TEXAS TECH UNIVERSITY
National Wind Institute
Debris Impact Facility™

Designation: NWI DIF Horizontal Hail impact Standard 2.1.2015

Standard Test Method for Materials attached to Vertical or Near Vertical Surfaces and Their Resistance to Horizontally Propelled Freezer Ice Balls

The Debris Impact Facility (DIF) is an A2LA accredited ISO/IEC 17025:2005 test laboratory in the National Wind Institute (NWI) at Texas Tech University, Lubbock, Texas

INTRODUCTION

Purpose

ANSI FM 4473 is a *Test Standard of Impact Resistance of Testing of Rigid Roofing Materials by impacting with Freezer Ice Balls.*(ANSI/FM_4473 2011) The standard is developed assuming that damage is produced by a free falling ice ball and that the greatest damage is produced by a perpendicular impact on the rigid roofing material. Currently, no standard exists to assess damage produced by horizontally wind-driven hailstones that impact vertical surfaces. This Guidance Standard refers generously to the ANSI FM 4473 Standard and all references are annotated.

Scope

This standard provides a procedure for determining the impact resistance performance of new building materials applied to vertical and near vertical surfaces. Tested building materials can include, but are not limited to, siding, glazing, screening, awnings, paint, etc. Most hail strikes on a subject occur at some angle of incidence. This test uses the impact forces of freezer ice balls propelled at wind-driven speeds and the related kinetic energy for a perpendicular impact.

Hail is a form of solid precipitation and is possible within most thunderstorms as it is produced by cumulonimbus cloud formations.(Wikipedia) Wind speeds in thunderstorms can vary from 25 mph to 60 mph and with 100 mph for extreme wind storms.(Ohio) A conservative speed for wind driven hail used in this guide is 71.76 mph (105.25 fps). Hail can also be produced in a small column of air caused by a small intense downdraft called a microburst. Localized severe winds up to 150 mph can be produced by these downdrafts.(NWS 2015) These higher wind speeds occur as gusts and can inflict serious damage to trees, out-buildings, and building overhangs, components, and cladding. Hail propelled by such winds can produce extreme damage to vertical and near vertical surfaces. This guide standard provides a method of testing at conservative wind speeds and a guideline to compare material performance near the threshold of damage (no damage), just over the threshold (repairable damage), and material failure. Results are categorized by hail size, velocity, and the resulting kinetic energy (K_e).

Ice balls are used in this test method to simulate hailstones. Hail stones are variable in properties such as shape, density and frangibility…Ice balls generally are harder and denser than hailstone; therefore, an ice ball simulates the worst case hailstone…Ice balls can be uniformly and repeatedly prepared to assure a projectile with known properties.(ANSI/FM_4473 2011)

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.(ANSI/FM_4473 2011) This guide standard assumes a worse-case scenario by testing with impact perpendicular to the test specimen.

This standard is intended to verify that the product as described will meet minimum specific stated conditions of impact resistance without ire-repairable damage. The performance criterion is useful in determining the potential suitability of these products under hailstorm conditions.

Unlike the ANSI/FM 4473 for hail impact resistance for rigid roofing materials with a **Pass/Fail Criteria**, this standard is intended for vertically and near vertically oriented building materials and a **Pass/Repairable/Fail Criteria**.

Basis for Requirements
This is a Standard Test Method for Materials attached Vertical and Near Vertical Surfaces and Their Resistance to Horizontally Propelled Freezer Ice Balls, no current standard exists. The recommendations of this guide 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 is appreciated.

Definitions(ANSI/FM_4473 2011)

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 (0.23g)

Test Specimen---the individual product to be tested

Test Panel---the substrate for supporting the specimen in a fashion that simulates typical application

Test Assembly---the completed application of a test specimen, consisting of the specimen, substrate and the intended supporting assembly

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

Speed Meter---a device for measuring ice ball speeds within +/- 1 mph (0.45 m/s)

System of Units---Units of measurement are U.S. customary units with (SI equivalents)

TEST REQUIREMENTS(ANSI/FM_4473 2011)

Classification

The sizes of freezer ice balls in this guide correspond to the classes shown below in Table 1:

Table 1 - *Nominal Ice Ball*

Diameter In. (mm)	***Class***
1 ¼ (31.8)	*1*
1 ½ (38.1)	*2*
1 ¾ (44.5)	*3*
2 (50.8)	*4*

Calibration

All examinations and test performed in evaluation to this standard shall use calibrated measuring instruments traceable and certified to acceptable national standards

TEST PROTOCOL

Sample Preparation(ANSI/FM_4473 2011)

Test specimens are mounted on a minimum of 4 ft. x 4 ft. (1.2 m x 1.2 m) test panel simulating actual field applications and securely mounted to the test fixture. The test samples shall be conditioned between 60°F and 90°F (15.6°C and 32.2°C) for a sufficient period of time to attain thermal equilibrium.

Ice Ball Sample Preparation(ANSI/FM_4473 2011)

Molds for casting spherical ice balls made of distilled water of 1 ¼, 1 ½, 1 ¾, 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°F +/- 7°F (-22° +/- 4°C). All 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 in Table 2:

Table 2 - *Nominal Ice Ball*

Diameter in. (mm)	***Mass lbs. (g)***
1 ¼ (31.8)	*0.0338 (15.30)*
1 ½ (38.1)	*0.0584 (26.50*
1 ¾ (44.5)	*0.0928 (42.10)*
2 (50.8)	*0.1385 (62.90)*

Test Conditions

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

A conservative velocity for wind driven hail is shown in Table 3 below. 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%). Material thresholds of damage can be obtained by increasing ice ball size until damage is observed.

Table 3 – Kinetic Energy of Ice Ball Classes

Class	***Nominal Ice Ball in. (mm)***	***Velocity fps***	***Velocity mph***	***Kinetic Energy***	
				Target ft-lbf (j)	***+10% ft-lbf (j)***
1	*1 ¼ (31.8)*	*105.25*	*71.76*	*5.82 (7.89)*	*6.40 (8.68)*
2	*1 ½ (38.1)*	*105.25*	*71.76*	*10.05 (13.63)*	*11.06 (15.00)*
3	*1 ¾ (44.5)*	*105.25*	*71.76*	*15.97 (21.65)*	*17.58 (23.84)*
4	*2 (50.8)*	*105.25*	*71.76.*	*23.75 (32.2)*	*23.13 (35.5)*

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

$E_k = ½ (mV^2) / g$

Where:

E_k = ice ball kinetic energy, foot-pound-feet
M = ice ball mass, pound
V = ice ball wind driven velocity, feet per second
g = acceleration of gravity (32.2 feet per second)

Testing

Position the specimen/wall assembly vertically against the reaction frame and securely clamp. Position the ice ball launcher and the test assembly to assure that the trajectory of the ice ball is perpendicular (90°F +/- 5°) to the test panel, see Figure 1. Determine the target impact locations that are particularly sensitive to impact damage and impact the specimens at those locations, as shown in Figure 2.

Figure 1 – Panel installation and launcher setup

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 location. The operator shall be fitted with a face shield for protection.

Launch an ice ball at a target impact point based upon examination of vulnerability. Testing shall proceed from the smallest desired ice ball with a minimum three *"Unremarkable"* impacts. This process shall proceed with increasing hail ball sizes until *"Repairable Damage"* or *"Failure"* occurs. Nine additional impacts shall be made to validate the *"Repairable"* classification. Failure to validate this classification requires an additional nine impacts of the previous size hail ball. Each target shall be impacted with two different size hail balls for a minimum quantity of twelve impacts per size. Impact spacing shall approximate 1.0 in (26 mm) apart in separate locations per size. Impact locations should include, but are not limited to edges, corners, unsupported areas, overlaps and joints. The outside edge of the ice ball shall not be closer than ¼ in. (6.4 mm) to the edge of the 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 above. Impacts failing to achieve or surpassing the required speed shall be repeated until a total of twelve impacts within the limits of velocity and kinetic energy are achieved.

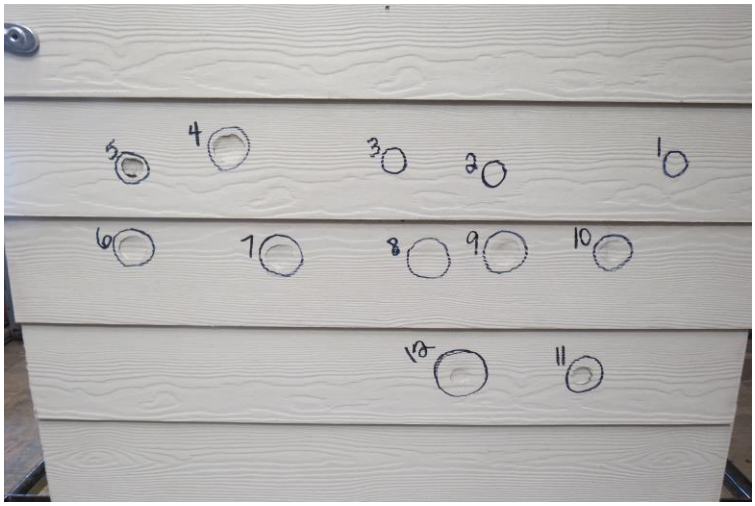

Figure 2 – Typical impact location

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

After impact testing, visually inspect top and bottom surfaces of the test specimen. Record any damage to the specimen for indentations, splits, punctures, fractures, chips, disengagement of lap elements, etc.

PASS / REPAIRABLE / FAIL CRITERIA

Pass: The test specimen shall show no evidence of visible cracking or breakage or any damage such as splits, punctures, dents, fractures, chips, disengagement of lap elements or exposure of materials not so intended.

Repairable: Specimens with flakes or chips less than ¼ in. in diameter or dents less than ½ in. in diameter and less than 1/8 in. deep are deemed repairable.

Failure: When a test specimen fails to meet the above Pass/Repairable Criteria a second specimen shall be tested. Ultimate failure shall be deemed if the second specimen fails to meet the Pass/Repairable Criteria.

REPORTING

Report, as minimum, the following information:

1. Manufacturer and specific description of test components including dimensions;
2. Specific details regarding the application including substrates, sub-structure, and method of construction and installation;
3. Record of conditioning of sample and conditions during testing to include temperature, relative humidity, and duration of time;
4. Size, mass and speed of each ice ball used;
5. Target locations;
6. Kinetic energy of ice ball impacts;
7. Damage assessment, including photographic standardation locating and numbering each impact;
8. A description of the ice ball launcher and ice ball speed measurement equipment including any deviation from the test method;
9. Product Classification based on the test results.

APPENDIX A: Units of Measurement

Length	in. - "inches"; (mm – "millimeters"); mm = in. x 25.4
	ft - "feet; (m – meters"); m = ft x 0.3048
Kinetic Energy:	ft-lbf – "foot-pound-feet"; (j – joules"); j = ft-lbf x 1.3448
Area:	in^2 – "square inches"; (mm^2 – "square millimeters"); $mm^2 = in^2$ x 645.16
Mass:	lb – "pound"; (g – "grams"); g = lb x 435.6
Speed:	mph – "miles per hour"; f/s – "feet per second"; (m/s – meters per second"); m/s = mph x 0.44704; m/s = f/s x 0.3048
Temperature:	°F – "degrees Fahrenheit"; (°C – "degrees Celsius"); °C = (°F – 32) x 0.556

REFERENCES

ANSI/FM_4473 (2011). ANSI/FM 4473 Test Standard for Impact Resistance Testing of Rigid Roofing Materials b Impacting with Freezer Ice Balls. ANSI/FM 4473. Norwood, MA, FM Approvals LLC.

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