

Approval Standard

Residential Automatic Sprinklers for Fire Protection

Class Number 2030
August 2009



Member of the FM Global Group

Approval Standard for Residential Automatic Sprinklers for Fire Protection

Class Number 2030

August 2009

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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 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.



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1. INTRODUCTION

1.1 Purpose

- 1.1.1 This standard states Approval criteria for automatic residential sprinklers for fire protection service.
- 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 sets performance requirements for automatic residential sprinklers in class number 2030.
- 1.2.2 Other types of automatic residential sprinklers may be FM Approved if they meet the requirements and intent of this standard. Residential sprinklers of unusual design may be subjected to special tests to determine their suitability.
- 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 automatic residential sprinklers for the purpose of obtaining Approval. Residential sprinklers 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, automatic residential sprinklers 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 examination of the manufacturing facility(ies) and audit of quality control procedures shall be made to evaluate the manufacturer's ability to consistently produce the product which was examined and tested, and the marking procedures used to identify the product. These examinations are repeated as part of FM Approvals' product follow-up program. (Refer to Section 5.2, Facility and Procedures Audit.)

1.5 Basis for Continued Approval

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 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 Approval's product follow-up program.

Also, as a condition of retaining Approval, manufacturers may not change a product or service without prior authorization by FM Approvals.

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 **August 31, 2010** 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 American Society for Testing Materials (ASTM) SI10-2002, *"IEEE/ASTM SI 10 American National Standard for Use of the International System of Units (SI): The Modern Metric System."* Two units of measurement (liters 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 or beneficial in understanding this standard:

ANSI/ASME B1.20.1-1983 (R2001), *Pipe Threads, General Purpose (Inch)*

ANSI/ASME B16.3-1998, *Malleable-Iron Threaded Fittings*

ANSI/ASME B16.4-1998, *Gray Iron Threaded Fittings*

ASTM SI10-2002, *IEEE/ASTM SI 10 American National Standard for Use of the International System of Units (SI): The Modern Metric System*

ASTM B117-2003, *Standard Practice for Operating Salt Spray (Fog) Apparatus*

ASTM E1-2003a, *Standard Specification for ASTM Liquid-in-Glass Thermometers*

ASTM E11-2004, *Standard Specification for Wire Cloth and Sieves for Testing Purposes*

ASTM G36-1994(2000), *Standard Practice for Evaluating Stress-Corrosion-Cracking Resistance of Metals and Alloys in a Boiling Magnesium Chloride Solution*

FM Global Property Loss Prevention Data Sheets

International Organization for Standardization, ISO 17025 - 2005, *General requirements for the competence of testing and calibration laboratories*

PPP-B640d (as amended) Class II Government Grade
Rail Classification Rule 41, Section 3
National Motor Freight Classification Rule 222
IATA & ATA shipment by air, both domestic and overseas

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. It is installation specific. A product accepted for one installation may not be acceptable elsewhere. (Contrast with FM Approved.)

Amplitude

The maximum displacement of sinusoidal motion from position of rest to one-half of the total displacement.

Assembly Load

The force which is applied to the sprinkler frame due to assembly of the operating parts plus the equivalent force resulting from the maximum rated inlet pressure.

Coated or Plated Sprinkler

A sprinkler which has a factory applied coating or plating for corrosion protection or decorative purposes.

Concealed Sprinkler

A sprinkler in which the entire body, including the operating mechanism, is above a concealing plate, the margin of which is nearly flush to the ceiling surface.

Conductivity (C-Factor)

A measure of the conductance between the sprinkler's heat responsive element and the other components of the sprinkler expressed in units of $(\text{ft/s})^{1/2}$ or $(\text{m/s})^{1/2}$.

Corrosion Resistant

Materials having resistance to corrosion equal to or exceeding that of bronze alloy having a minimum copper content of 80 percent.

Decorative Sprinkler

A sprinkler which is factory-painted or coated to improve its aesthetics. The coating is not considered a corrosion-resistant barrier.

Design Area

The maximum area that a single residential sprinkler is intended to protect.

Design Load

See Element Design Load.

Discharge Coefficient (K-Factor)

The coefficient of discharge as expressed in the equation:

$$K = \frac{Q}{P^{1/2}}$$

Where Q is the flow in gallons per minute (gal/min) and P is the pressure in pounds per square inch (psi). Expressed in SI units: Q is the flow in liters per minute (L/min) and P is the pressure in bar.

Element Design Load

The load actually applied on the operating element (fusible element or bulb) at the maximum rated inlet pressure.

FM Approvals Certification Marks

The FM Approvals Certification Marks are detailed in Appendix C. Their use is mandatory on all units of FM Approved automatic residential sprinklers for fire protection service. 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 online resource 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. This form obligates the manufacturer to allow re-examination of the product and audit of facilities and procedures at FM Approvals' discretion. It further requires the manufacturer not to deviate from the FM Approved configuration of the product without review by and agreement of FM Approvals. Approval is manufacturing site and product specific.

Flush Sprinkler

A sprinkler in which essentially all of the body, with the exception of the heat responsive assembly, is mounted above the lower plane of the ceiling.

Fusible Element Sprinkler

A sprinkler that opens under the influence of heat by the melting of a component.

Glass Bulb Sprinkler

A sprinkler that opens under the influence of heat by bursting of a glass bulb due to pressure resulting from expansion of the enclosed fluid.

Hang-Up (Lodgement)

A malfunction in the operation of a sprinkler which, when operated under a typical system water pressure, experiences the lodging of an operating part (cap, gasket, lever, etc.) on or between the frame, deflector and/or compression screw, adversely affecting the water distribution for a period in excess of 10 seconds. A momentary hesitation of an operating part to clear itself from temporary contact with the frame, deflector and/or compression screw does not constitute a hang-up.

Heat Responsive Element

The component of a sprinkler assembly that, when subjected to the influence of heat, ruptures, bursts or otherwise functions, causing water to be discharged through the sprinkler orifice.

Leak Point

The pressure at which leakage of water in excess of one drop per minute occurs.

Maximum Service Pressure

The maximum rated working pressure of a sprinkler, typically 175 psi (12.1 bar).

Operating Temperature

The temperature, in degrees Fahrenheit (°F) or Celsius (°C), at which the heat responsive element of a sprinkler operates when subjected to a controlled rate-of-temperature-rise liquid bath.

Orientation, Best Case

When testing sprinklers for sensitivity in the FM Approvals plunge tunnel, the orientation of a sprinkler which results in the fastest operating time, or the lowest Response Time Index (RTI). Typically, this orientation is one in which the sprinkler waterway axis and the plane of the frame arms are both perpendicular to the air flow and, in the case of non-symmetric elements, the heat responsive element is upstream of the frame arms.

Orientation, Worst Case

For use in this standard, when testing sprinklers for sensitivity in the FM Approvals plunge tunnel, the worst case orientation is a given angular offset from the orientation which results in the slowest operating time, or the highest Response Time Index (RTI). The angular offset for residential (quick response rated) sprinklers is 25 degrees.

Orifice

The opening in a sprinkler body through which the water is discharged.

Pendent Sprinkler

A sprinkler designed such that the water exiting the orifice is directed downwards against the deflector.

Quick Response Sprinkler

A sprinkler having a Response Time Index (RTI) and Conductivity factor (C) combination which fall into the indicated area on the graph in Figure E-1. Generally, this is a sprinkler having an RTI equal to or less than $90 \text{ (ft}\cdot\text{s)}^{1/2}$ [$50 \text{ (m}\cdot\text{s)}^{1/2}$] and a C-factor equal to or less than $1.81 \text{ (ft/s)}^{1/2}$ [$1.0 \text{ (m/s)}^{1/2}$], when the sprinkler is tested in the best-case orientation.

Recessed Sprinkler

A sprinkler in which part or most of the body of the sprinkler, other than the part which connects to the piping, is mounted within a recessed housing with the plane of the orifice above the plane of the ceiling, or behind the plane of the wall on which the sprinkler is mounted.

Residential Sprinkler

A thermo-sensitive device designed to react at a predetermined temperature by automatically releasing a stream of water and distributing it in a specified pattern and quantity over a designated area. When properly installed in a wet pipe system and below horizontal smooth ceilings in accordance with internationally recognized installation standards, residential sprinklers are intended to aid in the control of open flame type residential fires, prevent flashover (i.e. transition to full involvement) in the room of fire origin resulting in improved tenability. Sprinkler spacing will be in accordance with the manufacturer's published guidelines and the product's listing.

Response Time Index (RTI)

A measure of sprinkler sensitivity expressed as $RTI = \tau (u)^{1/2}$ where τ is the time constant of the heat responsive element in units of seconds, and u is the gas velocity expressed in feet per second (or meters per second). The quantity τ relates the properties of the heat responsive element and the heated gas flow. RTI can be used in combination with the C-factor to predict the response of a sprinkler in fire environments defined in terms of gas temperature and velocity versus time. RTI is expressed in units of $(\text{ft}\cdot\text{s})^{1/2}$ or $(\text{m}\cdot\text{s})^{1/2}$.

Service Pressure

The working hydrostatic pressure of a sprinkler system.

Sidewall Sprinkler

A sprinkler intended for installation near a wall and ceiling interface and designed to discharge water outward and onto adjacent walls.

Single Sprinkler Flow Rate

The minimum water flow rate specified for operation of a single residential sprinkler.

Strutting

Partial fracture of a glass bulb or partial rupture of a fusible element which does not result in sprinkler operation.

Upright Sprinkler

A sprinkler designed such that the water exiting the orifice is directed upward against the deflector.

Weep Point

The pressure at which any visible leakage of water is detected.

1.10 References

1. Heskestad, G. and Smith, H. F. *Investigation of a New Sprinkler Sensitivity Approval Test: The Plunge Tunnel*, Factory Mutual Research Corporation, FMRC Serial Number 22485, December 1976.
2. Heskestad, G. and Smith, H. F., *Plunge Test for Determination of Sprinkler Sensitivity*, Factory Mutual Research Corporation, FMRC Job Identifier (J. I.) 3A1E2.RR, December 1980.
3. Heskestad, G. and Bill, R. G. Jr., *Conduction Heat Loss Effects on Thermal Response of Automatic Sprinklers*, Factory Mutual Research Corporation, J. I. 0N0J5.RU, and J. I. 0N1J6.RU, September 1987.
4. Heskestad, G. and Bill, R. G. Jr., *Plunge Test Procedures for Recessed, Flush and Concealed Sprinklers*, Factory Mutual Research Corporation, J. I. 0Y0J1.RA, February 1995.
5. Khan, M. M., Chaffee, J. L., and Alpert, R. L., *Determination of Operating Temperatures of Glass Bulb Sprinklers Using a Thermal Liquid Bath*, Project Identifier 0003002215, August 2000.

2. GENERAL INFORMATION**2.1 Product Information**

- 2.1.1 A residential automatic sprinkler is a thermo-sensitive device designed to react at a predetermined temperature by releasing a stream of water and distributing it in a specified pattern and density over a designated area when installed on the appropriate sprinkler piping.
- 2.1.2 In order to meet the intent of this standard, sprinklers shall 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 the manufacturing of sprinklers requires sufficient skill in its execution 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 sprinklers, selected in conformance to this criterion, shall satisfy all of the requirements of this standard.

2.2 Approval Application Requirements

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

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

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 control mode sprinklers being submitted for Approval consideration;
- A complete set of manufacturing drawings, general assembly drawings, materials list(s), assembly load calculations, anticipated marking format, brochures, sales literature, specification sheets, installation, operation and maintenance procedures, and;
- The number and location of facilities manufacturing the specified product.

All documents 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.

2.3 Requirements for Samples for Examination

Following generation and authorization of an Approval examination proposal, 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 or similar 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, such as those which may be required to evaluate the strength of heat responsive elements, requested by FM Approvals to evaluate the residential sprinklers.

3. GENERAL REQUIREMENTS

3.1 Review of Documentation

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.

3.2 Physical or Structural Features

- 3.2.1 Stampings shall show no cracking or splitting and be free of burrs.
- 3.2.2 Deflectors of sprinklers shall be securely attached.
- 3.2.3 Sprinklers shall be designed and manufactured such that adjustment of the assembly load or replacement of operating parts shall not be possible without visible permanent damage to the device.
- 3.2.4 All connections shall be suitable for use with fittings having tapered pipe threads which conform to a national or internationally recognized standard. Sprinklers which are to be sold in the United States shall be threaded to suit fittings manufactured in accordance with ANSI/ASME B1.20.1, *Pipe Threads, General Purpose (Inch)*.
- 3.2.5 Residential sprinklers having water passageways with cross-sectional dimensions less than 3/8 in. (9.5 mm) may necessitate the use of individual or system strainers per appropriate installation standards. At the sole discretion of FM Approvals, sprinklers incorporating such passages shall require

a statement in various publications (i.e. manufacturer's literature, Approval Reports, Approval Guide, etc.) referring to the size of the openings and indicating their need for use with appropriate strainers.

- 3.2.6 A special wrench, facilitating installation, shall be available from the manufacturer and provided to FM Approvals for evaluation. If installation using a common wrench is permitted by the manufacturer, such wrench shall not easily damage the sprinkler. If a common wrench is to be used for installation, the possibility of wrench slippage exists with possible subsequent damage to the sprinkler and the possibility of hidden damage so as to render the sprinkler inoperative. For this reason, sprinklers permitted by the manufacturer to be installed with a common wrench shall meet the following requirement: the minimum length of the wrench flats shall be equal to the distance between the flats of the sprinkler.
- 3.2.7 All operating parts shall have ample clearance with near zero possibility of binding or wedging. An analysis of the design drawings may be conducted to evaluate the worst combination of tolerances in parts so as to assess the possibility of such malfunction.
- 3.2.8 Plated or coated residential sprinklers shall be subjected to additional evaluation and testing, beyond that specified in this standard, to verify the integrity of their mechanical and operational properties and marking clarity. Factory plating or coating of residential sprinklers shall not change the mechanical or operational properties of the sprinkler beyond acceptable limits stated in this standard.
- 3.2.9 Finishes such as plating, decorative painting, or coating shall not be applied to sprinklers by anyone other than the sprinkler manufacturer, or vendor, at the time of manufacture. Examination of residential sprinklers with such finishes or coatings is required. Such sprinklers shall meet all requirements of residential sprinklers.
- 3.2.10 Ornamental sprinklers such as concealed types may have factory-painted cover plates, if the painted plates have been tested as part of the sprinkler evaluation.
- 3.2.11 Inlet protrusion into the fitting shall not adversely affect the flow of water through the fitting.
- 3.2.12 Approval of residential automatic sprinklers is restricted to a maximum nominal operating temperature of 225°F (107°C).

3.3 Materials

All materials used in automatic residential sprinklers shall be suitable for the intended application. Residential sprinkler parts exposed to water shall be constructed of corrosion resistant materials. When unusual materials are used, special tests, beyond those specified in this standard, may be necessary to verify their suitability.

3.4 Markings

- 3.4.1 All sprinklers shall be marked in accordance with one of the two marking schemes described in Section 3.4.1.1 and 3.4.1.2. The manufacturer may use either one or both of the schemes and shall notify FM Approvals prior to making any marking changes on the sprinklers.

- 3.4.1.1 The following marking scheme is intended to meet the National Fire Protection Association (NFPA) marking requirements adopted in 1999 and effective January 1, 2001.

Sprinklers shall be permanently marked with a one- or two-character manufacturer symbol, followed by three or four numbers. This marking, or sprinkler identification number (SIN) shall uniquely identify the sprinkler based upon the following:

- Orifice size or shape
- Deflector type or orientation

- Pressure rating
- Thermal sensitivity (i.e. response classification)

The manufacturer shall be assigned the one- or two-character manufacturer symbol by contacting the International Fire Sprinkler Association (www.sprinklerworld.org).

The manufacturer shall not place this identification mark on any other product.

In addition to the SIN, the following shall be displayed on a non-operating part of the sprinkler:

- Nominal temperature rating (in °F or °C at a minimum);
- Year of manufacture (Note: sprinklers manufactured in the first 6 months or last 3 months of a calendar year may be marked with the previous or following year respectively, as the year of manufacture);
- The FM Approvals Certification Mark (see Appendix C).

Optionally, the following additional information may be displayed on a non-operating part of the sprinkler:

- Manufacturer's name or identifying symbol (logo);
- Model designation (see Section 3.4.2 below);
- Nominal K-factor (in English units: gal/min/(psi)^{1/2});
- The word "PENDENT", the word "UPRIGHT", or other designation to indicate type or orientation, as appropriate;

3.4.1.2 In lieu of the marking requirements of section 3.4.1.1, sprinklers shall be permanently marked on a non-operating component with the following:

- Manufacturer's name or identifying symbol (logo);
- Model designation (see Section 3.4.2 below);
- Nominal K-factor (in English units: gal/min/(psi)^{1/2});
- The word "PENDENT", the word "UPRIGHT", or other designation to indicate type or orientation, as appropriate;
- Nominal temperature rating (in °F or °C at a minimum);
- Year of manufacture (Note: sprinklers manufactured in the first 6 months or last 3 months of a calendar year may be marked with the previous or following year respectively, as the year of manufacture);
- The FM Approvals Certification Mark (see Appendix C).

3.4.2 Regardless of the marking scheme utilized, the sprinkler identification number (SIN), model designation, and/or type identification shall correspond with the manufacturer's catalog designation and shall uniquely identify the sprinkler as FM Approved. The manufacturer shall not place this identification mark on any other product.

3.4.3 For fusible type sprinklers, the operating temperature, or the temperature rating color code, as defined in Table 3.4.5, shall appear on a visible area of the fusible element or an associated operating component.

3.4.4 If a manufacturer produces residential sprinklers with the same model designation at more than one facility, each sprinkler shall bear a distinctive marking on a non-operating part to identify it as the product of a particular location.

3.4.5 All residential sprinklers, with the exception of glass bulb type sprinklers, shall be color coded in accordance with Table 3.4.5. Paint of the correct color shall be applied to at least 50 percent of each frame arm surface. This application of paint shall be visible on the sprinkler from all directions. The color identification for coated, plated and recessed sprinklers may be a dot on the top of the deflector,

the color of the coating material or colored frame area. This dot shall be visible from a distance of 3 feet (0.9 m).

Table 3.4.5 Temperature Ratings, Classifications, and Color Code

<i>Nominal Temperature¹ Rating Range</i>		<i>Maximum Ambient Temperature at Sprinkler Level</i>		<i>Temperature Classification</i>	<i>Sprinkler Frame Color Code</i>
<i>°F</i>	<i>(°C)</i>	<i>°F</i>	<i>(°C)</i>		
135 to 170	(57 to 77)	100	(38)	Ordinary	None or Black
175 to 225	(79 to 107)	150	(66)	Intermediate	White

Note: ¹ FM Approved sprinklers shall have a specific temperature rating within the range.

- 3.4.6 Bulb type sprinklers, including decorative factory-painted or coated sprinklers, shall comply with the bulb color designation shown in Table 3.4.6. The bulb fluid color shall be considered a suitable method of temperature identification in addition to permanent marking elsewhere on the sprinkler.

Table 3.4.6 Temperature Ratings and Bulb Color Codes

<i>Nominal Temperature Rating</i>		<i>Bulb Color Code</i>
<i>°F</i>	<i>(°C)</i>	
135	(57)	Orange
155	(68)	Red
175	(79)	Yellow
200, 225	(93, 107)	Green

- 3.4.7 Flush sprinklers shall be color coded. Such color identification may be a dot suitably located and visible on the link, arms, or other component as appropriate. Such location shall be evaluated on a case-by-case basis.
- 3.4.8 For all concealed sprinklers, the cover plate shall be marked with the words "Do Not Paint" in characters at least 1/8 in. (3.2 mm) in height.
- 3.4.9 Horizontal sidewall sprinklers shall include the word "Top" on the deflector to indicate orientation.
- 3.4.10 Vertical sidewall sprinklers shall bear an arrow indicating the direction of flow and the word "flow."
- 3.4.11 Factory plated sprinklers shall be identified as such with a distinctive marking so as to distinguish the product from unauthorized field plating.
- 3.4.12 For factory decorative-painted (coated) sprinklers, some portion of the sprinkler shall remain unpainted and readily visible from a minimum of 1 foot (0.3 m). This would allow a means to determine if the sprinkler were repainted in the field. Field painting is prohibited.
- 3.4.13 For bulb-type residential sprinklers, the manufacturer shall place a distinctive mark on a non-operating part of the sprinkler to denote the bulb manufacturer if more than one source is used in a given design.
- 3.4.14 All markings shall be permanent and visible from a distance of 3 feet (0.9 m). The markings shall remain visible through any factory-applied plating or decorative coating.

3.5 Manufacturer's Installation and Operation Instructions

The manufacturer shall provide the user with adequate instructions for proper installation with each shipment. Residential sprinklers shall be installed and maintained in accordance with applicable installation rules. Field modification, such as replacing a component on a sprinkler, plating, or painting, is prohibited.

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. 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 an 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. 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 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 B, unless otherwise specified.

4. PERFORMANCE REQUIREMENTS

Test Pressures

All test pressures are based on the maximum rated working pressure of 175 psi (12.1 bar). Other pressures will be considered at the sole discretion of FM Approvals.

4.1 Examination

4.1.1 Requirements

The residential sprinklers shall conform to the manufacturer's drawings and specifications and to FM Approvals 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.

4.2 Assembly Load/Frame Strength

4.2.1 Requirements

The frame of a residential sprinkler shall be capable of withstanding twice the assembly load without sustaining permanent elongation or deformation in excess of 0.2 percent of the distance between the load bearing parts of the sprinkler.

4.2.2 Test/Verification

- A. Fifteen previously untested sprinklers shall be individually tested to determine the assembly load. With the threaded portion of the sprinkler restrained from movement, the heat responsive element of the test sample shall be removed and the negative axial deflection of the frame, resulting from the release of the assembly shall be recorded. Deflection measurements shall be made using an indicator capable of reading to an accuracy of 0.00001 in. (0.00025 mm). A force necessary to return the deflection of the frame to the original zero position shall then be applied and the value of the force recorded.
- B. Each of these sprinklers shall then be subjected momentarily (for 1 second to 5 seconds) to twice the sum of the force recorded in Section 4.2.2.A, plus the force applied to the sprinkler as a result of the maximum rated working pressure [typically 175 psi (12.1 bar)]. The amount of permanent set after the load application shall be determined. The percentage of permanent frame elongation shall be calculated using the minimum distance between the load bearing points, determined to the nearest 0.001 in. (0.03 mm), from the plane of the sprinkler orifice to the center of the compression bearing surface of the sprinkler.

4.3 Strength of Heat Responsive Element

4.3.1 Requirements

- A. A heat responsive element of the fusible type shall be (1) capable of sustaining a load 15 times its maximum design load for a period of 100 hours or (2) demonstrate the ability to sustain the maximum element design load when tested in accordance with Section 4.3.2.A.2.
- B. For a heat responsive element of the glass bulb type, the lower tolerance limit of bulb strength shall be greater than two times the upper tolerance limit of sprinkler assembly load based on calculations with a degree of confidence of 0.99 (99 percent). Calculations shall be based on the Normal or Gaussian Distribution except where another distribution can be shown to be more applicable due to manufacturing or design factors. The method for calculating the upper and lower tolerance limits is shown in Appendix D.

4.3.2 Tests/Verification

A. Heat Responsive Element of the Fusible Type

1. Fifteen samples shall be loaded with a weight representing the equivalent of 15 times the design load. All samples must remain undamaged after sustaining this load for a period of 100 hours.
2. Fusible type heat responsive elements which cannot pass the test described in 4.3.2.A.1 shall meet the following requirements. Sample fusible type heat-responsive elements shall be subjected to loads in excess of the design load which will produce failure both within and after 1000 hours. The test samples shall be maintained at an environmental temperature of 70°F ± 5°F (21°C ± 2.6°C). At least 15 samples shall be loaded to various degrees in order to establish a basis of time as a function of load. Failures which are not related to the solder bond shall be disregarded. A least square, full logarithmic regression curve shall be plotted

from which both the load to failure at 1 hour (L_o) and the load to failure at 1000 hours (L_m) shall be determined. The actual maximum design load (L_d) on the fusible element, as determined using the upper tolerance limit of assembly load from Section 4.2.2.A, shall be less than or equal to the value determined in the expression:

$$L_d = 1.02 \frac{L_m^2}{L_o}$$

Where:

- L_d = Maximum design load for the heat responsive element
- L_m = Load resulting in failure at 1000 hours
- L_o = Load resulting at failure in 1 hour

3. Where physical limitations of the fusible element prevent the application of the loads described in Section 4.3.1.A, alternate methods of determining the adequacy of the design shall be developed to ensure that such elements should not fail during the anticipated life span.

B. Heat Responsive Element of the Bulb Type

The results of the assembly load test, Section 4.2.2.A, shall form the basis for calculating the upper tolerance limit of the sprinkler assembly load. The lower tolerance limit for bulb strength shall be determined using the results obtained from subjecting a minimum of 25 sample bulbs to an increasing load until the bulbs fail. Each test shall be conducted with the bulb mounted in hardened steel inserts with seating surfaces having dimensions which conform to the actual mating components of the sprinkler. The inserts shall have a hardness within the range Rockwell C 38-50 (see Figure E-2). They shall be provided by the manufacturer each time the test is specified. The load shall be applied at a rate of compression not exceeding 0.05 in./min (1.27 mm/min). The results obtained from the two sets of data shall be utilized for the tolerance limit calculations as described in Appendix D, Tolerance Limit Calculations.

4.4 Leakage

4.4.1 Requirements

Residential sprinklers shall not weep or leak at, or below, 500 psi (34.5 bar) hydrostatic pressure and shall not leak at 30 psi (2.1 bar) pneumatic pressure.

4.4.2 Test/Verification

- A. Hydrostatic Leakage - Ten previously untested sprinklers shall be individually subjected to a slowly rising hydrostatic pressure. The pressure shall be increased from 0 psi to 500 psi (0 bar to 34.5 bar), at a rate not to exceed 300 psi (20.7 bar) per second, and maintained at 500 psi (34.5 bar) for 1 minute.
- B. Pneumatic Leakage - Four previously untested sprinklers shall be individually conditioned at $-20^{\circ}\text{F} \pm 10^{\circ}\text{F}$ ($-29^{\circ}\text{C} \pm 6^{\circ}\text{C}$) for 24 hours. Each sample shall be pneumatically pressurized to $30 \text{ psi} \pm 2 \text{ psi}$ ($2.1 \text{ bar} \pm 0.1 \text{ bar}$) and immersed in glycol liquid conditioned to $-20^{\circ}\text{F} \pm 10^{\circ}\text{F}$ ($-29^{\circ}\text{C} \pm 6^{\circ}\text{C}$), and observed for 5 minutes.

4.5 Hydrostatic Strength

4.5.1 Requirements

Residential sprinklers shall be capable of withstanding, without rupture, an internal hydrostatic pressure of up to 700 psi (48.3 bar) for a period of 1 minute.

4.5.2 Tests/Verification

If all samples comply with the requirements of Section 4.4.2.A, each sample shall be further subjected to a gradually increasing hydrostatic pressure to 700 psi (48.3 bar) at a rate not to exceed 300 psi (20.7 bar) per minute. The test pressure shall be maintained for 1 minute. If leakage at the orifice prevents testing at 700 psi (48.2 bar), the maximum attainable test pressure shall be maintained for 1 minute. Leakage at the orifice above a hydrostatic pressure of 500 psi (34.4 bar) shall be deemed acceptable.

4.6 30-Day Leakage

4.6.1 Requirements

Residential sprinklers shall not weep or leak when subjected to an internal hydrostatic pressure of 300 psi (20.7 bar) for a continuous period of 30 days. Following this test period, the samples shall not weep or leak at, or below, 500 psi (34.5 bar) when tested in accordance with Section 4.4.2.A (Hydrostatic Leakage). The samples shall also show no evidence of distortion or physical damage.

4.6.2 Tests/Verification

Five previously untested samples shall be hydrostatically tested to confirm that there are no weep or leak points at, or below, 500 psi (34.5 bar). The samples shall then be installed on a water-filled test apparatus which is to be maintained at ambient temperature and at a constant pressure of 300 psi (20.7 bar) for 30 days. The samples shall be examined weekly during the test period for evidence of leakage at the seal.

Following this test, the samples shall be subjected to the post-tests detailed above.

4.7 Water Hammer

4.7.1 Requirements

Residential sprinklers shall be capable of withstanding 100,000 applications of a pressure surge from approximately 50 psi to 500 psi (3.4 bar to 34.5 bar) without leakage, distortion, or physical damage. Following satisfactory completion of this test, the samples shall not weep or leak at, or below, 500 psi (34.5 bar) when tested in accordance with Section 4.4.2.A (Hydrostatic Leakage). The samples shall also show no evidence of distortion or physical damage.

4.7.2 Tests/Verification

Five previously untested samples shall be hydrostatically tested to confirm that there are no weep or leak points at, or below, 500 psi (34.5 bar). They shall then be installed on a water-filled manifold and subjected to changes in pressure from approximately 50 psi +0/-50 psi to 500 psi +0/-50 psi (3.4 bar +0/-3.4 bar to 34.5 bar +0/-3.4 bar) for 100,000 cycles +1,000/-0 cycles. The cycle period shall be between 1 second and 10 seconds. Observations shall be made for evidence of leakage at least twice a day during the test period.

Following this test, the samples shall be subjected to the post-tests detailed above.