A. Shut off the main water supply control valve to sprinkler systems using the FM Red Tag alert system.

B. Deactivate automatic operation of the halocarbon or inert gas (clean agent) fire extinguishing system using the FM Global Red Tag alert system.

C. Maintain a fire watch within the chamber.

2.5.7 Whenever preaction and dry systems trip and water enters the branch lines, drain water from the system by removing all sprinklers from the branch lines.

2.5.8 At completion of maintenance operations, re-open all water control valves and re-activate automatic means of the halocarbon or inert gas (clean agent) fire extinguishing system.

2.5.9 Where hot work is unavoidable, use the FM Hot Work permit system prior, during and after completion of the work.

### 2.6 Training

2.6.1 Train all employees having access to the chamber on the general operation of the available protection system, including the adverse consequences of using manual pull stations or abort switches.

2.6.2 Train all contractors and maintenance personnel in at least the items listed below:

A. The hazards presented by the accidental tripping of fire protection systems.

B. The detailed operation of fire protection systems and recovery from false alarms.

C. Procedures for pre-testing, testing, and post-testing fire protection systems.

D. Procedures for scheduled and emergency maintenance, including the use of the red tag alert system for fire protection system shutdowns.

### 2.7 Contingency Planning

2.7.1 Establish a salvage plan as part of chamber operators' overall property conservation preparedness.

2.7.1.1 Include in this plan procedures for prompt drying of any liner material that becomes wet, and limit the time period that the chamber itself is allowed to remain wet after a water-based fire suppression system discharge.

2.7.2 Develop a written pre-incident planning procedure for anechoic chambers covering the following:

A. Means for actuation and abort of fire suppression systems.

B. Means for manual IR scanning of liner material, and firefighting in cones using lances.

C. Means for emergency removal of chamber high-value contents, such as satellites.

D. Means for removal of smoke from the chamber and surrounding occupancies.

### 2.8 Ignition Source Control

2.8.1 Do not leave anechoic chambers unattended when energized electrical equipment is inside. This includes any time periods during test set-up and ramp-up and test ramp down.

2.8.2 Do not leave anechoic chambers unattended for any length of time when tests are in progress. Constant attendance of tests in progress by well-trained chamber operators is critical for the success of any manual intervention during pre-fire alarms.

2.8.3 Use anechoic chambers for tests that are compatible with the intended use of the chamber. Do not conduct tests that would likely exceed the allowable absorbing capacity of the microwave absorbing material.

2.8.4 Do not use anechoic chambers for drying, curing or environmental testing of any kind.

2.8.5 Do not allow hot work to be performed in the chamber and prohibit any smoking or the use of open flames in the chamber.

2.8.6 Use high intensity floodlights only when and where approved by the person in charge of fire safety procedures.

## 3.0 SUPPORT FOR RECOMMENDATIONS

### 3.1 General

Anechoic chambers are enclosures designed to provide test regions that simulate free space for a variety of measurements, including antenna pattern, radar backscatter tests, soundproof measurements, etc. The chambers may also be shielded to provide RF isolation from undesirable external signals and to prevent internally generated RF energy from radiating outside the enclosure. The chambers are lined with expanded polyurethane absorber material, impregnated with carbon and some fire-retardant compounds. The material is typically in the form of pyramids or wedges which vary from a few inches to 6 ft (2 m) or longer from tip to base. The liner can also be flat. Liner material absorbs electrical energy, converts it to heat and stores it. Metal objects reflect the electrical energy, thereby creating unwanted signals that can greatly reduce the accuracy of the measurements taking place.

#### 3.1.1 Use of Anechoic Chambers

3.1.1.1 The use of sophisticated electronic equipment has created the need for properly engineered environments to eliminate background “hash” and spurious signals. Sensitive electrical measuring equipment is adversely affected by such extraneous signals. Radio and television transmitters, motors, switches and military communication systems create an ambient level of “noise” capable of serious interference with the use of electronic equipment. The installation of a properly designed RF-shielded enclosure guarantees an area free of such false signals, thereby producing readings that are correct and unaffected by other sources. The shielding may also serve a security function by preventing signals within the chamber from being monitored elsewhere.

3.1.1.2 The use of anechoic lining of floor, walls and ceiling increases the usefulness of a shielded enclosure by eliminating the standing waves that are present. This situation is especially true when RF signals are generated within the enclosure, either by radar-type systems or as a part of EMC (electromagnetic compatibility) systems tests.

3.1.1.3 The transmitting (generator) and receiving equipment used for antenna-range evaluation consist of an illuminating antenna mounted on the source end of the chamber and the probe or test antenna (receiver). The probe antenna is typically mounted in the quiet zone on a “reflectionless” transverse mechanism consisting of a plastic foam pedestal on a plastic foam cart which moves on plastic tracks. The cart is motor driven to provide motion of the probe antenna throughout the quiet zone. The amplitude of the signals emitted by the illuminating antenna are received by the probe antenna and recorded on a chart recorder during probe movement.

3.1.1.4 To measure reflections from the side walls, the probe antenna is moved across the chamber (transversely to the direction of propagation), and recordings are made of the amplitude variation encountered. Frequency testing varies from 30 MHz to over 100 GHz.

3.1.1.5 The most common type of work conducted in anechoic chambers involves functional checks, grouped by the following systems: a) communication, b) data link, c) ESM (electronic support measures), d) navigation and e) acoustics.

3.1.1.6 These rooms are also used for functional testing of computers against electromagnetic and acoustic (sound level) interference in production facilities where radar antenna or ESM testing, electronic component testing, satellite work, missile guidance work, radar/radio work, etc. are conducted.

3.1.1.7 The degree of sensitivity to electrical reflection varies from chamber to chamber, depending on its general purpose. Three typical types of chambers include: EMC (Electro Magnetic Compatibility), free space (microwave) and RCS (radar cross section).

3.1.1.8 EMC chambers operate in the 30-1000 MHz range and generally use large absorbers. These chambers can tolerate some exposed metal, but special precautions may be required in specific portions of walls or ceiling. Generally, even in quiet zones, sprinklers or nozzles can be employed; provided they are withdrawn at least one-third of the pyramid height from the tips.

3.1.1.9 Free space chambers operate in the higher frequency (100 MHz to 100 GHz) range and use smaller absorbers. These chambers are often used for testing, ranging from antennas to space satellites. Though certainly of a high-tech nature, the majority of these chambers are considered to be production rather than research chambers.

3.1.1.10 Production chambers can usually tolerate limited metal intrusion to an equivalent degree as EMC chambers.

3.1.1.11 Research chambers are more sensitive to and less tolerant of metal. These chambers may require specially designed protection installations closely coordinated with the chamber designer.

3.1.1.12 RCS chambers operate in the 100 Hz-100 GHz range and are inherently very sensitive to metal intrusion. Currently, these valuable chambers are quite rare, but as many as 1000 may be built in the next decade. These chambers may not only sense the smallest piece of metal, they may even be affected by smooth plastic. These chambers need protection designed in close collaboration with the chamber builder to achieve the intent of this data sheet.

#### 3.1.2 Location

Anechoic chambers may be located within major buildings or may be constructed as separate structures. Some chambers are attached to the outside wall of the building. In some cases, the separation wall is a fire barrier. However, in many cases this wall has been penetrated for cable access and/or doors, reducing its effectiveness as a fire barrier. When chambers are located within other buildings, the likelihood of fire exposing both areas is increased. Also, areas adjacent to the chambers may contain valuable equipment, easily damaged by heat, smoke or water. The exposed property and the chamber can be subjected to potential fire and smoke damage.

### 3.2 Construction

3.2.1 The size of anechoic chambers varies. The most common small sizes vary from 400 to 800 $ft^2$ (37 to 74.3 $m^2$), medium sizes vary up to 5000 $ft^2$ (465 $m^2$) and large chambers may reach 10,000 $ft^2$ (929 $m^2$).

3.2.2 The floor, ceiling, and wall construction of anechoic chambers is of wood, metal-clad wood, metal-clad plastic, metal-clad gypsum board, or all metal on wood or metal studs. The absorber is usually applied to all interior surfaces. Chambers are typically of wood composite board with metal cladding on both sides. The metal cladding serves as the RF shield, which may necessitate special design where pipes or wiring penetrate the metal. The chamber may also be structurally isolated from the main building by supporting it on anti-vibration mounts. (This design requires similar isolation of the sprinkler system, which can be accomplished by using conventional flexible couplings.) A space can often be found between the roof of the chamber and the roof of the building, or below a raised chamber floor. These spaces may be used to run electrical wiring and other auxiliary services. These spaces, if not protected, normally contain sufficient combustibles to expose the anechoic chamber enclosure and equipment.

3.2.3 Raised areas, normally called stages, may occasionally be present within the chamber and are framed with wood and/or metal studs. The stage deck is mostly plywood construction (see Figure 3.2.3-1). The equipment being tested is generally mounted at the opposite end of the chamber. The subfloor space of the stage houses the signal cables of the equipment being evaluated. This space may pose a fire and smoke hazard if not adequately protected. The chamber may also be tapered (see Figure 3.2.3-2) with the source at the tapered end and the test object in the quiet zone at the larger end.

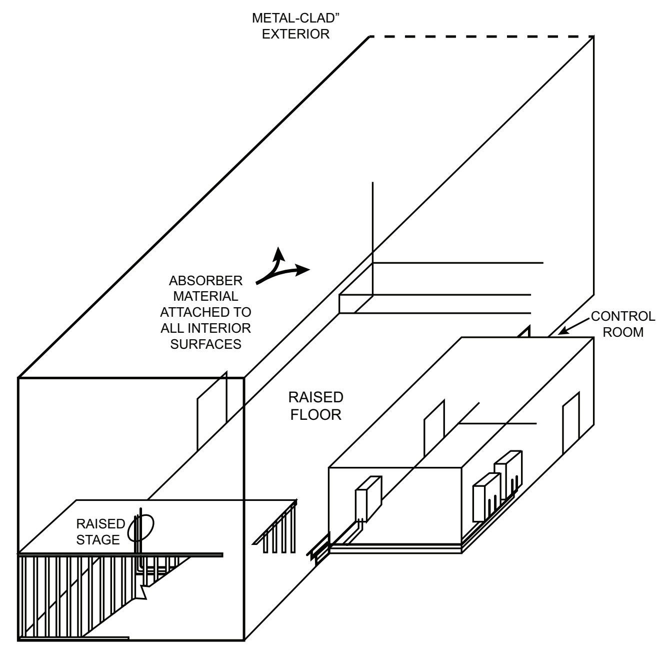


*Fig. 3.2.3-1. Typical anechoic chamber arrangement*

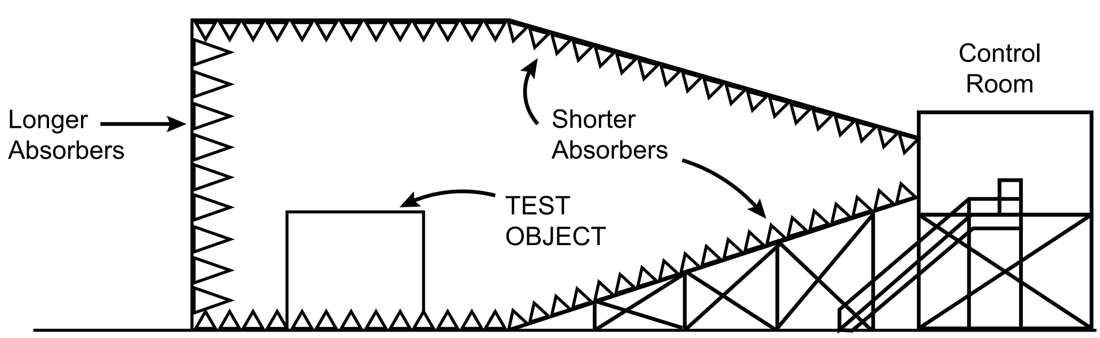


*Fig. 3.2.3-2. Possible anechoic chamber arrangement*

The control room is usually attached to the end or side of the chamber, and personnel doors connect the two. In the past, control room floors have been located at the grade of the chamber floor. Lately, the trend is to use computer room-type raised floors. Some of these subfloor spaces have reached 4 to 5 ft (1.2 to 1.5 m) deep. Signal cable is the prime occupant of the subfloor areas; it also exists in trays around the control room.

The control room is not sheathed with the absorber material used in the chamber. However, other construction features and occupancy of the room and subfloor may pose fire and smoke hazards that need evaluation to determine the warranted protection.

A minimum of two access doors are generally provided in an anechoic chamber. However, the number of doors required is governed by the size, type of testing and fire hazard posed by the installation. These doors remain closed most of the time. Small hose and fire extinguishers are generally installed outside these doors.

#### 3.2.1 Absorber Material

##### 3.2.1.1 Fire Hazards

3.2.1.1.1 The two types of lining used in anechoic chambers are the non-NRL and NRL materials. NRL materials have passed test criteria established by the Naval Research Laboratory (NRL). Except for a few special applications, this type of polyurethane liner material is currently the only one in use by the major chamber builders. Many older chambers, however, still have non-NRL foam.

3.2.1.1.2 Non-NRL types of lining used in older anechoic chambers pose unique fire and smoke hazards. The absorber consists of various polymers, such as polyurethane foam, polystyrene, polyvinyl chloride and nitrile rubber. These materials are quite easily ignited; the fire spreads rapidly and is very difficult to extinguish. During a fire, most of these materials produce dense smoke.

3.2.1.1.3 The NRL materials, though still made of carbon-impregnated polyurethane, tend to resist small ignition sources more effectively than the older materials. However, when exposed to a larger ignition, NRL material still exhibits intense burning. Thus, NRL material provides a certain degree of fire safety by being more resistant to small-scale ignition sources; however, these products are still combustible and warrant protection.

3.2.1.1.4 To serve as a good RF absorber, these materials must be impregnated with carbon and usually have a latex binder. The resulting material has low electrical resistance and is, therefore, a good conductor. However, the product is very combustible.

3.2.1.1.5 To reduce the fire hazard of the lining used in anechoic chambers, the material is impregnated with a fire-retardant additive, such as a chlorine-containing compound, to impart fire resistance without degrading the desired property of low electrical resistance.

3.2.1.1.6 The most common liner base dimensions for pyramids or wedges are 2 by 2 ft, 2 by 3 ft and 3 by 3 ft (0.6 by 0.6 m, 0.6 by 0.9 m and 0.9 by 0.9 m). The shortest length is about 4 in. (52.4 mm) and the longest is usually 6 ft (1.8 m). However, in some rare cases, lengths up to 15 ft (4.6 m) are found. The thickness of the liner material depends upon the location in the chamber and the use of the chamber.

##### 3.2.1.2 Ignition Sources

Ignition sources in anechoic chambers include:

- Heat from welder's torches during repair work
- Overheating by high intensity light bulbs countersunk into the ceiling of the chamber
- Smoking
- Arcing from power cords supplying the antenna
- Radiated energy from the microwave transmitter (potentially)

The emission of low frequency and high-power radio wavelengths from the test equipment have also been found to overheat and eventually ignite nearby absorber material. The electric positioning equipment used to orient the test object may also present sources for heat buildup, sparking or even open flame.

##### 3.2.1.3 Smoke Hazard

3.2.1.3.1 Fires involving anechoic chambers tend to be smoky. This smoke is a result of the inherent combustion properties of the liner material and the relatively inefficient (though still intense) burning created by the high surface area to air volume ratio. The inefficient combustion can result in a smoke that contains unburned combustible gases. The presence of combustible gases is minimized in chambers with fixed protection systems. However, in unprotected chambers, the inrushing air created by opening doors to allow manual firefighting may actually intensify the fire.

3.2.1.3.2 For the most part, smoke does not pose an excessive threat to the chamber itself. However, many of the objects tested in a chamber may be severely damaged.

3.2.1.3.3 A conventional chamber will usually be unable to contain all smoke. The possibility of smoke spreading to nearby areas should be recognized. This situation is of special importance when the chambers are located within clean room environments.

3.2.1.3.4 Smoke control systems can be used to reduce smoke levels within the chamber if the loss expectancy justifies. This concept is discussed further in FM Data Sheet 1-53.

### 3.2.2 Water Damage

3.2.2.1 Anechoic chambers and their contents are very susceptible to water damage. Simply wetting down the liner material may be sufficient to require its replacement. In most cases, it can be dried, but damage may still exceed 25% of the liner value. Other properties may also be exposed to water damage resulting from a fire in an anechoic chamber. This situation occurs when the chamber is located in the upper floors of a building, or the chamber floor is allowed to drain toward other properties. When the chamber is not adequately protected and the building housing it is sprinklered, heat from a fire can activate its sprinklers and cause unnecessary water damage. Consequently, steps should be taken to minimize water damage as much as possible (such as the provision of an adequate drainage arrangement).

3.2.2.2 While absorber material can often be dried and salvaged, this ability can be reduced if the sprinkler water contains dirt, pipe scale, cutting oils or other contaminants. These problems can be avoided to a large extent by swabbing the pipe interior as it is installed (as is routinely done with halocarbon and inert gas extinguishing systems) and by using galvanized pipe (as is currently recommended for dry, preaction and deluge systems).

## 3.3 Protection

3.3.1 Due to the range of chamber sizes, purposes, sensitivities and locations, and because of the similar range in chamber contents, there is no single protection approach that is appropriate for all anechoic chambers.

3.3.2 FM insured working with FM consultants can establish a specific protection goal for each individual set of chamber conditions.

3.3.3 A summary of the protection being recommended in this data sheet for the different protection goals is provided in Table 3.3.3.

*Table 3.3.3. Summary of Protection Recommendations*

| Protection Goal | Recommended Protection Scheme | | | | | |
|---|---|---|---|---|---|---|
| | IR Scanning at Pre-fire Alarm[1] | Manual Lances[1] | Detection | Primary Fixed Protection | Back-up Protection | Smoke Control |
| **CHAMBER AND CONTENTS**<br><br>Description: This protection goal is intended to detect and control a fire in its incipient stages inside the chamber. Exposure to the contents, chamber integrity, and surrounding area is minimized. | Yes.<br><br>To be manually initiated at pre-alarm level. | Yes.<br><br>To effectively suppress incipient hot spots before they grow to a flaming fire requiring fixed system discharge. | Very early warning detection, air-aspirated or laser smoke detection with at least 3 levels of alarm. | Inert or halocarbon (clean agent) suppression system. | Equally sized connected gas reserve supply or preaction sprinkler system. | Not needed. |
| **CHAMBER**<br><br>Description: This protection goal is intended to provide early fire warning as well as confine the fire to the chamber of origin so exposure to the surrounding areas is minimized. Smoke removal is recommended to minimize exposure to surrounding areas. | Desirable, especially if primary protection system includes means for early fire warning, such as preaction systems. | Desirable, especially if primary protection system includes means for early fire warning, such as preaction systems. | Spot-type smoke detection or beam detection used for early fire warning and deployment of preaction system, if applicable. | Automatic sprinkler system or preaction or dry sprinkler system. No deluge protection. | Not needed. | Yes. |
| **SURROUNDING AREAS**<br><br>Description: This protection goal is intended to provide protection from fire to the surrounding chamber areas. Smoke removal is recommended to minimize exposure to surrounding areas. | Not needed. | Not needed. | Spot-type smoke detection or beam detection used for early fire warning and deployment of preaction system, if applicable. | Automatic sprinkler system or preaction or dry sprinkler system. | Not needed. | Yes. |

Note 1. Does not apply to EMI/EMC anechoic chambers.

## 4.0 REFERENCES

### 4.1 FM

Data Sheet 1-24, *Protection Against Liquid Damage in Light-Hazard Occupancies*
Data Sheet 2-0, *Installation Guidelines for Automatic Sprinklers*
Data Sheet 2-1, *Corrosion in Automatic Sprinkler Systems*
Data Sheet 4-9, *Halocarbon and Inert Gas (Clean Agent) Fire Extinguishing Systems*

Understanding the Hazard: *Fire and Water Damage in Anechoic Chambers* (P0331)
Understanding the Hazard: *Liquid Damage* (P10086)

### 4.2 NFPA Standards

There is no NFPA standard dealing specifically with anechoic chambers. There are no known conflicts with other NFPA standards.

## APPENDIX A GLOSSARY OF TERMS

**Acoustic:** Chambers that are used for testing in the audible range to assess noise reduction, cut-off frequency and vibration isolation. Products tested in these chambers include motor vehicles, industrial engines, office machines, loudspeakers, computers, sound systems and other audible products and devices.

**Air-aspirated detectors:** A smoke detection system that depends on a network of specialty piping that constantly and efficiently carries air samples from protected zones to highly sensitive detectors.

**Anechoic chamber:** A test room that is free from echoes and reverberations.

**Energy density:** Amount of incident electromagnetic energy (measured in Watts) per unit surface area of microwave absorbing material.

**EMC (electromagnetic compatibility):** Tests, equipment, or chambers used to ensure electronic components and products comply with federal and international standards for electromagnetic energy emissions.

**EMI:** Electrical or electromagnetic interference.

**FM Approved:** Products and services that have satisfied the criteria for FM Approval. Refer to the *Approval Guide*, an online resources of FM Approvals for a complete listing of products and services that are FM Approved.

**NRL foam:** Carbon-impregnated foam material that meets the Naval Research Laboratories (NRL) Report 8093, Tests 1, 2 and 3, for reduced ignitability. NRL foam typically has fire retardant salts added to it and is installed in cone shaped blocks, lining the ceiling, walls and floors of anechoic chambers. The foam is used to absorb incident microwave electromagnetic energy, reducing reflections that could interfere with tests conducted inside the chamber.

**Percent obscuration per foot (%obs/ft):** Amount of light obscuration caused by smoke across a 1 ft (0.3 m) air space between a calibrated light source and a photoelectric measuring cell. Percent obscuration per foot is the inverse of light transmission. If no smoke is present in the 1 ft (0.3 m) gap there is 0 %obs/ft and 100% light transmission. If the 1 ft (0.3 m) gap is completely obstructed there is 100% obscuration and 0% light transmission.

**RFI:** Radio frequency interference.

**Shielded enclosure (room):** Enclosure, typically of metal construction, designed to block or attenuate radio frequency (RF) and electromagnetic (EM) emissions and interference, entering or leaving the enclosure.

**Specialty filters:** Used for filtering of communication and data lines along with fire systems across shielded rooms.

**Waveguide:** A threaded brass fitting, with or without dielectric unions, used in pipe or other shielded enclosure penetrations to preserve shielding effectiveness (attenuation).

## APPENDIX B DOCUMENT REVISION HISTORY

The purpose of this appendix is to capture the changes that were made to this document each time it was published. Please note that section numbers refer specifically to those in the version published on the date shown (i.e., the section numbers are not always the same from version to version).

**April 2025.** Interim revision. Significant changes were made to the following:

A. Revised the Scope, 1.0, to clarify the intent is for Radio Frequency (RF) anechoic chambers and not acoustic anechoic chambers.

B. Revised Section 2.3.3, Sole Protection of Chamber, to clarify the installation of sprinklers at the ceiling if the ceiling height exceeds 25 ft (7.6 m).

C. Revised Section 2.3.4, Halocarbon or Inert Gas (Clean Agents) Fire Extinguishing Systems, including the following:

1. Identified the use of a halocarbon or inert gas extinguishing agent listed in the FM *Approval Guide* for the specific application of anechoic chambers.

2. Provided guidance on the Test Plan for existing situations with a halocarbon or inert gas extinguishing fire extinguishing system using concealed nozzles.

3. Revised Table 2.3.4.3, Design Extinguishment Concentrations for Gaseous Suppression Systems, to:

a. Revised title

b. Removed Note 1

c. Included FK-5-1-12

**July 2021.** Interim revision. Significant changes include the following:

A. Clarified protection of hazards outside the anechoic chamber.

B. Clarified recommendations for sole protection using sprinklers when the ceiling of the anechoic chamber is higher than 15 ft (4.6 m) (Section 2.3.3).

C. Renumbered figure and table numbers by section number.

**April 2017.** Added NOVEC 1230 extinguishing agent and minimum design concentration to Table 1. Editorial correction made to Section 2.3.2 title.

**April 2012.** Terminology related to ignitable liquids has been revised to provide increased clarity and consistency with regard to FM Global's loss prevention recommendations for ignitable liquid hazards.

**May 2003.** Section 2.9 ″Alert″ has been deleted. Refer to Section 2.3.2.1 for information on Approved movable devices.

**January 2003.** Recommendation 2.3.2.1 was revised to indicate that bulb-type sprinklers can be utilized, but only if the Approved telescoping assembly is specifically listed for use with bulb-type sprinklers.

**May 2002.** The May 2002 data sheet 1-53 resulted from an extensive loss study conducted in 2001, examining FM Global customer losses as well as other industry losses since 1987. As a result, the new data sheet introduced new concepts for protection of anechoic chambers. A highlight of the major changes follows:

1. The data sheet introduces the concept of manual fire suppression of possible hot spots within the foam liner material, using IR cameras for detection and manual lances for fire suppression.

2. Recommendations for use of deluge systems have been eliminated. A new recommendation has been added for review of existing deluge systems toward possible conversion into preaction systems. This change is expected to impact both the severity and frequency of water leakage losses in anechoic chambers.

3. Air-aspirated smoke detection systems are now the recommended form of detection where protection of the chamber and contents is needed.

4. With the phase out of Halon 1301, this version of the data sheet also introduces Inergen and FM200 as two possible clean agents that can be used as standalone systems for the protection of chamber and contents, when connected to an equally sized reserve supply. The option for system back-up using preaction systems has been kept.

5. The option for use of heat detectors and pilot sprinkler heads has been eliminated. These types of detection devices are considered too slow in responding to a fire in anechoic chambers.

6. A new recommendation for use of FM Approved (see Appendix A for definition) telescoping sprinkler assemblies has been added, along with a comprehensive test protocol for acceptance and annual testing of telescoping assemblies.

7. The option of protecting chambers with Approved plastic pipe adequately insulated with noncombustible material in lieu of telescoping assemblies has been introduced.

8. Sprinkler protection criteria have been streamlined. The end-head minimum pressure criteria previously used to define water penetration into the valleys have been replaced with a density/area criterion. The pressure criteria were considered now obsolete given the variety of sprinkler orifice sizes currently available. A single sprinkler protection criterion now applies regardless of the protection goal selected. The option of installing sprinklers in valleys has been eliminated, since FM Global customer experience shows that this

provides little benefit and most customers opt for installing telescoping assemblies where reflections are a concern.

**October 1970.** New data sheet.

## APPENDIX C INSTALLATION OF FIRE PROTECTION AND DETECTION SYSTEMS IN ANECHOIC CHAMBERS

There are two main problems associated with the installation of any equipment in an anechoic chamber. First, the equipment may produce undesirable reflections within the chamber. Second, installation of equipment, such as piping, that penetrates the RF-shielded envelope of the chamber may destroy the chamber's integrity. In effect, such penetrations can act as antennas, which transmit signals within the chamber to exterior areas. This can be of particular concern when the chamber is used for testing confidential or classified equipment.

Anechoic chambers have such wide ranges of sensitivity, that what is allowed in one chamber may be unacceptable in another. Hence, the alternatives presented below will have various levels of applicability. It is difficult to generalize on the effect of exposed metal. Even when a chamber can tolerate metal in some areas, it may not in others. In nearly all cases, when handled on a cooperative basis between the fire protection designer and the chamber builder, sufficient compromise can be achieved that the intent of this standard can be met.

### C.1 Installation Methods for Reducing Reflection

#### C.1.1 Preaction Systems

To be effective, automatic sprinklers used in preaction systems should extend 6 to 12 in. (150 to 300 mm) beyond the tips of the liner material (Figure C.1.1-1). This makes the system prone to cause reflections.

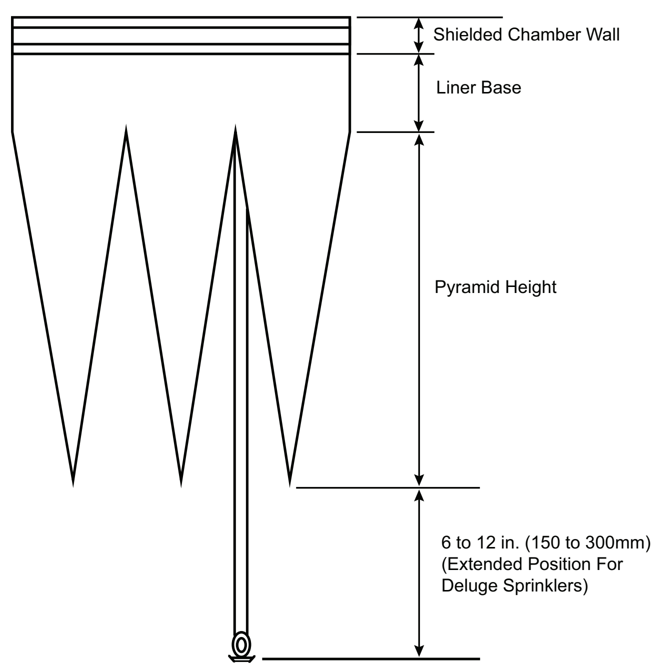


*Fig. C.1.1-1. Position of open/deluge sprinklers*

In some production chambers, it has been possible to install fixed piping systems complete with the extended sprinkler positioning. This is done by wrapping the extended pipe in liner material and gluing the point of a pyramid to the underside of the deflector.

This is an acceptable arrangement provided that discharge from the sprinkler is unobstructed. The wrapping on the piping should, therefore, be limited such that its total diameter does not exceed 2 in. (50 mm) i.e., a 1/2 in. (13 mm) thickness on a 1 in. (25.4 mm) pipe. Because the sprinkler is installed to direct water back toward the ceiling or walls, the piece of material fastened to the deflector should not pose a problem. It should not, however, extend beyond the plane of the deflector. (See Figure C.1.1-2.)

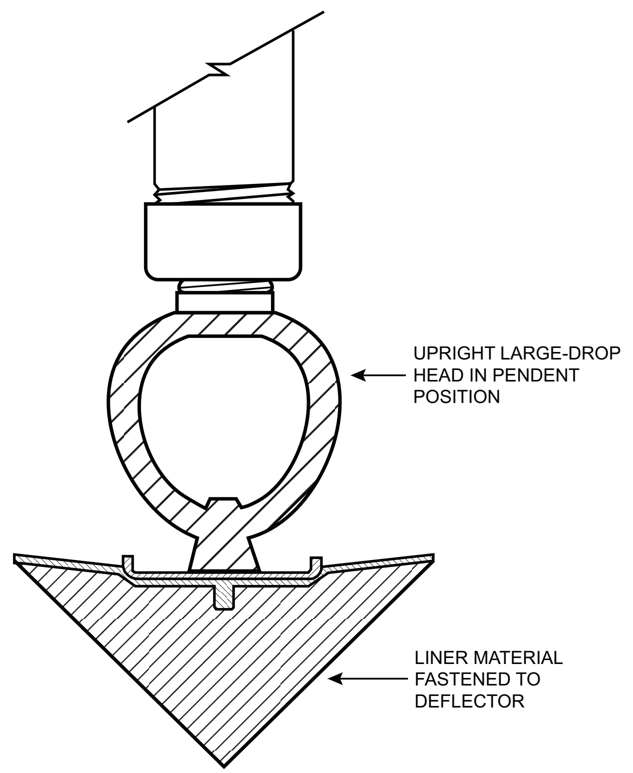


*Fig. C.1.1-2. Extended sprinkler with attached liner material*

If the arrangement described above will not yield acceptable results, it is possible to provide a system that keeps the sprinkler in a withdrawn position and then causes it to extend out beyond the liner when water flows. This is called a “telescoping sprinkler assembly” (Figure C.1.1-3).

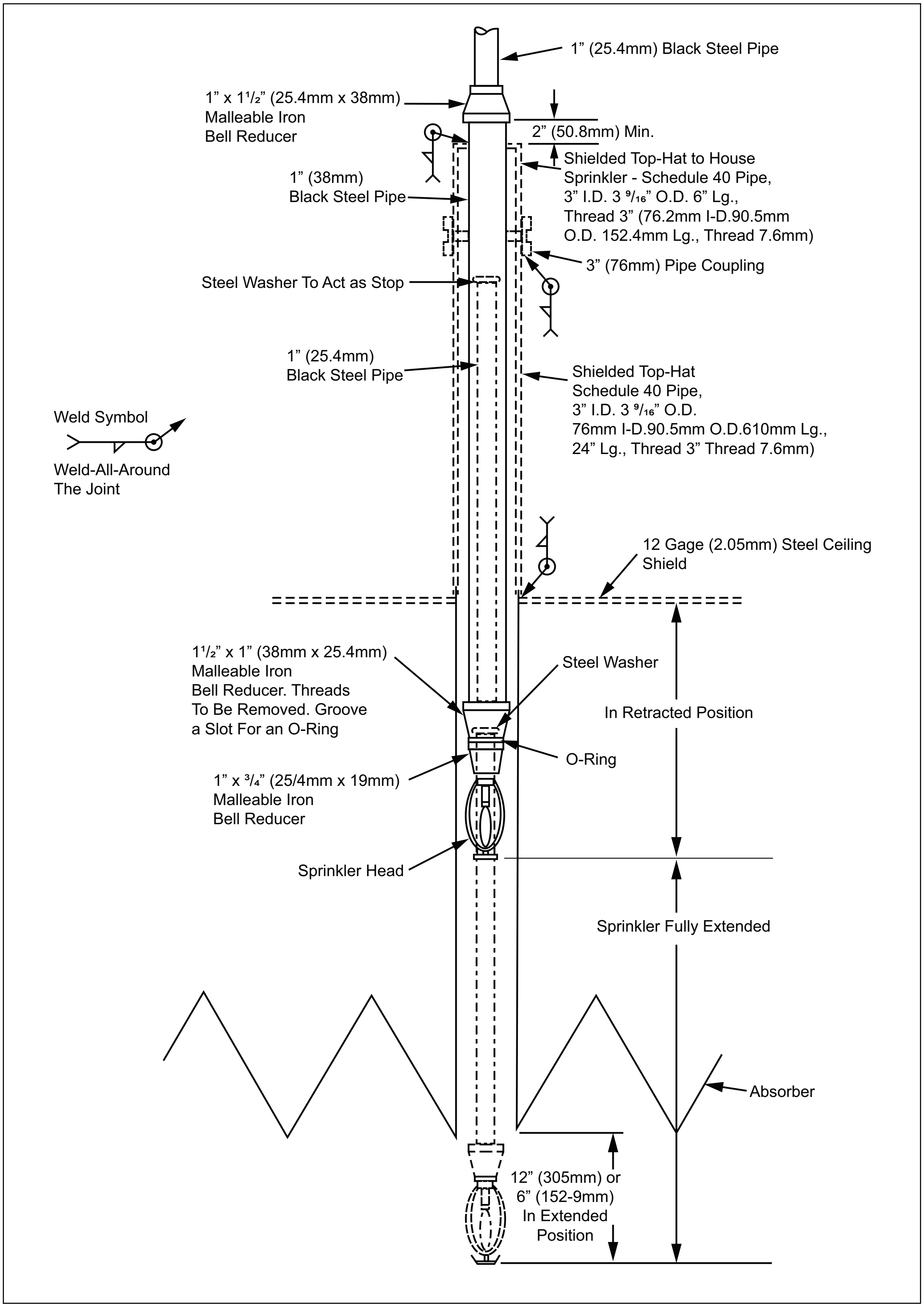


*Fig. C.1.1-3. Typical telescoping sprinkler.*

Most telescoping assemblies are constructed as follows:

Telescoping assemblies normally consist of 1 in. (25.4 mm) Schedule 40 stainless steel pipe with a steel washer at the end to act as a stop, and a 1 x 3/4 in. (25.4 x 19 mm) malleable iron or stainless steel bell reducer where the sprinkler is installed. This assembly is installed inside a fixed 1½ in. (38 mm) steel or stainless steel pipe equipped with a 1½ x 1 in. (38 x 25.4 mm) malleable iron or stainless steel bell reducer, with threads at the bottom of the reducer removed and a slot built to fit an O-ring. This O-ring prevents water leakage through the space between the 1 in. (25.4 mm) and 1½ in. (38 mm) pipes when the sprinklers are fully extended during operation (see Figure C.1.1-3).

During a fire, smoke detectors activate the preaction system. Water pressure inside the sprinkler piping pushes the 1 in. (25.4 mm) pipe into a fully extended position with the sprinklers protruding approximately 12 in. (300 mm) below the tips of the anechoic chamber lining, for pyramids over 2 ft (0.6 m) long, and 6 in. (150 mm) for those less than 2 ft (0.6 m) long. The steel washer at the end of the 1 in. (25.4 mm) pipe stops the pipe from sliding beyond the O-ring position. Similar design assemblies that can accomplish the same function are also available.

### C.1.2 Halocarbon or Inert Gas (Clean Agent) Fire Extinguishing Systems

Installation of a halocarbon or inert gas (clean agent) fie extinguishing systems is normally much less troublesome than sprinkler systems. The discharge nozzles can generally be kept out of the more sensitive “quiet zones”, and they need not protrude a great distance beyond the base of the liner valleys.

The nozzles may be located at ceiling level wherever the chamber characteristics allow, provided that spacing does not exceed approved limits and discharge is not obstructed.

Where necessary, the nozzles may even be countersunk within the liner material. In all cases, however, a discharge test should be conducted to ensure adequate gas distribution.

### C.1.3 Detection Systems

Smoke tends to stratify near the pyramid tips for a fairly long time before moving into the valleys. Therefore, positioning the detectors out toward the pyramid tips is necessary. Tests have shown that recessing detectors too far within the valley area can greatly delay or even prevent their operation. For this reason, conventional detectors should be located as close to the pyramid tips as can be tolerated. At most, they should be recessed one-third of the pyramid height. Nothing should be applied to any detector surfaces to shield reflections since this also may affect smoke movement.

If the level of sensitivity does not allow smoke detectors to be positioned as described above, either projected-beam or air-aspirated smoke detectors may be used. Because of their operating concept, projected-beam detectors may be countersunk, or even mounted outside the chamber wall with a small opening provided for the beam. Air-aspirated detectors sample air through plastic tubes. While the tubes should extend to or below the pyramid tips, their plastic material does not normally cause intolerable reflections.

### C.1.4 Installation Methods to Maintain RF Shielding

Because wiring for smoke detectors can enter the chamber in the same manner as that for lighting, in most cases RF shielding is a problem only for piping. One method of providing for pipe or conduit penetrations is to provide a mesh RF gasket at the entry point to create a “waveguide” filter. These honeycomb-type filters look like, and are installed like conventional pipe gaskets. These are acceptable in sprinkler piping. Some filters use larger holes and extend through the pipe’s open cross section. These filters are undesirable because of the increased friction created and because they may become clogged by any debris in the water. The penetrating pipe also can become a “waveguide” if it is allowed to extend a specified distance on the chamber’s exterior from the actual point of penetration and to meet certain other physical criteria. The distance and criteria must be determined by the chamber designers in the same manner in which they accommodate other necessary metal penetrations.

An alternative approach is to use a telescoping sprinkler assembly with the sprinklers retracted totally outside the chamber. A cylindrical hole is cut through the liner and the wood and metal ceiling diaphragm to allow the sprinkler to enter the chamber to its proper position when needed. A piece of light metal foil may be placed over the hole to maintain the continuity of the shield. Several tests should be conducted (with closed sprinklers temporarily replacing the open ones) at low operating pressure (use one-half to two-thirds of design pressure) to ensure that the assembly will break through and achieve proper position. A similar arrangement also may be achieved by using a specially designed “recessing cup” arrangement with integral RF shielding.