



Member of the FM Global Group

Approval Standard for Nitrogen Generators

Class Number 1035

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Foreword

The FM Approvals certification mark is intended to verify that the products and services described will meet FM Approvals' 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 FM Approval of various types of products and services, as guidance for FM Approvals personnel, manufacturers, users and authorities having jurisdiction.

Products submitted for certification by FM Approvals shall demonstrate that they meet the intent of the Approval Standard, and that quality control in manufacturing shall ensure a consistently uniform and reliable product. Approval Standards strive to be performance-oriented. They are intended 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.

Continuance of Approval and listing depends on compliance with the Approval Agreement, satisfactory performance in the field, on successful re-examinations of equipment, materials, and services as appropriate, and on surveillance audits of the manufacturing facility.

FM Approvals LLC reserves the right in its sole judgment to change or revise its standards, criteria, methods, or procedures.

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1. INTRODUCTION

1.1 Purpose

- 1.1.1 This standard states Approval criteria for nitrogen generators for use in dry pipe and preaction fire protection systems. Nitrogen generators provide pressurized nitrogen to the sprinkler piping to minimize interior pipe corrosion.
- 1.1.2 Approval criteria may include, but are not limited to, performance requirements, marking requirements, examination of manufacturing facility(ies), audit of quality assurance procedures, and a follow-up program.

1.2 Scope

- 1.2.1 This standard encompasses the design and performance requirements for nitrogen generators.
- 1.2.2 Nitrogen generators may use membranes or pressure swing adsorption as the nitrogen separation mechanism. Other technologies may be evaluated on a case-by-case basis. The use of nitrogen storage bottles or plant nitrogen is allowed by FM Global, but not in the scope of this standard.
- 1.2.3 Approval Standards are intended to verify that the product described will meet stated conditions of performance, safety and quality useful to the ends of property conservation.

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 nitrogen generators for the purpose of obtaining Approval. Nitrogen generators 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, nitrogen generators 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 Approval

Approval 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 by FM Approvals; and, as far as practical,
 - The durability and reliability of the product.
- 1.4.2 A first audit shall be conducted to evaluate the manufacturer's ability to consistently produce the product that was examined and tested as part of the Approval project. The audit shall review the facility and in-place quality control procedures used in the manufacturing of the product. Typically, areas of review are incoming inspection, work in progress, production testing, final quality control, marking, calibration of equipment, shipping procedures, and document and drawing control. These audits are repeated periodically for as long as the product remains FM Approved, as part of FM Approvals' Surveillance Audit program. (Refer to Section 5.2, Surveillance Audit Program.)

1.5 Basis for Continued Approval

- 1.5.1 Continued Approval is based upon:

- Production or availability of the product as currently FM Approved;
- The continued use of acceptable quality assurance procedures;
- Satisfactory field experience;
- Compliance with the terms stipulated in the Master Agreement;
- Satisfactory re-examination of production samples for continued conformity to requirements; and
- Satisfactory Surveillance Audits conducted as part of FM Approval's product surveillance audit program.

1.5.2 Also, as a condition of retaining Approval, manufacturers may not change an FM Approved product or service without prior authorization by FM Approvals. (Refer to Section 5.1.4 for further details regarding changes.)

1.6 Effective Date

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

The effective date of this Standard is the **Issue Date** 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. 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) SI10-2010, *American National Standard for Metric Practice*.

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 Applicable Documents

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

American Society of Mechanical Engineers (ASME) B16.5 - 2013, *Pipe Flanges and Flanged Fittings: NPS ½ through NPS24 Metric/Inch Standard*
American National Standards Institute (ANSI)/American Water Works Association (AWWA) C606 - 2011, *Grooved and Shouldered Joints*
ASME B1.20.1 - 2013, *Pipe Threads, General Purpose (Inch)*
ASME Boiler and Pressure Vessel Code - 2013, Section VIII, Division 1 – *Rules for Construction of Pressure Vessels*
FM Global Property Loss Prevention Data Sheet 2-0 - January 2014, *Installation Guidelines for Automatic Sprinklers*
IEEE/ASTM SI 10-10, *American National Standard for Metric Practice*
International Organization for Standardization (ISO)/International Electrotechnical Commission (IEC) 17025 - 2005, *General Requirements for the Competence of Testing and Calibration Laboratories*
National Fire Protection Association (NFPA) 13, 2013 Edition, *Standard for the Installation of Sprinkler Systems*
FM Global Property Loss Prevention Data Sheet 8-29, May 2007, *Refrigerated Storage*
SAE International J10-2013, *Automotive and Off-Highway Air Brake Reservoir Performance and Identification Requirements – Truck and Bus*
Code of Federal Regulations Title 49, Section 178.61 – *Specification 4BW welded steel cylinders with electric-arc welded longitudinal seam*

1.9 Definitions

Accepted

This term refers to installations acceptable to the authority enforcing the applicable installation rules. When the authority is FM Global, such locations are termed “FM Global Accepted.” Acceptance is based upon an overall evaluation of the installation. Factors other than the use of FM Approved equipment impact upon the decision whether to accept the product. Acceptance is not a characteristic of a product. It is installation specific. A product accepted for one installation may not be acceptable elsewhere. (Contrast with *FM Approved*.)

Air Pressure Maintenance Device

This term refers to a device that automatically maintains the air pressure within a dry pipe or pre-action sprinkler system within pre-set limits. These devices may also be used with pressurized nitrogen in a nitrogen filled system.

Bypass Mode

Most nitrogen generators can not produce enough nitrogen to completely fill the sprinkler system in 30 minutes. Therefore, they contain valves that allow the nitrogen separator to be bypassed so the system can be filled with compressed air. For the purposes of this standard the valve settings that bypass the nitrogen separator is called Bypass Mode. (Contrast with *Nitrogen Generating Mode*)

Control Panel

The control panel is the portion of the nitrogen generator that contains the controls. Minimum requirements for the control panel are found in Section 3.2.4.

Conditioning Equipment

For the purposes of this standard, conditioning equipment refers to all filters and other devices used to condition the compressed air before it enters the nitrogen separating mechanism.

End Connections

The term “End Connections” refers to the method of connecting components of a fire protection system. Typical end connections in fire protection service are flanged, grooved, threaded, and welding end.

FM Approvals Certification Marks

The FM Approvals Certification Marks are detailed in Appendix B. Their use is mandatory on all units of FM Approved products. These registered marks cannot be used except as authorized by FM Approvals via the granting of Approval to a specific product.

FM Approved

This term refers to products FM Approved by FM Approvals. Such products are listed in the *Approval Guide*, an on-line resource of FM Approvals (see Appendix D). All products so listed have been successfully examined by FM Approvals, and their manufacturers have signed and returned a Master Agreement to FM Approvals. This form 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 as-FM Approved configuration of the product without review by and agreement of FM Approvals. Approval is product specific.

Pressure Swing Adsorption (PSA)

A method of generating nitrogen using the process of adsorption by which a thin layer of molecules temporarily adheres to the surface of another material. A PSA nitrogen generator consists of two or more towers filled with

adsorbent material. Air is drawn into one tower and oxygen adheres to the adsorbent material. The remaining atmospheric gas, which is mostly nitrogen, passes through. The towers are cycled so that waste oxygen is being “cleaned” from one tower while the other is used to produce nitrogen, and the two are switched periodically.

Membrane nitrogen generator

A method of generating nitrogen using the process of passing compressed air through a membrane. Different gases have different rates of permeation and this can be used to separate nitrogen from the other atmospheric gases. The resulting product is mostly nitrogen.

Nitrogen Generating Mode

Most nitrogen generators can not produce enough nitrogen to completely fill the sprinkler system in 30 minutes. Therefore, they contain valves that allow the nitrogen separator to be bypassed so the system can be filled with compressed air. For the purposes of this standard, the valve settings that include the nitrogen separator is called ***Nitrogen Generating Mode***. (Contrast with ***Bypass Mode***)

Purging

Purging is defined as the removal of air/nitrogen from the sprinkler system via a purge valve. The purge valve allows some gas to escape from the system, which then requires the nitrogen generator to supply nitrogen to maintain system pressure. This process therefore increases the nitrogen concentration within the system piping over time. The purge valve and any associated controls are not within the scope of this standard. The control panel may, but is not required to, accept signals from an automatic purging valve/system.

Rated Working Pressure

This is the maximum sustained pressure at or below which the device shall operate trouble free for its entire design life. This value sets the basis for the testing described in Section 4. The rated working pressure will be different for different parts of the nitrogen generator. For example, the rated working pressure of the conditioning filters would be the maximum output of the compressor, but the rated working pressure of a valve downstream of the nitrogen separator may be lower due to pressure drops between it and the compressor.

Regeneration

The process where a portion of the air flow is used to regenerate one adsorption tower, preparing it to enter a new period of operation. At atmospheric pressure the bond between the oxygen and the adsorbent material is broken and the waste oxygen can be removed.

System Pressure

The maximum output pressure the system is rated for. This pressure is chosen by the manufacturer and listed in the *Approval Guide*, an on-line resource of FM Approvals.

Sprinkler System Capacity

This capacity is listed in the *Approval Guide*, an on-line resource of FM Approvals. The nitrogen generator must be capable of producing a minimum of this volume of compressed air at 40 psi (275 kPa) in 30 minutes in bypass mode and a minimum of this volume of nitrogen at atmospheric pressure in 24 hours in nitrogen generating mode.

2. GENERAL INFORMATION

2.1 Product Information

- 2.1.1 Nitrogen generators provide compressed nitrogen to dry pipe and preaction sprinkler systems. Replacing oxygen with nitrogen minimizes the corrosion in the sprinkler system.

- 2.1.2 In order to meet the intent of this standard, nitrogen generators must be examined on a model-by-model, type-by-type, manufacturer-by-manufacturer, and plant-by-plant basis. This is predicated on the basis that identical designs, fabricated using identical materials and components by different manufacturers, or even by different plants of the same manufacturer, have been seen to perform differently in testing. Sample assemblies, selected in conformance to this criterion, shall satisfy all of the requirements of this standard.

2.2 Approval Application Requirements

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

Manager of Fire Protection
FM Approvals Hydraulics Laboratory
743A Reynolds Road
West Glocester, RI 02814
U.S.A.

- 2.2.2 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 or services being submitted for Approval consideration;
- General assembly drawings, complete set of manufacturing drawings, materials list, anticipated marking format, piping and electrical schematics, nameplate format, brochures, sales literature, spec. sheets, installation, operation and maintenance procedures; and
- The number and location of manufacturing facilities.

- 2.2.3 All the above referenced documents shall be controlled by the manufacturer's Quality Assurance procedures, and shall identify:

- the manufacturer's name
- document number or other form of reference
- title
- date of last revision and/or revision level

All foreign language documents shall be provided with English translation.

2.3 Requirements for Samples for Examination

- 2.3.1 Following authorization of an Approval examination, the manufacturer shall submit samples for examination and testing. Sample requirements are determined by FM Approvals following review of the preliminary information.
- 2.3.2 Requirements for samples may vary depending on design features and/or results of prior or similar testing.
- 2.3.3 The manufacturer shall submit samples representative of production. Any decision to use data generated using prototypes is at the discretion of FM Approvals.

3. GENERAL REQUIREMENTS

3.1 Review of Documentation

- 3.1.1 During the initial investigation and prior to physical testing, the manufacturer's specifications, technical data sheets, and design details shall be reviewed to assess the ease and practicality of installation and use. The product shall be capable of being used within the limits of the Approval investigation.
- 3.1.2 The manufacturer's dimensional specifications and/or dimensional drawings shall fully describe the product. All critical dimensions shall be indicated with the allowed upper and lower tolerance limits clearly shown.
- 3.1.3 All documents pertaining to the product materials, dimensions, processing, and marking shall be controlled by the manufacturer's Quality Assurance procedures, and shall identify the manufacturer's name, document number or other form of reference, title, date of last revision, and revision level. All foreign language documents shall be provided with English translation.

3.2 Physical or Structural Features

- 3.2.1 Nitrogen generators supply compressed nitrogen to an air maintenance device. They shall be compatible with the piping and threads of the country of installation.
- 3.2.2 Nitrogen generators submitted for testing shall be true production samples and shall be free of sharp edges, burrs, or other imperfections which might injure the installer or interfere with proper assembly of the unit.
- 3.2.3 Nitrogen generators generally contain four main parts: a control panel, an air compressor (may be supplied by others), a compressed gas storage tank, and a nitrogen separating mechanism. Two common types of nitrogen separation are membrane separation and pressure swing adsorption.
- 3.2.4 The control panel shall be a metal enclosure containing all equipment necessary to control the nitrogen separator. The panel shall include a run time meter, and a storage tank pressure gauge or pressure gauge for other critical systems.
- 3.2.5 The separating mechanism shall have easily changed water separators, pre-filters, adsorption material and/or membrane. Other components needing regular service shall be readily accessible.
- 3.2.6 Typical end connections are cut grooved in accordance with ANSI/AWWA C606, threaded in accordance with ASME B1.20.1, or flanged in accordance with ASME B16.5. Other types of end connections may be evaluated on a case-by-case basis, provided such ends are compatible with the requirements of FM Global Property Loss Prevention Data Sheet 2-0, "Installation Guidelines for Automatic Sprinklers".
- 3.2.7 Pressure Vessels (Storage Tanks and Adsorption Towers)
- 3.2.7.1 Pressure vessels utilized in nitrogen generators shall conform to the appropriate regulations and design standards for the installation location. They shall be new vessels, cleaned and dried, and have safety relief valves as required by the design standards for the installation location. In the U.S.A., pressure vessels must typically conform to the following regulations:
- ASME Boiler & Pressure Vessel Code, Section VIII, Division 1 – "*Rules for Construction of Pressure Vessels*" or SAE International J10-2013, *Automotive and Off-Highway Air Brake Reservoir Performance and Identification Requirements – Truck and Bus* or Code of Federal Regulations Title 49, Section 178.61 – *Specification 4BW welded steel cylinders with electric-arc welded longitudinal seam*
- 3.2.7.2 Samples of the following documents shall be submitted for each size pressure vessel design, to demonstrate compliance with the relevant design standard:

- Calculation of wall thicknesses in accordance with the method specified in the design standard, with appropriate supporting references, as necessary
- Certificate of chemical analysis of materials
- Certificate of physical properties of materials

3.3 Materials

All materials used in these nitrogen generators shall be suitable for the intended application. Parts exposed to moist compressed air shall be constructed of corrosion resistant materials. When unusual materials are used, special tests may be necessary to verify their suitability. All components shall withstand the normal abuse of shipping, handling, and installation.

3.4 Conditioning of Compressed Air

The nitrogen generator shall contain sufficient equipment to condition the air produced by the compressor in order to protect the nitrogen separating mechanism. The air shall be conditioned to the membrane or adsorption media manufacturer's specifications. This typically includes a prefilter, a coalescing filter, and a particle filter with water removal. Coalescing filters and filters with water removal shall have provisions for piping the water to a drain fitting on the nitrogen generator.

The conditioning should be designed to accommodate air intake conditions typically found in sprinkler rooms (high humidity, minor levels of dust, etc).

3.5 Bypass Mode Operation

The nitrogen generator shall be equipped with a mechanism to prevent it being left in bypass mode accidentally. This may be an interlock so that bypass mode can't be engaged with the control panel door closed, a visual indication with a minimum of 2" (50mm) diameter flashing light or an audible alarm with a minimum of 75dB if the system is in bypass, or an automatic system to switch from bypass to nitrogen generating mode after 1 hour. Other methods may be allowed at the discretion of FM Approvals.

3.6 Markings

- 3.6.1 All FM Approved nitrogen generators devices shall bear the FM Approvals Certification Mark (see Appendix B). The FM Approvals Certification Mark shall be displayed visibly and permanently on the product. The manufacturer shall not use this Mark on any other product unless such product is covered by separate agreement with FM Approvals.
- 3.6.2 Each nitrogen generator discussed in this Standard shall be permanently marked with the following information:
- Manufacturer's name or trademark
 - Model designation
 - Sprinkler System capacity
 - Electrical input voltage/phase/Hz
 - Date of manufacture or serial number
 - The FM Approvals Certification Mark
- 3.6.3 Additional pertinent marking information required by a national or international Standard to which the product is manufactured shall be permanently marked on the outside surface of each assembly.
- 3.6.4 Each required marking listed in Section 3.6.2 shall be legible, durable, and applied by casting, die stamping, forging, roller embossing and/or electro-etching. As an alternate method, the markings may be inscribed on a label or tag applied to the assembly that has been shown to be durable and non-fading.

3.6.5 The model or type identification shall correspond with 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.

3.6.6 All markings shall be legible and durable throughout the useful life of the product.

3.7 Manufacturer's Installation and Operation Instructions

3.7.1 The manufacturer shall provide the user with:

- Instructions for the installation, maintenance, and operation of the product
- Adequate facilities for repair of the product and replacement parts
- The manufacturer (or his designee) shall be able to provide, for a fee, proper installation, inspection and/or maintenance of the product

3.7.2 The instruction manual that is supplied with each unit shall outline in detail the field procedures for installing and repairing the units. The manual shall be reviewed by FM Approvals for completeness and ease of comprehension prior to testing.

3.7.3 The manual should include instructions for system start up including purging and how nitrogen concentration should be monitor/measured at the purge valve/orifice.

3.7.4 The manual shall include instructions and frequency for conditioning equipment maintenance. Conditioning equipment shall be designed so that no more than annual maintenance is required under typical sprinkler room conditions.

3.7.5 The manual shall include instructions and frequency for other maintenance of the equipment contained in the nitrogen generator (lubrication, filter changes, oil changes, etc).

3.7.6 The manual shall include instructions for maintaining the separator mechanism, including ordering information for replacement membrane cartridges or adsorption material. The manual shall include the proper replacement interval for membrane cartridges or adsorption material.

3.7.7 If the nitrogen generator is not supplied with a compressor, the manual shall contain the requirements for compressed air including air quality, minimum pressure and volume that must be supplied to the nitrogen generator.

3.8 Calibration

All equipment used to verify the test parameters for tests described in Section 4 shall be calibrated within an interval determined on the basis of stability, purpose, and usage of equipment. A copy of the calibration certificate for each piece of test equipment is required for FM Approvals' records, indicating that the calibration was performed against working standards whose calibration is certified as traceable to the National Institute of Standards and Technology (NIST) or to other acceptable reference standards and certified by a ISO/IEC 17025 calibration laboratory. The test equipment shall be clearly identified by a label or sticker showing the last date of the calibration and the next due date. A copy of the service accreditation certificate as an ISO 17025 "*General Requirements for the Competence of Testing and Calibration Laboratories*", 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 the testing must be within an interval that does not require the equipment to be recalibrated.

3.9 Tolerances

Tolerances on units of measure for tests described in Section 4 shall be as described in Appendix C, unless otherwise specified.

4. PERFORMANCE REQUIREMENTS

4.1 Examination

4.1.1 Requirement

The nitrogen generators shall conform to the manufacturer's drawings and specifications and to FM Approval requirements.

4.1.2 Test/Verification

Sample nitrogen generators shall be examined and compared to drawings and specifications. It shall be verified that the samples conform to the physical and structural requirements described in Section 3, General Requirements.

4.2 Bypass Mode Capacity

4.2.1 Requirement

Sprinkler System capacity listed in the *Approval Guide*, an on-line resource of FM Approvals shall be the amount of compressed air at 40 psi that can be produced in 30 minutes in bypass mode. This capacity shall be listed in the *Approval Guide* as an equivalent volume of the sprinkler system (in gallons/liters).

4.2.2 Test/Verification

Start and run the nitrogen generator in bypass mode. Connect the output of the generator to a pressure vessel with a volume of at least 10 percent of the sprinkler system capacity. Record initial pressure in the vessel (atmospheric pressure) and measure the time to increase the pressure in the vessel to 40 psi (275 kPa).

This test shall be recorded as successful if the time (in minutes) to increase the pressure in the vessel, T_{meas} is less than T_{req} in the following formula:

$$T_{req} = 30 \times (\text{Volume of pressure vessel}) / (\text{Sprinkler System Capacity})$$

4.3 Nitrogen Generation Capacity

4.3.1 Requirement

The unit shall be capable of producing nitrogen at a concentration of at least 98%. The volume of nitrogen generated in 24 hours shall be equal to or greater than the sprinkler system capacity listed in the *Approval Guide*.

4.3.2 Test/ Verification

The nitrogen generator shall be placed in an environmental chamber at 77°F (25°C) and 50% relative humidity. The unit shall draw supply air from this chamber. The output of the nitrogen generator shall be independently vented to outside the chamber.

Start and run the nitrogen generator and pipe the output through a flow meter to atmosphere. Allow the system to stabilize by running for a minimum of 1 minute. After the stabilization period, measure the output flow, concentration of nitrogen in the output stream and pressure. Record the flow for a minimum of 10 minutes. The nitrogen concentration shall be a minimum of 98% for the entire duration of the test.

Calculate the volume of 98% nitrogen generated and compare this volume to the manufacturer's stated sprinkler system capacity of the unit. This test shall be recorded as successful if the unit produces sufficient nitrogen at a minimum of 98% purity to fill the stated capacity in 24 hours or less.

$$F \cdot 1440 \geq \text{System Volume}$$

Where:

F = flow/minute during test

1440 = number of minutes in 1 day

System Volume = manufacturer's stated sprinkler system capacity to be listed in the Approval Guide

4.4 Service Assessment

4.4.1 Requirement

Using the manufacturer's instructions, perform periodic parts replacement and/or maintenance procedures on typical portions of the device, using spare parts supplied by the manufacturer. Maintenance shall be possible without specialized training and using only commercially available tools or tools supplied with the unit.

4.4.2 Test/ Verification

Check safety valves, replace membrane/adsorbent material, replace filters, and service other parts of the nitrogen generator, using the manufacturer's supplied instructions. Oil changes are not deemed to be a necessary portion of this program. All components requiring periodic replacement and/or maintenance shall be changed or installed satisfactorily, in accordance with the supplied instructions.

4.5 Pressure Integrity

4.5.1 Requirement

The components of the nitrogen generator shall withstand pressure equal to or greater than two times the design pressure of that portion of the nitrogen generator for a period of 5 minutes without leakage or rupture. Components may be tested individually or in subassemblies of like pressure rating. Safety relief valves and other relief mechanisms may be removed prior to this test if necessary.

4.5.2 Test/Verification

The components of one sample of each type of nitrogen generator shall be subjected to a pressure integrity test. Test pressure for each component or test assembly of components shall be two times the design pressure of that portion of the nitrogen generator. Gaskets and seals may be reinforced if necessary during this test. Pressure relief valves and materials may be removed for this test. Pressure shall be maintained for 5 minutes without leakage or rupture. Tests may be conducted with either air or water.

4.6 System Durability

4.6.1 Requirement

The entire nitrogen generator shall be designed to operate reliably while generating a nitrogen volume of 25 times the sprinkler system capacity without maintenance.

4.6.2 Test/Verification

Connect the output of the generator to a regulator and then a pressure vessel with a volume of at least 10 percent of the sprinkler system capacity. Set the regulator to 40 psi (275 kPa). Nitrogen shall be discharged from the pressure vessel through a solenoid valve. The solenoid valve shall be cycled so that the Nitrogen Generator compressor runs approximately 50% of the time, with the duration of the cycles acceptable to the manufacturer.

The system shall be run until the total volume of nitrogen generated reaches 25 times the sprinkler system capacity. At the conclusion of this test, no mechanical failure, nor any appreciable change in operating characteristics of the air compressor section or the nitrogen separator section, shall have occurred. The system shall still generator 98% nitrogen.

4.7 Control Panel Cycling (dual tower systems only)

4.7.1 Requirement

The control panel shall be designed to operate reliably for 25,000 cycles.

4.7.2 Test/Verification

A sample device shall be subjected to 25,000 cycles of operation, not including the compressor and electric motor. Inlet pressure to the nitrogen separating section shall be supplied by the laboratory air supply. The control panel shall be supplied with AC power to the control circuitry to simulate a continuously running motor. Outlet pressure piping shall be vented through a solenoid. Outlet pressure shall be set to the system pressure. Nitrogen shall be discharged through the solenoid valve for 30 seconds, and then held for 30 seconds. This shall be considered one cycle. At the conclusion of this test, no mechanical failure, nor any appreciable change in operating characteristics of the air compressor section or the nitrogen separator section, shall have occurred.

4.8 Dielectric Strength

4.8.1 Requirement

Electrical components shall withstand application of twice their rated voltage plus 1000 volts between all terminals provided for external connections and ground for a duration of 1 minute.

4.8.2 Test/Verification

Voltage shall be applied between each terminal and ground. Components subjected to the Dielectric Strength test shall continue to function normally after the test.

This test may be waived at the FM Approvals engineer's discretion if there are no significant electrical components in the unit.

4.9 Additional Tests

Additional tests may be required, depending on design features, results of any tests, or to verify the integrity and reliability of the nitrogen generator, at the discretion of FM Approvals.

Unexplainable failures shall not be permitted. A re-test shall only be acceptable at the discretion of FM Approvals and with adequate technical justification of the conditions and reasons for failure.

5. OPERATIONS REQUIREMENTS

A quality control program shall assure that subsequent nitrogen generators produced by the manufacturer at an authorized location, demonstrate the same quality and reliability as the specific nitrogen generators examined. Design quality, conformance to design, and performance are the areas of primary concern. Design quality is determined during the Approval examination and tests, and is covered in the Approval Report. Conformance to design is verified by control of quality and is covered in the Surveillance Audit Program. Quality of performance is determined by field performances and by periodic re-examination and testing.

5.1 Demonstrated Quality Control Program

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

- 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
- Handling and disposition of non-conforming materials

5.1.2 Documentation/Manual

There shall be an authoritative collection of procedures and policies. Such documentation shall provide an accurate description of the quality management system while serving as a permanent reference for implementation and maintenance of that system. The system shall 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 on each nitrogen generator, and their results, 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 does not allow unauthorized changes to the product. Revisions to critical documents, identified in the Approval Report, must be reported to, and authorized by, FM Approvals prior to implementation for production. The manufacturer shall assign an appropriate person or group to be responsible for reporting proposed revisions to FM Approved products to FM Approvals before implementation. In situations involving significant modifications to an Approved product, the notification shall be in the form of a formal request for an Approval examination. For modifications of a more common nature, the manufacturer shall provide notification to FM Approvals by means of FM Approvals Form 797, *FM Approved Product/Specification-Tested Revision Request Form*. Records of all revisions to all FM Approved products shall be maintained.

5.1.4.1 The table below has been included as a guide to manufacturers of FM Approvals considers to be a significant change. The table is not all-inclusive. As mentioned above, modifications that fit this category should be documented by means of a letter stating the change, and requesting a quotation for an Approval examination.

<i>Modification</i>	<i>Description/Example</i>
Increase of Pressure Rating	The product was originally FM Approved for 175 psi (1205 kPa), and now is to be evaluated to 300 psi (2070 kPa).
Addition of Product Sizes	The product was originally FM Approved for 500 gallon capacity, and now Approval at a capacity of 750 gallons is desired.
Additional or Relocation of the Manufacturing Location	The product was originally FM Approved as manufactured in location A, and now is desired to be made in locations A and B, or only in location B.
Major Changes to Critical Dimensions or Components	Modifications that would depart from the national or international standards that are used in the manufacturing of the product as originally FM Approved.
	Modifications that may affect the results of earlier satisfactory testing of the nitrogen generator such as a change in the membrane or electric motor.

5.1.4.2 The listing below has been included as a guide to manufacturers of modifications that are commonly submitted on FM Approvals Form 797.

<i>Modification</i>	<i>Description / Example</i>
Change in Company Contact Information:	Company Name, Company Office Address, Company Contact and Title, Phone Number, Fax Number, Email Address.
Updating of Drawings:	Form 797 is used to notify FM Approvals in the event of: minor dimensional changes to non-critical features, minor changes in notes, relocation of title block, re-creation of the same drawing on CAD, etc.
Changes in Markings:	Proposed changes should include a drawing of the proposed marking.
Changes in Materials:	Where new material is either superior, or comparable, to material used in original Approval
Updating of Documentation:	Creation of new, or revisions to existing, sales literature, Installation Instructions, Quality Manual, etc.

5.1.4.3 In instances where the modification is difficult to categorize, manufacturers are encouraged to contact FM Approvals to discuss the nature of the change, and to inquire about how to send the information to FM Approvals for further review. The examples shown in Sections 5.1.4.1 and 5.1.4.2 are based on common examples of modifications as they relate to the manufacture of nitrogen generators.

5.2 Surveillance Audit Program

- 5.2.1 An audit of the manufacturing facility is part of the Approval investigation to verify implementation of the quality control program. Its purpose is to ensure that the manufacturer's equipment, procedures, and quality program are maintained to produce a consistently uniform and reliable product. Initial inspections of facilities already producing similar products may be waived at the discretion of FM Approvals.
- 5.2.2 Surveillance audits shall be conducted periodically, but at least annually, by FM Approvals or its representatives or more frequently depending on jurisdictional requirements. At issue of this standard, the Occupational and Safety Health Administration (OSHA) of the United States Department of Labor requires audits of manufacturing sites producing products for use in hazardous locations during each quarter the product is manufactured.
- 5.2.3 The client shall manufacture the FM Approved product or service only at the location(s) audited by FM Approvals and as specified in the Approval Report. Manufacture of products bearing the FM Approvals Certification Mark is not permitted at any other locations without prior written authorization by FM Approvals.

- 5.2.4 In the event that all or part of the quality inspection is subcontracted, the manufacturer shall provide FM Approvals with documentation outlining the nature of the inspection, frequency, test details, and pass/fail criteria that was provided to the subcontracted company, and documentation that they have received and implemented these procedures.

5.4 Manufacturing and Production Tests

- 5.4.1 All documents pertaining to the product materials, dimensions, processing, and marking shall be controlled by the manufacturer's Quality Assurance procedures, and shall identify the manufacturer's name, document number or other form of reference, title, date of last revision, and revision level.
- 5.4.2 The manufacturer shall perform production testing for 100 percent of control panels used on nitrogen generators that have the FM Approvals certification mark. The production test shall verify the operation of all switches, lights, and alarms.
- 5.4.3 The manufacturer shall perform leak testing on 100 percent of production of nitrogen generators that have the FM Approval certification mark. The production leak test shall ensure that the connections in the assembly are leak free when subjected to the rated working pressure.
- 5.4.4 The manufacturer shall have a controlled procedure on file for conducting the above manufacturing and production tests, calibration records for the equipment used, and a disposition procedure for the rejected materials

APPENDIX A: Units of Measurement

LENGTH: in. - “inches”; (mm - “millimeters”)
mm = in. x 25.4

ft - “feet”; (m - “meters”)
m = ft x 0.3048

AREA: in.² - “square inches”; (mm² - “square millimeters”)
mm² = in.² x 6.4516 x 10⁻²

ft² - “square feet”; (m² - “square meters”)
m² = ft² x 0.0929

MASS: lb - “pounds”; (kg - “kilograms”)
kg = lb x 0.454

PRESSURE: psi - “pounds per square inch”; (bar - “bar”)
kPa = psi x 6.895

bar - “bar”; (kPa - “kilopascals”)
bar = kPa x 0.01
bar = psi x 0.06895

TEMPERATURE: F - “degrees Fahrenheit”; (C - “degrees Celsius”)
C = (F - 32) x 0.556

LIQUID: gal. - “gallons”; (L - “liters”)
L = gal. x 3.785

L - “liters”; (dm³ - “cubic decimeters”)
L = dm³

FLOW RATE: gal./min. - “gallons per minute”; (L/min. - “liters per minute”)
L/min. = gal./min. x 3.785

FLOW VELOCITY: ft/s - “feet per second”; (m/s - “meters per second”)
m/s = ft/s x 0.3048

HUMIDITY: % = percent

DEW POINT: F - “degrees Fahrenheit”; (C - “degrees Celsius”)
C = (F - 32) x 0.556

APPENDIX B: FM APPROVALS CERTIFICATION MARKS



FM APPROVED mark:

Authorized by FM Approvals as a certification mark for any product that has been FM Approved. There is no minimum size requirement for the mark, but it must be large enough to be readily identifiable and shall be permanent. The mark should be produced in black on a light background, or in reverse on a dark background.



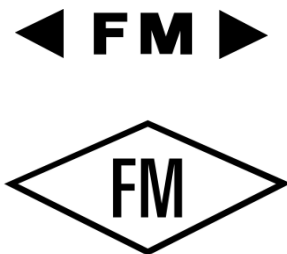
FM APPROVED Mark with “C” only:

Authorized by FM Approvals as a certification mark for any product that has been evaluated by FM Approvals in accordance with Canada codes and standards. There is no minimum size requirement for the mark, but it must be large enough to be readily identifiable and shall be permanent. The mark should be produced in black on a light background, or in reverse on a dark background.



FM APPROVED mark with “C” and “US”:

Authorized by FM Approvals as a certification mark for any product that has been evaluated by FM Approvals in accordance with Canada and US codes and standards. There is no minimum size requirement for the mark, but it must be large enough to be readily identifiable and shall be permanent. The mark should be produced in black on a light background, or in reverse on a dark background.



Cast-On APPROVED marks:

Where reproduction of the FM APPROVED mark described above is impossible because of production restrictions, use these modified versions of the FM APPROVED mark. There is no minimum size requirement for the mark, but it must be large enough to be readily identifiable and shall be permanent.

Downloadable art and other FM Approvals resources are available by visiting our website at fmapprovals.com.

FM Approvals Certification Marks

Usage Guidelines

- All FM Approvals certification marks are the sole property of FM Approvals LLC (“FM Approvals”) and are registered or the subject of applications for registration in the United States and many other countries. They are for use only according to these guidelines.

Who May Use FM Approvals Certification Marks

- The use of the term “FM Approved” or use of the trademark certification logo shall not be used by any company without a valid relationship with FM Approvals.
- FM Approvals certification marks shall be used only on FM Approved products in accordance with the product listing requirements.
- FM Approvals customers often have legitimate FM Approval for products being advertised and sold by others, including online trading platforms, drop-ship companies, web-based advertisers, distributors, suppliers and other legitimate business entities. The FM Approvals customer may not transfer the right to use FM Approvals certification marks or the use of the term “FM Approved” when dealing with any advertisers or marketers of these products.
- In order for the advertiser or marketer to depict the FM Approvals certification mark, the FM Approvals customer (owner) must be clearly identified in the advertisement or marketing literature. Otherwise, a Private Labeler Agreement (PLA) must exist among the two parties and FM Approvals..

Use of FM Approvals Certification Marks on Packaging/Marketing Materials

- FM Approvals certification marks shall appear on all products or packaging materials of FM Approved products in accordance with the FM Approval requirements for those products. Any similar products that are not marketed as FM Approved shall be uniquely identified and distinctive from the FM Approved product(s).
- FM Approvals certification marks are strictly limited to use in association with those products that have attained FM Approval. Use of FM Approvals certification marks in advertisements, catalogs, news releases, websites or email marketing is not a substitute for use of the complete FM Approvals certification mark on FM Approved products and/or product packaging. When an FM Approvals certification mark is used in advertising material, website display, electronic imaging, and quick reader scanner code or on product packaging, all material must reflect the specific circumstances under which the product was FM Approved. The material must clearly differentiate between products that are FM Approved and those that are not, and may not, in any way, imply a more substantial relationship with FM Approvals.

Invalid Use of FM Approvals Certification Marks

- No FM Approvals certification mark or aspect thereof may be incorporated as part of a business name, Internet domain name, or brand name/trademark for products/product lines. This includes both design aspects (the FM Approvals “diamond”, etc.) and word aspects (“FM,” “FM Approved,” etc.) The use of any FM Approvals certification mark as a trademark is strictly prohibited.
- The Approval Standard number or class number may not be incorporated as part of a business name, Internet domain name or brand name/trademark for products/product lines. For example, a company may not say “ABC Company’s 4100 Fire Door is FM Approved”; the proper terminology is, “ABC Company’s Fire Door is FM Approved per Approval Standard 4100.”

FM Approvals Certification Marks

- FM Approvals certification marks, except for the FM Approvals Quality System Registration mark, may not be used on business stationery/cards/signage, because this could mischaracterize the relationship with FM Approvals. Additionally, these items should not reference any FM Approvals certification mark.
- FM Approvals certification marks may not be used in a ‘general’ context on websites or other online trading platforms. The certification mark must be used in conjunction with the actual product which is FM Approved and if being advertised by an entity other than the Original Equipment Manufacturer (OEM) the FM Approved manufacturer’s name must be evident.
- Products or services may not be marketed under any mark or name similar to “FM Global,” “FM Approvals” or any of the FM Approvals certification marks. Further, products or services may not be marketed to imply a relationship beyond the scope of any Approval made by FM Approvals.
- A company may not reference the intent to submit a product for Approval or the expectation that a company will have a certain product FM Approved in the future. For example, a company may not state “Approval by FM Approvals pending” or “Approval by FM Approvals applied for.”
- FM Approvals certification marks should not be preceded or followed by a qualifier that indicates a degree of certification or acceptability. For example, “exceeds,” “first” or “only” may not be used to qualify any FM Approvals certification mark.

Proper Appearance of FM Approvals Certification Marks

- Only original artwork issued by FM Approvals should be used. The FM Approvals certification marks should not be altered in any way other than to resize the artwork proportionately. Unacceptable uses of the marks include, but are not limited to, adding/deleting wording or artwork, reducing the artwork to an illegible size, animation or distortion.
- The text of the FM Approvals certification marks may not be translated into any language other than English.
- FM Approvals certification marks must appear in a size and location that is readily identifiable, but less prominent than the name of the owner of the certification or manufacturer/seller/distributor of the certified products.

Examples of Misuse of FM Approvals Brand Identity

- Factory Mutual Approved;
- FM Global Approved;
- Factory Mutual Research Corporation tested and certified;
- Third party tested by FM;
- Accepted for use by FM Global;
- Approved for use in Factory Mutual insured facilities;
- Factory Mutual System Approved

APPENDIX C: Testing Tolerances

Unless otherwise stated, the following tolerances shall apply:

Angle	$\pm 2^\circ$
Frequency (Hz)	± 5 percent of value
Length	± 2 percent of value
Volume	± 1 percent of value
Pressure	± 0.1 psi (690 Pa)
Air Flow	± 1 percent of value
Dew Point	± 1 percent of value
Nitrogen Percentage	- 0.1 percent
Humidity	± 2 percent of value
Temperature	$\pm 2^\circ\text{F}$ (1°C)
Time	+ 5/-0 seconds
	+0.1/-0 minutes

Unless stated otherwise, all tests shall be carried out at a room (ambient) temperature of $68 \pm 9^\circ\text{F}$ ($20 \pm 5^\circ\text{C}$).

APPENDIX D: Sample Listings

Nitrogen generators

Fire Protection / Automatic Sprinkler Systems / Nitrogen generators

These devices are intended for use in dry sprinkler system applications. Each unit, in conjunction with an FM Approved air maintenance device, provides nitrogen to lower the possibility of corrosion in a sprinkler system.

Sprinkler System capacity listed below is the volume of 98% nitrogen at 40 psi (275kPa) the system can generate in 24 hours. This volume has been converted to gallons (liters) to allow it to be compared to the sprinkler system volume.

The system is also required to supply sufficient volume of compressed air (in Bypass Mode) to increase the sprinkler system pressure from atmospheric to 40 psi (275 kPa) in 30 minutes.

BDW Co., Inc, 4321 E West Ave, Coventry RI 02816

Product Designation	Outlet Pipe Connection Size, NPS (DN)	Sprinkler System Capacity, gallon (liter)	Maximum Output Pressure, psi (kPa)
Figure 101	$\frac{3}{4}$ (20)	250 gal (950 L)	50 psi (345 kPa)
Figure 102	1 (25)	500 gal (1890 L)	50 psi (345 kPa)
Figure 102	1 (25)	800 gal (3030 L)	50 psi (345 kPa)