



*Member of the FM Global Group*

# **Approval Standard for Vacuum and Pressure Gauges for Fire Protection Systems**

**Class Number 2311**

**April 2008**

---

# 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 periodic follow-up 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.

---

# Table of Contents

<b>1. INTRODUCTION.....</b>	<b>1</b>
1.1 Purpose.....	1
1.2 Scope.....	1
1.3 Basis for Requirements.....	1
1.4 Basis for Approval.....	1
1.5 Basis for Continued Approval.....	2
1.6 Effective Date.....	2
1.7 System of Units.....	2
1.8 Applicable Documents.....	2
1.9 Definitions.....	3
<b>2. GENERAL INFORMATION.....</b>	<b>5</b>
2.1 Product Information.....	5
2.2 Approval Application Requirements.....	5
2.3 Requirements for Samples for Examination.....	5
<b>3. GENERAL REQUIREMENTS.....</b>	<b>6</b>
3.1 Review of Documentation.....	6
3.2 Physical or Structural Features.....	6
3.3 Materials.....	7
3.4 Markings.....	7
3.5 Manufacturer's Installation and Operation Instructions.....	8
3.6 Calibration.....	8
3.7 Tolerances.....	8
<b>4. PERFORMANCE REQUIREMENTS.....</b>	<b>9</b>
4.1 Examination.....	9
4.2 Overpressure.....	9
4.3 Accuracy/Hysteresis.....	9
4.4 Readability.....	10
4.5 Cycling Pressure Endurance.....	10
4.6 Moisture Exposure.....	10
4.7 Hydrostatic Strength/Rupture.....	11
4.8 Vibration.....	11
Table 4.8.2 Vibration Conditions.....	12
4.9 Salt Spray Exposure.....	12
4.10 Additional Tests.....	12
<b>5. OPERATIONS REQUIREMENTS.....</b>	<b>13</b>
5.1 Demonstrated Quality Control Program.....	13
5.2 Facilities and Procedures Audit (F&PA).....	14
5.3 Manufacturer's Responsibilities.....	15
5.4 Manufacturing and Production Tests.....	15
5.4.1 Cycle Test.....	15
5.4.2 Accuracy.....	15
<b>APPENDIX A: Units of Measurement.....</b>	<b>16</b>
<b>APPENDIX B: FM Approvals Certification Marks.....</b>	<b>17</b>
<b>APPENDIX C: Tolerance.....</b>	<b>19</b>
<b>APPENDIX D: Sample Listing.....</b>	<b>20</b>

## 1. INTRODUCTION

### 1.1 Purpose

- 1.1.1 This standard states FM Approvals criteria for water and air vacuum and pressure gauges for use in fire protection systems. Compound pressure gauges may be used in the suction line of fire pump packages. They shall be of the single needle, direct-reading, elastic element style. Positive pressure gauges may be used in sprinkler systems, in a variety of locations.
- 1.1.2 FM Approvals 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 of pressure gauges with nominal case sizes of 3-1/2, 4, or 4-1/2 inch (90, 102, or 115 mm) diameter. The minimum case size shall be 3-1/2 in. (90 mm). Other, larger sizes may be evaluated on a case-by-case basis. In cases where metric sized pressure gauges are to be examined for Approval, test criteria comparable to the United States equivalent size shall be used. Throughout this Standard, the term "pressure gauge" shall mean "vacuum and pressure gauge". The gauges may be of the vacuum type, positive pressure type, or compound type.
- 1.2.2 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 pressure gauges for the purpose of obtaining Approval. Pressure gauges 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, pressure gauges 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 An initial facilities and procedures 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 examinations are repeated periodically as part of the FM Approvals product follow-up program. (Refer to Section 5.2, Facility and Procedures Audit.)

## 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 Facilities and Procedures Audits (F&PAs) conducted as part of FM Approvals' Product Follow-up Program.

- 1.5.2 Also, as a condition of retaining Approval, manufacturers may not change an FM Approved product or service without prior written authorization by FM Approvals. (Refer to Section 5.1.3 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 forfeit Approval.

The effective date of this standard is **April 30, 2009** 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) SI 10-2002, *"American National Standard for Use of the International System of Units (SI): The Modern Metric System."*

## 1.8 Applicable Documents

The following standards, test methods, and practices are referenced in this standard or beneficial in understanding this standard.

ANSI/American Society of Mechanical Engineers (ASME) B1.20.1 - 1983 (R2001), *Pipe Threads, General Purpose (Inch)*

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

ASME B40.100 - 2005, *Pressure Gauges and Gauge Attachments*

ASTM B-117 – 2003, *Practice for Operating Salt Spray (Fog) Apparatus*

FM Global Property Loss Prevention Data Sheets  
International Electrotechnical Commission (IEC) 60529 - January 2003, *Degrees of Protection Provided By Enclosures (IP Code)*  
International Standards Organization (ISO) 17025 – 1999, *General Requirements for the Competence of Testing and Calibration Laboratories*  
National Electrical Manufacturers Association (NEMA) Standards Publication 250-2007, *Enclosures for Electrical Equipment (1000 Volts Maximum)*  
National Fire Protection Association (NFPA) 13 – 2007, *Standard for the Installation of Sprinkler Systems*  
NFPA 14 - 2003, *Standard for the Installation of Standpipe and Hose Systems*  
NFPA 20 - 2007, *Standard for the Installation of Stationary Pumps for Fire Protection*  
NFPA 24 - 2002, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*  
NFPA 750-2006, *Water Mist Fire Protection Systems*

## 1.9 Definitions

For purposes of this standard, the following terms apply:

### ***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 to accept, or not to accept. Acceptance is not a characteristic of a product. A product accepted for one installation may not be acceptable elsewhere. (Contrast with FM Approved.)

### ***Back Connected***

The tapped connection for pressure input into the gauge extends out of the back of the gauge case.

### ***Bottomed Connected***

The tapped connection for pressure input into the gauge extends out of the bottom of the gauge case.

### ***Compound Gauge***

A gauge that indicates both positive and negative gauge pressures. The gauge will have two pressure ranges, such as -15 to 0 psi vacuum plus 0 - 150 psi positive pressure in the same instrument. The zero point of the gauge range will not be at the zero point of the dial.

### ***Drag Pointer***

An indicator, painted in a contrasting color, which follows the standard pointer up-scale, and stops at the maximum pressure reached during that pressure cycle. The drag pointer can be manually reset by a knob that protrudes through the center of the dial window. The drag pointer will be permitted as an option, only if it does not affect accuracy and hysteresis of the gauge on which it is installed. Not suitable for liquid-filled gauges.

### ***FM Approvals Certification Marks***

The FM Approvals Certification Marks are detailed in Appendix B. Their use is mandatory on all units of FM Approved pressure gauges. 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, a publication of FM Approvals. All products so listed have been successfully examined by FM Approvals, and their manufacturers have signed and returned a Master Agreement to FM Approvals. These forms obligate the manufacturer to allow re-examination of the product and audit of facilities and procedures at FM Approval’s 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.

**Face Plate**

The component that contains the scale, graduations, and units of measure. Also referred to as a dial.

**Graduations**

The individual division marks on the scale that indicate pressure magnitude.

**Hydrostatic Dead Weight Tester**

A test apparatus that is capable of applying a hydrostatic pressure of a specified magnitude to the test sample at a controlled rate. The applied pressure is known to great accuracy.

**Master Gauge**

A gauge that has significantly better accuracy than the gauge being tested. This gauge shall be calibrated 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.

**NEMA 4 Enclosure**

NEMA 4 enclosures are intended for indoor or outdoor use. A NEMA 4 enclosure is designed provide a degree of protection against windblown dust and rain, splashing water, and hose directed water; and to be undamaged by the formation of ice on the enclosure. See reference NEMA 250.

**Pressure Gauge**

A device that senses and indicates pressure using ambient pressure as its datum.

**Proof Pressure**

The maximum constant internal pressure that can be exerted continuously, with a high degree of certainty, that failure of the pressure gauge case will not occur. This is the maximum pressure shown on the gauge face plate.

**Range**

The high and low limits of the scale, including retarded portions, expressed in the sequences and units in which they occur. For example: 0/300 psi, or 30 in. Hg vac/30 psi.

**Retard Gauge**

A gauge having a scale that is compressed at one end, or both ends. For example, a gauge may have a range, such as 0 - 80 psi, which is not a full scale range. A retarded or compressed range may extend the gauge to a maximum pressure of 250 psi. Pressures as high as the maximum pressure shown on the gauge dial face will not damage the gauge, or affect its accuracy.

**Vacuum Gauge**

A device that has a standard scale range which measures pressures from below atmospheric up to zero atmospheric pressure. Typical units of measure are 15 to 0 psi, or 30 to 0 in. Hg.

## 2. GENERAL INFORMATION

### 2.1 Product Information

- 2.1.1 Pressure gauges for use in fire protection systems addressed in this standard have a nominal case size of 3-1/2, 4, or 4-1/2 inch (90, 102, or 115 mm) diameter. The minimum case size shall be 3-1/2 in. (90 mm). Other sizes, larger than 4-1/2 in. (115 mm), shall be evaluated on a case-by-case basis.
- 2.1.2 In order to meet the intent of this standard, pressure gauges 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 in identical materials by different manufacturers or, even by different plants of the same manufacturer, have been seen to perform differently in testing. Sample pressure gauges 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 an authorized representative, shall submit a request to:

Group Manager - Hydraulics  
FM Approvals, A Member of the FM Global Group  
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, one complete set of manufacturing drawings, materials list(s), anticipated marking format, brochures, sales literature, specification sheets, installation, operation and maintenance procedures, and
  - Number and location of manufacturing facilities making the products submitted for Approval.

### 2.3 Requirements for Samples for Examination

- 2.3.1 Following set-up and 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. Sample requirements may vary depending on design features, results of prior testing, and results of the foregoing tests. It is the manufacturer's responsibility to submit samples representative of production. Any decision to use data generated utilizing prototypes is at the discretion of FM Approvals. The manufacturer shall provide any special test fixtures, which may be required to evaluate the pressure gauges. Testing may be performed at FM Approvals, at the manufacturer's test facility, or at a third-party location, as mutually agreed.

### 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 Gauges will have a dual scale face, reading in two different units of pressure, most commonly in psi and in kPa or Bars. The second unit of measure, in parentheses, will be considered approximate. The primary value will be the unit evaluated for accuracy. Other scale units will be considered based on the national standards in common use where the product will be sold.
- 3.2.2 Cases shall be of steel, or other rugged material, with paint or other protective coating as appropriate. Cases designed to vent system pressure, without rupture of the case, upon failure of the elastic element, are the preferred design. Other conventional case designs are acceptable if they successfully pass the hydrostatic strength test and the rupture test as described in Section 4.2, Hydrostatic Strength/Rupture.
- 3.2.3 Connections will be located at the bottom or the back of the case as appropriate. Threaded connections shall normally be male 1/4-18 NPT, or the national standard thread commonly used in the country of point of installation.
- 3.2.4 The gauge face shall be of safety glass or suitable shatter-resistant clear plastic of sufficient strength and thickness to keep internal components from being expelled from the case during a gauge movement failure due to over-pressurization. In case of breakage, the window shall be easily replaced.
- 3.2.5 The rated working pressure of all vacuum and low pressure gauges covered by this standard shall be 175 psi (1205 kPa) minimum. Gauges with higher pressure ratings than 175 psi (1205 kPa) will use the upper pressure limit on the gauge dial face for their rated pressure.
- 3.2.6 Typical ranges for the gauges are:

Pressure Gauges

- 0 to 150 psi (0 to 1035 kPa)  
0 to 250 psi (0 to 1725 kPa)  
0 to 300 psi (0 to 2070 kPa)  
0 to 600 psi (0 to 4135 kPa)

Retard Gauges

0 to 80, 250 retard psi (0 to 550, 1725 kPa)

Compound Gauges

-15 to 0 to 150 psi (-105 to 0 to 1035 kPa)  
30 in. Hg to 0 to 150 psi (760 mm Hg to 0 to 1035 kPa)

Vacuum Gauges

0 to -15 psi (0 to -105 kPa)  
0 to 30 in. Hg (0 to 760 mm Hg)

Atmospheric pressure (0 psi) shall be the datum (zero) point on all scales.

- 3.2.7 Dial graduations shall radiate out from the pointer rotation center. Numerals shall be at sufficient intervals to permit the viewer to easily determine the value of the pressure which is displayed. The dial scale will normally be 270 degrees of arc.
- 3.2.8 The pointer shall be removable from the post, so that it may be reset for calibration purposes. There shall be an internal stop in the mechanism, preventing the pointer from traveling more than 300 degrees of arc.
- 3.2.9 All gauges shall be of the stem or socket-mounted type, and shall be provided with flats on the stem or socket to allow tightening by means of a conventional wrench.
- 3.2.10 Inspection access to the pressure element and movement shall be available without damage to any part of the gauge. No special tools shall be required for this access. No recalibration shall be necessitated by the level of disassembly required for this access.

**3.3 Materials**

Corrosion resistance of the components of the gauges shall be equivalent to yellow brass, or to bronze containing 15 percent of zinc or less.

**3.4 Markings**

- 3.4.1 All FM Approved pressure gauges 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.
- 3.4.2 Pressure gauges shall be clearly marked on the dial face, and shall include, as a minimum, the following information:
- Manufacturer's name or trademark;
  - Model number unique to the FM Approved product;
  - Units of pressure; and
  - The FM Approvals Certification Mark.
- 3.4.3 The location and order of these markings is optional, as long as all are present.
- 3.4.4 Additional markings are allowed if arranged in such a way as not to interfere with the legibility of the required markings.
- 3.4.5 All markings shall be legible and durable throughout the useful life of the product.

### 3.5 Manufacturer's Installation and Operation Instructions

The manufacturer shall provide the user with installation instructions which clearly indicate how gauges qualified under this standard are to be used, in case of special requirements. FM Approvals shall review the minimum acceptable extent of these instructions based upon the specific nature of the product submitted for Approval. Any instructions specific to FM Global Loss Prevention Data Sheets should be labeled as such.

### 3.6 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 is required for FM Approvals' records that indicate that 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. The test equipment must be clearly identified by label or sticker showing 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.

### 3.7 Tolerances

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

## 4. PERFORMANCE REQUIREMENTS

### 4.1 Examination

#### 4.1.1 Requirement

The pressure gauges shall conform to the manufacturer's drawings and specifications and to Approval requirements.

#### 4.1.2 Test/Verification

A sample shall be examined and compared to drawings and specifications. It shall be verified that the sample conforms to the physical and structural requirements described in Section 3, General Requirements. The gauge connection shall be of the back- or bottom-connected type. The connection shall normally be male 1/4-18 NPT thread in conformance with ANSI B1.20.1, or thread of the nearest equivalent size in conformance with a recognized national standard of the nation where the gauge is to be used.

### 4.2 Overpressure

#### 4.2.1 Requirements

Pressure equal to 150 percent of the full scale range of the gauge shall be applied to a new gauge by hydrostatic means for a period of five seconds minimum. The pressure shall then be reduced to zero. The accuracy test per Section 4.3, Accuracy/Hysteresis, shall then be conducted. No increase in deviation from the original accuracy measurements is allowed.

#### 4.2.2 Tests/Verification

After conducting the accuracy test on the over-pressured test gauge, the data obtained shall be compared to the data obtained during the original accuracy test. The results of this test shall be no less accurate than the original test.

### 4.3 Accuracy/Hysteresis

#### 4.3.1 Requirement

The pressure gauge shall retain required accuracy when subjected first to increasing and then to decreasing pressure. The gauge under test shall read within  $\pm 2$  percent of full scale for the middle one-half of the scale, and  $\pm 3$  percent of full scale for the first and last quarters of the scale. The hysteresis effect shall compare the measurements recorded during increasing pressure to the measurements collected during decreasing pressure. The differential values shall comply with the same tolerances as the accuracy requirement.

#### 4.3.2 Test/Evaluation

While mounted to a calibrated dead weight tester or a pressure comparator fitted with a master gauge, a sample gauge shall be subjected to a minimum of five pressure settings over the full span of the scale, first in increasing pressure, and then in decreasing pressure, at the same points. The pressures will be applied to the gauge, in both ascending and descending order. Each measurement shall comply with the accuracy requirement of plus or minus two percent of full scale of the true pressure over the center one-half of the scale, and within plus or minus three percent over the lower and upper quarters of the scale. Gentle tapping of the gauge case is permitted prior to taking each reading to minimize frictional effects.

The required accuracy level shall also be met in the differential pressure readings. The differential pressure between the increasing and decreasing readings shall be within plus or minus two percent of full scale of the true pressure over the center one-half of the scale, and within plus or minus three percent over the remaining lower and upper quarters of the scale.

This test shall be repeated three times on each test gauge, the test gauges shall meet the requirements in all three tests.

#### 4.4 Readability

##### 4.4.1 Requirement

Gauges shall be correctly readable to within one minor scale calibration increment in uniform lighting conditions of 50 lm/ft<sup>2</sup> (538 lux) by an observer whose vision has been corrected to 20/20 and who is stationed 6 ft. (1.8 m) from the gauge.

##### 4.4.2 Test/Verification

A minimum of five readings shall be recorded, spanning the entire scale range of the gauge. An attempt to minimize parallax errors will be made, by judicious positioning of the observer in relation to the gauge position. All observations must be within +/- one scale graduation.

#### 4.5 Cycling Pressure Endurance

##### 4.5.1 Requirement

A pressure gauge shall withstand 20,000 pressure surges without leakage or loss of accuracy.

##### 4.5.2 Test/Verification

First conduct an accuracy test per Section 4.3, Accuracy/Hysteresis, one time. Then the representative sample assembly shall be subjected to 20,000 cycles of hydrostatic pressure from 0 to approximately one half of rated working pressure, with 90 psi (620 kPa) as a minimum test value. The rate of application will be 60 cycles per minute or less. Subsequently, the assembly shall be retested for accuracy one time in accordance with the requirements of Section 4.5, Accuracy/Hysteresis.

#### 4.6 Moisture Exposure

##### 4.6.1 Requirement

A pressure gauge shall be subjected to a moisture exposure test at room temperature. Following this test the gauge case shall be opened and the inside of the case shall be examined for signs of water entry. Minimal water shall be allowed inside the gage case as a result of this test.

##### 4.6.2 Test/Verification

The top and all sides of the gauge shall be subjected to the water spray created by three rain test spray nozzles when orientated as indicated in Figure 5-1, NEMA Standard 250-2007. The gauge shall be upright and unpressurized during this test. The inlet port will be capped during the test, or assembled into a supporting structure. Any supporting structure shall not obstruct water mist or spray from reaching the test gauge. The supply water pressure shall be maintained at 5 psi (35 kPa) at each spray nozzle for a period of one hour. The spray nozzles shall comply with Figure 5-2 of NEMA Standard 250-2007, or equivalent, as deemed by FM Approvals. Following the water spray test the

gauge shall stand in still air for 120 hours (5 days). Subsequently, the assembly shall be retested for accuracy one time in accordance with the requirements of Section 4.5, Accuracy/Hysteresis.

#### 4.7 Hydrostatic Strength/Rupture

##### 4.7.1 Requirements

The gauges shall withstand a hydrostatic pressure test of four times the rated working pressure with no evidence of rupture or cracking. Rated working pressure will be in accordance with Section 3.2.5. Gauges shall resist rupture after the completion of the hydrostatic pressure test, when the gauge is subjected to increasing pressure until failure occurs.

##### 4.7.2 Test/Verification

NOTE! Take appropriate safety measures to enclose the gauge in a test chamber which will prevent debris from causing personnel injury during this test.

Pressure gauges shall be installed and aligned in their normal upright position per the manufacturer's instructions. One gauge of each pressure range submitted for Approval shall be hydrostatically tested for 5 minutes, at four times the rated working pressure. There shall be no rupture or cracking of any pressure element as a result of this test.

At the completion of the hydrostatic pressure test at four times the rated working pressure, continue to increase the hydrostatic pressure until failure occurs. Failure is defined as the inability of the gauge to contain pressure. Record the failure pressure. No component parts are to be ejected outside of the case of the gauge with sufficient force to be a personnel hazard. No debris shall be thrown outside of a 6 ft. (1.8 m) diameter sphere centered about the gauge.

#### 4.8 Vibration

##### 4.8.1 Requirement

A new gauge shall be mounted vertically on a vibration table by means of an adapter plate or test fixture. The gauge shall be pneumatically pressurized to approximately 50 percent of the full scale range of the gauge, but not in excess of 100 psi (690 kPa). The sample shall be subjected to the twenty five hour vibration test per Table 4.8.2. No leakage, sticking or binding of the needle, or other failure causing non-performance of the gauge is allowed.

##### 4.8.2 Test/Evaluation

The pressurized gauge shall be subjected to five hours of vertical vibration at each of the five settings shown in the table below. The five vibration inputs shall be along the vertical centerline of the gauge.

The assembly shall be pressurized to approximately 50 percent of the full scale range of the gauge, but not in excess of 100 psi (690 kPa), during the entire test and shall be subjected to the vibration sequence of Table 4.8.2; each 5-hour test increment shall be run continuously. No leakage or other failure is allowed during this 25 hour test.

Table 4.8.2 Vibration Conditions

<i>Total Stroke</i>		<i>Frequency</i>	<i>Time</i>
<i>in.</i>	<i>(mm)</i>	<i>Hz</i>	<i>Hours</i>
0.020	(0.51)	28	5
0.040	(1.04)	28	5
0.150	(3.81)	28	5
0.040	(1.04)	18 to 37 (variable)*	5
0.070	(1.78)	18 to 37 (variable)*	5

\*continuously and regularly varied over the 18 to 37 Hertz frequency range at approximately one complete cycle every 25 +/- 5 seconds

At the conclusion of the test, the gauge shall operate freely through its full dial pressure range, with no instance of sticking or binding of the pointer.

**4.9 Salt Spray Exposure**

4.9.1 Requirements

Gauges shall be resistant to a salt spray exposure. The gauges shall remain accurate after being subjected to the salt spray.

4.9.2 Test/Verification

In order to determine the susceptibility of gauges to damage from salt spray exposure, a sample gauge, previously untested, shall be subjected to an accuracy test per Section 4.3, Accuracy/Hysteresis. This gauge shall then be subjected to a salt spray environment for a period of 10 days.

The inlet end of the sample shall be capped with a non-reactive material (e.g., plastic cap) so as to minimize the introduction of the salt spray atmosphere into the waterway of the gauge.

Place the test sample upright in the salt spray cabinet. The sample shall be subjected to 5 percent salt spray per ASTM B-117 for 10 days.

After removal from the test environment, the gauge shall be left to sit unpressurized in an upright position, in room atmosphere, for an additional 2 days. The gauge shall then be subjected to a visual inspection while salt coated. Note findings. Wash the assembly in tap water and air dry for one hour. Repeat the visual inspection and note any differences in findings.

Subsequently, the assembly shall be retested for accuracy one time in accordance with the requirements of Section 4.5, Accuracy/Hysteresis.

**4.10 Additional Tests**

Additional tests may be required, depending on design features, results of any tests, material application, or to verify the integrity and reliability of the pressure gauge, 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 is required to assure that subsequent pressure gauges produced by the manufacturer at an authorized location, shall present the same quality and reliability as the specific pressure gauges 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 documented in the Approval Report. Conformance to design is verified by control of quality and is covered in the Facilities and Procedures Audit (F&PA). 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:

- Existence of corporate quality assurance guidelines
- Incoming quality assurance, including testing
- In-process quality assurance, including testing
- Final inspection and tests
- Equipment calibration
- Drawing and change control
- Packaging and shipping
- Handling and disposition of non-conformance materials.
- In order to assure adequate traceability of materials and products, the manufacturer shall maintain records of all quality control tests performed, for a minimum period of two years from the date of manufacture.

5.1.2 Documentation/Manual

There shall exist 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 Drawing and Change Control

The manufacturer shall establish a system of product configuration control that shall allow no unauthorized changes to the product. Changes to critical documents, identified in the 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, and require that, proposed changes to FM Approved or Listed products be reported to FM Approvals before implementation. The manufacturer shall notify FM Approvals of changes in the product or of persons responsible for keeping FM Approvals advised by means of FM Approvals Form 797, FM Approved Product/Specification-Tested Revision Report or Address/Main Contact Change Report. Records of all revisions to all FM Approved products shall be maintained.

5.1.3.1 The table below has been included as a guide to manufacturers of what is considered to be a significant change to FM Approvals. As mentioned above, modifications that fit this category shall 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>
Addition of Allowed Sizes:	The product was originally FM Approved in 0 to 150 psi range, and now Approval of a new gauge is to be evaluated with a 0 to 300 psi range.
Addition or Relocation of the Manufacturing Location:	The product was originally FM Approved in location A, and now is desired to be made in locations A and B, or only in location B.

5.1.3.2 The table 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:	Name, Title, Phone Number, Fax Number, Email Address, Company Office Address, Company Name
Updating of Drawings:	The Form 797 is used to notify FM Approvals in the event of: minor dimensional changes to non-critical features, minor changes in notes, location of title block, re-creation of the same drawing on CAD, etc.
Changes in Markings:	Please describe what changes are to be made and include a drawing of the proposed marking.
Updating of Documentation:	Creation of New or Revisions to Sales literature, Installation Instructions, Grooving Dimensions, Quality Manual, etc.

5.1.3.3 For the instances where the modification is difficult to categorize, manufacturers are encouraged to contact FM Approvals to discuss the nature of the change, and inquire about how to send the information to FM Approvals.

5.1.3.4 FM Approvals, at its sole discretion, shall determine when additional testing is necessary to validate proposed changes.

**5.2 Facilities and Procedures Audit (F&PA)**

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 determine that the manufacturer's equipment, procedures, and quality program are maintained to insure a consistently uniform and reliable product. Initial inspections of facilities already producing similar FM Approved products may be waived at the discretion of FM Approvals.

5.2.2 Unannounced follow-up inspections shall be conducted at least annually by FM Approvals, or its designate, to determine continued compliance. More frequent audits may be required by FM Approvals.

5.2.3 The manufacturer shall manufacture the 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.

### 5.3 Manufacturer's Responsibilities

- 5.3.1 The manufacturer shall notify FM Approvals of changes in product construction, design, components, raw materials, physical characteristics, coatings, component formulation or quality assurance procedures prior to implementation of such changes.
- 5.3.2 Where all or part of the quality control has been subcontracted, the manufacturer shall, at a minimum, conduct sufficient oversight audits to verify the continued application of the required controls.

### 5.4 Manufacturing and Production Tests

All tests shall be run at an ambient temperature of 68 °F +/-9 F (20 °C +/- 5 C) unless otherwise noted.

#### 5.4.1 Cycle Test

Each gauge shall be cycled through the full scale pressure range to confirm free operation of the mechanism.

#### 5.4.2 Accuracy

Each gauge shall be checked for accuracy at a minimum of five pressure settings.

---

**APPENDIX A: Units of Measurement**

<b>LENGTH:</b>	in. - "inches"; (mm - "millimeters") mm = in. x 25.4 ft - "feet"; (m - "meters") m = ft x 0.3048
<b>PRESSURE:</b>	psi - "pounds per square inch"; (kPa - "kilopascals") kPa = psi x 6.895
<b>TEMPERATURE:</b>	°F - "degrees Fahrenheit"; (°C - "degrees Celsius") °C = (°F - 32) x 0.556
<b>VACUUM:</b>	inHg - "inches of mercury" psi - "pounds per square inch" (kPa - "kilopascals") psi = inHg x 0.4912; kPa = inHg x 3.3864

## APPENDIX B: FM Approvals Certification Marks

FM Approvals certifications marks are to be used only in conjunction with products or services that have been Approved by FM Approvals and in adherence with usage guidelines.



### ***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. The mark should be produced in black on a light background, or in reverse on a dark background.



### ***Cast-On FM Approvals 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.



### ***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 Canadian codes and standards. There is no minimum size requirement for the mark, but it must be large enough to be readily identifiable. 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 US and Canadian codes and standards. There is no minimum size requirement for the mark, but it must be large enough to be readily identifiable. The mark should be produced in black on a light background, or in reverse on a dark background.

## 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.

FM Approvals certification marks may be used only on FM Approved products and related product packaging, in advertising material, catalogs and news releases. Use of FM Approvals certification marks on such material is not a substitute for use of the complete FM Approvals certification mark on FM Approved products and/or product packaging.

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,” “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, 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.

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.

When an FM Approvals certification mark is used in advertising material 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.

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.

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 the manufacturer/seller/distributor of the certified products.

## APPENDIX C: Tolerance

Unless otherwise stated, the following tolerances shall apply:

Angle:  $\pm 2^\circ$

Frequency (Hz):  $\pm 5$  percent of value

Length:  $\pm 2$  percent of value

Volume:  $\pm 5$  percent of value

Pressure:  $\pm 2$  percent of center half of dial  
 $\pm 3$  percent outer quarters of dial

Temperature:  $\pm 4^\circ\text{F}$  ( $2^\circ\text{C}$ )

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 Listing**

**Pressure Gauges**

Gauges for sprinkler systems and fire pumps are designed for use with air or water. These gauges are usually of the Bourdon tube type. The moving parts are fabricated of appropriate corrosion-resistant materials.

When installed on the air side of a dry pipe system, a retard type gauge may be used. This gauge is assembled with a tube appropriate to the unretarded pressure range of the gauge and is provided with a spring to resist the full scale load.

The two common sizes are 3-1/2 and 4-1/2 in. diameter. These gauges can be calibrated with a hydraulic testing unit by adjusting the dial pointer to read correctly at known pressures. Accuracy requirements are that the gauge be correct within 2 percent over the center half of its scale and within 3 percent over the remaining two quarters. Dial marking subdivisions correspond to the maximum accuracy of the gauge.

For service on fire pumps where the suction may be taken under a lift, compound pressure vacuum gauges are available graduated in pressure units over both the vacuum and pressure scales, and are designed not to be damaged by vacuum.

To minimize possible damage and provide maximum accuracy, gauges should be selected with scales of about twice the maximum system pressure.

**Smith, Inc., 453 Allard Street, City, State, 20392**

Model AB1. Steel case and a 1/4 in. male NPT rear connection, 4-1/2 in. (115 mm) size

Measuring Ranges:

<i>Psi</i>	<i>kPa</i>
-15 to 0	-1 to 0
-15 to 150	-1 to 9
0 to 150	0 to 10
0 to 300	0 to 20
0 to 600	0 to 40

**Jack Inc, 548 MCF Way, Coventry CT 08564**

Pressure Gauge. "Jack" Model. Steel case only, 3-1/2 in (100 mm) size. 1/4 male NPT, bottom connection.

Measuring Ranges:

<i>Psi</i>	<i>kPa</i>	<i>Bar</i>
-15 to 0	-100 to 0	-1 to 0
0 to 150	0 to 1000	0 to 10
0 to 300	0 to 2070	0 to 20
0 to 400	0 to 2500	0 to 25
0 to 80 to 250 (Retard)	0 to 55 to 1725	0 to 5.5 to 17



*Member of the FM Global Group*

Printed in USA