ANECHOIC CHAMBERS

Table of Contents

List of Figures

List of Tables

1.0 SCOPE

This data sheet provides loss prevention and control recommendations for fire and associated perils in 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.

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) 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

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.

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.

2.2.1.3 Replace non-NRL 8083 microwave foam absorber liner material in existing chambers.

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

2.2.2.2 Consider the use of bolted type construction for anechoic chambers and shielded rooms where levels of attenuation are 100 dB or lower. Chambers designed for higher than 100 dB may require 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.

2.2.2.4 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 of 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. (Plastic materials may be used for the piping and drain covers.)

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. 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 smoke control system only if the extinguishing agent, and any connected gas 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.

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

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

2.3 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. Design systems to be actuated by air-aspirated very early warning fire detection (VEWFD) systems, and to meet the recommendations in Section 2.3.4.

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-fire 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 2.3.5).

B. Provide means of manual hot spot quenching using manual lances in accordance with Section 2.3.7.

2.3.2.5 Provide an equally sized, manually activated, connected reserve supply of halocarbon or inert gas extinguishing agent as backup. Alternatively, install a standard preaction sprinkler system as back-up to the primary halocarbon or inert (clean agent) extinguishing system designed in accordance with Sections 2.3.3.1 and 2.3.3.2. Deploy back-up preaction systems via air-aspirated very early warning fire detection (VEWFD) arranged per Section 2.3.5.

2.3.3 Sole Protection of Chamber

2.3.3.1 Use automatic sprinklers on a wet system as follows:

A. Install FM Approved quick-response, 160ºF (70ºC) 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 chamber so 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 Figure C.1.1-1). The extension may be interpolated for intermediate pyramid lengths. 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.

Alternatively, 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. 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:

- the most remote 2000 ft^2 (186 m^2) of floor area, or
- 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.

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 sprinklers and arrange them to direct the water spray back toward the wall. Position the sprinklers so they extend past the anechoic material tips in the same manner as the ceiling sprinklers in accordance with 2.3.3.1.B. 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.

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 2.3.2.1 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.

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

D. Whenever preaction and dry systems trip and water enters the branch lines, drain water from the system by removing all sprinkler heads.

E. Pressurize the system with reliably dry compressed air or with nitrogen. 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.

2.3.3.3 Convert an existing deluge sprinkler system to a preaction sprinkler system and arrange preaction sprinkler system as recommended above in Section 2.3.3.2.

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

2.3.4.1 Use FM Approved clean agent fire extinguishing systems only 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 Extinguishment Concentrations for Gaseous Suppression Systems

Agent Name (Note 1)	*Minimum Design Concentration (Note 1)*
Inergen or PROINERT	49%
FM-200	9%
NOVEC 1230	6.1%

Note 1. Other design concentrations, or concentrations for other agents not covered in Table 2.3.4.3 are acceptable when demonstrated effective by actual fire test data reviewed and accepted by FM Global.

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 Certify that fire detection and fire alarm control system are designed and installed so that testing conducted inside the anechoic chamber will not interfere with proper fire detection and 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 Certify that the design and installation of the fire alarm and detection system will preserve 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. 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. 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:

- Automatically notify chamber evacuation.
- Shut down all electrical power to the chamber and its contents, except for emergency lights.
- Immediately actuate door closing devices, dampers, fan shut down control, and any other devices needed to close off the chamber.
- Immediately actuate the gaseous systems and deploy the preaction system, if available.

If information about the minimum threshold for flame breakout is not provided, use a minimum threshold of 0.030% obscuration/ft (0.0984% obscuration/m).

Higher percent obscuration thresholds for the fire alarm can be used provided that 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 systems at a % obscuration threshold not exceeding 1.5% obs/ft (4.92% obs/m). Alternatively, a higher fire alarm threshold can be achieved by cross-zoning the fire alarm from an air-aspirated 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. Do not use spot-type heat detectors for this function.

2.3.5.7 A non-recycling time delay in the actuation of the active protection system for up to 30 seconds may be provided to accommodate evacuation of the chamber.

2.3.5.8 In addition to a non-recycling time delay, “deadman” type abort switches may be used if located 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. 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 When linear beam detectors are used, arrange detectors at the ceiling with photoelectric beams spaced at not more than 10 ft (3 m) apart. To enhance reaction time in chambers 30 ft (9.1 m) or higher, provide a second level of beams at an unobstructed height above the test object or equipment.

2.3.5.11. When spot type smoke detectors are used, 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. 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. Where necessary, detectors may be recessed by up to one-third of the pyramid height. Do not embed or countersink detectors in the microwave absorbing material liner base.

2.3.5.13 Where both photoelectric and ionization detectors are installed to accommodate a possible larger detection threshold, they should be arranged in a single zone system so that each detector is individually capable of actuating the protection systems.

2.3.5.14 The use of programmed delays, delay switches and abort switches is discouraged with the use of spot-type or linear beam detectors.

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 1½ in. (38 mm) hose outlets, fire hose and nozzles. Locate hose stations just outside the doors of the chamber.

2.3.7.2 Where recommended in 2.3.2.4, provide hose stations with manual lances in addition to hose nozzles, and with enough hose length so that all points within the chamber (including far upper corners) are within reach of at least one hose and manual lance capable of penetrating the depth of the foam absorbing material.

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 Use manual lances of sufficient length to readily penetrate the entire depth of the foam liner. 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). Make lances light and of sufficient mechanical strength to penetrate foam material without breaking or being damaged.

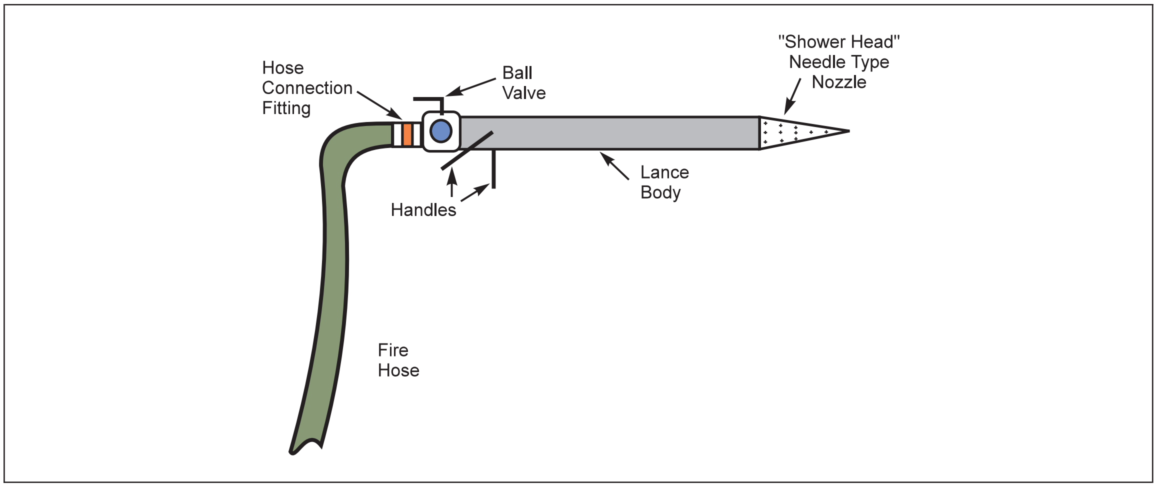

Fig. 2.3.7.4. Example of manual lance for hot spot suppression within anechoic foam material — Not to scale

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: ½ in. (13 mm)
Nozzle type: "shower head", "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 head’’ orifices: approximately ⅛ in. (3 mm) or less
Spacing of orifices: ½ in. (13 mm) o.c.
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 in actual spare cones of anechoic foam material. Ensure that lances can be easily inserted in the material. Verify that nozzles are not deformed by insertion or become obstructed by displaced foam material, preventing water discharge. Verify that water distribution is uniform and not excessive. 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

2.3.8.1 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 FM Global Data Sheets. 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 2.5.5, where protection systems use telescoping assemblies. Conduct tests by allowing the assemblies to be moved through their full travel distance. Deluge sprinkler systems should be manually extended. 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 assemblies in accordance with this procedure at new system acceptance and annually thereafter.

2. Completely empty the anechoic chamber 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 Global Red Tag system to prevent accidental water damage to the chamber.

4. If deluge systems, install plugs in the orifices of the deluge sprinkler heads to prevent significant air loss when the system is pressurized. Record the number of plugs used. At the end of the test, provide written confirmation that all plugs have been removed and accounted for.

5. Install an accurate pressure gauge that is properly rated for the pressure to be applied (e.g., 0 to 50 psi). 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 (m^3/min) capacity. The air regulator maintains a consistent air pressure in the manifold of the sprinkler systems as the telescoping sprinklers deploy.

6. 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 30 psi (207 kPa). Should all sprinkler assemblies deploy prior to reaching 30 psi (207 kPa), the test is complete. Deployment of all sprinkler assemblies shall be completed within 10 minutes after the manifold pressure has stabilized at 30 psi (207 kPa). Service or replace any telescopic assembly that fails to deploy properly.

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

8. Replace the O-rings in all sprinkler assemblies as part of the initial test and maintenance, with replacement to occur every 5 years thereafter. Use Replacement O-rings that meet the same specification as the original O-ring.

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

10. Re-open the sprinkler control valve.

11. 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 Global 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 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.

2.5.8 Where hot work is unavoidable, use the FM Global 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. 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 For chambers where deluge systems are not converted to preaction systems, determine whether the downtime associated with obtaining new liner material after a wet down would justify maintaining a standby supply.

2.7.3 Develop a written pre-fire 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

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.

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

Table 3.0 provides a summary of the protection being recommended in this data sheet for the different protection goals.

Table 3.0. Summary of Protection Recommendations

	Recommended Protection Scheme					
Protection Goal	*IR Scanning at Pre-fire Alarm (Note 1)*	*Manual Lances (Note 1)*	*Detection*	*Primary Fixed Protection*	*Back-up Protection*	*Smoke Control*
CHAMBER AND CONTENTS 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. To be manually initiated at pre-alarm level.	Yes. 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 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 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. This does not apply to acoustic and EMC chambers.

4.0 REFERENCES

4.1 FM Global

Data Sheet 1-24, *Protection Against Liquid Damage*
Data Sheet 2-0, *Installation Guidelines for Automatic Sprinklers*
Data Sheet 2-1, *Corrosion in Automatic Sprinkler Systems*
Data Sheet 4-8N, *Halon 1301 Extinguishing Systems*
Data Sheet 4-9, *Halocarbon and Inert Gas (Clean Agent) Fire Extinguishing Systems*

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. Products tested in these chambers include loud speakers, 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).

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 stand alone 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.

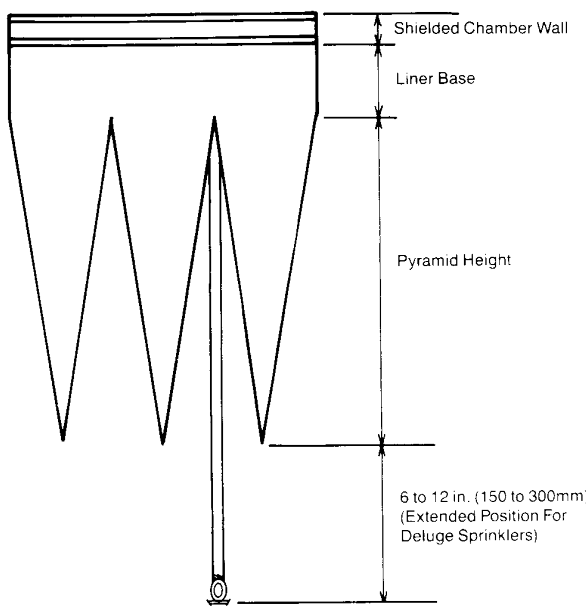

Fig. C.1.1-1. Position of open/deluge sprinkler heads

In some production chambers, it has been possible to install fixed piping systems complete with the extended sprinkler head 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.)

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).

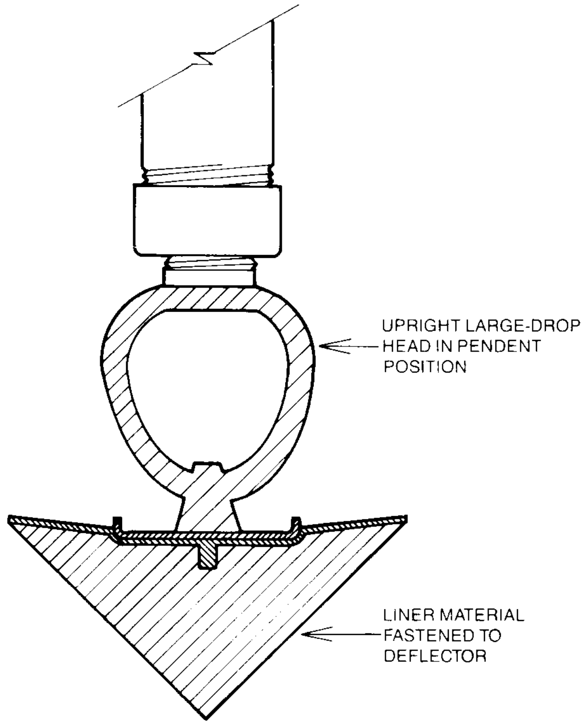

Fig. C.1.1-2. Extended sprinkler with attached liner material

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.

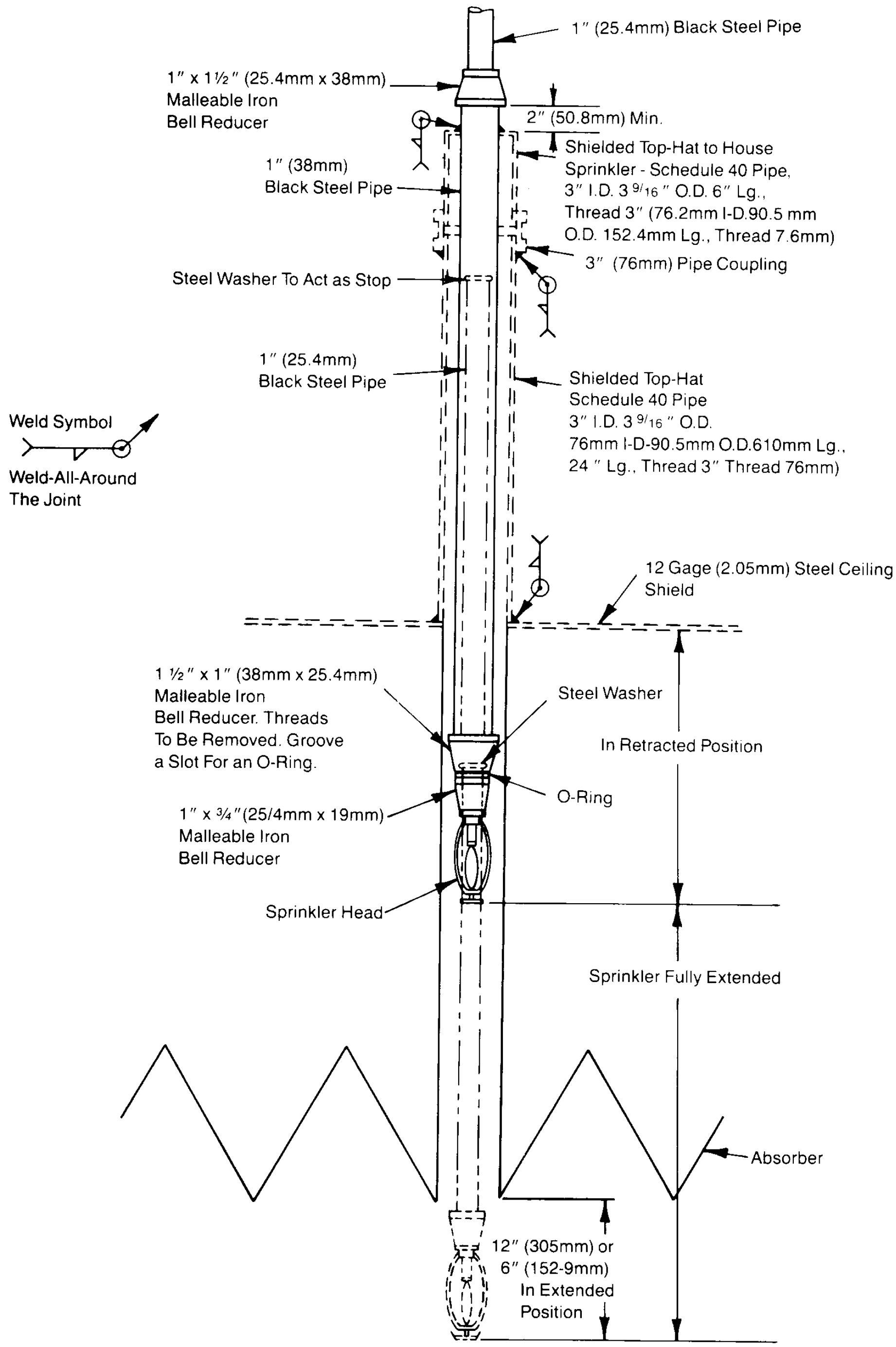

Fig. C.1.1-3. Typical telescoping sprinkler.

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 withdrawn 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.