FM Approvals

CLASS NUMBER 4473

Specification Test Standard for Impact Resistance Testing of Rigid Roofing Materials by Impacting with Freezer Ice Balls

Impact Resistance Testing of Rigid Roofing Materials by Impacting with Freezer Ice Balls

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1. INTRODUCTION

1.1. PURPOSE

1.1.1. This test standard states FM Approvals test requirements and procedures for the assessment of impact resistance of new rigid roofing materials. Rigid roofing materials are manufactured in a rigid configuration and remain rigid during usage. These roof materials are manufactured as tiles or planks from materials such as slate, concrete or clay.

1.1.2. This test standard does not qualify products for Approval based solely on these test results, as the end use of the product will determine the applicable Approval Standard requirements.

1.1.3. An FM Approvals' Specification Tested Listing program per this test standard is available to roofing manufacturers. This program includes FM Approvals Quality Assurance Auditing of the products, wherein the manufacture of test sample material will be monitored by a representative of FM Approvals at the manufacturing facilities. The successful completion of the Listing program requires the manufacturer to reference the FM Approvals name and Hail Impact Resistance Classification on the packaging and on the product.

1.2. SCOPE

1.2.1. This test standard provides a procedure for determining the impact resistance performance of new prepared rigid roofing materials which are intended for use mainly on, but not restricted to, ''Steep Slope'' roof systems. The test uses the impact forces of freezer ice balls propelled to develop free-fall kinetic energies of the same size hail.

1.2.1.1. Slope as defined by the National Roofing Contractors Association (NRCA) is the incline of the roof expressed either in percent or in the number of vertical units of rise per horizontal unit of run. It is generally measured in inches per foot. The NRCA ranks slope as follows: Low Slope — Less than 3 inches per foot (< 3 in 12); and Steep Slope — 3 inches per foot and greater (<3 in 12).

1.2.1.2. Ice balls are used in this test method to simulate hailstones. Hailstones are variable in properties such as shape, density and frangibility. These properties affect factors such as the duration and magnitude of the impulsive force acting on the roof and the area over which the impulse is distributed. Ice balls (with a density, frangibility, and terminal velocity near the range of hail- stones) are the nearest hailstone approximation known at this time. Ice balls generally are harder and denser than hailstones; therefore, an ice ball simulates the worst case hailstone. A major difference between ice balls and hailstones is that hailstones are more variable than ice balls. Ice balls can be uniformly and repeatedly prepared to assure a projectile with known properties.

1.2.2. This test method defines test specimens and test panels, defines a procedure for determining impact locations on test specimens, provides kinetic energies of propelled ice balls, provides a method for impacting test specimens with ice balls, and specifies parameters that must be recorded and reported.

1.2.3. This standard is intended to verify that the product as described will meet minimum specific stated conditions of impact resistance performance. This performance criterion is useful in determining the potential suitability of these products under hailstorm conditions.

1.2.4. Exposure of roof coverings to the elements over an extended period of time has a potential to significantly lower the hail resistance of the roof materials. This standard is intended for the testing of new rigid roof cover systems.

1.3. BASIS FOR REQUIREMENTS

1.3.1. The requirements of this test standard are based on experience, research and testing, and/or the standards of other organizations. The advice of manufacturers, users, trade associations, jurisdictions and/or loss control specialists has been considered.

1.3.2. Meeting these requirements does not qualify a product for Approval. Additional testing and requirements for Approval are specified in the Approval Standards which are based on the end use of the product.

1.4. EFFECTIVE DATE

The effective date of a test standard mandates that all products tested for evaluation after the effective date shall satisfy the requirements of that standard.

The effective date of this standard is September 1, 2005 for compliance with all requirements.

1.5. APPLICABLE DOCUMENTS

The following article is referenced in this standard: *Hail Resistance of Roofing Products,* Greenfeld, S.H., National Bureau of Standards, Building Science Series 23, Washington, D.C., August 1969.

1.6. DEFINITIONS

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

Molds	Devices for casting spherical ice balls of appropriate diameters
Freezer	Appliance for making ice balls in the molds, controlled at -7° ± 7°F (-22 ± 4°C)
Balance	For weighing the ice balls, weight measurement accurate within ± 0.0005 lbs (0.23 gr)
Test Specimen	The individual tile or plank to be impact-tested
Test Panel	The substrate for supporting the roofing material in a fashion that simulates typical application
Test Assembly	The completed application of a test specimen, consisting of multiple tiles or planks, secured on the test panel in accordance with the manufacturer's specifications
Launcher	A device capable of propelling ice balls at speeds necessary to develop the intended kinetic energy. Aiming accuracy of the launcher must be sufficient to assure that the ice balls strike the specified impact areas; otherwise, the surrounding area must be masked for protection against inadvertent impacts
Speed Meter	A device for measuring ice ball speeds within ± 1 mph (0.45 m/s)

1.7. SYSTEM OF UNITS

Units of measurement are U.S. customary units. These are followed by their arithmetic equivalents in International System (SI) units, enclosed in parentheses. Appendix A lists the selected units for qualities dealt with in testing these products; conversions to SI units are included. Conversion of U.S. customary units is in accordance with ANSI/IEEE/ASTM SI 10-97, *Standard for Use of the International System of Units (SI): The Modern Metric System*.

2. TEST REQUIREMENTS

2.1. CLASSIFICATION

The sizes of freezer ice balls in the standard correspond to the classes shown below:

Nominal Ice Ball

Diameter in. (mm)	Class
1¼ (31.8)	1
1½ (38.1)	2
1¾ (44.5)	3
2 (50.8)	4

2.2. CALIBRATION

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

3. TEST PROTOCOL

3.1. SAMPLE PREPARATION

3.1.1. Test specimens are mounted on a minimum 3 × 3 ft (0.9 × 0.9 m) test panel simulating actual field applications using plywood decking having a minimum span rating 32⁄16 [typically 15⁄32 in. (12 mm) thick] supported by a frame consisting of nominal 2 × 4 in. (50 × 100 mm) lumber perimeter elements and mid-span brace. The test specimen shall be applied to the test panel in accordance with the manufacturer's instructions. Test specimens shall cover a minimum area of 3 × 3 ft (0.9 x 0.9 m) on the test panel.

Exception: Other test panels are permitted to be used in order to more accurately simulate actual field applications. Any deviation to the test panel described in Section 3.1.1 shall be noted in the report and listing.

3.1.2. Condition the test samples at temperatures between 60° and 90°F (15.6° and 32.2°C) for the period of time sufficient to attain thermal equilibrium. When adhesives are used, seal by placing the test assembly in an oven at temperatures between 135° and 140°F (57° and 60°C) for a continuous 16 hours. The test assembly shall be positioned in the oven with test specimen materials on top. Test samples shall be allowed to cool to room temperature prior to testing.

3.2. ICE BALL SAMPLE PREPARATION

Molds of distilled water for casting spherical ice balls of 1¼, 1½, 1¾, and 2 in. (31.8, 38.1, 44.5 and 50.8 mm) diameters are placed in a freezer at a controlled temperature of -7° ± 7°F (-22 ± 4°C) until frozen solid (a minimum of 48 hours). Acceptable ice balls will be free of cracks and air bubbles and will meet the following criteria within 0 and + 10% of the values listed:

Nominal ice ball diameter in. (mm)	Mass lbs (gr)
1¼ (31.8)	0.0338 (15.3)
1½ (38.1)	0.0584 (26.5)
1¾ (44.5)	0.0928 (42.1)
2 (50.8)	0.1385 (62.9)

3.3. TEST CONDITIONS

3.3.1. Maintain temperature of the test area between 60° and 90°F (15.6° and 32.2°C).

3.3.2. Calibrate the speed of the ice ball launcher to meet the impact kinetic energy range shown below (between Target Kinetic Energy and Target Kinetic Energy +10%):

Class	Nominal ice ball in. (mm)	Kinetic Energy	
		Target ft-lb (j)	+10% ft-lb (j)
1	1¼ (31.8)	3.72 (5.0)	4.09 (5.5)
2	1½ (38.1)	7.77 (10.4)	8.55 (11.6)
3	1¾ (44.5)	14.95 (20.3)	16.5 (22.4)
4	2 (50.8)	26.81 (36.4)	29.5 (40.0)

Calculate the kinetic energy of the propelled ice ball using the following equation:

$$KE = (mV_t^2)/64.34$$

Where:

KE = ice ball kinetic energy, foot pound

m = ice ball mass, pound

Vt = ice ball free-fall speed, feet per second

3.3.3. Position the test deck on an incline of minimum 15° from vertical to allow the test specimens to seat properly against the test panel. Position the ice ball launcher and the test assembly to assure that the trajectory of the ice ball is perpendicular (90° ± 5°) to the test panel and determine target impact locations particularly sensitive to impact damage.

3.3.4. Position the speed meter such that the ice ball speed will be measured between the launcher and the test specimen. The ice balls shall exit the speed meter not more than 5 ft (1.5 m) from the target impact location.

Note: A shield should be fitted near the impact point for protection of the operator and the equipment.

3.3.5. The number of impact locations shall be based on the exposed surface area of the test specimen as follows:

Exposed Area of Test Specimen in.^{2} (mm^2)	Minimum Number of Impact Locations
<125 (80,645)	2
≥125 < 195 (≥80,645 < 125,805)	3
≥195 (125,800)	1 for each multiple of 50 in.^{2} (32,260 mm^2) Round up for multiples <50 in.^{2} (32,260 mm^2)

Additional test specimens or impact areas shall be required when the geometry or configuration of the test specimen cannot be adequately evaluated otherwise; e.g., a test specimen composed of more than one piece or section.

3.3.6. Launch an ice ball at a target impact point based upon examination of vulnerability. Each target location shall be impacted twice, with a maximum 0.5 in. (13 mm) distance between impacts. Impact locations will include, but are not limited to edges, corners, unsupported areas, overlaps and joints. The outside edge of the ice ball shall be a minimum of 0.25 in. (6.4 mm) from the edge of the test specimen. Provide a minimum 6 in. (152 mm) distance between impact locations so that the effects of each impact location are independent. Calculate the kinetic energy of the ice ball impact using the formula stated in paragraph 3.3.2.

3.3.7. Ice balls shall impact the test specimen within 60 seconds after removal from the storage container.

3.3.8. After impact testing visually scrutinize top and bottom surfaces of the test specimen. Record any damage to the specimen such as splits, punctures, fractures, disengagement of lap elements, exposure of materials not so intended, etc.

4.   PASS/FAIL CRITERIA

4.1.   DEMONSTRATED QUALITY CONTROL PROGRAM

4.1.1.   The test specimen shall show no evidence of visible cracking or breakage.

4.1.2.   When, for a tested classification, a test specimen fails to meet the acceptance criteria, two successful test specimens must meet the acceptance criteria to qualify for the given classification.

5. REPORTING

Report, as a minimum, the following information:

A. Roofing manufacturer and specific description of test components including dimensions;

B. Specific details regarding the application including substrates, underlayments, method of installation and any deviations in the test panel assembly from the specifications given in Section 3.1.1;

C. Record of conditioning of sample and conditions during testing to include temperature, relative humidity, and duration of time;

D. Size, mass and speed of each ice ball used;

E. Target locations;

F. Kinetic energy of ice ball impacts;

G. Damage assessment, including a line drawing of the roofing with impact locations marked;

H. A description of the ice ball launcher and ice ball speed measurement equipment including any deviation from the test method;

I. Product Classification based on the test results.

6. MARKING

The packaging and the product shall bear the manufacturer's name, product trade name and wording that it is a FM Approvals' Specification Tested product with appropriate Hail Impact Resistance Classification.

All markings or labels indicating the above shall only be applied at the FM Approvals' audited manufacturing location.

(A): APPENDIX A: UNITS OF MEASUREMENT

Length:	in. - "inches''; (mm – "millimeters'')
	mm = in. × 25.4
	ft – "feet''; (m – "meters'')
	m = ft × 0.3048
Kinetic Energy:	ft-lb – "foot-pound''; (j – "joule'')
	j = ft-lb × 1.3558
Area:	in.^{2} – "square inches''; (mm^2 – "square millimeters'')
	mm^2 = in.2 × 645.16
Mass:	lb – "pounds''; (g – " grams'')
	g = lb × 435.6
Speed:	mph – "miles per hour'';
	f/s – "feet per second'' (m/s – "meter per second'')
	m/s = mph × 0.44704
	m/s = f/s × 0.3048
Temperature:	°F – "degrees Fahrenheit''; (°C – "degrees Celsius'')
	°C = (°F – 32) × 0.556