Approval Standard
for
Heat and Smoke Vents

Class Number 4430

April 2007
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 requirements for heat and smoke vents.

1.1.2 Heat and smoke vents are usually manufactured from plastic or metal and are exposed to a number of hazards, including natural hazards, and must reject wind, hail and other deleterious effects caused from everyday exposure to heat, cold and sunlight.

1.1.3 When exposed to a fire from an internal source, automatic operating vents must be provided with a sufficiently rated heat sensing device so that they do not operate prematurely and adversely affect the activation of any sprinklers. Plastic drop-out type vents must maintain their structural integrity for a period of time so that they also won’t adversely affect sprinkler operation.

1.1.4 Approval criteria shall include, but are not limited to, performance requirements, marking requirements, an examination of manufacturing facility(ies), an audit of quality assurance procedures, and a follow-up program.

1.2 Scope

1.2.1 This standard sets the performance requirements for heat and smoke vents under simulated laboratory conditions. They shall be examined for their ability to remain in place until such time as sprinklers would have been expected to operate so as not to adversely affect the sprinkler operation. Additionally, this standard also sets their performance requirements when exposed to various natural hazards such as high wind events, the impact of simulated hail and the possible degradation effects of sunlight. The standard also examines their ability to withstand the impact effects of temporary live loads as well as to be able to operate under anticipated roof live (snow) loads.

1.2.2 This standard is not intended to be used to determine when or where heat and smoke vents are to be used or how to determine the amount of vented area needed.

1.2.3 This standard is not intended to qualify skylights. For the Approval requirements of skylights, see FM Approval Standard 4431, Skylights.

1.2.4 This standard is intended to evaluate only those hazards investigated and is not intended to determine suitability for the end use of the product.

1.2.5 The results of tests conducted under the controlled conditions required by this standard shall not be used to describe or appraise performance under actual fire or natural hazard conditions as actual fire and natural hazard conditions vary widely.

1.2.6 This standard does not examine the product’s solar optical values such as transmittance, reflectance or absorbance or other properties such as air leakage, water leakage, solar radiation, insulating properties or other properties related to the resistance of heat flow through the product due to indoor and outdoor temperature differentials.

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 heat and smoke vents for the purpose of obtaining Approval. Heat and smoke vents 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, heat and smoke vents 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 facilities and audit of quality control procedures is made to evaluate the manufacturer’s ability to consistently produce the product which is examined and tested, and the marking procedures used to identify the product. These examinations may be repeated as part of FM Approvals’ product follow-up program.

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 the terms stipulated in the Approval report;
- 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.

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 else forfeit Approval.

The effective date of this Standard is May 1, 2008 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 National Standards Institute (ANSI)/Institute of Electrical and Electronics Engineers (IEEE)/American Society for Testing Materials (ASTM) SI 10-97, *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:

**FM Approvals Standards**
- Approval Standard 4431, *Skylights*

**FM Global Data Sheets**
- FM Global Property Loss Prevention Data Sheet 1-10, *Smoke and Heat Venting in Sprinklered Buildings*
- FM Global Property Loss Prevention Data Sheet 1-28, *Wind Design*
- FM Global Property Loss Prevention Data Sheet 1-29, *Roof Deck Securement and Above-Deck Roof Components*

**American Society for Testing and Materials (ASTM)**

1.9 Definitions

For purposes of this standard, the following terms apply:

*Crack* – to break in such a way that a fine split or splits appear but the section does not come apart.

*Fragility* – the measure of a materials resistance to damage, brittleness or cracking.

*Heat Vent* – an operable opening in a roof designed to operate either automatically or manually in the event of a fire to allow heat and smoke to escape the building.

*Skylight* – an opening in a roof that is permanently covered with a translucent or transparent material. Skylights are generally inoperable and are provided mainly as a means of admitting light while maintaining the building envelope.

*Smoke Vent* - see Heat Vent.

*Thin Break* – a flaw that is visible as a thin line or a network of fine cracks.
2. GENERAL INFORMATION

2.1 Product Information

2.1.1 Heat and smoke vents were originally used as an aid to firefighting in unsprinklered buildings. In such cases, vents take advantage of the principle that hot air and gases tend to rise. When a fire occurs in an unsprinklered building, the smoke and gases rise until blocked. They then move radially outward in a mushrooming, deepening bank, slowly lowering to floor level and making manual fire fighting difficult.

2.1.2 In a sprinklered building, this may not be the case. In sprinklered buildings, the passage of hot air and smoke through the vent opening causes fresh air to enter into the building through any other available opening resulting in greater fuel consumption and an increased water demand. Refer to FM Global Property Loss Prevention Data Sheet 1-10, Smoke and Heat Venting in Sprinklered Buildings (May 1998) for a further discussion of the pros and cons of using heat and smoke vents in sprinklered buildings.

2.1.3 The selection of a heat and smoke vent system is a critical component in the overall effectiveness of a building’s ability to perform the functions for which it has been designed, especially during fire conditions. It is the first line of defense in combating the effects of natural hazards and protecting the lives of those in or near the building as well as the contents of the building. The system selected must be durable, cost effective, and aesthetically pleasing. It must be able to withstand the design conditions that have been placed on the system from internal sources for which it has been constructed as well as natural external sources such as wind and hail. Selection of a system that has not demonstrated that it can withstand the design conditions over long periods of time can lead to a loss of property as well as a loss of business.

2.1.4 Design conditions vary widely throughout the world. The selection of any exterior building component should be based, in part, on the geographical location where it will be constructed, its surroundings as well as the historical meteorological events that have occurred and are likely to occur in the future.

2.1.5 Heat and smoke vents are different from skylights. Heat and smoke vents are normally of smaller size and are designed to open automatically in fire situations to vent smoke and hot gases. Skylights are inoperable and are mainly provided as a means of supplementing a building’s lighting.

2.2 Approval Application Requirements

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

Materials-Director
FM Approvals
1151 Boston-Providence Turnpike
PO Box 9102
Norwood, MA 02062
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 products or services being submitted for Approval consideration;

- general assembly drawings, complete set of manufacturing drawings, materials list, sales literature and installation procedures;
• the number and location of manufacturing facilities and;

• all documents shall identify the manufacturer’s name, document number or other form of reference, title, date of last revision, and revision level. All documents shall be provided in English or with English translation.

2.3 Requirements for Samples for Examination

2.3.1 Following authorization of an Approval examination, the project engineer will inform the manufacturer of the number and type of samples that shall be submitted for examination and testing.

2.3.2 The manufacturer shall submit samples representative of production. FM Approvals, at their sole discretion, shall reserve the right to witness production of test samples and/or any components or raw materials that are deemed to be critical to the performance of the product. Any decision to use data generated using prototypes is at the discretion of FM Approvals.

2.3.3 Requirements for samples may vary depending on design features, results of prior or similar testing (if applicable), and results of any foregoing tests.

3. GENERAL REQUIREMENTS

3.1 General Information

The requirements of this standard shall be used to measure and describe the performance of heat and smoke vents to simulated fire testing, resistance to wind uplift and wind loading, resistance to hail, the effects of temporary live loads such as those imposed by foot traffic as well as to be able to operate under anticipated roof live (snow) loads. They also take into account the deleterious affects caused from everyday exposure to sunlight.

3.2 Types of Heat and Smoke Vents

3.2.1 There shall be two (2) categories of heat and smoke vents. One category shall be identified as automatic operating heat and smoke vents. The other category shall be identified as drop-out type heat and smoke vents. Heat and smoke vents can be further classified based on the material used to manufacture the domes or lids – either metal or plastic. The test requirements for each type of heat and smoke vent, and their material of construction, are shown in Table 1.

3.2.2 Automatic operating heat and smoke vents shall be permitted to utilize either metal or plastic lids and shall be provided with a manual opening device that is accessible from floor level. Additional manual opening devices shall be permitted provided that they do not interfere with the automatic opening capabilities of the vent. Automatic heat and smoke vents that utilize a metal lid are not required to be subjected to a fire test as they are provided with a heat activating device. Automatic heat and smoke vents that utilize plastic domes or lids shall be subjected to the fire test to verify that the lids will not melt, drip or drop out prior to activation of the heat activating device.
3.2.3 Drop-out type heat and smoke vents shall be provided with a tether to prevent the dome from falling to the floor after it has dropped out of the frame. The tether shall be designed such that it allows the drop-out section to fully clear the opening and not obstruct the horizontal cross section of the open vent.

<table>
<thead>
<tr>
<th>Type of Test</th>
<th>Automatic Type Metal Lids</th>
<th>Automatic Type Plastic Lids</th>
<th>Drop Out Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind Uplift</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Wind Load</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Live Load</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Fire Test</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Operational Test</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Impact Test</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Hail Test</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>ESFR</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Windborne Debris</td>
<td>Optional</td>
<td>Optional</td>
<td>Optional</td>
</tr>
</tbody>
</table>

3.2.4 Heat and smoke vents that do not meet the requirements of the Simulated Impact Test for Heat and Smoke Vents shall be eligible for Approval as long as they are provided with a safety cage that meets the requirements of OSHA Regulation 29 CFR 1910.23(e)(8) and 1926.501.

3.2.5 The Simulated Hail and UV/Hail ratings available are for moderate or severe exposure. As an option, a more severe test is available to satisfy other jurisdictional requirements.

3.2.6 All heat and smoke vents shall have a Simulated Wind Uplift Resistance rating. The minimum rating shall be 60 lbs/ft² (2.9 kPa). Additional ratings shall be in increments of 15 lbs/ft² (0.75 kPa).

3.2.7 The manufacturer of all resin systems or all plastic used to manufacture plastic domes and lids, and the facility where plastic domes and lids are manufactured and/or formed, shall be placed under the FM Approvals follow-up Facilities and Procedures Audit program. Further, a representative of FM Approvals shall witness production of all plastic domes and lids used in the test program.

3.3 Markings

3.3.1 Marking on the product or label accompanying the product shall include the following information:
- name and address of the manufacturer or marking traceable to the manufacturer;
- date of manufacture or code traceable to date of manufacture or lot identification;
- model number or designation and applicable ratings, as appropriate.

3.3.2 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.

3.3.3 The Approval Mark (see Appendix B) shall be displayed visibly and permanently on the product and/or packaging as appropriate. The manufacturer shall not use this mark on any other product unless such product is covered by a separate report.

3.3.4 All markings shall be legible and durable.
3.4 Manufacturer’s Installation Instructions

The manufacturer shall provide the user with instructions for the installation of the product.

3.5 Calibration

All examinations and tests performed in evaluation to this Standard shall use calibrated measuring instruments traceable and certified to acceptable national standards.

4. PERFORMANCE REQUIREMENTS

4.1 Simulated Wind Uplift Resistance Test for Heat and Smoke Vents

4.1.1 Requirement

All heat and smoke vents submitted for Approval shall be subjected to a simulated wind uplift resistance test in order to determine the product’s ability to resist anticipated loads imposed by wind forces on a roof system.

4.1.2 Test/Verification

One (1) test shall be conducted using the minimum thickness dome material and maximum size opening for which Approval is desired. The minimum rating shall be 60 lbs/ft² (2.9 kPa). Additional ratings shall be in increments of 15 lbs/ft² (0.75 kPa). The test shall be conducted in accordance with Appendix C. The conditions for acceptance are shown in C-5.1.

Thicker dome materials and/or smaller size openings shall be permitted to be tested in order or achieve higher wind uplift ratings.

4.2 Simulated Wind Load Resistance for Heat and Smoke Vents

4.2.1 Requirement

All automatically operated heat and smoke vents shall be examined for resistance to closing when subject to a simulated wind load.

4.2.2 Test/Verification

One (1) test shall be conducted, with the vent lid in the open position, to simulate a wind loading that would try to cause the vent to close after it has been activated and has reached the open position.

The test shall be conducted using the maximum area size vent lid for which Approval is desired. The applied pressure during the test shall be 5 lbs/ft² (0.25 kPa).

The vent assembly shall be secured such that it shall be unable to slide when the simulated wind load is applied. With the lid in the open position, a rope shall be tied around the horizontal center line of lid parallel to the long dimension of the lid. A spring loaded scale shall be applied to the inside face of the lid. A load equivalent to $5 \times L \times W$ shall be applied to spring loaded scale and perpendicular to the horizontal center line of the lid. This load shall be held for a period of sixty (60) seconds. The vent lid shall remain within 10° of the fully open position. See Figures 1 and 2.
Fig. 1. Simulated Wind Load Resistance Test Set-Up

Fig. 2. Simulated Wind Load Resistance Test Set-Up
4.3 Simulated Live Load Test for Heat and Smoke Vents

4.3.1 Requirement
All heat and smoke vents shall be examined to demonstrate that the vent lids can withstand an applied live load. Automatic opening heat and smoke vents shall also demonstrate their ability to attain the fully open position when subjected to an applied live load. The minimum live load shall be 10 lbs/ft² (0.5 kPa). Approval shall be granted to greater live loads in multiples of 5 lbs/ft² (0.25 kPa).

4.3.2 Test/Verification
Heat and smoke vents shall be subjected to the Simulated Live Load Test as described in Appendix D. The Conditions of Acceptance are shown in Paragraph D-4. All automatic operating vents shall have each combination of size or number of springs, dampers or other opening mechanisms subjected to a simulated live load test using the largest size dome for which the combination is to be Approved. (See Paragraph D-3.2)

4.4 Fire Exposure Test

4.4.1 Requirement
All heat and smoke vents that incorporate a plastic dome or lid shall be subjected to a fire exposure test to verify that the vent’s lid or dome will not drop out prematurely and affect sprinkler activation.

4.4.2 Test/Verification
4.4.2.1 The test consists of supporting the test sample on sawhorses and placing an exposure under the dome of the vent. The saw horses shall be suitably sized to adequately support the entire vent. The top of the saw horses shall be 30 in. ± ½ in. (760 mm ± 13 mm) above the floor. The height of the vent curb shall be a maximum of 12 in. (300 mm). The underside of the vent shall be equipped with a thermocouple taped to the underside of the dome to monitor the temperatures during the test.

4.4.2.2 The fire exposure consists of a ½ in. (13 mm) depth of isopropyl alcohol placed in a 12 in. × 12 in. × 12 in. (300 mm × 300 mm × 300 mm) steel pan. The liquid surface shall be located 18 in. (450 mm) below the top of the saw horses. When ignited, the exposure gradually increases to 500°F (260°C) after five (5) minutes. During the fire test, a one (1) in. (25 mm) per hour simulated rainfall is applied over the vent to evaluate the cooling effects of snow or rainfall. The temperature of the simulated rain shall be permitted to range between 50°F to 90°F (10°C to 32°C).

For drop-out types of vents, the vent dome or lid must drop-out and achieve the full open position within five (5) minutes of ignition. In addition, no burning or flaming particles are allowed to be dislodged from the vent and continue to burn after reaching the floor.

4.4.3 For automatic opening types of vents that utilize plastic lids, the vent lid must not develop any through openings or drop-out until after the fusible link device has activated. In addition, no burning or flaming particles are allowed to be dislodged from the vent and continue to burn after reaching the floor.
4.5 Operational Test

4.5.1 Requirement

All automatic type heat and smoke vents shall be subjected to an operation test to simulate expected service life and reliability. The operational test shall consist of cycling the vent dome through the complete open and close cycle sixty (60) times.

4.5.2 The test consists of supporting the test sample on saw horses or other sturdy surface and opening the vent by using the manual release. The vent shall attain the fully open position within ten (10) seconds of activation. The vent lid shall be closed and the manual release reset, if applicable. The open and close cycle shall be repeated a total of sixty (60) times. Once the test has started, no maintenance or adjustments shall be allowed other than resetting the release, if applicable.

4.6 Simulated Impact Test for Heat and Smoke Vents

4.6.1 Requirement

Heat and smoke vents shall be subjected to an impact test in order to determine the product’s ability to resist anticipated live loads and other possible loads due to foot traffic. Vents shall be permitted to be provided with a safety cage. In this case, the use of the safety cage will be required as a condition of Approval.

4.6.2 The test shall be conducted in accordance with the Simulated Impact Test for Heat and Smoke Vents (Appendix E). One (1) test shall be conducted on the minimum thickness of each profile for which Approval is desired. The test shall be conducted at the maximum span that the particular profile and thickness are to be Approved. The specimen shall be considered to meet the test criteria if no through opening develops through which a four (4) in. (102 mm) diameter sphere can pass. The vent lid shall not become dislodged from the vent curb or drop out. When a safety cage has been provided, the safety cage shall not come into contact with the dome or lid as a result of deflection caused by the impactor.

4.7 Simulated Hail Resistance Test Using Freezer Ice Balls

4.7.1 Requirement

All Approved heat and smoke vents that utilize non-metallic domes or lids shall be subjected to a simulated hail impact test in accordance with the Simulated Hail Resistance Test Using Freezer Ice Balls (Appendix F). Two (2) ratings are available: Severe (S) and Moderate (M). The test is based on FM Approvals Test Standard 4473, Specification Test Protocol for Impact Resistance Testing of Rigid Roofing Materials Impacted with Freezer Ice Balls, with some variations. The Severe Hail rating will consist of a nominal 1.75 in. (44 mm) diameter ice ball having a kinetic energy of 14.9 ft-lbs (20.3 J). The Moderate Hail rating shall consist of a nominal 1.5 in. (38 mm) diameter ice ball having a kinetic energy of 7.8 ft-lbs (10.4 J).

4.7.1.1 As an option, at the test sponsor’s discretion, the Severe Hail rating shall be permitted to consist of a nominal 2.0 in. (51 mm) diameter ice ball having a kinetic energy of 26.8 ft-lbs (36.4 J). In such cases, a note will be added to the Approval Guide listing so that other jurisdictional requirements can be met.

4.7.1.2 The Severe and Moderate designations are equivalent to the Class 3 and Class 2 ratings, respectively, shown in Test Standard 4473. The level referenced in paragraph 4.7.1.1 is equivalent to a Class 4 rating per Test Standard 4473.
4.7.2 Verification/Test

Two (2) test specimens of each profile shall be subjected to either the Severe or Moderate impact energy in accordance with the Simulated Hail Resistance Test for Skylights Using Freezer Ice Balls (Appendix F). One sample shall be exposed to ultra-violet (UV) light for a period of not less than one thousand (1000) hours prior to impact from the freezer ice balls. Each sample shall be impacted ten (10) times. The specimen shall be considered to meet the test criteria if no through openings develop however cracking and thin breaks shall be permitted. If successful, Approval will be granted to thicker specimens of the same profile without additional testing.

4.8 Approval for Use with ESFR Sprinklers

4.8.1 Requirement

As an option, heat and smoke vents shall be permitted to be subjected to a modified fire test in order to determine if the product can be used in conjunction with ESFR sprinklers without adversely affecting their ability to activate. This shall be determined by assessing the dome’s ability not to allow venting until a 360°F (182°C) fusible link has activated. This test shall be conducted in addition to the fire test described in Paragraph 4.4.

4.8.2 Test/Verification

One (1) test shall be conducted in accordance with the Fire Exposure Test shown in Paragraph 4.4. For heat and smoke vents that utilize non-metallic domes or lids. The dome shall not release or drop out of the opening until the 360°F (182°C) fusible link has activated. The test shall be conducted on the largest size vent for which Approval is desired. If a mechanical device, cable or restraining system is used to keep the dome from venting, the device, cable or restraining system shall support the dome in such a manner that venting does not occur until the 360°F (182°C) fusible link has activated.

4.9 Windborne Debris Rating

4.9.1 As an option, heat and smoke vents shall be permitted to be Approved for resistance to windborne debris such as large or small missiles.

4.9.1 Test/Verification

Tests shall be conducted on the minimum thickness of each material for which Approval is desired. The test(s) shall be conducted in accordance with Approval Standard 4350, Windstorm Resistant Fenestrations.
5. OPERATIONS REQUIREMENTS

A quality assurance program is required to assure that subsequent heat and smoke vents produced by the manufacturer shall present the same quality and reliability as the specific products examined. Design quality, conformance to design, and performance are the areas of primary concern.

- Design quality is determined during the examination and tests, and is documented in the Approval Report.
- Continued conformance to this Standard is verified by the Facilities and Procedures Audit (F&PA).
- Quality of performance is determined by field performance 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; and
- handling and disposition of non-conforming materials.

5.1.2 Documentation/Manual

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

5.1.3 Records

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

5.1.4 Drawing and Change Control

- The manufacturer shall establish a system of product configuration control that shall allow no unauthorized changes to the product. Changes to critical documents, identified in the 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.
5.2 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 assurance program. Its purpose is to determine that the manufacturer’s equipment, procedures, and quality program are maintained to insure a uniform product consistent with that which was tested and FM Approved.

5.2.2 These audits shall be conducted periodically but at least annually by FM Approvals or its representatives.

5.2.3 FM Approved products or services shall be produced or provided at or from the location(s) audited by FM Approvals and as specified in the Approval Report. Manufacture of products bearing the Approval Mark is not permitted at any other location without prior written authorization by FM Approvals.

5.3 Installation Inspections

Field inspections may be conducted to review an installation. The inspections are conducted to assess ease of application, and conformance to written specifications. When more than one application technique is used, one or all may be inspected at the discretion of FM Approvals.

5.4 Manufacturer’s Responsibilities

The manufacturer shall notify FM Approvals of changes in product construction, components, raw materials, physical characteristics, coatings, component formulation or quality assurance procedures prior to implementation.
APPENDIX A

Units of Measurement

**LENGTH:**

in. - “inches”; (mm - “millimeters”)

\[
\text{mm} = \text{in.} \times 25.4
\]

ft - “feet”; (m - “meters”)

\[
\text{m} = \text{ft} \times 0.3048
\]

**AREA:**

\[\text{in}^2 - \text{“square inches”}; \ (\text{mm}^2 - \text{“square millimeters”})\]

\[
\text{mm}^2 = \text{in}^2 \times 6.4516 \times 10^2
\]

\[\text{ft}^2 - \text{“square feet”}; \ (\text{m}^2 - \text{“square meters”})\]

\[
\text{m}^2 = \text{ft}^2 \times 0.0929
\]

**MASS:**

lb - “pounds”; (kg - “kilogram”)

\[
\text{kg} = \text{lb} \times 0.454
\]

oz - “ounces”; (g - grams)

\[
\text{g} = \text{oz} \times 28.35
\]

**PRESSURE:**

psf - “pounds per square foot”; (bar - “bar”)

\[
\text{kPa} = \text{psf} \times 0.048
\]

bar - “bar”; (kPa - “kilopascals”)

\[
\text{bar} = \text{kPa} \times 0.01
\]

\[
\text{bar} = \text{psi} \times 0.06895
\]

**TEMPERATURE:**

F - “degrees Fahrenheit”; °C - “degrees Celsius”

\[
\text{°C} = (\text{°F} - 32) \times 0.556
\]

**DENSITY:**

\[\text{lb/ft}^3 - \text{“pounds per cubic foot”}\]

(Kg/m³ - kilograms per cubic meter)

\[
\text{Kg/m}^3 = \text{lb/ft}^3 \times 16.018
\]

**KINETIC ENERGY**

ft-lb - “foot pound” (J - Joules)

\[
\text{J} = \text{ft-lb} \times 1.356
\]

**VELOCITY**

\[\text{ft/sec} - \text{“feet per second”} \ (\text{meters per second})\]

\[
\text{m/s} = \text{ft/sec} \times 0.305
\]
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.
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.

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

Simulated Wind Uplift Resistance Test for Heat and Smoke Vents

C-1 Introduction

C-1.1 This test method is designed to measure the wind uplift resistance of a heat and smoke vent assembly under static conditions which simulate the uplift loads imposed by wind forces on a roof system.

C-2 Test Apparatus and Arrangement

C-2.1 The description of the apparatus is general in nature. Any equipment capable of performing the test procedure within the allowable tolerances is permitted. Only the major components are described.

C-2.2 The test apparatus shall consist of a pressure vessel that is large enough to incorporate the unit being tested. The pressure vessel shall consist of four (4) sides and a bottom. The top of the vessel shall remain open for the placement of the test sample. The side members shall be fabricated from minimum nominal 8 in. (200 mm) deep steel channel shaped section. They shall be arranged into a square or rectangle such that the inside dimensions are equivalent to the opening of the test sample. The channel shaped members shall be securely fastened or welded to each other in each corner. The bottom of the vessel shall be permitted to be fabricated from sheet metal and will be sized such that it fits completely under the test frame. The bottom shall be securely fastened to the test frame or welded along the inside perimeter of the test frame. Other structural shapes, sizes and materials of construction shall be permitted to be used as long as the frame will provide a rigid base for the test sample.

C-2.3 The air supply into the sealed vessel is provided by an inlet manifold construction with a nominal 4 in. (102 mm) diameter PVC pipe. The air supply shall be permitted to penetrate through either the bottom of the pressure vessel or through the side of one of the channel shaped members. A 1⁄4 in. ± 1⁄8 in. (6.4 mm ±3.2 mm) opening on the bottom or side of the vessel serves as the manometer connection. The test sample shall be placed on top of the frame with a gasket placed between the top channel of the pressure vessel and the sample construction frame to minimize air leakage. The sample shall be fastened to the flanges of the test frame in accordance with the manufacturer’s written installation instructions using fasteners and fastener spacings representative of an actual installation. Any other joints in the test frame shall be permitted to taped or gasketed as necessary in order to achieve the anticipated pressure levels.

C-2.4 Air shall be supplied to the inlet manifold by a Turbo Pressure Blower, or equivalent, having the capability of generating 600 ft³/min (17 m³/min) or as needed to attain the desired uplift pressure. Pressure readings are obtained from a water filled manometer to be read directly in lbs/ft² (kPa) and capable of being read in minimum increments of 2 lbs/ft² (0.1 kPa). As an alternative, other types of pressure measuring devices shall be permitted to be used provided that the alternative device(s) have an equivalent or tighter graduation and tolerance levels.

C-3 Test Specimen

C-3.1 The test specimen shall utilize the minimum thickness dome and curb material and maximum size opening for which Approval is desired.

C-3.2 Both the widest and longest units shall be tested.
C-3.4 If the necessary pressure levels can not be reached because of air leakage through the assembly, a single layer of polyethylene film no thicker than 0.006 in. (0.15 mm) shall be permitted to be placed on the underside of the vent. The application of the film shall be such that the maximum load is transferred to the test specimen and that the membrane does not prevent movement or failure of the specimen. The film should be applied loosely with extra folds of material provided at the corners and all offsets or recesses. Any cracks or joints through which air leakage can occur shall be sealed with tape or other effective means.

C-4 Test Procedure

C-4.1 Air is introduced from below the sample until the pressure level reaches 15 lbs/ft² (0.7 kPa) with a tolerance of +2 lbs/ft², -0 lbs/ft² (+0.1 kPa, -0 kPa). The air shall be introduced at a rate that will increase the resulting pressure 1.5 lbs/ft²/sec ±1 lbs/ft²/sec (0.7 kPa/sec ± 0.05 kPa/sec). Upon reaching 15 lbs/ft² (0.7 kPa), the pressure level shall be maintained for a period of 60 seconds. The air and clamps shall be permitted to be adjusted as necessary in order to maintain a constant reading. While the sample is being maintained at this pressure level, the sample shall be visually examined to ensure that it continues to meet the Conditions of Acceptance.

C-4.1.1 Upon mutual agreement between the test sponsor and the testing entity, the 15 lbs/ft² (0.7 kPa) pressure level noted above may be omitted. This results in the initial pressure level being 30 lbs/ft² (1.4 kPa) with a tolerance of +2 lbs/ft², -0 lbs/ft² (+0.1 kPa, -0 kPa). Subsequent pressure increases shall be as described in C-4.3.

C-4.2 Depending on the type of assembly being tested, it is not always possible to adhere to the 1.5 lbs/ft²/sec ±1 lbs/ft²/sec (0.7 kPa/sec ± 0.05 kPa/sec) rate of increase needed to reach the next pressure level. In these situations, the rate of increase between pressure levels shall be conducted as evenly as practical. The 60 second time period required to attain the next pressure level shall not start until the new pressure level has been reached.

C-4.3 After 60 seconds, the pressure level shall be increased in 15 lbs/ft² (0.7 kPa) increments by introducing additional air at the rate and within the tolerance as described above. Upon reaching the next 15 lbs/ft² (0.7 kPa) level, the pressure shall be maintained for a period of 60 seconds. The supply air and clamps shall be permitted to be adjusted as necessary in order to maintain a constant reading. While the sample is being maintained at this pressure level, the sample shall be visually examined to ensure that it continues to meet the conditions of acceptance.

C-4.4 The sequence described above in C-4.3 shall be repeated until the sample fails, additional pressure levels are unable to be attained or maintained, or at the discretion of the test sponsor.

C-5 Performance Requirements

C-5.1 The specimen shall be considered to meet the test criteria if:

- all fasteners, clips and other items used to secure the vent dome or lid shall remain fully engaged with the vent dome and shall not pull through, become dislodged or disconnected;
- all fasteners, clips and other items used to secure the curb to the test frame shall remain fully engaged and shall not pull through, become dislodged or disconnected;
- the vents shall not delaminate, break, crack or develop any through openings;
- vent lids shall not open or become disengaged from the mechanical devices used to secure the dome to the curb;
- the vent assembly can no longer withstand the applied pressure.
APPENDIX D

Simulated Live Load Test for Heat and Smoke Vents

D-1 Introduction

D-1.1 All heat and smoke vents must be able to withstand roof live loads that simulate rain and snow. In addition, automatic opening heat and smoke vents must be able to attain the fully open position when subjected to roof live loads.

D-1.2 This Appendix contains two different test methods.

D-1.2.1 Test Method A is used to assess heat and smoke vents ability to withstand the maximum sustained live load for which it is rated without having any deleterious affects on the vent. All heat and smoke vent designs shall be subjected to Test Method A. As an alternative and at the sole discretion of FM Approvals, units constructed completely of metal shall be permitted to be qualified using engineering calculations.

D-1.2.2 Test Method B is used to assess the ability of an automatic operating heat and smoke vent to attain the open position while it’s being subjected to the maximum live load for which it is rated. As such, only automatic operating heat and smoke vents shall be subjected to Test Method B.

D-2 Test Method

D-2.1 One (1) test shall be conducted using the minimum thickness dome material and maximum size opening for which Approval is desired. The live load shall consist of bags of sand being placing on the lid until the desired live load is achieved. The bags shall be applied evenly over the entire area of the vent. When the vent lids are not flat or of an irregular shape, the load shall be applied as uniformly as possible to follow the contour of the vent.

D-3 Conduct of Tests

D-3.1 Test Method A – All Vents

After placement of the sand bags, the unit shall be subjected to the test load for a minimum period of seventy-two (72) hours. The seventy-two (72) hour period shall not start until the last sand bag has been placed. The bags of sand shall be placed flat and uniformly over the entire surface of vent.

D-3.1 Test Method B – Automatic Operating Vents

Steel plates shall be placed on the lid to simulate the roof live load. Each 0.25 in. (6 mm) thickness of steel plate shall be considered to represent a 10 lbs/ft² (0.5 kPa) live load. The centroid of the steel plates shall be centered along the centerline of the moveable portion of the vent. The plates shall be securely fastened to the vent frame and the vent frame shall be fastened to the floor or other supports such that it does not topple when the vent is opened.

When the steel plates have been fastened to the vent and the unit is ready for testing, the manual release shall be activated. The test shall be repeated five (5) times.
D-4 Performance Requirements

D-4.1 Test Method A – All Vents
The vent shall remain in place for the entire test period without developing any through openings. When the sand bags have been removed, the vents shall not suffer any permanent deformation greater than 1 in. (25 mm) from its original position.

D-4.1 Test Method B – Automatic Operating Vents
For each test, when the manual release is activated, the vent shall attain the fully open position, ±10%, within ten (10) seconds. No maintenance or adjustments are permitted during the series of tests.
APPENDIX E

Simulated Impact Test for Heat and Smoke Vents

E-1 Introduction

E-1.1 This test method is intended to evaluate the fragility of heat and smoke vents when subjected to the impact of a simulated live load.

E-2 Test Apparatus and Arrangement

E-2.1 The description of the apparatus is general in nature. Any equipment capable of performing the test procedure within the allowable tolerances is permitted. Only the major components are described.

E-2.2 Impactor – the impactor shall be a cylindrical canvas bag having a diameter of 12 in. (300 mm). The sand shall be dry, have a nominal density of 95 lbs/ft³ (1500 kg/m³) and pass through a #8 size sieve [0.0937 in. (2.4 mm) aperture]. The bag shall be filled with dry sand in layers not exceeding 6 in. (150 mm) thick to a total assembly weight of 100 lbs (45.5 kg) ± 4 oz. (113.4 g). Each layer shall be compacted using a 1.0 in. (25 mm) diameter reinforcing bar. The compacting action shall be spread over as much of the surface of the sand as possible. Upon completion of the compaction of the sand, the bag shall be drawn tight as close as possible to the top surface of the sand. The bag shall be tied to ensure that the sand cannot escape. A ring or similar device shall be attached to the top of the bag to facilitate the quick release mechanism used to drop the impactor. Duct tape shall be permitted to be wrapped around the exterior and the bottom of the sand bag.

E-2.3 Test Frame – the test frame shall be fabricated from steel sections that are sufficiently sized to prevent movement and deflection when hold the impactor at the required pre-impact height above the test sample.

E-2.4 Quick Release Device – a quick release device shall be used to release the impactor such that it can freely fall when released. The device shall be permitted to be attached to a rope or cable and a pulley system to aid raising the impactor to the proper height and to assist in raising the impactor from the test sample after it’s been released. The rope or cable shall not be attached in any way to the impactor as it is falling onto the sample.

E-2.5 Impact Table – the impact table shall be sufficiently sized to provide sufficient stiffness to prevent any flexibility from affecting the test results. The table shall be sufficiently sized to allow for the skylight to be installed at the maximum span for which Approval is desired.

E-3 Test Specimen

The test specimen shall be the minimum thickness and maximum size for which Approval is desired.

E-4 Test Procedure

E-4.1 The test specimen shall be fastened along both its length and width with the appropriate size fasteners and spacing that is representative of the products installation.
E-4.2 Each profile being considered for Approval shall be subjected to two (2) separate impacts from the impactor. The 1st impact shall be located within a 12 in. (300 mm) diameter circle located at the test specimen’s center point. The 2nd impact shall be located with 12 in. (300 mm) from the end support. It shall be permitted to use separate test specimens for each impact.

E-4.3 The impactor shall be connected to the quick release mechanism and then raised to a position such that the bottom of the impactor is 4 ft (1.2 m) above the highest surface of the test panel. The impactor shall then be released such that it falls freely under gravity onto the surface of the test specimen. The impactor shall not be removed for a period of five (5) minutes after each impact. The 2nd drop of the impactor shall be released from the same height as the 1st drop.

E-5 Performance Requirements

The specimen shall be considered to meet the test criteria if no through openings develop through which a four (4) in. (102 mm) diameter sphere can pass. The vent lid shall not become dislodged from the vent curb or drop out.
APPENDIX F

Simulated Hail Resistance Test Using Freezer Ice Balls

F-1 Introduction

F-1.1 This test method is intended to evaluate the performance of heat and smoke vents when subjected to the impact of simulated hail. It is based on FM Approvals Test Standard 4473, Specification Test Protocol for Impact Resistance Testing of Rigid Roofing Materials by Impacting with Freezer Ice Balls. This test is consistent with Standard 4470 in that equivalent impact energies are used but different in that it utilizes ice balls instead of steel balls.

F-1.2 Two ratings are available – Severe (S) and Moderate (M). The Severe Hail rating will consist of a nominal 1.75 in. (44 mm) diameter ice ball having a kinetic energy of 14.9 ft-lbs ± 0.4 ft-lbs (20.3 J ± 0.05 J). The Moderate Hail rating shall consist of a nominal 1.5 in. (38 mm) diameter ice ball having a kinetic energy of 7.8 ft-lbs ± 0.2 ft-lbs (10.4 J ± 0.03 J). The impact speeds are 101.8 ft/sec ± 2 ft/sec (31.0 m/sec ± 0.6 m/sec) and 92.5 ft/sec ± 2 ft/sec (28.2 m/sec ± 0.6 m/sec), respectively.

F-1.2.1 As an option, at the test sponsor’s discretion, the Severe Hail rating shall be permitted to consist of a nominal 2.0 in. (51 mm) diameter ice ball having a kinetic energy of 26.8 ft-lbs ± 0.7 ft-lbs (36.4 J ± 0.1 J). The impact speed shall be 111.6 ft/sec ± 2 ft/sec (34.0 m/sec ± 0.6 m/sec).

F-1.2.2 The Severe and Moderate designations are equivalent to the Class 3 and Class 2 ratings, respectively, shown in Test Standard 4473. The level referenced in paragraph F-1.2.1 is equivalent to a Class 4 rating per Test Standard 4473.

F-2 Test Apparatus and Arrangement

F-2.1 The description of the apparatus is general in nature. Any equipment capable of performing the test procedure within the allowable tolerances is permitted. Only the major components are described.

F-2.2 Launcher – the launcher shall be a device capable of propelling ice balls at the speeds necessary to develop the intended kinetic energy. Aiming accuracy of the launcher must be sufficient to assure that the ice balls strike the test specimen at the specified impact areas.

F-2.3 Velocity Measuring Device – a velocity measuring device shall be used to monitor the speed of the ice balls. It shall be accurate within ±1 ft/sec (±0.3 m/sec).

F-2.4 Conditioning Box or Freezer – a conditioning box or freezer shall be capable of maintaining the conditioning requirements stated below.

F-3 Test Specimen

F-3.1 Two (2) samples shall be cut from a dome for testing. The samples shall be 13 in. × 13 in. ± 1 in. (330 mm × 330 mm ± 25 mm) and shall be representative of the samples being submitted for Approval.

F-3.2 One sample shall be designated as Sample A and shall be conditioned at 40°F ±5°F (4°C ±3°C) for a period of not less than 48 hours immediately prior to the test. It shall be tested within five (5) minutes of being removed from the conditioning box. Prior to being placed in the conditioning box, the sample shall be protected from exposure to direct sunlight.
F-3.3 One sample shall be designated as Sample B and be subjected to an ultra-violet (UV) exposure of a minimum of one thousand (1000) hours in accordance with ASTM G154-05, *Standard Practice for Operating Fluorescent Light Apparatus for UV Exposure for Non Metallic Materials*. Upon completion of the UV exposure, the Sample B shall be conditioned at 40°F ±5°F (4°C ±3°C) for a period of not less than 48 hours immediately prior to the test. It shall be tested within five (5) minutes of being removed from the conditioning box.

F-3.4 The test specimens shall be placed over and secured to 1/2 in. (13 mm) thick plywood. The plywood shall be sized such that it is a minimum of 2 ft × 2 ft (0.6 m × 0.6 m). Prior to securing the test specimen in place, nominal 1 in. × 2 in. (25 mm × 50 mm) wooden strips shall be secured to the plywood such that they form a 13 in. × 13 in. (330 mm × 330 mm) square centered around the center of the plywood. The purpose of the strips is to allow the test specimen to be secured to the plywood in such a manner that the field of the test specimen is not in contact with the plywood. The test specimen shall be secured on all four (4) sides with a minimum of one (1) fastener on each side.

F-3.4.1 The specimens shall be permitted to be secured to the plywood as it is being conditioned to facilitate testing when the specimen is removed from the conditioning area. The specimen shall not be secured to the plywood as it is being exposed to UV.

F-3.5 The ice balls shall be molded using distilled water by placing them in a freezer for a minimum of 48 hours at a controlled temperature of -7°F ±7°F (-22°C ±4°C) until they are frozen solid. Acceptable ice balls shall be free of cracks and air bubbles. They shall meet the criteria listed in Table F-1 within 0 and +10% of the values shown. The ice balls shall be propelled at the sample within two (2) minutes of being removed from the freezer.

### Table F-1

<table>
<thead>
<tr>
<th>Nominal Ice Ball Diameter in. (mm)</th>
<th>Mass in Pounds (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5 (38)</td>
<td>0.0584 ± 0.003 (26.5 ± 1.3)</td>
</tr>
<tr>
<td>1.75 (45)</td>
<td>0.0928 ± 0.006 (42.1 ± 2.1)</td>
</tr>
<tr>
<td>2.0 (51)</td>
<td>0.1385 ± 0.008 (62.9 ± 3.1)</td>
</tr>
</tbody>
</table>

F-4 Test Procedure

F-4.1 Calibrate the ice ball launcher to meet the minimum missile speeds shown in Table F-2. These speeds are designed to impart the kinetic energies shown. The calibrated speed used during the tests shall not exceed the values shown by more than 5 ft/sec (1.5 m/sec).

F-4.2 Maintain the temperature of the test area between 60°F and 90°F (16°C and 32°C).

F-4.3 Remove the test specimen from its conditioning box and position it vertically to assure that the trajectory of the ice ball is perpendicular (90° ±5°) to the test specimen and to determine the impact locations. Once the impact locations have been determined, remove a sufficient number of ice balls from the freezer.

F-4.3.1 In order to obtain a Severe Hail rating, the test specimen shall be impacted with either the 1.75 in. (45 mm) or the 2.0 in. (51 mm) diameter ice balls as shown in Table F-2. When the 2.0 in. (51 mm) diameter ice ball is used to obtain the Severe Hail rating, a note will be added to the Approval Guide listing so that other jurisdictional requirements can be met. In order to obtain a Moderate Hail rating, the test specimen shall be impacted with the 1.5 in. (38 mm) diameter ice balls as shown in Table F-2.
F-4.4 Each test specimen shall be impacted a total of ten (10) times with the appropriate ice balls within a 12 in. (300 mm) diameter circle located at the center of the specimen. Each missile shall be fired separately.

Table F-2

<table>
<thead>
<tr>
<th>Nominal Ice Ball Diameter, in. (mm)</th>
<th>Missile Impact Speed, ft/sec (m/sec)</th>
<th>Kinetic Energy, ft-lbs (J)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5 (38)</td>
<td>92.5 ± 2 (28.2 ± 0.06)</td>
<td>7.8 ± 0.2 (10.4 ± 0.03)</td>
</tr>
<tr>
<td>1.75 (45)</td>
<td>101.8 ± 2 (31.0 ± 0.06)</td>
<td>14.9 ± 0.4 (20.3 ± 0.05)</td>
</tr>
<tr>
<td>2.0 (51)</td>
<td>111.6 ± 2 (34.0 ± 0.06)</td>
<td>26.8 ± 0.7 (36.4 ± 0.1)</td>
</tr>
</tbody>
</table>

F-5 Performance Requirements

The specimen shall be considered to meet the test criteria if none of the samples develop a through opening after being impacted as described above. The specimens shall be permitted to develop cracks and thin breaks.