



Member of the FM Global Group

Approval Standard for Clean Agent Extinguishing Systems

Class Number 5600

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Foreword

Approvals are 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 Approval Standards is to present the criteria for Approval of various types of products and services, as guidance for FM Approvals personnel, manufacturers, users, and authorities having jurisdiction.

Products submitted for Approval shall demonstrate that they meet the intent of the Approval Standard, and that quality control in manufacturing and/or applications shall ensure a consistently uniform and reliable product or service. Approval Standards strive to be performance-oriented and to facilitate technological development.

For examining equipment, materials, and services, Approval Standards:

- a) must be useful to the ends of property conservation by preventing, limiting or not causing damage under the conditions stated by the Approval listing; and
- b) must be readily identifiable and readily available in the marketplace.

Continuance of Approval and Listing depends on compliance with the Master Agreement, satisfactory performance in the field, on successful re-examinations of equipment, materials, and services as appropriate, and on periodic surveillance audits of the manufacturing facility or service/application.

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1. INTRODUCTION

1.1 Purpose

- 1.1.1 This standard describes requirements for fixed fire extinguishing systems which use vaporizing liquid or inert gas clean agents as the extinguishant.
- 1.1.2 FM Approvals criteria may include, but are not limited to, performance requirements, marking requirements, examination of manufacturing and filling facilities, audit of quality assurance procedures, and a surveillance audit program.

1.2 Scope

- 1.2.1 This standard contains requirements for vaporizing liquid and inert gas clean agent extinguishing systems for total flooding protection. Extinguishing systems shall be designed for automatic control to protect single or multiple hazard areas. The following product categories and class numbers are included in the scope of this standard.

Table 1.2.1 - *Product Categories and Class Numbers*

Class	Product Category
5611	Inert Gas Extinguishing Systems
5612	Liquefied Gas Extinguishing Systems
5613	Clean Agents

- 1.2.2 A basic vaporizing liquid or inert gas clean agent extinguishing system comprises one or more agent storage containers, discharge control valves arranged for automatic or manual/automatic control, lock-out valves (when required), piping, and discharge nozzles. Compatible FM Approved detectors and detection and release controls are required for automatic electrical operation of these systems, but are not included in the scope of this standard. If a system uses an integral detection and actuation system, it may be evaluated as a part of that system, using criteria derived from those used for standalone detection and control systems.
- 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 Approval. However, the manufacturer may, at any time, submit additional components or auxiliary equipment for use on the Approved 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 FM Approved and listed by FM Approvals. At minimum, a system shall consist of those components and auxiliary equipment considered necessary by FM Approvals for the system to operate properly when connected to an Approved detection and control system. Incomplete systems shall not be FM Approved.

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 has also been considered.
- 1.3.2 The requirements of this standard reflect tests and practices used to examine characteristics of clean agent fire extinguishing systems (hereinafter referred to as “systems”) for the purpose of obtaining FM Approval. Systems having characteristics not anticipated by this standard may be FM Approved if performance equal or superior to that required by this standard is demonstrated, or if the intent of the standard is met.

Alternatively, systems which meet all of the requirements identified in this standard may not be FM Approved if other conditions which adversely affect performance exist, or if the intent of this standard is not met.



1.4 Basis for FM Approval

FM Approval is based on satisfactory evaluation of the product and the manufacturer in the following 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 by FM Approvals
- The durability and reliability of the product

1.4.2 Surveillance audits of the manufacturing and filling facilities and quality control procedures shall be made to evaluate the manufacturer's ability to produce the product which was examined and tested, and the marking procedures used to identify the product. These examinations are repeated as part of FM Approvals' surveillance audit program.

1.5 Basis for Continued Approval

Continued Approval is based on:

- Production or availability of the product as currently FM Approved
- Continued use of acceptable quality assurance procedures
- Satisfactory field experience
- Compliance with the terms stipulated in the Approval Agreement
- Satisfactory re-examination of production samples for continued conformity to requirements.
- Satisfactory audits conducted as part of FM Approvals' Surveillance Audit program.

Also, as a condition of retaining Approval, manufacturers may not change a product or service without prior authorization by FM Approvals (refer to Section 5.1.4).

1.6 Effective Date

The effective date of an Approval standard mandates that all products tested for Approval after that date shall satisfy the requirements of the standard. Products FM Approved under a previous edition shall comply with the new version by the effective date or forfeit Approval.

The effective date of this standard is **One Year from date of Issue** for full 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. Appendix A lists the selected units and conversions to SI units for measures appearing in this standard. Conversion of U.S. customary units is in accordance with the Institute of Electrical and Electronics Engineers (IEEE)/American Society for Testing Materials (ASTM) SI 10-2002, *American National Standard for Use of the International System of Units (SI): The Modern Metric System*. Two units of measurement (liter and bar), outside of but recognized by SI, are commonly used in international fire protection and are used in this standard.

1.8 Applicable Documents

The following standards, test methods, and practices are referenced in this standard:

American National Standards Institute (ANSI)

American National Standards Institute, Inc., 11 West 42nd Street, 13th Floor, New York, NY 10036

ANSI/ASA S1.4-1983, *Specification for Sound Level Meters*

American Society of Mechanical Engineers (ASME)

American Society of Mechanical Engineers, Three Park Avenue, New York, NY 10016-5990

BPVC-CC-N – 2004, Boiler and Pressure Vessel Code 04

American Society for Testing and Materials (ASTM)

American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959

ASTM B 117 - 05, *Standard Practice for Operating Salt Spray (Fog) Apparatus*

ASTM D 412 - 98a(2002)e1, *Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers*

ASTM E – 1 - 05, *Standard Specification for ASTM Thermometers*

ASTM E1354-04a, *Standard Test Method for Heat and Visible Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter*

ASTM G 36 – 94(2000), *Standard Practice for Evaluating Stress-Corrosion-Cracking Resistance of Metals and Alloys in a Boiling Magnesium Chloride Solution*

ASTM G 155 – 05a, *Standard Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials*

Comité Européen des Assurances (CEA)

3 bis, rue de la Chaussée d'Antin – 75009, Paris, France

CEA 4008, *Fire Protection Systems - Specifications for Fire Extinguishing Systems Using Non-liquefied "Inert" Gases - Planning and Installation*, April 2005 (en).

CEA 4009, *Fire Protection Systems - Specifications for Fire Fighting Systems Using a Gaseous Extinguishant - Requirements and Test Methods for Selector Valves and Their Actuators*, February 2000 (en).

CEA 4012, *Fire Protection Systems - Specifications for Fire Fighting Systems Using a Gaseous Extinguishant - Requirements and Test Methods for Check and Non-return Devices*, February 2000 (en).

CEA 4013, *Fire Protection Systems - Specifications for Fire Fighting Systems Using a Gaseous Extinguishant - Requirements and Test Methods for Hoses and Container Connection Pipes*, February 2000 (en)

CEA 4014, *Fire Protection Systems - Specifications for Fire Fighting Systems Using a Gaseous Extinguishant - Requirements and Test Methods for Container and Valve Assemblies*, February 2000(en)

CEA 4016, *Fire Protection Systems - Specifications for Inert Gas Fire Fighting Systems: Requirements and Test Methods for Nozzles*, February 2000(en)

CEA 4045, *Fire Protection Systems - Specifications for Fire Extinguishing Systems Using Liquefied "Halocarbon" Gases - Planning and Installation*, April 2005 (en)

Compressed Gas Association (CGA)

Compressed Gas Association, 4221 Walney Road, Fifth Floor, Chantilly, VA 20151-2923

CGA G10.1, *Commodity Specification for Nitrogen*, Edition 6.

CGA S-1.1, *Pressure Relief Standards Part 1 - Cylinders for Compressed Gases*, Edition 12.

FM Approvals

1151 Boston-Providence Turnpike, P.O. Box 9102, Norwood MA 02062

<http://www.fmglobal.com/approvals/resources/standards.asp>

FM Approvals requirements for Class Number 3010, *Fire Alarm Control Equipment*

FM Approvals Standard Class Number 3600, *Electric Equipment for Use in Hazardous (Classified) Locations General Requirements*, November 1998.

FM Approvals Standard Class Number 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*, October 1999.

FM Approvals Standard Class Number 3611, *Nonincendive Electrical Equipment for Use in Class I and II, Division 2, and Class III, Divisions 1 and 2, Hazardous (Classified) Locations*, December 2004.

FM Approvals Approval Standard Class Number 3615, *Explosionproof Electrical Equipment General Requirements*, February 2006.

FM Approvals Approval Standard Class Number 3620, *Purged and Pressurized Electrical Equipment for Hazardous (Classified) Locations*, August 2000.

FM Approvals Approval Standard Class Number 3810, *Electrical and Electronic test, Measuring, and Process Control Equipment*, January 2005.

FM Approvals *Quality Assurance Guidelines for Manufacturers of FM Approved and Specification Tested Products*, September 2003.

FM Global

FM Global, 75 Remittance Drive, Suite 6182, Chicago, IL 60675-6182

<http://www.fmglobal.com/fmglobalregistration>

FM Global Property Loss Prevention Data Sheet 4-0, *Special Protection Systems*, April 2012.

FM Global Property Loss Prevention Data Sheet 4-9, *Clean Agent Fire Extinguishing Systems*, September 2010.

Institute of Electrical and Electronics Engineers (IEEE)

IEEE Standards Activities, 445 Hoes Lane, PO Box 1331, Piscataway, NJ 08855-1331

IEEE/ASTM SI 10-2002, *American National Standard for Use of the International System of Units (SI): The Modern Metric System*.

International Organization for Standardization (ISO)

International Organization for Standardization, 1 rue de Varembé, Case postale 56, CH-1211 Geneva 20, Switzerland

ISO 14520-1: 2006, *Gaseous fire-extinguishing systems - Physical properties and system design*

ISO 17025 - 2005, *General Requirements for the Competence of Calibration and Testing Laboratories*

NFPA Publications

National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101

NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems*, 2004 Edition.

NFPA 72 - 2002, *National Fire Alarm Code*

National Institute of Standards and Technology (NIST)

NIST, 100 Bureau Drive, Stop 1070, Gaithersburg, MD 20899-1070

NIST Technical Note 1278, *Preliminary Screening Procedures and Criteria for Replacements for Halons 1211 and 1301*

U.S. Department of Transportation (DOT)

Bureau of Explosives, 55500 DOT Road, Pueblo, CO 81001

Title 49, Code of Federal Regulations (CFR), *Hazardous Materials Regulations of the Department of Transportation*

1.9 Definitions

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

Accepted

Installations acceptable to the authority having jurisdiction and enforcing the applicable installation rules. When the authority is FM Global, such installations are termed “FM Global Accepted.” Acceptance is based on an overall evaluation of the installation. Factors other than the use of FM Approved equipment impact on the decision to accept the equipment. Acceptance is not a characteristic of a product; acceptance is installation specific. A product accepted for one installation may not be acceptable elsewhere (contrast with the definition of FM Approval).

Actuation Device

A means of initiating clean agent fire extinguishing system discharge by opening the discharge valve.

Agent Storage Container

The assembly holding the clean agent supply for a fire extinguishing system. This includes the pressure vessel and various accessories necessary for management of the supply, such as valves, dip tubes, pressure gauges, and pressure relief devices.

Agent Storage Cylinder

See “Agent Storage Container”

Amplitude

The maximum displacement of sinusoidal motion from position of rest, or one-half the total table displacement, during a vibration test.

Area of Coverage

The maximum area that can be protected by a clean agent discharge nozzle or automatic extinguisher unit.

Authority Having Jurisdiction

The organization, office, or individual responsible for approving equipment, materials, an installation, or a procedure.

Automatic Control

An operating device, or arrangement of devices, which does not require human intervention. The automatic control includes a control panel that monitors fire detection devices and releases the agent when pre-established conditions have been met.

Automatic Extinguisher Unit

A clean agent extinguishing storage container that discharges following the operation of a heat responsive element. Automatic extinguisher units may also include optional mechanical manual controls. A single automatic extinguisher unit shall be used to protect each hazard area, unless it is possible to configure multiple units such that operation of any one will operate all others simultaneously.

Class A Fires

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

Class B Fires

Fires in ignitable liquids (also known as flammable or combustible liquids), petroleum greases, tars, oils, oil-based paints, solvents, lacquers, alcohols, and flammable gases.

Class C Fire

Fires that involve energized electrical equipment and during which the electric power is maintained, thereby continuously adding electrical energy.

Discharge Head

A removable portion of a discharge valve assembly that is required to be installed for system operation.

Discharge Nozzle

A device with one or more orifices that is connected to a termination of a pipe network for the purpose of controlling the discharge rate and uniformly distributing the extinguishing agent within a specific volume.

Discharge Time

The time interval between the first appearance of extinguishing agent at the discharge nozzle or unit and the time at which 95 percent of the agent has been discharged from the nozzle or unit.

Element Operating Temperature

The nominal temperature in degrees Fahrenheit (°F) or Celsius (°C) at which a heat responsive element operates when subjected to the influence of heat.

Engineered System

A clean agent fire extinguishing system designed using hydraulic calculations to predict mass flows and pressures at individual nozzles. These calculations analyze the entire piping system, taking into account variables such as friction loss in piping, nozzles, and other components.

Expellant Gas

The medium used to facilitate the discharge of the extinguishing agent from the agent storage container.

Flow Rate

The quantity of fluid passing through a nozzle or other device in a unit time. When a minimum discharge rate is indicated, reference is made to the minimum quantity of agent discharged per unit time, measured within ± 1 second.

FM Approvals Certification Marks

The FM Approvals Certification Marks are detailed in Appendix C, and their use is mandatory on all FM Approved systems. These registered marks cannot be used except as authorized by FM Approvals via the granting of Approval to a specific product. For clean agent extinguishing systems, the FM Approvals Certification Marks shall be placed on the system placard and not on individual components, unless those components have undergone a separate evaluation to the applicable standards.

FM Approved

Products certified by FM Approvals to the applicable FM Approval Standard(s). Such products are listed in the Approval Guide, an online resource of FM Approvals, or one of the supplements. All products listed in the Approval Guide have been successfully examined by FM Approvals, and their manufacturers have signed and returned a Master Agreement to FM Approvals. This contract obligates the manufacturer to allow re-examination of the product and surveillance audits at FM Approvals' discretion. It further requires the manufacturer not to deviate from the FM Approved configuration of the product without review by and agreement of FM Approvals. Approval is product specific.

Fully Mechanical Manual Control

A manual discharge control which can function in the absence of electric power or other energy sources other than stored system pressure.

Halocarbon Clean Agent

A gaseous fire extinguishant, electrically nonconducting and volatile, that does not leave a residue subsequent to evaporation. The material is delivered by a fire extinguishing system and acts to suppress or extinguish a fire, and includes as primary components one or more organic compounds containing the elements fluorine, chlorine, bromine, and iodine. Such an agent is more properly and more generally called a Vaporizing Liquid Clean Agent.

Heat Responsive Element

An operating device that does not require human intervention. This device includes an operating element that, when subjected to the influence of heat, ruptures, bursts, or otherwise functions, to cause the release of clean agent.

Inert Gas Clean Agent

A gaseous, electrically nonconducting fire extinguishant that does not leave a residue subsequent to evaporation. The material is delivered by a fire extinguishing system and acts to suppress or extinguish a fire, and includes as primary components one or more elemental gases such as helium, neon, argon, and nitrogen. Blends of inert gases may also contain carbon dioxide as a secondary component.

Lock-Out Valve

A supervised, lockable, manually operated valve located in the discharge line between the supply and the nozzles, which can be used to isolate the agent supply from all or part of the system during maintenance and service.

Manual Control

An operating device, or arrangement of devices that requires action by a human operator. The manual control may be initiated either mechanically or electrically.

Master Cylinder

One or more agent storage containers in a clean agent extinguishing system using multiple agent storage containers that are directly actuated by an operating device, then supply pressure to actuate one or more secondary cylinders.

Maximum Discharge Time

The longest allowable discharge time at 70°F (21°C) specified by the manufacturer. This time cannot be longer than 10 seconds for vaporizing liquid agents; for inert gas agents this time cannot exceed 120 seconds for the protection of Class A or Class C fire hazards, or 60 seconds for the protection of Class B fire hazards.

Maximum Working Pressure

The pressure in an agent storage container or other pressurized container, as applicable, associated with the maximum installation temperature.

Minimum Bending Radius

The smallest radius (expressed in inches [mm]) specified by the manufacturer to which a flexible hose is safely allowed to bend without damage.

Minimum Working Pressure

The pressure in an agent storage container or other pressurized container, as applicable, associated with the minimum installation temperature.

Operable Pressure Range

The minimum and maximum pressures of the agent storage container or other pressurized container, as applicable, over which the system is intended to be functional. These operating pressures result from the minimum and maximum storage temperatures and the physical characteristics of the agent and/or expellant gas, as applicable.

Operating Device

See "Actuation Device"

Operating Pressure

See "Operable Pressure Range"

Pilot Cylinder

A pressurized cylinder separate from the agent storage containers in a clean agent extinguishing system that is directly actuated by an operating device, then supplies pressure to actuate either a master cylinder, or one or more secondary cylinders.

Pre-Engineered System

A clean agent fire extinguishing system designed using a predetermined range of piping and nozzle characteristics and configurations to determine individual nozzle flow rates.

Proof Test Pressure

The factory test pressure used to verify the structural integrity of the agent storage container.

Resonance

The maximum magnification of applied vibration during a vibration test.

Secondary Cylinder

One or more cylinders in a clean agent fire extinguishing system using multiple agent storage containers that are operated by pressure supplied from a pilot or master cylinder, rather than directly by an operating device.

Selector Valve

A supervised valve normally operated automatically, but that also includes an emergency fully mechanical manual control, that can be used to restrict agent discharge to one of multiple zones protected by the same agent supply. Selector valves are controlled by the detection and control system and are used to avoid discharging the clean agent 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.

Specified

The value of a design parameter set by the manufacturer that shall be equal to, or more conservative than, the limiting values of this standard.

Supervised

A type of 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 an alarm via a control panel.

Total Flooding System

An extinguishing system designed to protect an enclosed hazard volume by discharging clean agent throughout the enclosed volume to reach and maintain an extinguishing concentration for the specific fuels for which it has been designed for a sufficient period of time to extinguish fires in those fuels.

Vaporizing Liquid Clean Agent

An electrically nonconducting, compressed liquid fire extinguishant that is vaporized at discharge and does not leave a residue subsequent to evaporation. The material is delivered by a fire extinguishing system and acts to suppress or extinguish a fire, and includes as primary components one or more organic compounds containing the elements fluorine, chlorine, bromine, and iodine.

Working Pressure

The pressure in a fully charged agent storage container or other pressurized container, as applicable, at 70° F (21° C).

Zone

A segment of a fire extinguishing system distribution piping supplied through a selector valve that delivers clean agent to one of the spaces protected by the system.

2. GENERAL INFORMATION

2.1 Approval Application Requirements

To apply for an Approval examination, the manufacturer, or its authorized representative, should submit a request to:

Fire Protection Group Manager
FM Approvals
Hydraulics Laboratory
743A Reynolds Road
West Glocester, Rhode Island 02814 U.S.A.

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

- A complete list of all models, types, sizes, and options for the products being submitted for Approval consideration
- Assembly drawings, component drawings, materials list, anticipated marking format, nameplate format, brochures, sales literature, specification sheets, and design, installation, operation and maintenance instructions
- The number and location of manufacturing facilities

2.1.2 All documents shall identify the manufacturer's name, document number or other form of reference, title, date of last revision, and revision level.

2.1.3 All documents shall be provided with English translation.

2.1.4 The manufacturer may also be asked to complete an Application for FM Approval Services.

2.2 Requirements for Samples for Examination

2.2.1 Following authorization of an Approval examination, the manufacturer shall submit samples for examination and testing. Sample requirements are to be determined by FM Approvals following review of the preliminary information.

2.2.2 Sample requirements may vary depending on design features, results of prior testing, and results of any foregoing tests.

2.2.3 The manufacturer shall submit samples representative of production. Any decision to use data generated using prototype components or systems shall be at the sole discretion of FM Approvals.

2.2.4 The manufacturer shall be responsible for providing any necessary test fixtures that may be required to evaluate the system.

3. GENERAL REQUIREMENTS

3.1 Review of Documentation

During the initial investigation and prior to physical testing, the manufacturer's specifications, technical datasheets, and design details shall be reviewed to assess the ease and practicality of installation and use. The system and its components shall be suitable for use within the defined limits of the Approval investigation.

3.2 Physical or Structural Construction Features

3.2.1 Operating Range

All system components shall operate within the temperature ranges of Table 3.2.1. System and component evaluations will be based on the specified minimum and maximum operating temperatures. Operating temperatures outside these limits shall be specified at discrete 10°F (5.6°C) increments.

Table 3.2.1 *Required Operation Temperature Range*

<i>Allowable Minimum Operating Temperature °F (°C)</i>	<i>Allowable Maximum Operating Temperature* °F (°C)</i>
32°F (0°C), or lower	120°F (49°C), or higher

NOTE: Automatic extinguisher units only may specify a 100°F (37.8°C) maximum storage temperature.

3.2.2 Materials

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

3.2.2.2 Any seals used in the system shall be compatible with the clean extinguishing agent. Compatibility shall be determined by successful performance when subjected to the requirements listed in Sections 4.9.2 (Long Term Leakage Test), 4.9.3 (30-Day Maximum Temperature Leakage Test), 4.9.4 (30-Day Minimum Temperature Leakage Test), and 4.22 (Elastomeric Materials Tests).

3.2.3 Controls

3.2.3.1 For normal operation, a system shall be either automatically controlled or operable from a manual control, easily accessible to the hazard, or both. If the normal manual means of actuation incorporates electric power, the source of that power shall be completely independent of any electric power source used for automatic operation. A power source used for both normal manual and automatic operation shall be provided with an independent backup, such as a battery. All systems shall be provided with an alternate means of fully mechanical manual emergency control, regardless of their normal means of operation. Fully mechanical manual emergency controls shall not require an electric power source, but may make use of the clean agent extinguishing system's working 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 72 and FM Approvals' Approval Standards Class Number 3010 and 3810. Control panels are not required to be submitted as a part of a system. However, system design shall be such that the system is operable by a minimum of one FM Approved detection and release panel that is compatible for use with the clean agent extinguishing system.

3.2.4 Pressure Vessels

- 3.2.4.1 Storage containers shall conform to the appropriate regulations for the installation location. In the U.S.A., DOT Title 49, CFR, Parts 171 through 180 are applicable for clean agent storage containers that are shipped under pressure.
- 3.2.4.2 In a system utilizing multiple storage containers, all containers supplying the same manifold shall be of the same size and design, allowing for interchangeability of position.
- 3.2.4.3 The following documents shall be submitted for each storage container design, to demonstrate compliance with the relevant design standard:
- Calculation of wall thicknesses per the method specified in the applicable standard, with appropriate supporting references as necessary
 - Certificate of chemical analysis of materials
 - Certificate of physical properties of materials
- 3.2.4.4 The pressurization level and the minimum and maximum filling densities shall be specified by the manufacturer for vaporizing liquid clean agents. The pressurization level and filling volume shall be specified by the manufacturer for inert gas agents.

3.2.5 Valves

If applicable, equivalent tube or pipe length of discharge valves shall be measured to allow accurate calculations for system design. Discharge valves shall incorporate varying sizes or connection designs for all ports to minimize the likelihood of improper connection during installation. Selector, check, and other valves not designed for mounting directly on a storage 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.

3.2.6 Gauges and Indicators

- 3.2.6.1 A pressure gauge shall be included with all extinguishing systems to indicate the pressure in the agent storage container, and shall comply with the following requirements:
- The face of the gauge shall indicate the appropriate units of pressure for which it is calibrated
 - The range of the gauge shall be based on the system's operable pressure range
 - The minimum indicated gauge pressure shall be marked on the left side of the gauge's range
 - A 70°F (21°C) value shall be marked at the system's working pressure
 - The maximum gauge pressure shall be between 150 and 250 percent of the system working pressure at 70°F (21°C), and shall be marked on the right side of the gauge's range
 - The gauge shall be provided with a means of pressure relief to allow venting in the event of an internal leak
 - The face of the gauge shall identify the clean agent with which it is intended to be used
- 3.2.6.2 When the storage container cannot be easily weighed due to size or installation location, liquid level indicators or an alternative method of determining agent storage container fill level shall be provided for vaporizing liquid agents. When provided, liquid level indicators shall meet the requirements of Section 4.15.

3.2.7 Siphon Tubes

- 3.2.7.1 Systems containing a siphon tube to discharge the clean extinguishing agent from the storage container shall be configured so that the discharge end of the siphon tube is mechanically locked and sealed to remain in place during all conditions of use.
- 3.2.7.2 Vaporizing liquid clean agents are stored as liquids and superpressurized to the specified working pressure. Siphon tubes in these systems shall be designed to prevent gas discharge until the liquid level drops below the opening on the free end of the siphon tube.
- 3.2.7.3 The free end of the siphon tube shall be configured to prevent restriction of flow by contact with the cylinder wall. If the minimum clearance between the end of the siphon tube and the cylinder wall is less than 0.25 times the tube's inside diameter, equivalent length measurements for the system discharge valve shall be performed with the siphon tube in place and installed in the normal design proximity to the cylinder wall. Compliance with this requirement shall be demonstrated by drawings showing the calculated assembly clearance, based on worst case dimensional tolerance stack-ups. Alternatively, the manufacturer's assembly process may contain controlled procedures 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 to comply with the flow capacity and operating pressure requirements specified in CGA S-1.1, or equivalent regulations acceptable to the authority having jurisdiction. The construction and size of the pressure relief device shall, at a minimum, be appropriate for the system pressure at the maximum specified operating temperature.

3.2.9 Anti-Recoil Devices

The discharge valve outlet of an agent storage container shall be provided with an anti-recoil device for the purpose of shipping, handling, and storage. The device shall be an integral part of or attached to the container via a chain, or otherwise designed to minimize the likelihood of removal from the container.

3.2.10 Discharge Heads and Connectors

If a system discharge head must be removed from the valve assembly during weighing or recharging operations, the assembly shall contain a check valve. When a flexible loop connector must be removed, 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.

3.2.11 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 the 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 remaining cylinders, regardless of the total number of pilot cylinders in the system. All cylinders in a manifold arrangement shall be of the same size and design.

3.2.12 Cylinder Supports

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

3.2.13 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 electrical cables and wires, or pressurized tubes outside the enclosures. Tubing used for heat detection may be exposed in the areas being monitored, but shall be enclosed where not performing this function and vulnerable to mechanical damage. Mechanical cables shall be sheathed or otherwise protected to minimize the likelihood of damage or mechanical interference with operation.

3.2.14 Actuation Devices

3.2.14.1 The device which opens a cylinder discharge valve shall either be an independent actuation device attached to the valve, or an internal component of either the discharge head or the valve assembly itself.

3.2.14.2 One action shall actuate all the cylinders in a manifold arrangement. 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, pressure from a pilot cylinder acts through some mechanism in the secondary cylinder actuation device, 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 testing or by the submission of appropriately annotated drawings displaying the area ratio calculation. Mechanical systems shall be configured to provide sufficient force to operate secondary cylinders pressurized to the maximum system pressure when actuated by the minimum available force.

3.2.14.3 Actuation devices on pilot cylinders shall be designed for single or simultaneous multiple unit operation. They shall be actuated automatically by a compatible Approved detection and control system, or by a fully manual emergency release device. Handles or levers on manual controls shall not require a force to operate exceeding 40 lb (178 N), a travel distance of more than 14 in. (355 mm), or a rotation of more than 270 degrees.

3.2.14.4 Electric actuation devices shall be designed with a provision for remote supervision of installation onto the valve or device they control, or operability for actuators integrated into the discharge valve (remote supervision of electric actuation devices required by January 1, 2016).

3.2.15 Auxiliary Manual Controls

Auxiliary manual controls shall be provided for systems using automatic-only actuation devices or mechanical release devices that 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 manual controls that are not located within the protective enclosures provided for other components shall be protected against accidental operation by a suitable enclosure or other means. Corner pulleys shall be provided for smooth operation of control devices that require cables.

3.2.16 Selector and Lockout Valves

The equivalent length of selector and lockout valves shall be measured to allow accurate calculations for system design. The actuation of one selector valve shall not open other selector valves in the system. Lockout valves shall be designed with a provision for remote supervision of valve position (fully open or fully closed). Selector valves shall be designed with a provision for remote supervision of electric actuation device installation, or operability for actuators integrated into the valve (remote supervision of electric actuation devices required by January 1, 2016). Lockout valves are not normally required for clean agent extinguishing systems. However, lockout valves may be required when design concentrations are above the No Observable Adverse Effect Level (NOAEL) for occupied spaces. Supervisory devices shall be compatible with the appropriate FM Approved control equipment.

3.2.17 Nozzles

Discharge nozzles shall be evaluated for the intended use, including flow characteristics and area of coverage. Nozzles or outlets shall be made of metallic, corrosion resistant materials that will not deform or otherwise be damaged by fire exposure or discharge pressure. Nozzles shall be permanently marked with their part number. When the part number alone does not identify orifice size, the orifice size shall also be permanently marked on the nozzle.

3.2.18 Nozzle Caps or Frangible Seals

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 not obstruct flow from the outlet subsequent to release.

3.2.19 Clean Agents

Vaporizing liquid and inert gas clean extinguishing agents for use in fire extinguishing systems shall be recognized under the United States Environmental Protection Agency's Significant New Alternatives Program, and shall meet the requirements of NFPA 2001 or the equivalent local standard(s) acceptable to the authority having jurisdiction, and shall either be FM Approved as a clean agent system component or shall be examined for the system manufacturer to the same extent as an agent submitted for component Approval. All agent storage containers shall be filled at an FM Approved location, which is included in the FM Approvals' Surveillance Audit Program.

3.2.20 Expellant Gases

Nitrogen used in a clean agent system shall have a dew point of no greater than -60°F (-51.1°C), and shall be grade H, I, J, K, L, M, N, O, or P, as described in Table 1 of *Commodity Specification for Nitrogen*, CGA G-10.1. The use of any other expellant gas shall be evaluated at the discretion of FM Approvals.

3.2.21 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 FM Approvals according to the nature of the hazard. The devices listed below may be required for the system to attain Approval for specific applications. Other devices not included below may also be required.

3.2.21.1 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 40 psi (2.8 bar) from a piston or plunger driven by clean agent 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.

3.2.21.2 Pressure Operated Switches

Pressure operated switches may be used to shut down fans, conveyors, or other electrical equipment in or near the hazard area, as well as to activate alarm and indicator circuits. These switches shall not require a pressure of more than 40 psi (2.8 bar) to operate, and shall not release excessive gas from the system. They may also have an alternate manual control, and shall be designed for manual resetting only.

3.2.21.3 Time Delays

A delay device may be installed on systems when the evacuation of personnel from the hazard area prior to system discharge is required. This device may allow discharge to be aborted or immediately initiated through a manual override during the delay period. The duration of delay is a function of both the specific clean agent used and the design concentration, and is determined by the authority having jurisdiction.

3.2.21.4 Alarms

Alarms and/or indicators shall be provided to show that the system is operating, warn personnel of the forthcoming discharge of clean agent or of its presence in unventilated areas, and signal the failure of any supervised equipment. Indicators that show the system has been used and requires service shall operate following actuation of the system and require manual resetting. When pneumatically operated alarms are powered by a vaporizing liquid clean agent, the discharge of agent from the device shall be piped outside of the protected area to minimize potentially damaging products of decomposition prior to system operation.

3.2.21.5 Check Valves

Check valves shall be provided in the manifold piping on system installations incorporating multiple storage containers. They shall open at a maximum pressure of 0.1 times the system pressure at maximum storage temperature.

3.2.21.6 Venting Valves

Devices shall be provided to prevent the premature operation of discharge or selector valves by residual pressures that may leak into enclosed manifolds, actuation devices, 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 actuation devices, they shall be closed when the control is in operation and open when the control is inoperative.

3.2.21.7 Changeover Devices

Changeover devices, such as valve or switch assemblies, shall be provided on automatic systems having both primary and connected reserve agent storage containers. This will direct the command of the automatic fire detection device to the proper series of containers. The changeover device shall be suitably protected and labeled and shall indicate which containers are subject to operation.

3.2.22 Hazardous Location Rating of Components

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

Table 3.2.22 *Hazardous Location Electrical Equipment Standards*

FM Approvals Class Number	Standard Title
3600	Electric Equipment for use in Hazardous (Classified) Locations General Requirements
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
3611	Nonincendive Electrical Equipment for Use in Class I and II, Division 2, and Class III, Divisions 1 and 2, Hazardous (Classified) Locations
3615	Explosionproof Electrical Equipment General Requirements
3620	Purged and Pressurized Electrical Equipment for Hazardous (Classified) Locations
3810	Electrical and Electronic Test, Measuring, and Process Control Equipment

3.3 Markings

3.3.1 Easily visible nameplates shall be affixed to the agent storage container assembly of clean agent extinguishing systems, and shall display the following markings at a minimum. Any additional markings required by the authority having jurisdiction shall also be provided:

- Manufacturer's name and address
- System type and model number
- The FM Approvals Certification Mark, (Appendix C)
- Clean agent identification
- System working pressure
- Allowable ambient storage temperature range
- Factory test pressure of storage container
- Year of manufacture of the storage container (if not directly stamped on the container)
- Reference to NFPA 2001, *Standard for Clean Agent Extinguishing Systems*, and/or any other relevant local standards
- Reference to the manufacturer's design, installation, operation, recharge, and maintenance instructions
- Weight of agent charge and total container weight

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

3.3.4 All marking plates shall be made of materials which will not corrode or otherwise become illegible due to system liquids or vapors, or normal environmental conditions.

3.3.5 When hazard warnings are required by the authority having jurisdiction, the markings should conform to the authority's requirements and if possible, be universally recognizable.

3.3.6 The system's model or type identification shall correspond to the manufacturer's catalog designation and shall uniquely identify the product as FM Approved. The manufacturer shall not place this model or type identification on any other product unless covered by a separate agreement with FM Approvals.

3.3.7 The FM Approvals Certification Mark (Appendix C) shall be displayed visibly and permanently on the product and/or packaging, as appropriate. The manufacturer shall not use this mark on any other product unless covered by separate agreement with FM Approvals.

3.3.8 All markings shall be legible and durable.

3.4 Manufacturer's Design, Installation, Operation, and Maintenance Instructions

- 3.4.1 The manufacturer shall provide information required to properly design, install, operate, and maintain the system. These instructions shall be submitted to FM Approvals prior to the examination of a system.
- 3.4.2 The manufacturer shall provide guidance for the design or evaluation of protected enclosures to ensure that the pressurization caused by system design will not damage the enclosure. Such guidance shall include consideration of the minimum enclosure strength, required leakage area, and proper vent sizing requirements. For inert gas clean agents, enclosure pressurization calculations shall incorporate a discharge time 10 seconds less than that calculated in the system design to account for the allowable tolerance in the Verification of Flow Calculation Method Test of Section 4.6. For all systems, enclosure pressurization calculations shall be based upon maximum fill density agent storage containers at the manufacturer's maximum specified installation temperature.
- 3.4.3 The manufacturer's design instructions for a system submitted for FM Approval shall be evaluated based on FM Global requirements, NFPA 2001, and any other relevant standards required by the local authority having jurisdiction.

3.5 Calibration

All equipment used to verify the test parameters shall be calibrated within an interval determined on the basis of stability, purpose, and usage of the equipment. For testing conducted at locations other than FM Approvals, a copy of the calibration certificate for each piece of test equipment that indicates the calibration was performed to standards traceable to the National Institute of Standards and Technology (NIST), or to other acceptable reference standards by an accredited ISO 17025 calibration laboratory, is required. The test equipment must be clearly marked with identification, including the last date of the calibration and the next due date. In addition, a copy of the ISO 17025 accreditation certificate for the calibration laboratory is required for FM Approvals records.

The calibration of recently purchased new equipment is also required. Documentation indicating either the date of purchase or date of shipment, equipment description, model and serial number is required for identification. The period from the time the equipment was put into service to the date of testing must be within an interval that does not require the equipment to be calibrated as determined on the basis of the parameters mentioned above.

3.6 Tolerances

Tolerances on units of measure shall be as described in Appendix B, unless otherwise specified.

4. PERFORMANCE REQUIREMENTS

4.1 Class A and B Fire Extinguishment Tests

4.1.1 Requirement

4.1.1.1 Class A Fire Extinguishment Tests

Clean agent extinguishing systems shall successfully extinguish each Class A fire within 600 seconds after the end of system discharge. For the purposes of these tests, the end of discharge shall be considered to be at the maximum discharge time. Following a 600 second soak period, there shall be no signs of re-ignition of the materials defined in Sections 4.1.2.1.A and 4.1.2.1.B. For the polymeric material tests, the weight loss of each sample between 10 seconds and 600 seconds after the end of discharge shall not exceed 15 grams. This test is used to confirm the minimum extinguishing concentration (MEC) for a clean agent on Class A combustible materials.

4.1.1.2 Class B Fire Extinguishment Tests

Clean agent extinguishing systems shall successfully extinguish each Class B fire within 30 seconds after the end of system discharge. For the purposes of these tests, the end of discharge shall be considered to be at the maximum discharge time. This test is used to confirm the minimum extinguishing concentration for a clean agent on Class B ignitable liquids (also known as flammable or combustible liquids). While certain Class B hazards may have MECs (cup burner values per NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems*, Annex B), FM Approved systems must use at least the MEC defined in these tests for all Class B hazards.

4.1.2 Tests/Verification

The test enclosure shall be constructed of plywood with a minimum thickness of 3/8 inch (9.5 mm), or an equivalent material. The enclosure shall contain a minimum volume of 3531 ft³ (100 m³), with a minimum ceiling height of 11.5 ft (3.5 m), and each wall shall be a minimum of 13.1 ft (4 m) long. 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).

Each test shall include a piping configuration and discharge nozzle resulting in the minimum specified nozzle design pressure at 70°F (21°C).

When a clean agent is being evaluated for component Approval and not a part of a system Approval, the highest nozzle pressure used in the component Approval fire tests shall define the minimum nozzle pressure that can be used with that clean agent in any system Approvals.

The agent storage container shall be conditioned to 70°F ± 5°F (21°C ± 3°C), and maintained at this temperature for the duration of each fire test.

The clean agent concentration used in each fire test shall be determined by dividing the specified design concentration at an ambient temperature of 70°F (21°C) by 1.2 for Class A materials or 1.3 for Class B materials, and shall be calculated for each test using the appropriate formula, as follows:

For vaporizing liquid clean agents:

$$W = \left[\frac{V}{s} \right] \times \left[\frac{C}{100 - C} \right]$$