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Examination Standard for Carbon Dioxide Extinguishing Systems

Class Number 5420

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Foreword

This standard is intended to verify that the products and services described will meet stated conditions of performance, safety and quality useful to the ends of property conservation. The purpose of this standard is to present the criteria for examination of various types of products and services.

Examination in accordance with this standard shall demonstrate compliance and verify that quality control in manufacturing shall ensure a consistent and reliable product.

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1. INTRODUCTION

1.1 Purpose

1.1.1 This standard states testing and certification requirements for fixed fire extinguishing systems which use carbon dioxide (CO_2) as the extinguishant.

1.1.2 Testing and certification criteria may include performance requirements, marking requirements, examination of manufacturing facility(ies), audit of quality assurance procedures, and a surveillance program.

1.2 Scope

1.2.1 CO_2 systems are classed in two general categories according to hazard coverage design, total flooding or local application. Either type shall be designed for automatic and manual control to protect single or multiple hazard areas.

1.2.2 A basic CO_2 extinguishing system comprises one or more agent supply containers; discharge control valves arranged for automatic (or both automatic and manual) control; lock-out valves; piping; and discharge nozzles. Compatible certified detectors and detection and release controls are required for automatic operation of these systems, but are not included in the scope of this standard.

1.2.3 This standard requires the examination of complete systems. Complete systems shall be submitted along with design, installation, operation, and maintenance instructions for certification. However, the manufacturer may, at any time, submit additional separate component parts or auxiliary equipment for use on the system. Purchased devices such as thermostats, releases, and timers must also be submitted by the system manufacturer for evaluation as a part of the system, even though such devices may already be certified and listed by a certification agency.

1.3 Basis for Requirements

1.3.1 The requirements of this standard are based on experience, research and testing, and/or the standards of other organizations. The advice of manufacturers, users, trade associations, jurisdictions and/or loss control specialists was also considered.

1.3.2 The requirements of this standard reflect tests and practices used to examine characteristics of CO_2 fire extinguishing systems (hereinafter referred to as "systems") for the purpose of obtaining certification. Systems having characteristics not anticipated by this standard may be certified if performance equal, or superior, to that required by this standard is demonstrated.

1.4 Basis for Certification

Certification is based upon satisfactory evaluation of the product and the manufacturer in the following major areas:

1.4.1 Examination and tests on production samples shall be performed to evaluate:

- the suitability of the product
- the performance of the product as specified by the manufacturer and required for certification;
- the durability and reliability of the product.

1.4.2 An examination of the manufacturing facility and audit of quality control procedures may be conducted to evaluate the manufacturer's ability to produce the product which is examined and tested, and the marking procedures used to identify the product. Subsequent surveillance may be required by the certification agency in accordance with the certification scheme to ensure ongoing compliance.

1.5 Basis for Continued Certification

The basis for continual certification may include the following based upon the certification scheme and requirements of the certification agency:

- Production or availability of the product as currently certified;
- The continued use of acceptable quality assurance procedures;
- Satisfactory field experience;
- Compliance with the terms stipulated by the certification;
- Satisfactory re-examination of production samples for continued conformity to requirements;
- Satisfactory surveillance audits conducted as part of the certification agency's product surveillance program.

1.6 Effective Date

The effective date of this examination standard mandates that all products tested for certification after the effective date shall satisfy the requirements of this standard.

The effective date of this standard is eighteen (18) months after the publication date of the standard for compliance with all requirements.

1.7 System of Units

Units of measurement used in this standard are United States (U.S.) customary units. These are followed by their arithmetic equivalents in International System (SI) units, enclosed in parentheses. The first value stated shall be regarded as the requirement. The converted equivalent value may be approximate. Conversion of U.S. customary units is in accordance with ANSI/IEEE/ASTM SI-10. Two units (liter and bar), outside of but recognized by SI, are commonly used in international fire protection and are used in this standard.

1.8 Normative References

The following referenced documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the cited edition applies.

ASTM B117, *Standard Practice for Operating Salt Spray (Fog) Apparatus*
Compressed Gas Association, Inc. (CGA) S - 1.1, *Pressure Relief Standards - Part 1 - Cylinders for Compressed Gases*,
ANSI/IEEE/ASTM SI 10, *American National Standard for Use of the International System of Units (SI): The Modern Metric System*
NFPA 12, *Standard on Carbon Dioxide Extinguishing System*s
ANSI/ASA S1.4, *Specification for Sound Level Meters*
ASTM G36, *Standard Practice for Evaluating Stress-Corrosion-Cracking Resistance of Metals and Alloys in a Boiling Magnesium Chloride Solution*.
ASTM D 412, *Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers Tension*
Title 49, Code of Federal Regulations (CFR), *Hazardous Materials Regulations of the Department of Transportation*
ASME BPVC-CC-N, *Boiler and Pressure vessel Code*

1.9 Definitions

For purposes of this standard, the following terms shall apply:

Agent

The material delivered by a fire extinguishing system which contacts the burning material and acts to suppress or extinguish the fire. For the purposes of this standard, the agent is gaseous carbon dioxide or CO_2, which is stored under pressure as a liquid.

Agent Supply Container

The assembly holding the CO_2 supply for a fire extinguishing system, which includes the pressure vessel and various accessories necessary for management of the supply, such as valves, dip tubes, pressure gauges, and pressure relief devices. An agent supply container for a Low Pressure System is termed a Storage Container, while that for a High Pressure System is termed a cylinder.

Area of Coverage

The maximum area which can be protected by a CO_2 discharge nozzle, based upon the minimum effective extinguishing flow rate (*EFR*) for the hazard, the maximum flow rate which will not cause splashing of flammable liquids (*SFR*), and the distance from the nozzle to the burning surface in local application systems.

Automatic Control

A device or arrangement of devices for initiating system discharge, including a panel which monitors fire detectors and releases the agent when pre-established conditions have been met, without requiring human intervention.

Class A Fires

Fires in ordinary combustible materials, such as wood, cloth, paper, rubber, and many plastics.

Class B Fires

Fires in flammable liquids, combustible liquids, petroleum greases, tars, oils, oil-based paints, solvents, lacquers, alcohols, and flammable gases.

Class C Fire

Fires in which the ignition source is energized electrical equipment.

Discharge Nozzle

A device that is used to distribute the extinguishing agent uniformly over or into a specific area, within a specific volume, or both.

Discharge Time

The time interval between when the extinguishing agent first becomes predominantly liquid at the nozzle and the time at which the discharge becomes predominately gaseous.

Engineered System

A CO_2 fire extinguishing system design in which friction loss of piping, nozzles, and other components, and an analysis of the piping configuration, are used in hydraulic calculations to predict flows at individual nozzles.

Fully Mechanical Manual Control

A manual discharge control which can function in the absence of electric power or other energy sources, except for stored agent pressure.

High Pressure System

A fire extinguishing system in which the agent is stored in cylinders which allow the temperature of the contents to vary with the ambient room temperature and in which the agent is stored at an initial pressure of 850 psi (58.6 bar) at 70 ºF (21 ºC) to maintain it in the liquid state.

Local Application System
A fire extinguishing system designed to protect a defined area or volume by the direct discharge of CO_2 onto burning materials.

Lock-Out Valve
A Supervised, lockable, manually operated valve, which can be used to isolate the CO_2 supply from the all or part of the system during maintenance and service.

Low Pressure System
A fire extinguishing system in which the agent is stored in refrigerated (and sometimes heated), insulated Storage Containers which automatically control its temperature at 0 ºF (-18 ºC), resulting in it being held in the liquid state at a nearly constant supply pressure of 300 psi (20.7 bar), independent of the ambient room temperature.

Main Shutoff Valve
A Supervised valve used in Low Pressure Systems, which is located at the Storage Container, and is intended to shut off the supply of CO_2 to the distribution system.

Manual Control
A device or arrangement of devices, for initiating fire extinguishing system discharge, which requires action by a human to release the agent.

Master Cylinder
See Pilot Cylinder.

Maximum Working Pressure
The pressure in an Agent Supply Container, which has been filled to the maximum specified density at the appropriate working pressure at 70º F (21 ºC) and subsequently warmed to the maximum installation temperature.

Minimum Working Pressure
The pressure in an Agent Supply Container, which has been filled to the minimum specified density at the appropriate working pressure at 70º F (21 ºC) and subsequently cooled to the minimum installation temperature.

Nozzle Code
See Nozzle Size Number.

Nozzle Size Number
A convention used to equate the flow characteristics of nozzles having multiple orifices or complex configurations to those of a standard nozzle. It is the diameter, measured in multiples of 1/32 of an inch, of a simple, concentric, round orifice nozzle having the same flow rate for a given inlet pressure, with that equivalency determined by test, rather than through analysis of the nozzle’s geometry.

Operable Pressure Range
The pressure range corresponding to the pressures in the Agent Supply Container at the specified minimum and maximum temperature for which the system is intended to be operable.

Operating Pressure
See working pressure.

Pilot Cylinder
One or more cylinders in a High Pressure System using multiple Agent Supply Containers which are directly actuated by the operating device and which supply pressure to actuate one or more Secondary or Slave Cylinders.

Pre-Engineered System
A fire extinguishing system design in which a predetermined range of piping and nozzle characteristics and configurations are used to predict individual nozzle flow rates.

Secondary Cylinder
One or more cylinders in a High Pressure System using multiple Agent Supply Containers which are operated by pressure supplied from a Pilot or Master Cylinder, rather than directly by an operating device.

Selector Valve
A valve, which is normally operated automatically, but which also has emergency Fully Mechanical Manual Control, and which restricts system discharge to one of multiple spaces or Zones protected by the same agent supply. Selector Valves are controlled by the detection and control system and are used to avoid discharging CO_2 into a space in which no fire has yet been detected, even though the overall system has been actuated to protect one or more other spaces.

Slave Cylinder
See Secondary Cylinder.

Specified
The value of a design parameter set by the manufacturer, which shall be at or less conservative than the limiting values of this standard.

Storage Container
An Agent Supply Container for a Low Pressure System, which includes an insulated pressure vessel jacket, liquid level indicator, and temperature maintenance equipment.

Supervised
A device, such as a valve, which is equipped with switches or is otherwise electrically monitored to allow its state to be displayed or to initiate and alarm via a control panel.

Total Flooding System
An extinguishing system designed to protect an enclosed hazard area by discharging Agent to reach and maintain an extinguishing concentration throughout the enclosed volume long enough to extinguish a fire. These systems are restricted to the use of specific nozzles within prescribed placement limits.

Working Pressure
The equilibrium pressure in a fully charged Agent Supply Container at 70 °F (21 °C).

Zone
A segment of the fire extinguishing system distribution piping, which is supplied through a Selector Valve, and which supplies Agent to one of the spaces protected by the system.

2. GENERAL INFORMATION

2.1 Certification Application Requirements

The manufacturer shall provide the following preliminary information with any request for certification consideration:

- A complete list of all models, types, sizes, and options for the products being submitted for certification consideration;
- Assembly drawings, component drawings, materials list, anticipated marking format, nameplate format, brochures, sales literature, specification sheets, installation, operation and maintenance procedures;
- The number and location of manufacturing facilities;
- All documents shall identify the manufacturer's name, document number or other form of reference, title, date of last revision, and revision level. All documents shall be provided with English translation.

2.2 Requirements for Samples for Examination

2.2.1 Following authorization of a certification examination, the manufacturer shall submit samples for examination and testing.

2.2.2 Requirements for samples may vary depending on design features, results of prior or similar testing, and results of any foregoing tests.

2.2.3 The manufacturer shall submit samples representative of production.

2.2.4 It is the manufacturer's responsibility to either provide any necessary test fixtures, such as those that may be required to evaluate the system.

3. GENERAL REQUIREMENTS

3.1 Review of Documentation

3.1.1 During the initial investigation and prior to physical testing, the manufacturer's specifications and details shall be reviewed to assess the ease and practicality of installation and use. The certification examination results may further define the limits of the final certification.

3.2 Physical or Structural Construction Features

3.2.1 Operating Range

All system components shall operate within the temperature ranges of Table 3.2. If the manufacturer specifies a lower minimum or higher maximum installation temperature, system and component evaluations will be based upon the resulting greater range.

Table 3.2.1 *Required Operation Temperature Range*

Highest Allowable Minimum Operating Temperature		***Lowest Allowable Maximum Operating Temperature***	
°F	(°C)	°F	(°C)
32	(0)	120	(49)

3.2.2 Materials

3.2.2.1 All components shall be made of corrosion resistant materials suitable for their intended use.

3.2.2.2 *Gaskets and O-Rings*

Gaskets and o-rings used in the system shall be compatible with the CO_2 extinguishing agent. Compatibility shall be determined by successful performance in the one-year and maximum and minimum storage temperature leakage tests of Sections 4.1 and 4.2 and review of manufacturer data demonstrating successful performance at maximum and minimum installation temperatures while exposed to the agent. For standard elastomers, the material manufacturer’s certificates of compliance verifying the compatibility of the specific elastomer compound with the carbon dioxide for the temperature and pressure range of usage shall be acceptable. Where such certifications are not available, tests of the elastomer shall be conducted. At minimum, tensile strength, ultimate elongation, and hardness of samples shall not be changed by more than 40 percent from new condition by a 45-day exposure to the agent at the maximum storage temperature and pressure.

3.2.3 Control

3.2.3.1 For normal operation, a system shall be automatically controlled and operable from a manual control, easily accessible to the hazard. If the normal manual means of actuation utilizes electric power, the source of that power shall be completely independent of any electric power source used for automatic operation. Alternatively, a power source used for both normal manual and automatic operation shall be provided with an independent back-up, such as a battery. Whether normally operated automatically or manually, all systems shall also be provided with an alternate means of fully mechanical manual emergency control. Fully mechanical manual emergency controls shall not require an electric power source but may make use of CO_2 pressure to operate the release. These emergency controls shall be located at or near the device being controlled.

3.2.3.2 Control panels shall comply with NFPA Standard 72 and certification requirements for FM 3010 and FM 3810 as a releasing control. Control panels need not be submitted as a part of a system. However, system design shall be such that the system is operable by a minimum of one certified detection and release panel.

3.2.4 Strength

All unprotected component parts which contain the flow of CO_2 shall have minimum bursting pressures as shown in Table 3.2.4. Components protected by a pressure relief device shall have minimum bursting pressures equal to or greater than twice the pressure relief setting. The discrepancy between the agent supply container requirement and that for other continuously pressurized components is due to the well-established pressure vessel design and manufacturing protocols which are used. Agent supply containers are typically cylindrical in form. Cylinders are simple forms which lend themselves well to calculation of applied stresses, whereas components such as valves typically exhibit more complex geometries and states of stress. Low pressure agent supply containers need not be subjected to burst pressure tests if designed to a recognized standard and burst pressure design calculations are submitted per that standard.

Table 3.2.4. *Required Minimum Bursting Pressures*

	High Pressure Systems		***Low Pressure Systems***	
Component Service	***psi***	***(bar)***	***psi***	***(bar)***
Subject to agent storage pressure	6000	(413.8)	1800	(124.1)
Subject to agent discharge pressure	5000	(344.8)	1800	(124.1)
Agent supply containers	5000	(344.8)	875	(60.3)

3.2.5 Pressure Vessels

3.2.5.1 Agent supply containers shall conform to the appropriate regulations for the installation location. In the U.S.A., U.S. Department of Transportation (DOT), Title 49, Code of Federal Regulations, Parts 171 through 180 are appropriate for high pressure system cylinders, which are shipped pressurized. The ASME BPVC-CC-N, Section VII is used for low pressure system storage containers, which are filled after installation. In a multiple cylinder system, all cylinders supplying the same manifold shall be of the same size and design for interchangeability of position. The following documents shall be submitted for each diameter of each storage container pressure vessel design to demonstrate compliance with the relevant design standard:

a. Calculation of wall thicknesses per the method specified in the standard, with appropriate supporting references, as necessary.
b. Certificate of chemical analysis of materials.
c. Certificate of physical properties of materials.

3.2.5.2 High pressure system cylinders transported within the United States of America shall be selected to contain no more than a 68 percent liquid filling volume according to the U.S. Department of Transportation (DOT). A higher percent liquid fill may be allowed for system cylinders shipped outside of the United States of America if allowed by the local transportation authority, and if system limitations, such maximum system storage temperature, are adjusted to maintain system pressure below the pressure relief device setting. Low pressure system storage containers shall be selected to contain no more than 95 percent liquid filling volume.

3.2.6 Discharge Valves

The pressure loss versus flow through discharge valves shall be measured to allow accurate calculations for system design. Discharge valves shall use different sizes or connection designs for all ports to minimize the likelihood of improper connection at installation. Valves not designed for mounting directly on an agent supply container may use inlet and outlet connections of the same size and design but shall be marked to indicate correct direction of flow. For pressure operated valves, the manufacturer shall provide data for the minimum available force or torque for each actuator and the maximum required operating force or torque for the corresponding valve. Proper operation of the most adverse combinations shall be verified by test.

3.2.7 Siphon Tubes

High pressure cylinder valve assemblies shall include a siphon tube to discharge liquid CO_2 from the cylinder. The discharge end of the siphon tube shall be mechanically fastened and sealed to remain in place during all conditions of use and to prevent gas discharge until the liquid level drops below the opening on the free end of the siphon tube. The free end of the siphon tube shall be configured to prevent restriction of flow by contact with the cylinder wall. Flow rate measurements for high pressure cylinder valves shall be performed with siphon tubes in place and installed in the normal design proximity to the cylinder wall if the minimum clearance between the end of the tube and the wall is less than 0.25 of the inside diameter of the tube. Siphon tubes in low pressure storage containers shall also meet the 0.25 tube inside diameter clearance requirement. In both cases, compliance with this requirement shall be demonstrated by drawings showing the calculated assembly clearance, based upon worst case dimensional tolerance stack-ups. Alternatively, the manufacturer's assembly process may contain some controlled procedure for verifying the minimum required clearance.

3.2.8 Pressure Relief Devices

Calculations shall be submitted to verify that the pressure relief device is designed and sized to comply with the uninsulated cylinder flow capacity requirements as specified in either the Compressed Gas Association Pamphlet S-1.1, or equivalent safety standard in the location of intended system installation. Supply container pressure relief devices shall operate between 2400 psi and 3000 psi (165.5 bar and 206.9 bar) on high pressure systems and at 350 psi (24.1 bar) on low pressure systems, unless the local safety code in the location of intended system installation permits a lower setting. Low pressure system piping that may contain CO_2 liquid trapped between closed valves after a discharge shall be provided with a pressure relief device set at 450 psi (31.0 bar).

3.2.9 Discharge Heads and Connectors

If a high pressure system discharge head must be removed from the valve assembly during weighing or recharging operations, the assembly shall contain a check valve. When a discharge connector must be removed, an anti-recoil device shall be installed on the valve's discharge connection and a plug or cap shall be provided to seal the disconnected end of the loop. Appropriate warnings shall be displayed on these devices to caution the user with regard to the high-pressure discharge hazard and the proper procedure for mitigating this hazard.

3.2.10 Manifolds and Piping

Manifolds of proprietary designs used in place of standard pipe and fittings shall have minimum internal diameters greater than or equal to that of their corresponding pipe sizes. In multiple container installations where the discharge of a pilot cylinder(s) actuates secondary cylinders, the manifold piping shall be arranged so that any one pilot cylinder will actuate the entire battery, regardless of the total number of pilot cylinders in the system. All cylinders in a battery shall be of the same size and design.

3.2.11 Cylinder Supports

Equipment which supports multiple cylinder installations shall be designed to facilitate removing individual cylinders for inspection and servicing.

3.2.12 Protective Covering

All valves and control devices with exterior movable parts that are vulnerable to obstruction or physical damage shall be protected by paneled enclosures or cages. Operating, levers, handles, or buttons requiring manual access for operation shall be exempt from this requirement to the extent necessary to allow for their unimpeded operation. Conduit shall be used for cables, wires, or tubes outside the enclosures.

3.2.13 Actuation Devices or Control Heads

The device which opens a high pressure cylinder discharge valve shall either be an autonomous control head attached to the valve, or an internal component of either the discharge head or the valve assembly itself. One action shall actuate all the cylinders in a battery. This shall be accomplished automatically by the connection of pilot to secondary cylinders, or by a mechanical system acting simultaneously on all cylinder valves. In the former arrangement, CO_2 pressure from a pilot cylinder moves a piston in the secondary cylinder control head, valve assembly, or discharge head to unseat the valve disk and open the valve. Such pistons shall have sufficient area such that, when acted upon by the minimum pilot pressure, sufficient force is generated to overcome the force generated by the maximum system pressure acting over the valve disk sealing area. Compliance shall be demonstrated by test or the submission of appropriately annotated drawings displaying the area ratio calculation. Control heads on pilot cylinders shall be designed for single or simultaneous multiple unit operation. They shall be actuated automatically by a fire detection device, or by a fully manual emergency release device (Section 3.2.3.1). Handles or levers on these and any other manual controls shall not require a force to operate exceeding 40 lb (178 N), nor travel of more than 14 in. (36 cm), nor rotation of more than 270 degrees. Valves controlled by gear operators shall not require more than 10 turns to open. Torque required to operate any device shall not exceed 40 lbf•ft (54 N•m).

3.2.14 Auxiliary Manual Controls

Auxiliary manual controls shall be provided for systems using automatic control heads or mechanical release devices which do not incorporate a fully mechanical manual control. These auxiliary controls shall be used for remote, manual operation or in emergencies due to failure of the automatic control. Auxiliary controls which are not located within the protective enclosures provided for other components shall be protected by a sturdy, break-open type box. Control devices that require cables shall demonstrate smooth, responsive motion with the most complex or lengthy specified arrangement.

3.2.15 Selector and Lockout Valves

Selector valves shall be provided for systems protecting multiple hazards. Lockout valves shall be provided to safeguard personnel from accidental discharge during servicing of the system. The rate of flow through selector and lockout valves shall be measured to allow accurate calculations for system design. Requirements for selector and lockout valve controls are the same as those for discharge valves. Therefore, the same design may be used for both types of valve on low pressure systems. The actuation of one selector valve shall not open other selector valves in the system. These valves shall be designed with a provision for remote supervision of valve position (fully open or fully closed). Supervisory devices shall be compatible with certified control equipment. Only low pressure tank shutoff and lockout valves require supervision. Selector valves are exempt from this requirement but may be supervised if required by the system controls.

3.2.16 Nozzles

Discharge nozzles shall be evaluated for the intended use, including flow characteristics and area of coverage. Nozzles or outlets shall he made of metallic, corrosion resistant materials that will not deform or otherwise be damaged by fire exposure. Nozzles shall not have orifices less than 0.040 in. (1 mm) in diameter. Nozzle flow paths shall be of decreasing area configurations. Orifice plates shall not be used in nozzles, unless the manufacturer can demonstrate by test that any solid CO_2 produced under any flow condition will not plug downstream nozzle flow paths or otherwise interfere with normal discharge. Nozzles shall be permanently marked to identify manufacturer, type, and nozzle size number.

3.2.17 Nozzle Screens

Outlets less than 1/8 in. (3.17 mm) diameter shall be protected from plugging due to foreign materials in the system by a screen. If the screen is placed in the passageway supplying the nozzle, it shall be formed into a cone or hemisphere with its outside surface facing the upstream direction. Nozzle screens shall provide a free area not less than five times the total nozzle orifice area and shall be fabricated of a mesh having openings between 0.020 in. and 0.030 in. (0.5 mm and 0.8 mm) in their least dimension.

3.2.18 Nozzle Covers

Caps or frangible seals shall be provided on nozzles for installations in which the nozzles are subject to clogging from external materials. Such caps or seals shall have a maximum releasing pressure of 44 psi (3 bar) as installed and shall in no way obstruct flow from the outlet, after release.

3.2.19 Carbon Dioxide

Carbon dioxide gas for use as an extinguishing agent shall meet the requirements of Table 3.2.19. Certificates of conformity shall be presented for all CO_2 used in testing for a certification examination. Unlike most other gaseous extinguishing agents, CO_2 is a pure substance and is commonly available. Accordingly, low pressure systems are usually refilled on site and high pressure supply containers are usually refilled in a commercial facility which refills other industrial gas cylinders. While this examination standard does not require factory filling of CO_2 cylinders, the recharge gas must also meet the following requirements.

Table 3.2.19. *Carbon Dioxide Requirements*

Characteristic	***Allowable Limit***
Vapor phase purity	99.5 percent, minimum
Liquid phase water content	0.01 percent maximum, by weight
Oil content	10 ppm maximum, by weight

3.2.20 Auxiliary Equipment

Auxiliary equipment includes those devices required in a system to protect against a specific hazard. The need for these devices shall be determined by the system manufacturer according to the nature of the hazard. The devices listed below may be required for the system to earn certification for specific applications. Other devices not included below may also be required.

3.2.20.1 Pressure Operated Release

A pressure operated release shall be provided on all doors and windows in a hazard area which is to be sealed off in the event of fire. The release shall operate at a maximum pressure of 50 psi (3.5 bar) from a piston or plunger driven by CO_2 from the extinguishing system. The release shall not permit the escape of excessive gas from the system. It shall automatically reset and may have a control for manual operation.

3.2.20.2 Pressure Operated Switches

Pressure operated switches may be used to shut down fans, conveyors, or other electrical equipment near the hazard area, and activate alarm and indicator circuits. These switches shall operate at a maximum CO_2 pressure of 50 psi (3.5 bar) and not release excessive gas from the system. They may have a means for alternate, manual control and shall be designed for manual resetting only.

3.2.20.3 Time Delays

A delay device shall be installed on systems to minimize the likelihood of accidental exposure of personnel to CO_2 discharge. This device may either delay the operation of the system or delay the discharge of CO_2 after the system has been actuated. In the first arrangement, the actual discharge shall be manually controlled. A manual override shall be provided in the second arrangement to allow immediate discharge.

3.2.20.4 Alarms

Alarms and/or indicators shall be provided to show that the system is operating, warn personnel of the forthcoming discharge of CO_2 or of its presence in unventilated areas, and signal the failure of any supervised equipment. Indicators which show that the system has been used and must be serviced shall operate upon actuation of the system and require manual resetting. Nozzles used on pressure operated alarms must meet the requirements in Section 3.2.16.

3.2.20.5 Check Valves

Check valves shall be provided on systems that utilize standby agent supplies or separate the flow of CO_2 to initial and delayed discharge lines. These valves may exhibit minor leakage in the reverse flow direction. They shall open at a maximum pressure of 0.1 times the system pressure at maximum storage temperature.

3.2.20.6 Safety Valves

Manifold relief valves shall be used on systems equipped with selector valves to vent closed sections of pipe, when necessary. These safety valves shall operate at pressures of 2400 to 3000 psi (165.5 and 206.9 bar) on high pressure systems and at 450 psi (31.0 bar) on low pressure systems and be arranged so that their discharge of CO_2 is not likely to injure personnel.

3.2.20.7 Venting Valves

Devices shall be provided to prevent the premature operation of cylinder or selector valves by residual pressures that may leak into enclosed manifolds, control heads or discharge heads. They shall have closing pressures of 25 to 100 psi (1.7 to 6.9 bar). If these vents are incorporated in control heads, they shall be closed when the control is in operation and open when the control is inoperative.

3.2.20.8 Changeover Devices

Changeover devices such as valve or switch assemblies shall be provided on automatic systems having both primary and manifold or secondary batteries of supply containers. This will direct the command of the automatic fire detection device to the proper batteries. The changeover device shall be enclosed in a mounting box and shall indicate which batteries are subject to operation.

3.2.21 Low Pressure Agent Supply Container Configuration Requirements

3.2.21.1 Low pressure supply containers shall be equipped with a liquid level gauge, a pressure gauge, a high-low pressure alarm, and a vapor connection for actuation of auxiliary devices.

3.2.21.2 The pressure gauge shall be selected to indicate normal tank pressure in the middle third of its range.

3.2.21.3 The high-low pressure alarm shall be set to low alarm at no lower than 250 psi (17.2 bar). The high pressure alarm shall be set no higher than 90 percent of the pressure vessel's maximum allowable working pressure (MAWP).

3.2.21.4 A refrigeration system shall be provided with adequate capacity to maintain 300 psi (20.7 bar) agent supply pressure at the maximum allowable ambient temperature of 120 ºF (49 ºC).

3.2.21.5 A heating system shall be provided for agent supply containers installed where ambient temperatures may go below -10 ºF (-23 ºC), at which temperature the CO_2 pressure could fall below 250 psi (17.2 bar).

3.2.22 Hazardous Location Rating of Components

Components designed for use in hazardous locations shall be certified only if successfully evaluated for compliance to the relevant requirements of one or more of the following Standards:

Table 3.2.22 *Hazardous Location Electrical Equipment Standards*

	Examination Standard Title
FM 3600	Electric Equipment for use in Hazardous (Classified) Locations General Requirements
FM 3610	Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, & III, Division 1,and Class I, Zone 0 & 1 Hazardous (Classified) Locations
FM 3611	Nonincendive Electrical Equipment for Use in Class I and II, Division 2, and Class III, Divisions 1 and 2, Hazardous (Classified) Locations
FM 3615	Explosionproof Electrical Equipment General Requirements
FM 3620	Purged and Pressurized Electrical Equipment for Hazardous (Classified) Locations
FM 3810	Electrical and Electronic Test, Measuring, and Process Control Equipment

3.3 Markings

3.3.1 Conspicuously mounted nameplates shall be affixed to the discharge valve-cylinder assembly of high pressure systems and the main agent supply container of low pressure systems and shall display the following markings, at minimum.

- Manufacturer's name and address
- System type and model number
- The certification agency’s mark of conformity
- Agent identification (liquefied carbon dioxide gas)
- Supply pressure at 70 °F (21 °C) ambient temperature
- Allowable ambient storage temperature range
- Year of manufacture of the storage container
- Location of manufacture if different from manufacturer’s address
- Reference to NFPA 12, or other relevant local standard and the manufacturer’s design, installation, operation, and maintenance instructions.
- Weight of agent charge and total container weight
- “WARNING: Actuation of this device will cause carbon dioxide to discharge. Before actuating, be sure personnel are clear of the area.”

3.3.2 Combination instruction and identification plates shall be mounted on or next to all control devices. All significant component parts or assemblies shall also bear an identification mark, such as a part, catalog, or pattern number.

3.3.3 Nozzles shall be permanently marked with their nozzle size number (“nozzle code”) so that the figures will be visible when the nozzles are installed. All nozzles, regardless of actual orifice area or design configuration, shall be assigned a nozzle size number to be used in calculating the "nozzle orifice ratio" of the system.

3.3.4 All marking plates shall be made of materials which will not corrode or otherwise become illegible from the action of system liquids or vapors, or normal, local conditions.

3.3.5 When hazard warnings are needed, the markings should be universally recognizable.

3.3.6 The model or type identification shall correspond with the manufacturer's catalog designation and shall uniquely identify the certification agency’s mark of conformity.

3.3.7 The certification agency’s mark of conformity shall be displayed visibly and permanently on the product and/or packaging as appropriate and in accordance with the requirements of the certification agency. The manufacturer shall exercise control of this mark as specified by the certification agency and the certification scheme.

3.3.8 All markings shall be legible and durable.

3.4 Manufacturer's Installation and Operation Instructions

3.4.1 The manufacturer shall provide complete instructions and any assistance required to properly design, install, operate, and maintain the system. These instructions shall be submitted to the certification agency as a part of the examination of a system.

3.4.2 The manufacturer’s design instructions for a system submitted for certification shall be evaluated based on NFPA 12 and any other relevant local standards.

3.5 Calibration

3.5.1 Each piece of equipment used to verify the test parameters shall be calibrated within an interval determined on the basis of stability, purpose, and usage. A copy of the calibration certificate for each piece of test equipment is required. The certificate shall indicate that the calibration was performed against working standards whose calibration is certified and traceable to an acceptable reference standards and certified by an ISO/IEC 17025 accredited calibration laboratory. The test equipment shall be clearly identified by label or sticker showing the last date of the calibration and the next due date. A copy of the service provider’s accreditation certificate as an ISO/IEC 17025 accredited calibration laboratory should be available.

3.5.2 When the inspection equipment and/or environment is not suitable for labels or stickers, other methods such as etching of control numbers on the measuring device are allowed, provided documentation is maintained on the calibration status of thus equipment.

4. PERFORMANCE REQUIREMENTS

4.1 One Year Leakage Test for High Pressure Supply Containers

4.1.1 Requirement

High pressure cylinder and valve assemblies shall not leak in excess of 0.008 times the minimum charge (agent) weight for all sizes of cylinders available as a part of the system over a one-year test at 70 °F ± 5 °F (21 °C ± 3 °C). This number is derived from a 10 percent maximum allowable loss divided by the 12-year maximum interval between recharging specified in NFPA 12.

4.1.2 Tests/Verification

Test sample assemblies shall incorporate all components subjected to the normal working pressure. A minimum of three fully assembled samples shall be pressurized with carbon dioxide to the normal system working pressure.

If the manufacturer states that cylinders may be mounted in orientations other than vertical, samples shall be tested in all orientations.

If different valve designs are used, each shall be tested. If different sizes of the same valve design are used, at minimum, those sizes judged to represent least strength ratios of wall thicknesses to diameters, or other "worst case" configurations shall be tested. If worst case sizes cannot be identified, then all sizes shall be tested. Samples shall incorporate all potential worst case leakage paths. However, this can be done through modified samples. For example, a smaller cylinder may be modified to incorporate the largest size valve joint to avoid using large cylinders in this test. The design of such nonstandard samples shall require prior review and acceptance by the certification agency. The total weight of each fully charged sample shall not exceed 300 lb (136 kg).

Each sample shall be weighed to the nearest gram at 0, 3, 6, 9, and 12 months and the projected weight loss over one year shall be calculated, based upon the weight loss to date and the appropriate ratio (4 for three months, 2 for six months, and 4/3 for 9 months). This is intended to allow an early warning of a potential failure, without having to wait for the full one year for the manufacturer to take any corrective action deemed necessary. The duration of this test for minor modifications to previously certified configurations, such as a new seal or any change to a leak path, shall be reduced to 6 months.

Throughout the duration of the test, samples shall be maintained at the specified temperature and protected from mechanical damage, corrosives, and other factors which may accelerate leakage.

Subsequent to the test, one sample of each valve size shall be operated by one of the manufacturer's normal means to verify proper response. Cylinders shall be secured during operation and provided with a recoil safety device on the discharge connection. This is necessary to minimize the likelihood of the sample being propelled by the reaction thrust of the discharge and thus becoming a potential hazard to personnel and facilities.

4.2 Leakage at Maximum and Minimum Storage Temperature Test for High Pressure Supply Containers

4.2.1. Requirements

The cylinder and valve assembly shall exhibit no leakage in excess of 0.0007 times the minimum charge weight for all cylinder sizes at maximum and minimum storage temperatures. This number is derived by dividing the one year allowable leakage of Section 4.1.1 by 12 months.

4.2.2 Tests/Verification

Samples shall be selected and prepared as described in Section 4.1.2. Two lots of samples shall be tested.

One lot of samples shall be subjected to the maximum specified storage temperature, but no less than 130 °F (54 °C), for 30 days.
A second lot of samples shall be subjected to the minimum specified storage temperature, but no greater than 32 °F (0 °C) for local application systems or 0 °F (-18 °C) for total flooding systems, for 30 days.

Samples shall be weighed before and after the temperature exposures to the nearest gram and the weight loss calculated.

4.3 Equivalent Length and Nozzle Size Number Determination

4.3.1 Requirement

The friction loss of all components in the system flow path and nozzle size numbers shall be determined to allow system design calculation.

4.3.2 Tests/Verification

The discharge valve assembly shall be flow tested to determine equivalent length. For high pressure systems, this test shall be performed on a fully equipped valve with siphon tube, a control head or assembly, and all connections which would affect the flow path. A minimum of four tests at different flow velocities shall be performed. The test medium shall be water. Flow rate and pressure differential shall be measured and the data used to perform a regression analysis to justify the equivalent length figure used in system design. Equivalent length shall be calculated on the basis of the discharge outlet nominal pipe size, using a Hazen-Williams coefficient of 130. This test shall be conducted for each different valve design.

Selector valves, check valves, and other non-standard components in the flow path shall be likewise tested to determine equivalent length. If valve designs are proportional over a range of sizes and the manufacturer submits equivalent length data for the range, then the certification agency may, at its discretion, chose to test only the smallest and largest valves from this range to verify the manufacturer's data.

Nozzles shall be flow tested to verify assigned nozzle size numbers ("nozzle codes"). A minimum of three tests at different flow velocities shall be performed on a minimum of five different sizes of each nozzle design. The test medium shall be water. Flow rate and pressure differential shall be measured and the data used to perform a regression analysis to justify equivalencies to the standard nozzle. The nozzle size number assignment shall be as described in Section 1.9, Definitions, herein. The equation used to calculate equivalent area is:

$$A_e = Q \big/ \left(38 \times \sqrt{P}\right)$$

Where A_e is the equivalent area in square inches, Q is the flow in gallons/minute, and P is the pressure in psi. Assigned size numbers shall result in calculated flow rates within ± 10 percent of those determined by test.

4.4 High Rate of Flow Discharge Integrity

4.4.1 Requirement

All components in the system flow path shall be subjected to a maximum flow rate discharge test to determine their ability to withstand the reaction forces without damage.

4.4.2 Tests/Verification

For high pressure systems, the cylinder/discharge valve assembly shall be filled with CO_2 and stabilized at the maximum installation temperature or pressurized to the maximum working pressure with nitrogen. The unit shall be mounted using the brackets provided by the manufacturer and connected to a simple system incorporating selector valves both flowing and blocking the flow to a branch, check valves both flowing and blocking the flow to a branch, and all flow path and mechanical and electrical elements normally connected to the discharge piping. All items shall be mounted and supported as required by the manufacturer's published instructions.

Low pressure system discharge components shall be similarly tested, but the pressure supply need only be sufficient for 60 seconds of flow. Water pressurized with nitrogen may be used as a test medium provided calculations are submitted to demonstrate equivalency with the rate of flow for carbon dioxide.

The system shall be configured to produce the maximum flow rate recommended for system design. After discharge, the system shall be inspected for visible damage. All components shall operate normally after this test. No damage which would impede performance shall be allowed.

4.5 Cycle Operation Test

4.5.1 Requirement

All components required for system operation shall operate properly through a total of 300 cycles at the temperatures and pressures shown in Table 4.5.1.

Table 4.5.1. *Operational Test Conditions*

System Type	***Temperature***		***Closed Valve Pressure***		***Open Valve Pressure***		***Number of Cycles At This Condition***
	ºF	***(ºC)***	***psi***	***(bar)***	***psi***	***(bar)***	
Low Pressure	70	(21)	290	(20)	29	(2)	100
High Pressure	70	(21)	870	(60)	73	(5)	100
Low Pressure	32*	(0)	290	(20)	29	(2)	100
High Pressure	0*	(-18)	870	(60)	73	(5)	100
Low Pressure	130**	(54)	290	(20)	29	(2)	100
High Pressure	130**	(54)	870	(60)	73	(5)	100

* Or at the manufacturer's specified minimum installation temperature, if lower.
** Or at the manufacturer's specified maximum installation temperature, if higher.

4.5.2 Tests/Verification

The test samples shall include all components required for operation, including electrical, pneumatic, and mechanical actuators, switches, relays, indicators, and gauges. The test fluid shall be carbon dioxide maintained at or greater than the "closed valve" pressures of Table 4.5.1 when the tested valves are closed and at or lower than the "open valve" pressures of 4.5.1 when they are open. At minimum, largest and smallest size valves of each design shall be tested. Further, pressure actuated valves having the lowest available actuator torque to required operation torque ratios shall also be tested, if not the largest and smallest sizes.

Alternate test media may be used provided documentation can be submitted which demonstrates compatibility with either carbon dioxide for the seal material.

Subsequent to this cycling, the tested assemblies shall be allowed to stabilize at approximately 70 ºF (21 ºC) for evaluation of the effects of the cycle testing.

All assemblies shall undergo the Leakage Test of Section 4.6, except at the normal working pressure.

Selector valves and all other devices that include parts undergoing mechanical movement during system operation shall also be subjected to this cycle operation test. Selector valves shall be tested as complete assemblies with their proper controls. If the controls are the same as those used on the cylinder valves, they need not be tested again on selector valves, except as necessary to operate the selector valves during the cycle test or to complete the pressure retaining envelope.

The tested samples shall exhibit no damage or wear sufficient to impair operation of the system. Leakage shall not exceed that specified in Section 4.6.2. Subsequent to cycling, valves shall not show any increase in required torque for mechanical operators or actuation pressure if pressure operated, when tested at approximately 70 ºF (21 ºC).

4.6 Valve Leakage

4.6.1 Requirement

No valve required for the operation of the system shall leak at a rate which would impair system integrity.

4.6.2 Tests/Verification

All valves shall be tested in new condition, as supplied by the manufacturer. Additional samples previously subjected to the cycle operation test shall remain within the acceptable limits of leakage when tested at the normal system working pressure.

The inlet of the valve shall be pressurized and the outlet shall remain open. Water shall be used as the pressurizing medium. The rate of rise of the pressure shall not exceed 300 psi (20.7 bar) per minute.

Discharge valves shall not show visible leakage when held at the pressure relief device set pressure for five minutes.

Selector and check valves shall not leak more than 1 fluid ounce (0.008 ml) per inch of nominal valve size per hour, when held at one half of the pressure relief device set pressure for a minimum of five minutes.

If a valve design is such that leakage is more likely at a lower pressure, then that valve shall also be tested at the lower pressure.

For low pressure systems, pneumatic actuators operating off the vapor line shall not leak in excess of 0.017 oz/min (0.5 ml/min) per inch of nominal valve size when tested at the maximum regulator or pressure relief device pressure setting for the vapor line.

4.7 Hydrostatic Integrity

4.7.1 Requirement

Agent supply containers shall withstand their prescribed minimum bursting pressure without failure. Minimum bursting pressures shall be determined based upon the standard to which cylinders have been manufactured but shall be no less than 5000 psi (344.8 bar) for high pressure systems and no less than 875 psi (60.3 bar) for low pressure systems. System certification shall be limited to installations within jurisdictions accepting the standard to which the cylinders have been manufactured.

Low pressure agent supply containers need not be subjected to burst pressure tests if designed to a recognized standard and burst pressure design calculations are submitted per that standard.

All components subjected to the normal storage pressure shall withstand the minimum bursting pressure required for the system pressure cylinders, but no less than 6000 psi (413.8 bar) for high pressure systems and 1800 psi (124.1 bar) for low pressure systems. Alternatively, components protected by a pressure relief device shall withstand a minimum bursting pressure of twice the relief valve setting.

4.7.2 Tests/Verification

The pressurizing medium is to be water. For the last 20 percent of the required pressure, the rate of pressure increase shall be no more than 10 percent per minute. Required pressures are to be held for five minutes.

Nozzles shall be included in the components tested. Representative samples of each nozzle design shall be tested with orifices either undrilled or plugged to simulate a nozzle blockage during discharge.

Check valves shall be subjected to a hydrostatic test with the disc open to pressurize the entire body. A separate test shall also be conducted with the pressure applied through the outlet connection against the disc while the inlet connection is open to atmosphere.

Leakage is acceptable during the hydrostatic tests, as long as the pressure source is adequate to maintain the required test pressure.

No cracking, fracture, or failure to retain the test pressure shall be allowed.

Finite Element Analysis (FEA) or other computational methods may be used as an alternate to demonstrate compliance to these requirements, subject to agreement by the certification agency.

Permanent volumetric expansion testing is required under some pressure vessel standards. If required by the standard to which the cylinder is designed, such tests shall be conducted in conformance to that standard.

Physical testing may be waived for pressure vessels being manufactured under continuous surveillance to a recognized pressure vessel regulation. In these circumstances, in lieu of physical testing, the manufacturer shall provide documentation detailing continuous oversight of the pressure vessel manufacturing, sample test results appropriate to the regulation, and certification documentation for the overseeing body.

4.8 Pressure Relief Devices

4.8.1 Pressure Relief Operation

4.8.1.1 Requirement

Pressure relief device pressure ratings shall be selected as specified in Section 3.2.8. The cylinder pressure relief device assembly shall be pressurized until relieving operation occurs. The pressure at operation shall be within -10/+0 percent of the manufacturer’s published rating.

4.8.1.2 Test/Verification

A minimum of ten pressure relief device assemblies shall be pressurized until operation. If the device does not contain a rupturing component, but rather operates similarly to a pressure relief valve, the same device may be subjected to all ten trials. Pressure shall be increased from 85 percent of the device’s rating to operation at a rate no greater than 10 percent per minute. The operating pressure shall be recorded. No assembly shall operate above or more than 10 percent below, the published rating, except that relief valves for low pressure systems using ASME code pressure vessels shall operate within ± 3 percent of the published rating.

4.8.2 Pressure Relief Calculations

4.8.2.1 Requirement

Documentation shall be submitted to verify that the construction and size of the pressure relief assembly comply with the flow capacity requirements.

The construction and size of the burst disc and dispersion device (high pressure) and pressure relief valve (low pressure) shall, at a minimum, be appropriate for the anticipated pressure of the extinguishing agent/medium at the maximum allowable pressure vessel storage temperature.

4.8.2.2 Tests/Verification

Appropriate documentation and calculations shall be submitted to verify that the construction and size of the burst disc and pressure relief valve comply with the flow capacity requirements as specified by the formula in CGA S-1.1.

4.9 Flexible Hose

4.9.1 Low Temperature Resistance

4.9.1.1 Requirement

Flexible hoses shall withstand flexure at the minimum storage temperature for the system.

4.9.1.2 Tests/Verification

Each hose assembly shall be conditioned for 16 hours at the minimum storage temperature and, while still at that temperature be bent around a mandrel of the hose's minimum bending radius and to the maximum angle allowed in the manufacturer's installation instructions. Bending shall be performed smoothly and continuously within an approximate 10 second time interval.

No cracking or other damage shall be visible.

After returning to ambient temperature, the hose shall be hydrostatically pressure tested for one minute at 5000 psi (344.8 bar). If a manifold relief valve is used, then testing shall be to twice the relief valve set pressure. No rupture or separation from end connections shall occur.

4.9.2 Resilience

4.9.2.1 Requirement

All hoses shall remain functional after 3000 cycles of flexure to the maximum specified angle.

4.9.2.1 Test/Verification

Each hose assembly shall be conditioned for 16 hours at 70 °F ± 5 °F (21 °C ± 3 °C) and, while still at that temperature, be bent around a mandrel of the hose's minimum bending radius and to the maximum angle allowed in the manufacturer's installation instructions. Bending shall be performed smoothly and continuously. The sample shall then be straightened to complete the cycle.

The bending and straightening cycle shall be repeated for a total of 3000 cycles.

No cracking or other damage shall be visible.

After completion of 3000 cycles, the sample shall be hydrostatically pressure tested for one minute at 5000 psi (344.8 bar). If a manifold relief valve is used, then testing shall be to twice the relief valve set pressure, if that number exceeds 5000 psi (344.8 bar). No rupture or separation from end connections shall occur.

4.10 Actuator and Control Operation

4.10.1 General

4.10.1.1 Requirement

All controls shall operate under the most adverse normal pressure (maximum or minimum, as appropriate) when conditioned to the maximum and minimum specified installation

temperatures. The range of installation temperatures specified shall include at minimum, those of Table 3.2.1.

4.10.1.2 Tests/Verification

A minimum of one sample of each device shall be conditioned to the minimum specified installation temperature for 16 hours. While still at that temperature, the device shall be operated and shall display no detectable hesitation, partial operation, or other failure. Devices motivated by pressure shall be tested at maximum or minimum normal system pressures, whichever is more adverse for the design of the specific component. If the most adverse condition is not readily discernable, the device shall be operated at both extremes of pressure.

A minimum of one sample of each device shall be conditioned at the maximum specified installation temperature for 16 hours and the same evaluations shall be conducted.

4.10.2 Electrically Operated Devices

4.10.2.1 Requirement

Electrically operated controls shall also operate properly at 85 and 110 percent of rated voltage while at maximum and minimum specified installation temperatures.

4.10.2.2 Tests/Verification

A minimum of one sample of each device shall be tested. The tests of Section 4.10.1.2 shall be conducted on a device powered at 85 percent of rated voltage and again at 110 percent of rated voltage. No deterioration in operation shall be allowed.

4.10.3 Manually Operated Controls

4.10.3.1 Requirement

Manual controls shall operate properly with applied forces no greater than 40 lb (178 N), linear movement no more than 14 in. (36 cm), torque no greater than 40 lb_f•ft (54 N•m), nor rotational movement of over 270 degrees when configured with the most adverse arrangement allowed by the manufacturer's installation instructions. Components shall exhibit strength equal to or greater than 1.5 times the required operating force.

4.10.3.2 Tests/Verification

A minimum of one sample of each device shall be tested. Properly calibrated force gauges, torque meters, and measuring tapes shall be used to measure operational requirements. Tests shall be conducted under the most adverse condition with respect to normal system pressure, if applicable. Devices using flexible mechanical cable actuation shall be tested with the most adverse cable routing (maximum length of cables, number of changes of direction, et cetera). No impairment of operation shall be allowed.

After measurement of the required actuating force or torque, 1.5 times that value shall be applied to the device. No failure or impairment of subsequent operation shall result.

4.10.4 Pilot Operated Controls

4.10.4.1 Requirement

Pneumatically operated pilot-secondary cylinder arrangements of the most adverse configuration shall operate all connected cylinders within one second.

4.10.4.2 Tests/Verification

The pilot or master cylinder shall be pressurized to its normal working pressure and conditioned to the minimum storage temperature for 16 hours. Similarly pressurized secondary or slave cylinders shall be conditioned to the maximum storage temperature for 16 hours. The maximum number of secondary cylinders shall be connected to the pilot cylinder through the most restrictive piping arrangement allowed by the manufacturer's installation instructions. Timing for the interval between operation of the first and last cylinders shall be measured. A properly calibrated automated data acquisition system, capable of taking pressure readings for the pilot and most remote secondary cylinder at a minimum of 10 data points per second shall be used to record the timing. The last secondary cylinder shall operate within 1 second of the first significant pressure decrease in the pilot cylinder.

4.10.5 Mechanical Time Delay Assemblies

4.10.5.1 Requirement

Mechanical time delay assemblies shall delay the actuation of a system no less than nor more than 20 percent longer than the manufacturer's stated delay time, throughout the stated operational temperature range and range of time delay settings.

4.10.5.2 Tests/Verification

The assembly shall be adjusted to the minimum delay time setting and conditioned at the minimum installation temperature for a minimum of 16 hours. While still at that temperature, it shall then be pressurized to the corresponding system pressure and the delay time until release of the pressure shall be recorded. The assembly shall be readjusted to the maximum time delay setting and the test repeated.

An assembly conditioned to the maximum installation temperature shall be similarly tested.

In no case, shall the assembly fail to operate or operate more quickly than the time delay setting nor more slowly than 20 percent longer than the setting.

4.10.6 Pressure Operated Audible Alarm Devices

4.10.6.1 Requirement

Audible alarm devices shall operate effectively and continuously without failure, throughout the range of system operating pressures.

4.10.6.2 Tests/Verification

The device shall be mounted not less than 10 ft (3.05 m) above the ground in its normal orientation. A sound level meter's microphone shall be positioned in a vertical plane through the device's centerline, 10 ft (3.05 m) away from the mounting plane, and 5 ft (1.5 m) above the ground. The microphone shall be oriented to obtain the strongest response. The sound meter shall comply with ANSI/ASA S1.4. Measurements are to be made using "C" weighting network and the fast response setting.

The test shall be conducted in a free field environment having an ambient noise level a minimum of 10 decibels below the measured level produced by the alarm. The alarm shall be operated at its minimum specified pressure for 5 hours and then at the maximum specified pressure for an additional hour.

In no case, shall the device fail to operate nor produce a sound level less than 90 decibels.

4.11 Dielectric Withstand

4.11.1 Requirement

Electrical components shall withstand application of twice their rated voltage plus 1000 V between all terminals provided for external connections and ground.

4.11.2 Tests/Verification

Voltage shall be applied, in turn, between each terminal and ground. For devices rated at 60 V, or less, the test voltage shall be 500 V. Components subjected to the Dielectric Withstand test shall continue to function normally subsequent to this test.

4.12 Salt Fog Corrosion

4.12.1 Requirement

System components shall withstand a 240-hour exposure to a 20 percent salt in water (laboratory grade sodium chloride in demineralized water) fog without incurring damage which would impair function.

4.12.2 Tests/Verification

Test samples shall be selected to represent all material combinations and configurations. At least two fully charged discharge valve assemblies shall be included among the test samples. Discharge nozzles manufactured from a corrosion resistant material and having protection for the discharge orifice(s) are not subject to salt fog testing.

The test shall be conducted in conformance to ASTM B117.

Tested samples shall remain fully functional and exhibit no corrosion, galvanic action, loss of legibility of markings, or separation of protective coatings which would impair future functionality. Superficial discoloration with no substantial attack of the underlying material shall be acceptable.

4.13 Individual Component Functionality

4.13.1 General

4.13.1.1 Requirement

Certified devices need not be tested for inclusion within a CO_2 extinguishing system if they are used in conformance to their certified listed ratings and applications. Otherwise, components shall be evaluated by the certification agency to determine suitability for the intended use. Such evaluations shall address all relevant functional requirements for the type of device.

4.13.1.2 Tests/Verification

Pressure operated devices, such as nozzle covers shall be tested to verify that they operate at the minimum required pressures, using a minimum of three trials. Section 3.2.20 states minimum or maximum required operating pressures for the various devices used in systems.

Devices for which there are no established certification requirements shall be evaluated to confirm function as required for system operation and integrity at the extremes of the anticipated service conditions.

4.13.2 Stress Corrosion

4.13.2.1 Requirement

Extinguishing system components shall be resistant to stress corrosion cracking resulting from exposure to the processes described in Section 4.13.2.2. Following the exposure period, the samples shall not show evidence of cracking, delamination, or degradation.

4.13.2.2 Test/Verification

A. Copper Based Parts (Ammonia Test)

Devices manufactured of copper alloys with a zinc content exceeding 15 percent shall be exposed to a moist ammonia environment. The inlet end of each sample shall be filled with deionized water and sealed with a non-reactive material (e.g., plastic cap) so as to prevent the introduction of the ammonia atmosphere to the interior of the component. The samples to be tested shall be free from any non-permanent protective coating and, if necessary, shall be degreased. If a permanent coating is an inherent part of the design, such coating shall be subjected to tests to evaluate its protective integrity. The samples shall be tested in their intended orientation.

There shall be provisions in the test chamber to prevent droplets of condensation from falling from the top of the enclosure directly onto the samples. Such shield or other means shall be constructed of glass or other non-reactive materials.

The samples shall be exposed to the moist ammonia-air mixture maintained in a glass chamber with a volume of 0.73 $ft^3 \pm 0.34$ ft^3 (0.02 $m^3 \pm 0.01$ m^3).

Aqueous ammonia having a density of 5.86x10-5 lb/ft^3 (0.94 g/cm^3) shall be maintained in the bottom of the chamber, approximately 1.5 in. (40 mm) below the bottom of the samples. A volume of aqueous ammonia equal to 0.075 gal/ft^3 (10 L/m^3) of the test chamber volume results in approximately the following atmospheric concentrations: 35 percent ammonia, 5 percent water vapor, and 60 percent air. Prior to beginning the exposure, the chamber shall be conditioned to a temperature of 93 °F ± 4 °F (34 °C ± 2 °C) for a period of not less than one hour, and shall be maintained at this temperature throughout the exposure period. The moist ammonia-air mixture shall be maintained at essentially atmospheric pressure. Provision shall be made for venting the chamber, such as by the use of a capillary tube, to avoid buildup of pressure.

Following exposure to the moist ammonia environment for a period of 10 days, the samples shall be removed, rinsed in potable water, and air dried. Following a two- to four-day drying period, visual examination of the samples shall be made.

B. Austenitic, Ferritic, and Duplex Stainless Steel Parts (Boiling Magnesium Chloride Test)

Samples shall be degreased and exposed to a boiling magnesium chloride solution for a period of 500 hours, in accordance with ASTM G36.

Samples are to be placed in a flask fitted with a wet condenser. The flask shall be filled approximately on-half full with a nominal 42 percent by weight magnesium chloride solution, placed on a thermostatically-controlled electrically-heated mantle, and maintained at a boiling temperature of 302 °F ± 4 °F (150 °C ± 2 °C).

Following exposure, the samples shall be removed and rinsed in potable water. Following a two-to four-day drying period, visual examination of the samples shall be made.

C. Parts Manufactured from Other Materials

Parts manufactured from other materials shall withstand comparable tests, based on the type of material employed.

4.13.3 Thermal Shock

4.13.3.1 Requirement

Components such as nozzles and nozzle caps, which are exposed to the protected space, shall remain functional if heated by a fire prior to the system discharge. Functionality shall be defined as appropriate for the specific component. In the case of a nozzle, no cracking or distortion which would change discharge characteristics shall be allowed.

4.13.3.2 Test/Verification

The component shall be connected to a 290 psi (20 bar) liquid CO_2 supply by means of piping of a minimum nominal diameter of 1 in. If the component under evaluation is not a nozzle, the component shall be tested with a nozzle with a 3/8 in. (10 mm) orifice.

The component shall be installed in its normal configuration in an assembly with a nozzle and placed in an oven and heated to 1112 ºF ± 54 ºF (600 ºC ± 30 ºC) for a period of 10 ± 2 minutes.

CO_2 shall then be passed through the nozzle for 30 to 40 seconds.

After being allowed to return to room temperature, the sample shall be inspected for damage. If the component is a nozzle cap, it may be destroyed in this test, but shall not fail in a manner which would interfere with discharge from the nozzle.

4.13.4 This Section Intentionally Left Blank

4.14 Temperature Maintenance for Low Pressure Storage Containers

4.14.1 Requirement

Low pressure storage containers shall maintain the liquid CO_2 between 250 psi and 325 psi (17.2 bar and 22.4 bar) throughout the full range of manufacturer specified installation temperatures, which shall include 32 ºF through 120 ºF (0 ºC through 48.9 ºC).

4.14.2 Tests/Verification

A sample storage container shall be placed in an insulated enclosure with heating and cooling and air circulation capable of maintaining the installation temperature extremes, ± 10 ºF (± 5.6 ºC), throughout a minimum 48-hour period. This is based upon stabilization of the maximum internal tank pressure for the test interval. The vessel shall be fully charged with CO_2 at 300 psi (20.7 bar). Continuous measurements of the internal pressure of the storage container, the enclosure air temperature, the voltage supply and current draw for the cooling and heating (if so equipped) systems, and the on-off status of these systems shall be recorded by a properly calibrated data collection system.

The enclosure shall be stabilized at 120 ºF (48.9 ºC) or the manufacturer's specified maximum installation temperature, whichever is greater. The container's temperature maintenance system shall stabilize the container's internal pressure for a minimum of 24 hours. For the next eight hours, the storage container shall be supplied with electric power at the nominal rated voltage, then for another eight hours at 0.85 of that value, and for a third eight hours at 1.1 times the nominal value.

Throughout the 48 hours, the internal pressure shall not exceed 325 psi (22.4 bar), the current draw, refrigerant pressures, and duty cycle for the refrigeration system shall not exceed the supplier's specifications, and no failure of any part of the storage container and its ancillary systems shall occur.

If the manufacturer's minimum specified installation temperature includes -10 ºF (-23 ºC), or lower, the storage container shall be equipped with a heating system and shall be tested at that specified minimum temperature. The enclosure shall be stabilized at the appropriate temperature and the three 8-hour voltage supply values shall be provided, as previously described. Throughout the 24 hours, the internal pressure shall not drop below 250 psi (17.2 bar), the current draw and duty cycle for the heating system shall not exceed the supplier's specifications, and no failure of any part of the storage container and its ancillary systems shall occur.

These tests may be used to qualify more than one design of refrigeration or heating system for a storage container. Where refrigeration compressors of different power ratings are offered, the system incorporating the lowest power rated compressor shall be tested. Where heating or refrigeration systems of different heating or cooling capacity are offered, the system displaying the lowest ratio of cooling capacity to heat input shall be tested. If requested by the manufacturer, the designs and specifications for alternate refrigeration or heating systems shall be reviewed by the certification agency to determine if the required samples can be reduced by one or more of these principles.

The manufacturer shall supply complete specifications for the refrigeration systems to be used, including refrigerant type and quantity, superheat setting, expansion valve type and setting, and design ambient temperature to assist in evaluation of the design.

4.15 Pressure Gauge (Low Pressure)

4.15.1 Accuracy

4.15.1.1 Requirement

Agent Supply Container Pressure Gauge:	0/+12 percent at 0 gauge pressure ± 6 percent at low and high pressure alarm points ± 4 percent at normal working pressure point ± 8 percent at pressure relief setting ± 15 percent at full scale
Vapor Line Pressure Gauge:	0/+12 percent at 0 gauge pressure ± 6 percent at actuation line low pressure alarm point ± 4 percent at normal vapor line pressure ± 15 percent at full scale

4.15.1.2 Test/Verification

Readings of a minimum of three sample gauges of each type at each of the points specified shall be compared to readings of a properly calibrated test gauge having a minimum accuracy of ±1 percent. Readings shall be taken in both ascending and descending order. All sample gauge readings shall match those of the test gauge within the tolerances specified in Section 4.15.1.1.

4.15.2 Impulse Resistance

4.15.2.1 Requirement

Pressure gauge accuracy shall remain within the limits of Section 4.15.1.1 after 1000 cycles of pressure impulse from 40 to 175 percent of system normal operating pressure.

4.15.2.2 Test/Verification

One sample gauge of each type shall be connected to an apparatus capable of varying pressure from 40 to 175 percent of the system normal operating pressure six times per minute. After 1000 cycles have been completed, the sample shall be retested for accuracy as described in Section 4.15.1.2.

4.16 Liquid Level Indicator (Low Pressure)

4.16.1 Requirement

Liquid level indicators shall correctly display the level or amount of CO_2 liquid in a low pressure supply container within ±5 percent of the actual level or weight.

4.16.2 Test/Verification

An empty supply container shall be placed on a calibrated weighing device having an accuracy of ± 1 percent. CO_2 shall be added to the container and the liquid level indicator readings compared to equivalent level or weight for all major divisions on the indicator's scale, spanning the full range of fill.

4.17 Area of Coverage for Total Flooding Systems

4.17.1 Requirement

A 28 percent CO_2 concentration shall be achieved within the test enclosure within 60 seconds of the beginning of visible full liquid discharge from the nozzle.

4.17.2 Tests/Verification

Systems designed within area of coverage limitations specified below need not be discharge tested to confirm these limitations. A discharge nozzle of either the radial type with a maximum side dimension limit of 36 ft (11m) or cone/multi-jet type with a maximum side dimension of 16 ft (4.9m), with a minimum discharge nozzle pressure of 300 psi (20.7 bar) for high pressure and 150 psi (10.3 bar) for low pressure are within the certification agency's established limitations.

When it is required by the certification agency, the discharge test shall be run under the most adverse combinations of minimum nozzle pressure, lowest storage temperature, maximum area per nozzle, both maximum and minimum nozzle heights, and the most offset nozzle locations. Separate tests shall be conducted with a single nozzle of each type. The enclosure shall be between 65 °F and 75 °F (18 °C and 24 °C) at the time of discharge.

The enclosure shall be square or rectangular. It shall be constructed of plywood with a minimum thickness of 3/8 inch (9.5 mm), or an equivalent material. Openings shall be provided for the purpose of venting prior to system discharge. Additionally, a pressure relief opening shall be provided in the top of the enclosure. Provisions for visual observations of the interior of the enclosure shall be provided. Prior to each fire test, the enclosure shall be maintained at 70 °F ± 5 °F (21 °C ± 3 °C).

The enclosure volume shall be constructed based on the maximum protected height limitation specified by the manufacturer. It shall be a minimum of 13.1 ft (4 m) wide by 13.1 ft (4m) long and include a volume of a minimum of 3531 ft^3 (100 m^3).

The enclosure shall contain a vertical baffle parallel to two of the walls. The baffle shall extend the full height of the enclosure. Its width shall be 20 percent of the width of the walls to which it is parallel. It is to be centered on the centerline of the nozzle, and perpendicular to the nozzle discharge. The baffle is to be located along that centerline halfway between the nozzle and the far wall. Therefore, the baffle shall be approximately in the center of the enclosure if the nozzle is located at a wall and approximately 3/4 of the distance between the walls if the nozzle is located at the center of the enclosure. If the enclosure is rectangular, separate tests shall be conducted with appropriate width baffles parallel to both the long and short walls. Figure F-1 illustrates the enclosure.

Achievement of concentration shall be measured by appropriately selected and calibrated oxygen or other gas analyzers. Continuous data logging of the gas analyzer readings is required for a minimum of 75 seconds from discharge initiation. Fluctuating readings may be averaged over the period from 50 to 70 seconds after discharge. Manual data collection shall not be acceptable. Sampling locations shall be centered on the opposite side of the baffle from the nozzle, at mid height and within 1 ft (300 mm) of the ceiling of the enclosure. For enclosure heights less than 3 ft (1 m), only one sampling point is required. Alternatively, continuously monitored agent storage container weight change or heptane can fire extinguishment may be used as a proxy for achievement of the extinguishing concentration. Oxygen concentration in the enclosure prior to discharge shall be recorded to adjust the evaluation of final concentration of CO_2, if needed.

Heptane can fires shall be designed per the following criteria:

A. Cans shall be fabricated out of schedule 40 steel pipe. Cans shall be 3 in. nominal diameter and a minimum of 4 in. (100 mm) high. The bottom of each can shall be a welded onto nominal 1/4 in. thick steel plate, approximately 4 in. (100 mm) square.

B. Cans shall be placed at each corner of the enclosure, with their outside walls approximately 2 in. (50 mm) from each wall of the enclosure. The top of the cans shall be within 12 in. (300 mm) of the floor and ceiling of the enclosure. If the minimum height enclosure is less than 3 ft (1 m) high, one set of cans will be sufficient. If taller, then cans shall be positioned at both the top and bottom of each corner.

C. An additional can shall be located at the sampling point(s) behind the baffle, as defined above for the gas analyzer sampling points. This correlates to the use of either five or ten cans, depending on the height of the enclosure.

D. Each can shall contain heptane with a freeboard of approximately 2 in. (50 mm).

E. The enclosure shall be provided with viewing ports allowing a clear sightline to each can. These ports shall remain open during the preburn to ensure that combustion gas buildup does not enhance extinguishment. They shall be closed 15 seconds prior to the initiation of discharge. Extinguishment of cans shall be logged by either videotaping all locations or by using thermocouple temperature measurements, infra-red imaging, or some other method of continuous automated surveillance, which has demonstrated sensitivity and consistency, to detect flameout at each can. Since it is extremely difficult for one observer to monitor all locations or to coordinate the activities of multiple observers, no non-automatic means of observation shall be permitted.

F. A 30 second preburn after ignition of the last can is required prior to initiation of discharge.

4.18 Area of Coverage for Overhead Local Application Systems

4.18.1 Requirement

The manufacturer’s system design instructions shall ensure that placement of nozzles will not cause splashing of flammable liquid hazards and that 30 second maximum discharge time and 20 second maximum extinguishing time are provided for all local application systems.

4.18.2 Tests/Verification

Fire extinguishment tests shall be conducted to check the manufacturer's recommendations for the placement of nozzles which will protect open tanks of flammable liquids and other unenclosed hazards. A minimum of three tests shall be conducted for each nozzle type. Actual nozzle flow rates shall be monitored by continuous recording of weight of the agent supply container during discharge.

The standard fire test fuel array shall consist of a 2 in. (50 mm) layer of heptane floated on sufficient water to provide a 6 in. (152.4 mm) freeboard and a 60 second pre-burn. The test pans shall be fabricated of welded steel a minimum of 1/4 in. (6 mm) thick. The pan shall incorporate a flanged top outer lip fabricated of steel angle a minimum of 1-1/2 in. (38 mm) on a side and 3/8 in. (9.5 mm) thick. Test pans shall be approximately 12 in. (300 mm) high and shall be fabricated in such dimensions as to match the manufacturer’s design curves for maximum area of coverage at maximum height, minimum height, and one intermediate height.

The evaluations shall be conducted in three phases. First, for each height, a system shall be designed to provide 1.1 times the nozzle design flow rate (*DFR*) at the maximum discharge pressure at 70 °F (21 °C). For a high pressure system the supply container shall be conditioned for 16 hours to the maximum installation temperature, but no less than 120 °F (49 °C). For a low pressure system, the minimum piping length shall be used to maximize nozzle pressure. Based upon these conditions, a new nozzle flow rate shall be calculated, per the manufacturer’s documented procedure. This flow rate shall be termed the “splash test flow rate” (*SFR*). Fires shall be extinguished within 20 seconds after the first appearance of liquid CO_2 at the nozzle, with no splashing of fuel outside of the pan, whether such splash remains ignited or not. These tests shall be repeated for each of the three nozzle heights. If splash occurs, the manufacturer may adjust heights, areas, or flow rates to eliminate splash. Such changes shall be incorporated in revisions to the nozzle flow rate versus height and area versus height design curves.

The second phase of these evaluations shall be the extinguishment of the test fires with minimum nozzle flow rate at each nozzle height. In these tests, the 70 °F (21 °C) nozzle flow rates shall be 0.75 of the successful splash test flow rates. These are termed the “extinguishing flow rates” (*EFR*). For high pressure systems the supply container shall be conditioned for 16 hours to the minimum installation temperature, but no more than 32 °F (0 °C). Conditioning time may be less if it can be demonstrated through temperature measurements of the liquid within the container that stabilization has been achieved at the desired temperature. For low pressure systems, the piping length should be adjusted to produce the minimum nozzle pressure of approximately 180 psi (12.4 bar). Based upon these conditions, an *EFR* shall be calculated, per the manufacturer’s documented procedure. Fires shall be extinguished within 20 seconds after the first appearance of liquid CO_2 at the nozzle. Liquid flow duration shall not be less than 30 seconds. These tests shall be repeated for each of the three nozzle heights. If extinguishment does not occur within 20 seconds, parameters may be varied, but substantial variations may require repeat of the splash tests to maintain a minimum 0.75 ratio between the extinguishment and splash test flow rates. The final, successful test conditions shall be used to finalize the manufacturer’s nozzle flow rate versus height and area versus height design curves.

Acceptability of test data does not require tests results exactly matching the calculated values. That is, measured *EFR* may be less than the required *EFR* and measured *SFR* may be higher than the required *SFR* (both of these calculated values based upon the specified *DFR*), as long as the accuracy requirements of the third phase of this evaluation are achieved.

The third phase of these evaluations shall be comparison of the measured actual flow rates with the calculated splash or extinguishment test flow rates. Measured flow rates shall be within ± 10 percent of the calculated rates.

4.19 Carbon Dioxide Calculation Method

4.19.1 An engineered extinguishing system shall be examined to determine the manufacturer's calculation software accurately predicts the discharge time, nozzle pressure and distribution of extinguishing agent.

4.19.2 Hand calculations in accordance with Appendix C of NFPA 12 shall be submitted for comparison to the manufacturer's calculation software. A minimum of three test configurations shall be submitted to verify reliability of the calculation model. The calculations should demonstrate:

- Range of pipe sizes, maximum and minimum;
- Range of orifice sizes;
- Maximum and minimum discharge time, and;
- Maximum and minimum nozzle pressure

4.19.3 The discharge time, nozzle pressure, rate of flow and agent of the manufacturer's calculation software shall not deviate from the hand calculation with an experimental discrepancy by more than the following:

- Discharge Time: ±10 percent;
- Nozzle Pressure: ± 10 percent;
- Rate of Flow: ± 10 percent, and;
- Quantity of agent: ± 10 percent

4.19.4 Systems used in certification testing for Local Application will be calculated with the manufacturer's calculation software. The empirical results from the discharge of these test systems will be in agreement with 4.19.3.

4.19.5 Percent experimental discrepancy will be calculated as follow:

- Comparison of hand calculation to calculation software, the hand calculation will be the standardized value.
- Comparison of the calculation software to the empirical discharge test, the empirical value will be he standardized value.

4.19.6 Alternative benchmarks for evaluation of calculation accuracy, such as empirical test data, will be considered if the certification agency judges them to improve the art.

4.20 Protection of Wet Benches and Similar Processing Equipment

4.20.1 Appendix E provides fire test requirements for CO_2 extinguishing systems for the protection of wet benches and similar processing equipment typically installed in a clean room manufacturing environment.

4.20.2 A CO_2 extinguishing system shall meet all relevant requirements of this standard to be considered for certification for use in this application.

5. OPERATIONS REQUIREMENTS

5.1 Demonstrated Quality Control Program

5.1.1 A quality assurance program is required to assure that subsequent systems produced by the manufacturer shall present the same quality and reliability as the specific system(s) examined. Design quality, conformance to design, and performance are the areas of primary concern.

- Design quality is determined during the examination and tests and may be documented in the certification report.
- Continued conformance to this standard is verified by the certifier's surveillance program.
- Quality of performance is determined by field performance and by periodic re-examination and testing.

5.1.2 The manufacturer shall demonstrate a quality assurance program which specifies controls for at least the following areas:

- existence of corporate quality assurance guidelines;
- incoming quality assurance, including testing;
- in-process quality assurance, including testing;
- final inspection and tests;
- equipment calibration;
- drawing and change control;
- packaging and shipping; and,
- handling and disposition of discrepant materials

5.1.3 Documentation/Manual
There should be an authoritative collection of procedures/policies. It should provide an accurate description of the quality management system while serving as a permanent reference for implementation and maintenance of that system. The system should require that sufficient records are maintained to demonstrate achievement of the required quality and verify operation of the quality system.

5.1.3 Records

To assure adequate traceability of materials and products, the manufacturer shall maintain a record of all quality assurance tests performed, for a minimum period of two years from the date of manufacture.

5.1.4 Drawing and Change Control

- The manufacturer shall establish a system of product configuration control that shall allow no unauthorized changes to the product. Changes to critical documents, identified in the certification report, may be required to be reported to, and authorized by the certification agency prior to implementation for production.
- Records of all revisions to all certified products shall be maintained.

5.2 Surveillance Audit

5.2.1 An audit of the manufacturing facility may be part of the certification agency's surveillance requirements to verify implementation of the quality assurance program. Its purpose is to determine that the manufacturer's equipment, procedures, and quality program are maintained to ensure a uniform product consistent with that which was tested and certified.

5.2.2 Certified products or services shall be produced or provided at, or provided from, location(s) disclosed as part of the certification examination. Manufacture of products bearing a certification mark is not permitted at any other location prior to disclosure to the certification agency.

5.3 Manufacturer's Responsibilities

5.3.1 The manufacturer shall notify the certification agency of changes in product construction, components, raw materials, physical characteristics, coatings, component formulation or quality assurance procedures prior to implementation

5.3.2 The manufacturer shall provide complete instructions for the recharge and usage of systems. The instructions shall provide specific quality assurance procedures on the usage of calibrated equipment, such as scales, pressure gauges, and other necessary critical equipment, in the recharging a system.

5.4 Manufacturing and Production

5.4.1 The manufacturer shall design systems in conformance to NFPA 12 or any other standard specifically referenced in the certification report and listing.

5.4.2 The manufacturer shall fabricate and test pressure cylinders in accordance with the standard(s) referenced in the certification report and listing.

5.4.3 The manufacturer shall leak test all filled agent supply containers prior to release for shipment.

5.4.4 The manufacturer shall only fill agent supply containers with carbon dioxide meeting the requirements of Table 3.2.1.

6. BIBLIOGRAPHY

CEA 4007, *Fire Protection Systems - Specifications for CO_2 Systems - Planning and Installation*

CEA 4009, *Fire Protection Systems - Specifications for fire fighting systems using a gaseous extinguishant - Requirements and test methods for selector valves and their actuators*

CEA 4010, *Fire Protection Systems - Specifications for CO_2 Fire Fighting Systems: Requirements and test methods for nozzles*

CEA 4001, *Sprinkler Systems, Planning and Installation*

CEA 4012, *Fire Protection Systems - Specifications for fire fighting systems using a gaseous extinguishant - Requirements and test methods for check and non-return devices*

CEA 4013, *Fire Protection Systems - Specifications for fire fighting systems using a gaseous extinguishant - Requirements and test methods for hoses and container connection pipes*

CEA 4014, *Fire Protection Systems - Specifications for fire fighting systems using a gaseous extinguishant - Requirements and test methods for container and valve assemblies*

FM 3010, *Fire Alarm Signaling Systems*

FM 3600, *Electric Equipment for Use in Hazardous (Classified) Locations General Requirements*

FM 3610, *Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, and III, Division 1, and Class I, Zone 0 and 1 Hazardous (Classified) Locations.*

FM 3611, *Nonincendive Electrical Equipment for Use in Class I and II, Division 2, and Class III, Divisions 1 and 2, Hazardous (Classified) Locations*.

FM 3615, *Explosionproof Electrical Equipment General Requirements*.

FM 3620, *Purged and Pressurized Electrical Equipment for Hazardous (Classified) Locations*.

FM 3810, *Electrical and Electronic test, Measuring, and Process Control Equipment*.

ISO 6183, *Fire Protection Equipment - Carbon Dioxide Extinguishing Systems for Use on Premises - Design and Installation*

ANSI/NFPA 72, *National Fire Alarm and Signaling Code*

ISO/IEC 17025: 2017 *General Requirements for the Competence of Testing and Calibration Laboratories*

APPENDIX A:

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APPENDIX B:

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APPENDIX C: Component Examination Guide

Evaluation	*Device(s)*	*Section References*	*Remarks*
One Year Leakage	High Pressure Cylinder & Discharge Valve Assemblies	4.1	Include all devices exposed to extinguishing agent pressure prior to discharge
Leakage at Maximum and Minimum Storage Temperatures	High Pressure Cylinder & Discharge Valve Assemblies	4.2	Include all devices exposed to extinguishing agent pressure prior to discharge
Equivalent Length and Nozzle Size Number Determination	Cylinder and Discharge Valve Assemblies, Selector Valves, Check Valves, Nozzles	4.3	Include all devices other than standard pipe and fittings which are in the discharge flow path
High Rate of Flow Discharge Integrity	Cylinder & Discharge Valve Assemblies, Selector Valves, Check Valves, Nozzles, Miscellaneous discharge component supported devices	4.4	Include all devices in the discharge flow path or attached to such devices or their piping
Cycle Operation Test	Cylinder & Discharge Valve Assemblies, Selector Valves, Pressure Switches	4.5	Include all devices subject to mechanical movement, flow reaction forces, or electrical actuation during system discharge
Valve Leakage	Discharge Valves, Selector Valves, Check Valves	4.6	Tested both new and subsequent to Cycle Operation Test
Hydrostatic Integrity	Cylinders, Valves, Nozzles, Hoses, Pressurized Devices	4.7	Include all devices subject to agent pressure. More severe requirements for normally pressurized components versus those only seeing pressure at discharge. Pressure vessels may also require permanent volume expansion tests as well as burst tests
Pressure Relief	Burst Discs and other pressure relieving devices	4.8	Relief Valves require multiple trials of single sample with leakage tests after operational tests
Flexible Hose	Flexible Hose Assemblies	4.9	Requires Hydrostatic Integrity test subsequent to both low temperature flexure and flexure cycling
Control & Actuator Operation	Pneumatic, electric, manual, & pilot actuated controls	4.10	Separate protocols to verify operation of all types of discharge controls under most adverse normal conditions of available power, temperature, pressure, mechanical complexity
Dielectric Withstand	All electrically powered devices	4.11	Across all combinations of two externally accessible terminals and ground
Salt Fog Corrosion	Pressurized Cylinder & Discharge Valve Assemblies and other representative components	4.12	All materials and material combinations exposed to atmosphere with function vulnerable to corrosion

Evaluation	*Device(s)*	*Section References*	*Remarks*
Individual Component Functionality	All operating devices	4.13	At extremes of service conditions. Includes stress corrosion for brasses with > 15 percent zinc and thermal shock for components exposed to the protected space
Temperature Maintenance for Low Pressure Storage Containers	Containers with both refrigeration and heating systems	4.15	Requires an enclosure which can be conditioned to the extremes of installation temperature
Documentation of Configuration or Function	Gaskets & O-Rings, Control, Pressure Vessels, Siphon Tubes, Pressure Reliefs, Manifolds, Component certified ratings	3.2.2.2, 3.2.3, 3.2.5, 3.2.7, 3.2.8, 3.2.10, 4.13.1.1, 4.8.2	As indicated in each individual referenced Section. This documentation is in addition to a complete set of drawings, specifications for all purchased components, and the Design, Installation, Operation and Maintenance manual(s)
Pressure Gauge	System and vapor line pressure gauges	4.15	Accuracy and pressure impulse resistance
Liquid Level Indicator	One of each type used	4.16	Readings compared to measured weights. Applies to low pressure storage containers, only

APPENDIX D. Sample Listing

Low (or High, as appropriate) Pressure System Equipment

Manufacturer Trade Name (if used)

Agent Storage Container Assemblies

Description, including Capacity ton (kg) for low pressure lb (L) for high pressure	*Part Number*	*Maximum Installation Temperature ºF (ºC)*
refrigerant type used (if low-pressure)		

Valves

Type	*Part Number*	*Nominal Pipe Size in. or mm, as appropriate*	*Equivalent Length ft (mm) of Schedule 40 (or 80) pipe, as appropriate*
Discharge Valve (low pressure only)			
Selector Valve			
Check Valve			
Manual Lockout Valve			

Nozzles

Type	*Part Number*	*Nominal Pipe Size in. or mm, as appropriate*	*Number of Ports*	*Nozzle Size Number (Nozzle Code) Range*
Radial, Fan, Angle, et cetera				

Controls

Description	*Part Number*	*Remarks*
Electric		Ratings, applications, et cetera
Pneumatic		
Manual		
Push Button Station		
Discharge Time Delay		
Pilot, Secondary		
Heat Actuated Device		
Rate of Rise Release		
et cetera		

Accessories

Description	*Part Number*	*Remarks*
Design, Installation, Operation, & Maintenance Manual		Revision Level or Date
Pressure Switch		Ratings, applications, et cetera
Flexible Connector		
Odorizer		
Support Bracket		
et cetera		

In general, all components appearing in the manual and which have been successfully evaluated as a part of the certification examination shall be listed. Whether available as assemblies, sub assemblies, or individual parts, the listed items shall be restricted to those normally sold by the manufacturer, either as a part of a new system or as replacements. Manufacturing subassemblies or individual components not normally sold as separate entities to the user shall not be listed. The intent is to allow comparison of quoted or installed systems to the listing for verification that they fall within the scope of the certification and to discourage users from repairing or modifying their systems without oversight by manufacturer-trained support personnel.

APPENDIX E. Fire tests for Carbon Dioxide Extinguishing Systems for the Protection of Wet Benches and Similar Processing Equipment

E.1 General Testing Requirements

A. For the ventilated subsurface (plenum) tests;

1. The wet bench mockup shall be installed in a certification agency simulated clean room facility. (Figures E-1 through Figure E-8)

2. The air flow of the open face wet bench shall be the maximum air flow as specified by the manufacturer. The minimum permitted air flow shall be 150 ft^3/min/linear ft (14 m^3/min/linear m).

3. Higher flow rates shall be in 50 ft^3/min/linear ft (4.5 m^3/min/linear m) increments.

4. The solid polypropylene fuel shall be a combination of polypropylene beads and polypropylene coupons. (Figure E-8)

5. The flammable liquids shall consist of Acetone, Isopropyl Alcohol (IPA), and Heptane.

B. The working surface protection system shall be installed as specified in the manufacturer's design manual for surface protection. (Figures E-1 through E-4 and E-7)

1. Fire tests shall be conducted at the minimum and maximum vertical distances from the surface. It is permissible to change nozzle configurations for the difference in height provided it is based upon the manufacturers' design specifications to be included as part of the certified system.

2. Systems modified to reflect a difference in height may be subjected to additional testing to determine the limitations of a given system configuration.

C. Instrumentation for the wet bench fire testing shall include a thermocouple, a load cell, and a video camera. The thermocouple shall be placed near the fire source. The load cell shall have a capacity of 2.0 lb (0.91 kg) and shall be used to monitor the fuel mass loss in all fire tests.

D. The certification agency simulated clean room facility shall be at an ambient temperature of 68 ºF ± 18 ºF (20 ºC ± 10 ºC) prior to the start of the test. The room shall be at as uniform an ambient temperature as reasonably possible. Localized hot or cold spots are not permitted. All non-fire induced or test specified drafts shall be eliminated.

E. All fuels shall be at an ambient temperature of 68 ºF ± 18 ºF (20 ºC ± 10 ºC).

F. With the exception of E.3.7, the placement of the dish/pan shall be varied for the test series, covering the entire working surface or subsurface area per the locations prescribed below. Each dish/pan size shall be repeated once, unless otherwise specified, to demonstrate effective nozzle coverage, but each dish/pan size shall not be repeated in the same location. For the working surface fire tests, the total number of required tests, including repeats, shall be divided evenly between the minimum and maximum nozzle heights. At a minimum, a dish/pan shall be placed in the following locations:

Ventilated Subsurface (Plenum) Fire Tests

- Centered under the nozzle at the carbon dioxide injection point
- At the midpoint along the horizontal centerline from the nozzle
- At the end point along the horizontal centerline from the nozzle
- At the nearest corner from the nozzle
- At the farthest corner from the nozzle

Wet Bench Working Surface Fire Tests

- At the midpoint of the front edge of the wet bench working surface centered between the ventilation openings
- At the midpoint of the rear edge of the wet bench working surface
- At the midpoint of the side edge of wet bench working surface
- At the furthest corner from the nozzle against the back wall of the wet bench working surface

E.2 Ventilated Subsurface (Plenum) Fire Tests (Figures E-3, E-5 and E-6)

E.2.1 Nominal 4 in. (102 mm) Diameter Polypropylene Pool Fire

Criterion: Fire extinguishment in 60 seconds or less (timed from system activation)

A nominal 4 in. (102 mm) diameter dish of solid polypropylene fuel shall be placed within the subsurface space at a location described in E.1-F. The fuel shall be ignited and allowed to reach a steady state condition. For systems using open nozzles with detector initiated release, the detector(s) shall be deactivated and the system shall be manually activated after a 30 second preburn.

E.2.2 Nominal 6 in. (152 mm) Diameter Polypropylene Pool Fire

Criterion: Fire extinguishment in 60 seconds or less (timed from system activation)

A nominal 6 in. (152 mm) diameter dish of solid polypropylene fuel shall be placed within the subsurface space at a location described in E.1-F. The fuel shall be ignited and allowed to reach a steady state condition. For systems using open nozzles with detector initiated release, the detector(s) shall be deactivated and the system shall be manually activated after a 30 second preburn.

E.2.3 Nominal 8 in. (203 mm) Diameter Polypropylene Pool Fire

Criterion: Fire extinguishment in 60 seconds or less (timed from system activation)

A nominal 8 in. (203 mm) diameter dish of solid polypropylene fuel shall be placed within the subsurface space at a location described in E.1-F. The fuel shall be ignited and allowed to reach a steady state condition. For systems using open nozzles with detector initiated release, the detector(s) shall be deactivated and the system shall be manually activated after a 30 second preburn.

E.2.4 Nominal 10 in. (254 mm) Diameter Polypropylene Pool Fire

Criterion: Fire extinguishment in 60 seconds or less (timed from system activation)

A nominal 10 in. (254 mm) diameter dish of solid polypropylene fuel shall be placed within the subsurface space at a location described in E.1-F. The fuel shall be ignited and allowed to reach a steady state condition. For systems using open nozzles with detector initiated release, the detector(s) shall be deactivated and the system shall be manually activated after a 30 second preburn.

E.2.5 Nominal 12 in. (305 mm) Diameter Polypropylene Pool Fire

Criterion: Fire extinguishment in 60 seconds or less (timed from system activation)

A nominal 12 in. (305 mm) diameter dish of solid polypropylene fuel shall be placed within the subsurface space at a location described in E.1-F. The fuel shall be ignited and allowed to reach a steady state condition. For systems using open nozzles with detector initiated release, the detector(s) shall be deactivated and the system shall be manually activated after a 30 second preburn.

E.2.6 Flammable Liquid Pool Fires

Criterion: Fire extinguishment in 60 seconds or less (timed from system activation)

A series of flammable liquid fuel pool fires shall be placed in the wet bench subsurface space using each pan size described in E.2.1 through E.2.5 at a location described in E.1-F. The fuel shall be ignited and allowed to reach a steady state condition. For systems utilizing open nozzles with detector initiated release, the detector(s) shall be deactivated and the system shall be manually activated after a 30 second preburn. At a minimum, the flammable liquid pool fire fuels shall consist of Acetone, Isopropyl Alcohol (IPA), and Heptane. A minimum of one test is to be conducted with each of these fuels. The fuels are to have the following nominal properties:

Table E.2.6 *Flammable Liquid Pool Fuel Properties*

Formula	Flash Point - Closed Cup		Flash Point - Open Cup		Burning Rate Nominal 6 in. (150 mm) Diameter Pool Fire	
	ºF	(ºC)	ºF	(ºC)	kW	(BTU/sec)
Acetone (CH3)CO	0	(-17.8)	15	(-9.4)	18	(17.1)
Isopropyl Alcohol (IPA) (CH3)2CHOH	53	(11.7)	60	(15.6)	12	(11.4)
Heptane CH3(CH2)5CH3	25	(-3.9)	30	(-1.1)	58	(55.0)

E.3 Wet Bench Working Surface Fire Tests (Figures E-1 through E-4 and E-7)

E.3.1 Nominal 4 in. (102 mm) Diameter Polypropylene Pool Fire

Criterion: Fire extinguishment in 60 seconds or less (timed from system activation)

A nominal 4 in. (102 mm) diameter dish of solid polypropylene fuel shall be placed on the wet bench surface at a location described in E.1-F. The fuel shall be ignited and allowed to reach a steady state condition. For systems using open nozzles with detector initiated release, the detector(s) shall be deactivated and the system shall be manually activated after a 30 second preburn.

E.3.2 Nominal 6 in. (152 mm) Diameter Polypropylene Pool Fire

Criterion: Fire extinguishment in 60 seconds or less (timed from system activation)

A nominal 6 in. (152 mm) diameter dish of solid polypropylene fuel shall be placed on the wet bench surface at a location described in E.1-F. The fuel shall be ignited and allowed to reach a steady state condition. For systems using open nozzles with detector initiated release, the detector(s) shall be deactivated and the system shall be manually activated after a 30 second preburn.

E.3.3 Nominal 8 in. (203 mm) Diameter Polypropylene Pool Fire

Criterion: Fire extinguishment in 60 seconds or less (timed from system activation)

A nominal 8 in. (203 mm) diameter dish of solid polypropylene fuel shall be placed on the wet bench surface at a location described in E.1-F. The fuel shall be ignited and allowed to reach a steady state condition. For systems using open nozzles with detector initiated release, the detector(s) shall be deactivated and the system shall be manually activated after a 30 second preburn.

E.3.4 Nominal 10 in. (254 mm) Diameter Polypropylene Pool Fire

Criterion: Fire extinguishment in 60 seconds or less (timed from system activation)

A nominal 10 in. (254 mm) diameter dish of solid polypropylene fuel shall be placed on the wet bench surface at a location described in E.1-F. The fuel shall be ignited and allowed to reach a steady state condition. For systems using open nozzles with detector initiated release, the detector(s) shall be deactivated and the system shall be manually activated after a 30 second preburn.

E.3.5 Nominal 12 in. (305 mm) Diameter Polypropylene Pool Fire

Criterion: Fire extinguishment in 60 seconds or less (timed from system activation)

A nominal 12 in. (305 mm) diameter dish of solid polypropylene fuel shall be placed on the wet bench surface at a location described in E.1-F. The fuel shall be ignited and allowed to reach a steady state condition. For systems using open nozzles with detector initiated release, the detector(s) shall be deactivated and the system shall be manually activated after a 30 second preburn.

E.3.6 Flammable Liquid Pool Fires

Criterion: Fire extinguishment in 60 seconds or less (timed from system activation)

A series of flammable liquid fuel pool fires shall be placed on the working surface utilizing each pan size described in E.3.1 through E.3.5 at a location described in E.1-F. The fuel shall be ignited and allowed to reach a steady state condition. For systems using open nozzles with detector initiated release, the detector(s) shall be deactivated and the system shall be manually activated after a 30 second preburn. At a minimum, the flammable liquid pool fire fuels shall consist of Acetone, Isopropyl Alcohol (IPA), and Heptane. A minimum of one test is to be conducted with each of these fuels. The fuels are to have the properties specified in Table E.2.6.

E.3.7 Splashing Test

Criterion: The spray of a single nozzle, or combination of nozzles, shall not cause a pool of heated liquid to splash any of its contents outside a nominal 16 in. (406 mm) diameter circle, centered about the target pan.

A nominal 12 in. (305 mm) diameter pan containing approximately 0.75 in. (19 mm) deep colored liquid [with a 0.5 in. (13 mm) freeboard] shall be placed directly under a single open nozzle. [Note: At the discretion of the certification agency, this test may be conducted using multiple nozzles if the certification agency deems that condition to be a worst case scenario.] The nozzle(s) shall be placed at the minimum vertical distance from the pan as permitted by the manufacturer’s design. The maximum flow rate or system pressure shall be used.

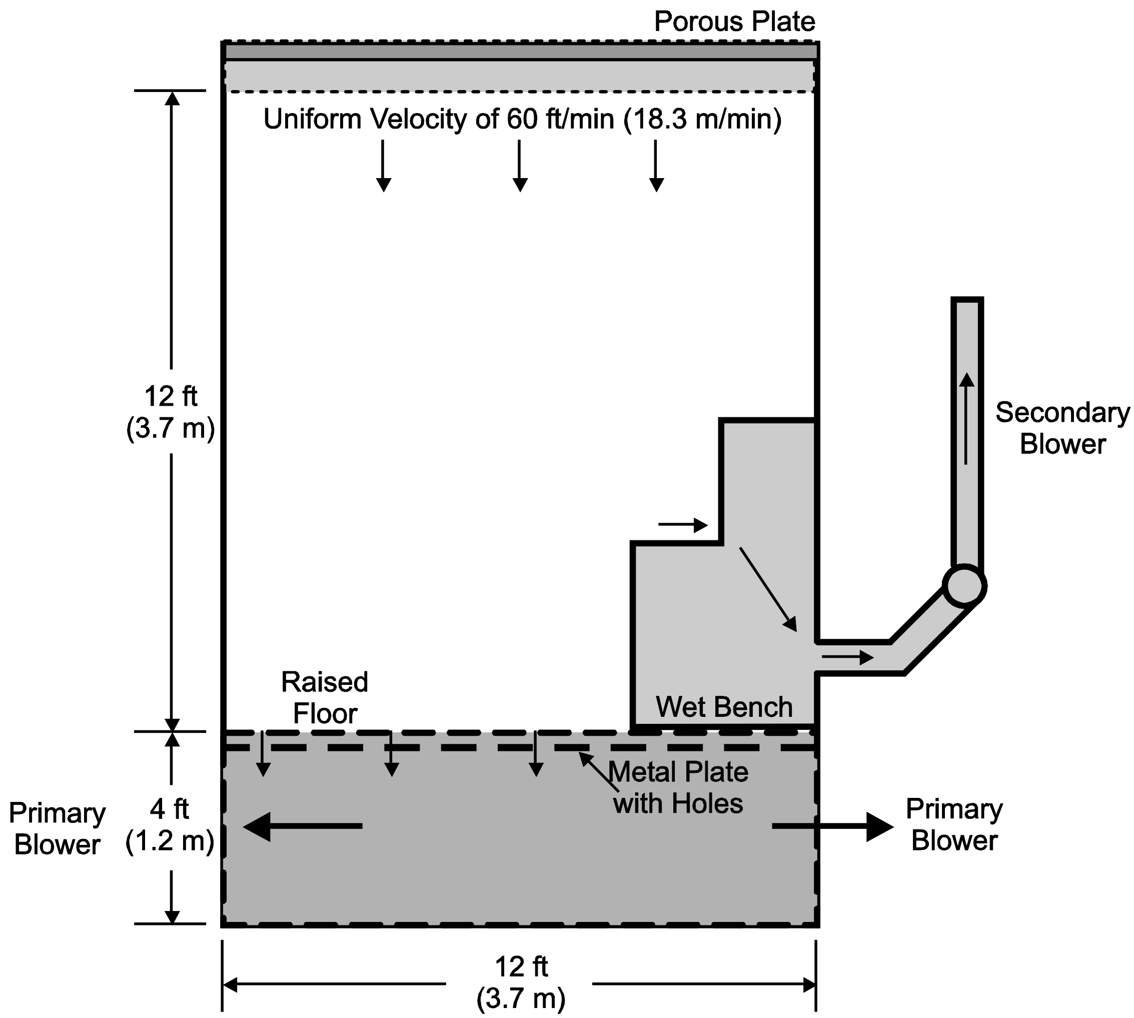

Figure E-1. Clean Room Simulation Facility - Side View

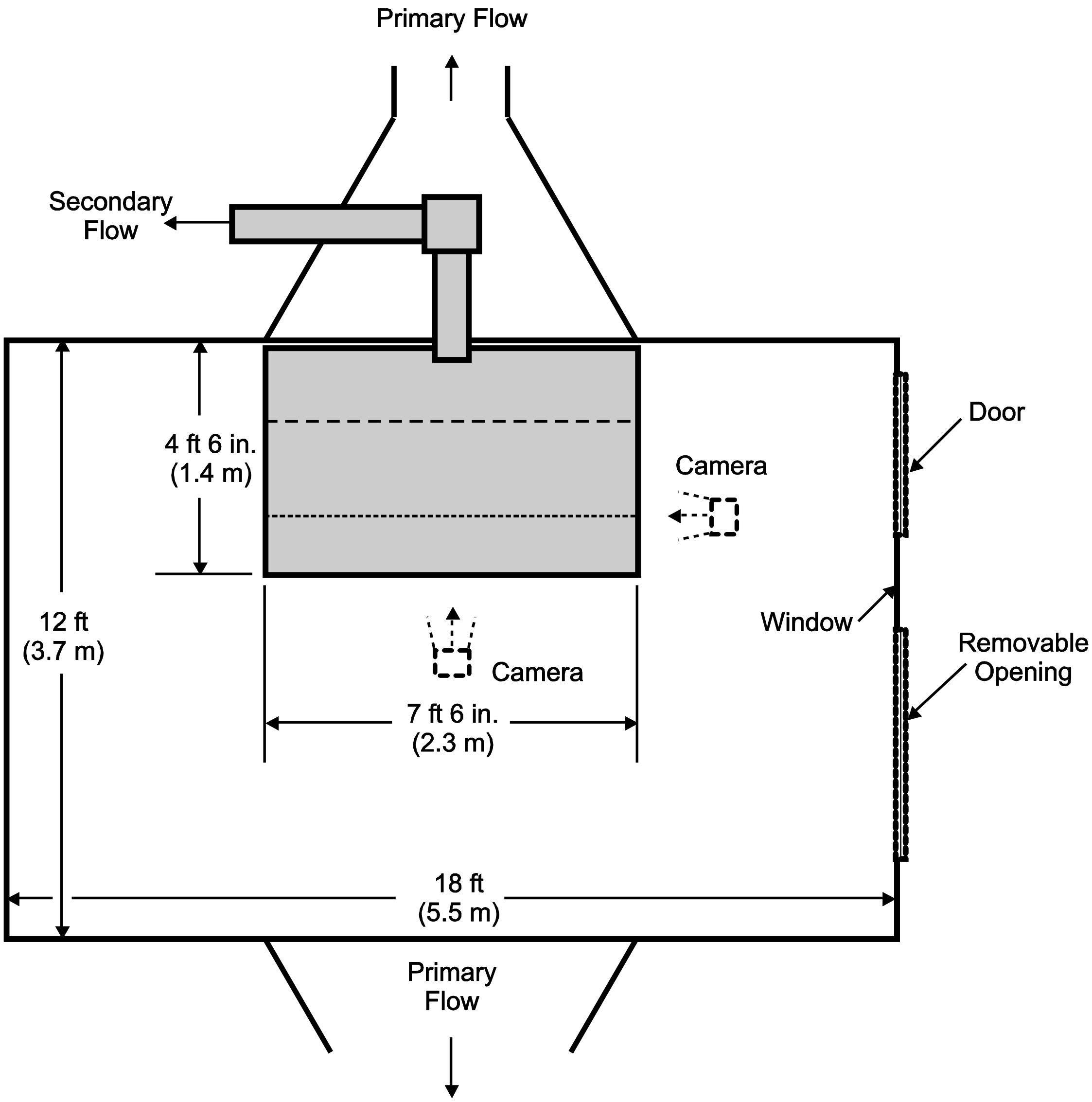

Figure E-2. Clean Room Simulation Facility - Top View

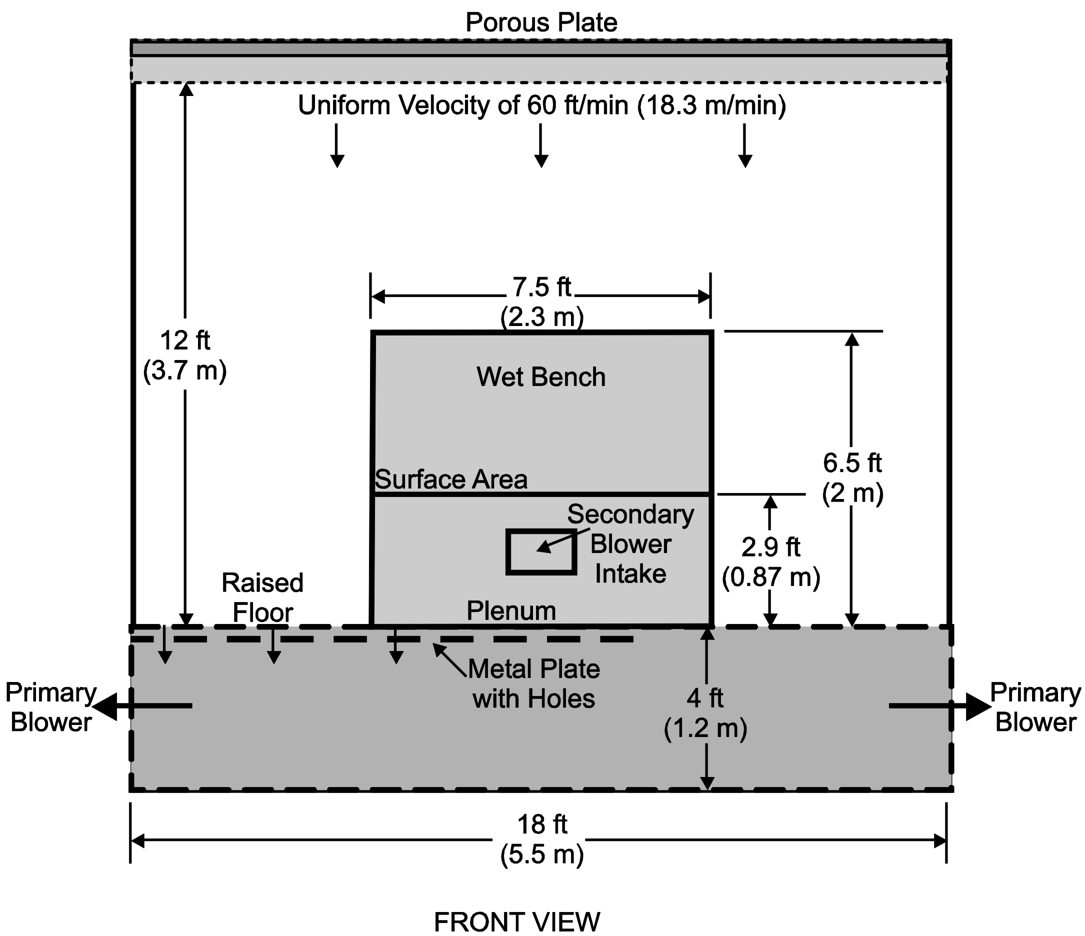

Figure E-3. Clean Room Simulation Facility - Front View

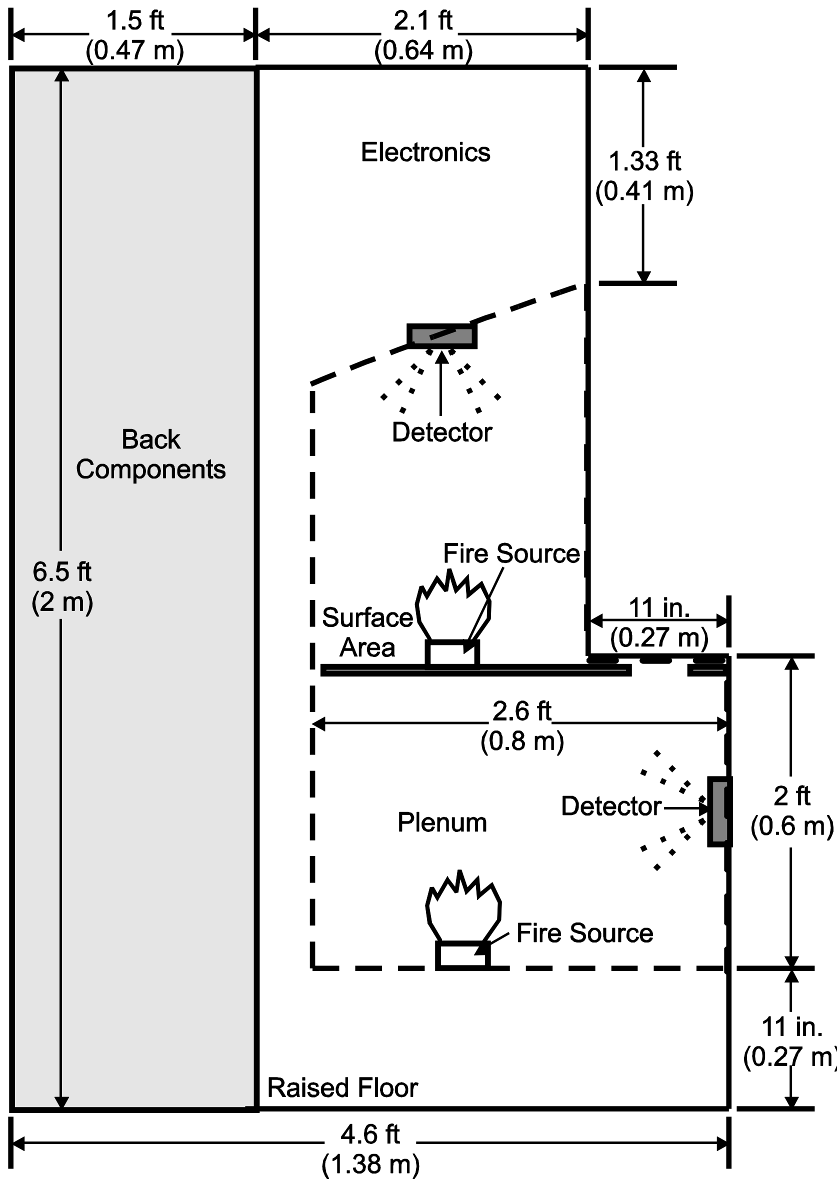

Figure E-4. Wet Bench Test Apparatus - Side View

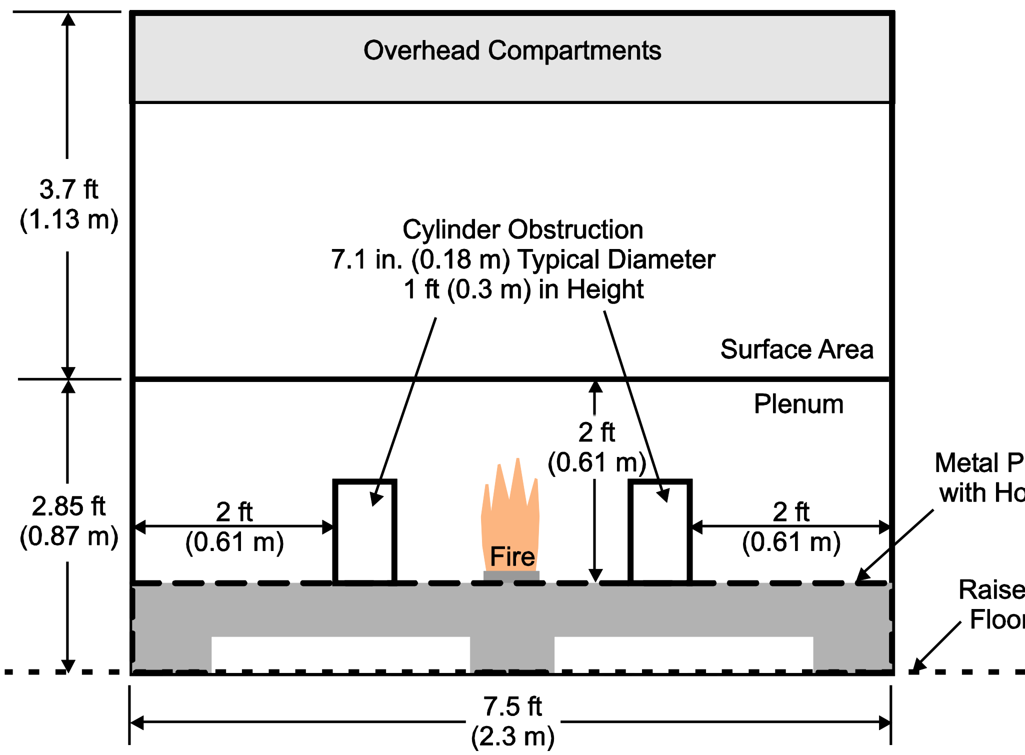

Figure E-5. Wet Bench Test Apparatus for Plenum Fire Subsurface Testing with Obstructions- Front View

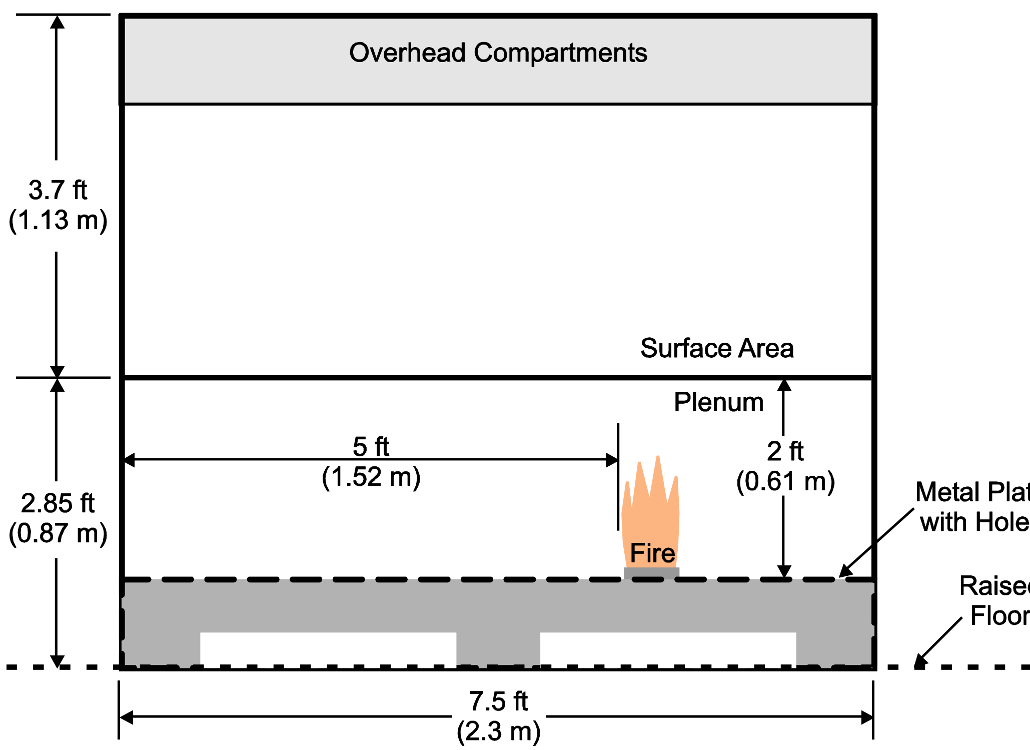

Figure E-6. Wet Bench Test Apparatus for Plenum Fire Subsurface Testing without Obstructions- Front View

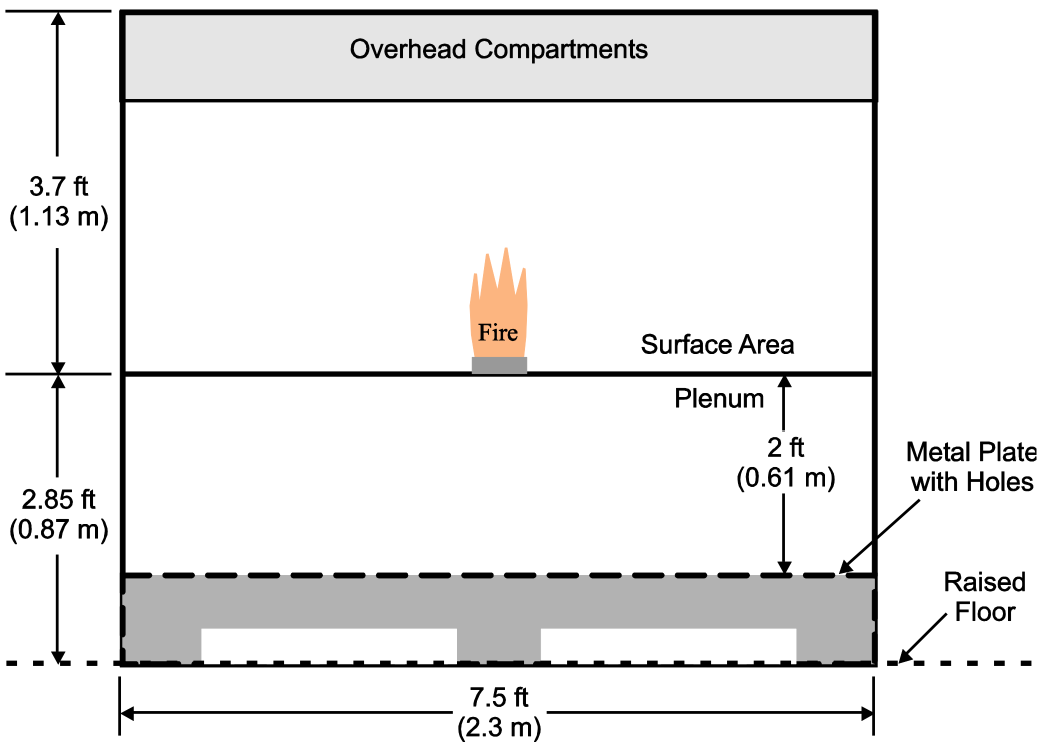

Figure E-7. Wet Bench Test Apparatus for Surface Area Fire Testing- Front View

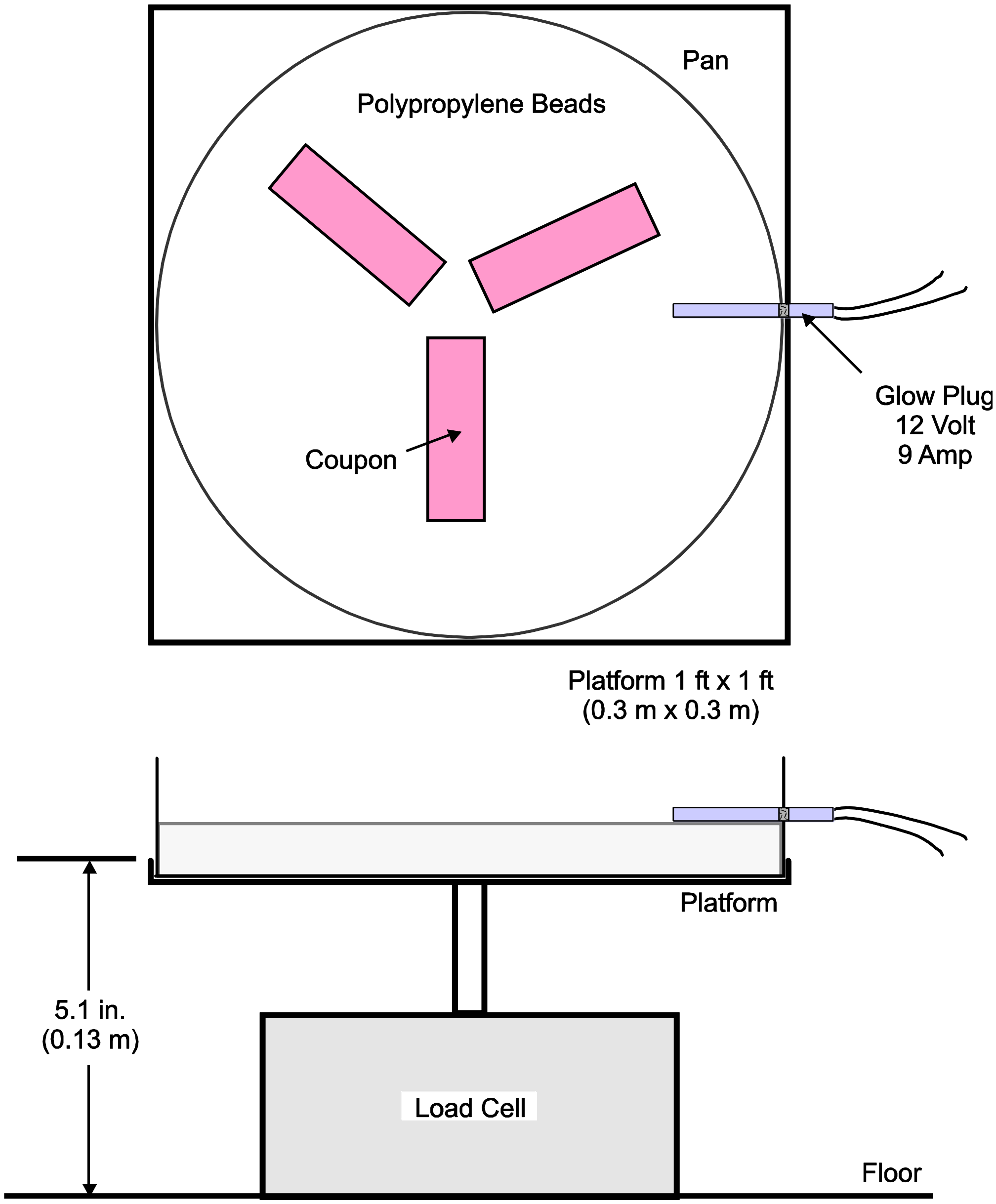

Figure E-8. Polypropylene Pool Fire for Wet Bench Fire Testing

APPENDIX F: Figures

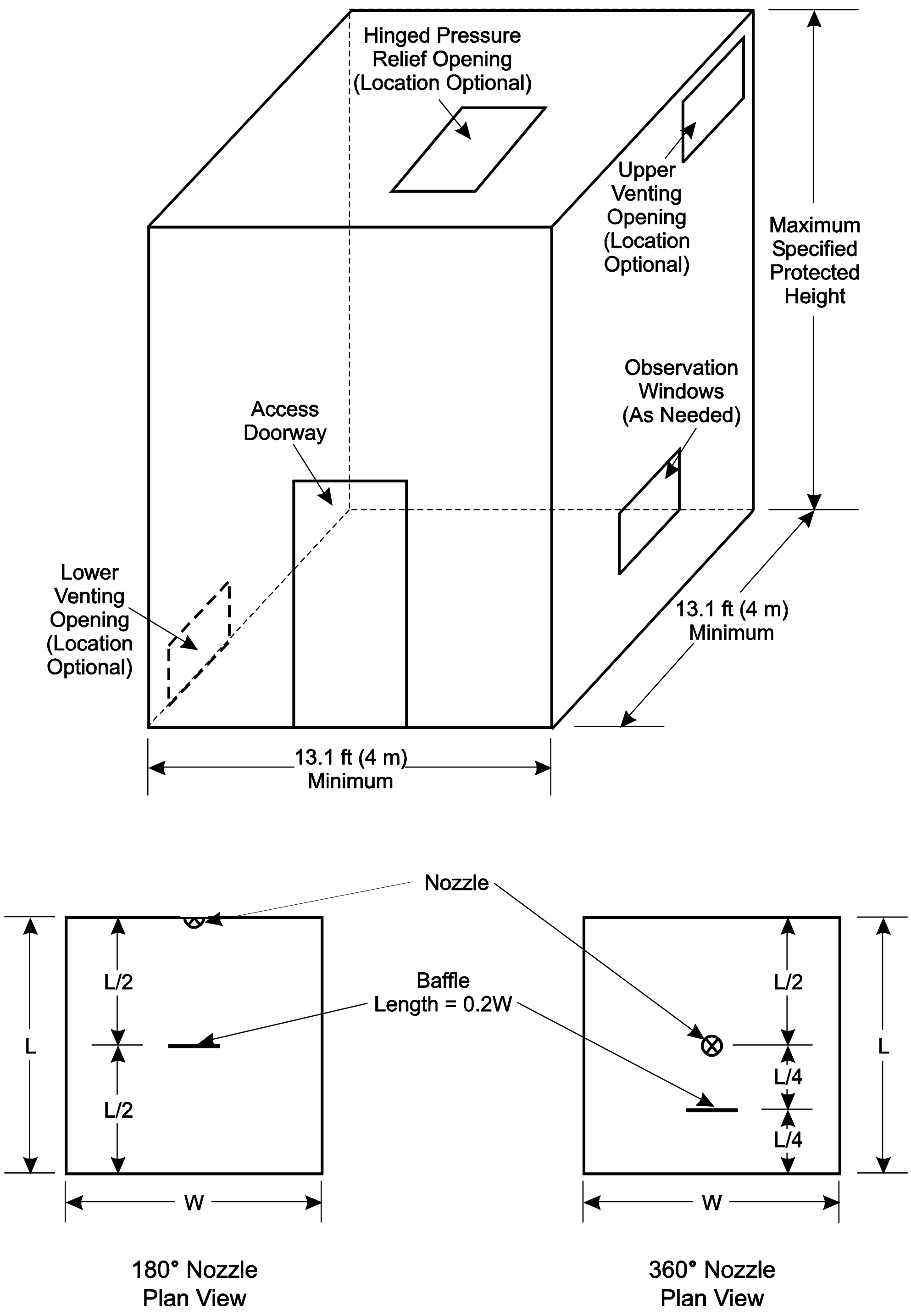

Figure F-1. Test Enclosure for Total Flooding Systems