FM Approvals

CLASS NUMBER 4350

Examination Standard for Windstorm Resistant Fenestrations

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Foreword

This standard is intended to verify that the products and services described will meet stated conditions of performance, safety and quality useful to the ends of property conservation. The purpose of this standard is to present the criteria for examination of various types of products and services.

Examination in accordance with this standard shall demonstrate compliance and verify that quality control in manufacturing shall ensure a consistent and reliable product.

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1 INTRODUCTION

1.1 PURPOSE

1.1.1 This standard states testing and certification requirements for windstorm resistant fenestrations such as doors, windows, storm shutters and impact resistant film and other materials. Fenestrations are exposed to a number of natural hazards and must withstand wind, hail, water infiltration and other deleterious effects caused from everyday exposure to heat, cold, building movement and sunlight. Products that receive certification recognition have been evaluated to provide assurance that they will perform their intended functions and maintain the integrity of the building envelop for the stated design conditions.

1.1.2 Testing and certification criteria may include performance requirements, marking requirements, examination of manufacturing facility(ies), audit of quality assurance procedures, and a surveillance program.

1.2 SCOPE

1.2.1 This standard sets performance requirements for windstorm resistant fenestrations under simulated laboratory conditions when exposed to wind, simulated hail and where required, the impact of windborne debris.

1.2.2 This standard is intended to qualify all types of fenestrations including, but not limited to doors, windows, storm shutters and impact resistant film and other materials.

1.2.3 This standard is not intended to qualify exterior wall panels nor does it address quality of workmanship or ease of or need for maintenance.

1.2.4 This standard is not intended to determine the suitability for all end use conditions of a product. Conditions under which fenestration systems are used vary widely. It is the responsibility of the manufacturer and building owner to determine the suitability of the fenestration products for the intended location.

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 windstorm resistant fenestrations for the purpose of obtaining certification.

1.4 BASIS FOR CERTIFICATION

Certification 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 the certification agency;
- the durability and reliability of the product.

1.4.2 An examination of the manufacturing facilities and audit of quality control procedures may be 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. Subsequent surveillance may be required by the certification agency in accordance with the certification scheme to ensure ongoing compliance.

1.5 BASIS FOR CONTINUED CERTIFICATION

1.5.1 The basis for continual certification may include, but is not limited to, the following based upon the certification scheme and requirements of the certification agency:

- production or availability of the product as currently certified;
- the continued use of acceptable quality assurance procedures;
- compliance with the terms stipulated by the certification;
- satisfactory re-examination of production samples for continued conformity to requirements; and
- satisfactory surveillance audits conducted as part of the certification agency's product surveillance program.

1.6 EFFECTIVE DATE

The effective date of this certification standard mandates that all products tested for certification after the effective date shall satisfy the requirements of this standard.

The effective date of this standard is eighteen (18) months after the publication date of the standard 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. Conversion of U.S. customary units is in accordance with ANSI/IEEE/ASTM SI 10.

1.8 NORMATIVE REFERENCES

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the cited edition applies.

ANSI/IEEE/ASTM SI 10, American National Standard for Metric Practice

ASTM International

ASTM E 330/330M, Standard Test Method for Structural Performance of Exterior Windows, Doors, Skylights and Curtain Walls by Uniform Static Air Pressure Difference

ASTM E 1233/1233M, Standard Test Method for Structural Performance of Exterior Windows, Doors, Skylights, and Curtain Walls by Cyclic Air Pressure Differential

ASTM E 1886, Standard Test Method for Performance of Exterior Windows, Curtain Walls, Doors and Impact Protective Systems Impacted by Missile(s) and Exposed to Cyclic Pressure Differentials

ASTM E 1996, Standard Specification for Performance of Exterior Windows, Curtain Walls, Doors, and Impact Protective Systems Impacted by Windborne Debris in Hurricanes

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FM 4881, Class 1 Exterior Wall Panels

ANSI FM 4881, American National Standard for Evaluating Exterior Wall Systems

ANSI FM 4473, American National Standard for Impact Resistance Testing of Rigid Roofing Materials by Impacting with Freezer Ice Balls

Southern Building Code Congress International

SSTD 12, *SBCCI Test Standard for Determining Impact Resistance from Windborne Debris*

Florida Building Code, Test Protocols for High Velocity Hurricane Zone

Testing Application Standard (TAS) 201-94, Impact Test Procedures

Testing Application Standard (TAS) 203-94, Criteria for Testing Products to Cyclic Wind Pressure Loading

1.9 TERMS AND DEFINITIONS

For purposes of this standard, the following terms apply:

Inward Wind Pressure	A condition created on the windward side of a building. It is caused by wind forces and places forces toward the fenestration system. It is referred to by some entities as positive pressure.
Outward Wind Pressure	A condition created on the leeward side of a building. It is caused by wind forces and places forces away from the fenestration system. It is referred to by some entities as negative pressure.
Pressure Coefficient	A factor accounting for variations in inward and outward wind pressure on fenestration systems at different locations and elevations of the same building.
Windborne Debris	Objects and pieces of broken materials that have become airborne projectiles due to the high winds caused by hurricanes, tropical cyclones and typhoons.

2 GENERAL INFORMATION

2.1 PRODUCT INFORMATION

2.1.1 The selection of a windstorm resistant fenestration system is a critical component in the overall effectiveness of a building's ability to perform the functions for which it has been designed. It is the first line of defense in combating the effects of natural hazards and protecting the contents of the building.

2.1.2 Anticipated design conditions at a particular location vary depending on the intensity of the event, the surrounding terrain and elevation. Components on the windward side of a building are subjected to design wind pressures [P^{inward}] which increase as the elevation of the building increases. Pressures on the leeward side [$P^{outward}$] of a building can reach twice the wind pressure normally found on the windward face of the building at the same elevation but acting in the opposite direction. Certification ratings will show both inward and outward pressures for which the system has been successfully tested. In an effort to allow for economic building construction, certification will be granted for two ratios of inward and outward pressure. The ratio of the inward and outward pressures shall be (+)1.0 to (-)1.4 or (+)1.0 to (-)2.0

2.1.3 In an effort to allow for economic building construction, in addition to the wind load ratings shown above, certification categories have been developed for the most common windstorm zones likely to be encountered.

2.1.4 These zones, as explained elsewhere, shall be designated as Zones TCM, TC and NTC. The zones have been established to certify products intended for use in areas that require protection against a) hurricane force winds and missile impacts resulting from windborne debris (TCM), b) hurricane force winds only (TC) and non-hurricane areas (NTC) that do not require either a) or b).

2.1.5 While the performance requirements contained in this examination standard would indicate that certified windstorm resistant fenestration systems will not suffer permanent deformation or physical damage (except as otherwise noted in Paragraph 2.1.4.1) after windstorms or hail storms, the systems should be examined after each storm for damage that could adversely affect its performance in future storms.

2.1.5.1 In the case where a system has been certified for use in areas prone to missile impacts from windborne debris, the system may sustain permanent physical damage. As such, the systems should be examined after each storm for damage that could adversely affect its performance in future storms. Repairs should be made as soon as possible to any damaged areas.

2.1.5.2 Because the acceptance criteria for systems impacted by windborne debris vary throughout the various regions, two (2) levels of both large and small missile certification have been created. This will assist manufacturers and end users in determining if the system will meet local codes requirements.

2.1.6 The requirements of this standard shall be used to measure and describe the performance of windstorm resistant fenestrations to simulated wind loads and hail impact under controlled laboratory conditions.

2.1.7 The performance of windstorm resistant fenestration systems can be greatly affected by the quality of the workmanship, exposure to sunlight, heat, building movement and the normal aging process. These items have not been considered in developing the test methods included in this standard.

2.2 CERTIFICATION APPLICATION REQUIREMENTS

The manufacturer shall provide the following preliminary information with any request for certification consideration:

- A complete list of all models, types, sizes, and options for the products or services being submitted for certification consideration;
- general assembly drawings, complete set of manufacturing drawings, materials list, anticipated marking format, installation and any maintenance procedures; and
- the number and location of manufacturing facilities.

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 with English translation.

2.3 REQUIREMENTS FOR SAMPLES FOR EXAMINATION

2.3.1 Following authorization of a certification examination, the manufacturer shall submit samples for examination and testing based on the following:

- Maximum size opening (width and height) for which certification is desired
- Minimum thickness of materials
- Most critical orientation, if applicable
- Sample requirements to be determined by the certification agency

2.3.2 Requirements for samples may vary depending on design features, results of prior or similar testing, and results of any foregoing tests.

2.3.3 The manufacturer shall submit samples representative of production.

2.4 CERTIFIED CATEGORIES AND RATINGS

2.4.1 Wind Load Ratings

2.4.1.1 All certified windstorm resistant fenestration systems shall have a wind load rating. The rating shall be expressed as a pair of inward and outward acting pressures (P^{inward} and $P^{outward}$) using a static pressure test and a cyclic pressure test. The certification rating shall be the deepest pair of pressures (inward and outward) from the static pressure test or the cyclic pressure test. The ratings shall be given in increments of 5 lbs/ft2 (0.25 kPa) based on the inward pressure. The minimum rating needed for certification shall be 30 lbs/ft2 (1.45 kPa) for the inward pressure.

2.4.1.2 The magnitude of the pressure on the leeward side is equal or higher than the pressure on the windward side. Because of this, the outward pressure used in the test program shall be of greater magnitude than the inward pressure. The certified outward pressure will be based on pressure coefficients of either (-1.4) or (-2.0) based on an applied pressure (+P) on the windward side. The positive sign is used to signify the fact that P^{inward} applies forces toward the fenestration system. The negative sign is used to signify that $P^{outward}$ places forces away from the fenestration system (suction). Examples of possible wind load ratings are +30 lbs/ft2, -42 lbs/ft2 (+1.45 kPa, -2.0 kPa) or +40 lbs/ft2, -80 lbs/ft2 (+1.9 kPa, -3.8 kPa). The test sponsor shall determine the pressure coefficient used in the test program.

2.4.1.3 As an option, the test sponsor may choose to qualify their fenestration system for windborne debris (missile impact) resistance. Two categories of impact resistance are available – large missile or small missile. The large missile test shall consist of a series of impacts using an 8 ft (2.4 m) long nominal wooden 2 x 4 weighing 9 lbs (4 kg) traveling at a speed of 50 ft/sec (15.25 m/s). The small missile test shall consist of a series of impacts with each impact consisting of ten (10) steel balls with each steel ball weighing 0.07 oz (2 g) traveling at a speed of 130 ft/sec (39.6 m/s).

2.4.1.4 The certified designation for the large or small missile impact resistance rating shall be categorized by the suffix LM (large missile impact resistance) or SM (small impact missile resistance) to denote the level of missile impact resistance.

2.4.1.5 Within each category of missile impact resistance, there shall be two (2) levels of certification. The level of certification shall be based on the acceptance criteria used. The first level of certification is based on the International Building Code (IBC). The second level of certification is based on the acceptance criteria of the Florida Building Code (FBC). This distinction is being made as the acceptance criteria for the FBC is more stringent than the acceptance criteria for other parts of the country. The main difference is that the IBC acceptance criteria allows for the development of small through openings which may be acceptable in some cases whereas the FBC does not allow the missile to penetrate the building component being tested. When the second level of certification is obtained, the connotation (FL) shall be shown after the category of missile impact resistance. For example, a windstorm resistant fenestration system that meets the large missile impact resistance using the first level (IBC) of certification criteria would be shown as Wind Zone TCM – LM (see paragraph 2.4.1.6 for wind zone designations). A windstorm resistant fenestration system that meets the small missile impact resistance using the second level (FBC) of certification criteria would be shown as Wind Zone TCM – SM (FL).

2.4.1.6 The certification agency recognizes three (3) different wind zone categories. These certification categories shall be referred to as Zone TCM, Zone TC and Zone NTC.

2.4.1.7 Zone TCM shall be used to denote those fenestration systems that have been qualified for locations that are subject to both hurricane force winds and missile impact from windborne debris. The ratings shall be determined from static and cyclic pressure tests and the missile impact test(s). Such assemblies may meet the requirements of either the large missile or the small missile impact test.

2.4.1.8 Zone TC shall be used to denote those fenestration systems that have been qualified for locations that are subject to hurricane force winds but not subject to missile impacts from windborne debris. The ratings shall be determined from static and cyclic pressure tests.

2.4.1.9 Zone NTC shall be used to denote those fenestration systems in non-hurricane zones that are not subjected to either hurricane force winds or missile impacts from windborne debris. The ratings shall be determined from static and cyclic pressure tests.

2.5 HAIL RESISTANCE RATINGS

2.5.1 All certified windstorm resistant fenestration systems shall have a Hail Resistance Rating. This rating simulates the expected impact of hail. The ratings available are SH (Severe Hail) and MH (Moderate Hail).

2.5.2 As an option, windstorm resistant fenestration systems shall be permitted to be tested to simulate hail impacts resulting in a greater impact energy in order to meet other jurisdictional requirements.

3 GENERAL REQUIREMENTS

3.1 REVIEW OF DOCUMENTATION

During the initial investigation and prior to physical testing, the manufacturer's specifications and details shall be reviewed to assess the ease and practicality of installation and use. The certification investigation shall define the limits of the certification.

3.2 PHYSICAL OR STRUCTURAL FEATURES

During the test program, fenestration systems shall be installed within a test frame that is representative of the construction for which it will be certified.

3.3 MARKINGS

3.3.1 The packaging for windstorm resistant fenestrations shall bear the manufacturer's name, product trade name and the certification agency's mark of conformity.

3.3.2 Upon completion of an installation, the manufacturer shall attach a permanent, corrosion resistant label to the product. At a minimum, the labels shall bear the manufacturer's name, product trade name, the certification agency's mark of conformity and the applicable ratings for wind zone, wind pressure and hail.

3.3.3 With the exception of the labels described above, labels or markings denoting certification shall be applied by the manufacturer only within and on the premises of manufacturing locations that are under the certification agency's surveillance program.

3.3.4 The model or type identification shall correspond with the manufacturer's catalog designation and shall uniquely identify the product as certified. The manufacturer shall not place this model or type identification on any other product unless covered by a separate agreement.

3.3.5 The certification agency's mark of conformity shall be displayed visibly and permanently on the product and/or packaging as appropriate. The manufacturer shall not use this mark of conformity on any other product unless such product is covered by a separate report.

3.3.6 All markings shall be legible and durable.

3.4 MANUFACTURER'S INSTALLATION AND OPERATION INSTRUCTIONS

3.4.1 The manufacturer shall provide the user with:

- instructions for the installation, maintenance and operation of the product;
- facilities for repair of the product and supply replacement parts; and
- services to ensure proper installation, inspection, or maintenance for products of such nature that it would not be reasonable to expect the average user to be able to provide such installation, inspection, or maintenance.

3.5 CALIBRATION

3.5.1 Each piece of equipment used to verify the test parameters shall be calibrated within an interval determined on the basis of stability, purpose, and usage. A copy of the calibration certificate for each piece of test equipment is required. The certificate shall indicate that the calibration was performed against working standards whose calibration is certified and traceable to an acceptable reference standard and certified by an ISO/IEC 17025 accredited calibration laboratory. The test equipment shall be clearly identified by label or sticker showing the last date of the calibration and the next due date. A copy of the service provider's accreditation certificate as an ISO/IEC 17025 accredited calibration laboratory should be available.

3.5.2 When the inspection equipment and/or environment is not suitable for labels or stickers, other methods such as etching of control numbers on the measuring device are allowed, provided documentation is maintained on the calibration status of thus equipment.

4 PERFORMANCE REQUIREMENTS

4.1 SIMULATED WIND LOAD RATING

4.1.1 Structural Test Method for Fenestration Systems Using Static Air Pressure Differentials

A. Requirement

In order to qualify as certified windstorm resistant fenestration system, all systems shall be tested in accordance with the Structural Test Method for Windstorm Resistant Fenestration Systems Using Static Air Pressure Differentials. This test method consists of sealing the test specimen into or against one face of a test chamber, supplying air to or exhausting air from the chamber according to a specific test loading program at the rate required to maintain the test pressure difference across the specimen, and observing, measuring and recording the nature of any distress or failure of the specimen. The inward pressure level, P^{inward}, that is used during the test, shall be at the discretion of the test sponsor. The tests shall be conducted such that the ratio of the outward pressure to the inward pressure ($P^{outward}$ / P^{inward}) shall be either (-1.4) or (-2.0).

B. Test/Verification

One (1) sample shall be tested per the Structural Test Method for Windstorm Resistant Fenestration Systems Using Static Air Pressure Differentials. This sample is not required to be subjected to any other tests as part of a test program. Upon completion of the test, the sample shall show no signs of cracking or any other signs of failure. At the discretion of the test sponsor, the sample shall be permitted to be reused for other tests in this program or to be retested at higher pressures in order to obtain a higher wind rating.

4.1.1.1 This test method is intended to evaluate the structural performance of windstorm resistant fenestration systems. It is based on ASTM E330 with several modifications incorporated into the procedure. The method consists of sealing a test specimen into or against one face of a test chamber and supplying air to or exhausting air from the chamber according to a specific test loading program.

4.1.1.2 The inward pressure level, P^{inward}, that is used during the test shall be at the discretion of the test sponsor. The tests shall be conducted such that the ratio of the outward pressure to the inward pressure ($P^{outward}$ / P^{inward}) shall be either (-1.4) or (-2.0). The minimum pressure levels used in the test program shall be [Poutward; P^{inward}] -42 lbs/ft2 and +30 lbs/ft2 (-2.0 kPa and +1.45 kPa) when the pressure coefficient of (-1.4) is used and -60 lbs/ft2 and +30 lbs/ft2 (-2.9 kPa and +1.45 kPa) when the pressure coefficient of (-2.0) is used.

4.1.1.3 Test Apparatus and Arrangement

4.1.1.3.1 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.

4.1.1.3.2 Test Chamber – the test chamber consists of a box shaped device with one side open onto which the specimen is installed. It shall incorporate a static pressure tap to measure the pressure difference across the specimen. The tap shall be located such that it is not affected by the velocity of the air supplied to or exhausted from the chamber. The air supply opening into the chamber shall be arranged so that the air does not impinge directly on the test specimen with any significant velocity. The test specimen mounting frame shall be of sufficient size so as not to deflect under the test load in a manner that will affect the performance of the test specimen.

4.1.1.3.3 Air System – the air system shall consist of a controllable blower, a compressed air supply, an exhaust system or a reversible controllable blower designed to provide the maximum air pressure differential across the specimen. The system shall provide an essentially constant air pressure difference for the required test period.

4.1.1.3.4 Pressure Measuring Apparatus – the pressure measuring apparatus used to measure the test pressure difference shall be capable of having a tolerance of ±2% or ±0.01 in. (±2.5 kPa) of water column, whichever is greater.

4.1.1.3.5 Deflection Measuring System – an optional deflection measuring system may be provided to measure deflections during the test. If used, such a device shall have a tolerance of ±0.01 in. (±0.25 mm).

4.1.1.4 Test Specimen

4.1.1.4.1 The test specimen shall be of sufficient size and configuration to determine the performance of all components of the system. The conditions of structural support shall simulate, as accurately as possible, the actual structural conditions of a building.

4.1.1.4.2 The test specimen shall be subjected to both inward and outward acting static pressures. The specimen shall incorporate the same number and type of fasteners and anchors normally used when installing the system on a building.

4.1.1.5 Test Procedure

4.1.1.5.1 The test specimen shall be fitted onto or against the test chamber. Air shall be supplied to or exhausted from the system until the test pressure has been achieved. The rate of air supplied or exhausted shall be such that the design pressure is reached in not less than 5 seconds and not more than 15 seconds.

4.1.1.5.2 If the test specimen is such that the specified air pressure cannot be maintained, then any cracks or joints through which air leakage is occurring shall be sealed with tape or other effective means. As an alternate, the entire specimen can be covered with a single thickness of polyethylene film no thicker than 0.002 in. (0.05 mm). 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 at the corners and all offsets or recesses.

4.1.1.5.3 Procedure A ((+1.0P, -1.4P) [where + denotes P^{inward} and – denotes $P^{outward}$]

Air shall be supplied until the loading reaches +0.5P. The pressure shall be held at this level for a period of 60 seconds. Upon holding the pressure at +0.5P for 60 seconds, the pressure difference shall be released. The sample shall be allowed a recovery period of not less than one (1) minute or more than two (2) minutes.

After the recovery period, air shall be supplied until the loading reaches +1.0P. The pressure shall be held at this level for a period of 60 seconds. Upon holding the pressure at +1.0P for 60 seconds, the pressure difference shall be released. The sample shall be allowed a recovery period of not less than one (1) minute or more than two (2) minutes.

After the recovery period, air shall be supplied until the loading reaches -0.7P [0.5P x (-1.4)]. The pressure shall be held at this level for a period of 60 seconds. Upon holding the pressure at -0.7P for 60 seconds, the pressure difference shall be released. The sample shall be allowed a recovery period of not less than one (1) minute or more than two (2) minutes.

After the recovery period, air shall be supplied until the loading reaches -1.4P [1.0P x (-1.4)]. The pressure shall be held at this level for a period of 60 seconds. Upon holding the pressure at -1.4P for 60 seconds, the pressure difference shall be released and examined.

4.1.1.5.4 Procedure B (+1.0P, -2.0P) [where + denotes P^{inward} and – denotes $P^{outward}$]

Air shall be supplied until the loading reaches +0.5P. The pressure shall be held at this level for a period of 60 seconds. Upon holding the pressure at +0.5P for 60 seconds, the pressure difference shall be released. The sample shall be allowed a recovery period of not less than one minute or more than two (2) minutes

After the recovery period, air shall be supplied until the loading reaches +1.0P. The pressure shall be held at this level for a period of 60 seconds. Upon holding the pressure at +1.0P for 60 seconds, the pressure difference shall be released. The sample shall be allowed a recovery period of not less than one (1) minute or more than two (2) minutes.

After the recovery period, air shall be supplied until the loading reaches -1.0P [0.5P x (-2.0)]. The pressure shall be held at this level for a period of 60 seconds. Upon holding the pressure at -1.0P for 60 seconds, the pressure difference shall be released. The sample shall be allowed a recovery period of not less than one (1) minute or more than two (2) minutes. -4.4.4. After the recovery

period, air shall be supplied until the loading reaches -2.0P [1.0P x (-2.0)]. The pressure shall be held at this level for a period of 60 seconds. Upon holding the pressure at -2.0P for 60 seconds, the pressure difference shall be released and examined.

4.1.1.5.5 As an alternative to Procedure B, upon completion of maintaining the -1.4P pressure level shown in 4.1.1.5.3, par.4 (Procedure A), the sample shall be allowed a recovery period of not less than one (1) minute or more than two (2) minutes. After the recovery period, air shall be supplied until the loading reaches -2.0P. The pressure shall be held at this level for a period of 60 seconds. Upon holding the pressure at -2.0P for 60 seconds, the pressure difference shall be released and examined.

If the specimen meets the performance requirements shown in Paragraph C-5, it shall be deemed to have qualified for a rating based on +1.0P and -2.0P provided that the sample also meets the criteria of the Standard Test Method for Windstorm Resistant Fenestration Systems Exposed to Cyclic Air Pressure Differentials using -2.0P as the outward pressure.

4.1.1.6 Performance Requirements

4.1.1.6.1 Upon completion of the test and upon examination, the test specimen shall show no signs of cracking or any other signs of failure.

Both an inward acting (positive) and an outward acting (negative) wind load rating shall be assigned based on the maximum pressure levels successfully maintained. The ratings shall be based on the positive pressure rating in increments of 5 lbs/ft2 (0.25 kPa). The pressure ratings shall be stated in multiples of +P, -1.4P or +P, -2P as applicable.

4.1.2 Structural Test Method for Fenestration Systems Exposed to Cyclic Air Pressure Differentials (Procedure A)

A. Requirement

In order to qualify as a certified windstorm resistant fenestration system, all systems shall be tested in accordance with the Structural Test Method for Fenestration Systems Exposed to Cyclic Air Pressure Differentials. Systems that are intended for use in areas subject to hurricane force winds (Zones TCM and TC) shall be examined in accordance with Procedure A of this test method. Systems that are intended for use in areas that are not subject to hurricane force winds (Zone NTC) shall be examined in accordance with Procedure B as shown on Paragraph 4.1.3.

This test method consists of sealing the test specimen into or against one face of a test chamber, supplying air to or exhausting air from the chamber according to a specific test loading program (a total of 9000 cycles) at various pressure levels across the specimen, and observing, measuring and recording the nature of any distress or failure of the specimen. The inward pressure level, P^{inward} that is used during the test shall be at the discretion of the test sponsor. The tests shall be conducted such that the ratio of the outward pressure to the inward pressure ($P^{outward}$/ P^{inward}) shall be either (-1.4) or (-2.0).

B. Test/Verification

The fenestration system shall be tested per the Structural Test Method for Fenestration Systems Exposed to Cyclic Air Pressure Differentials. Samples intended for use in Zone TC are not required to be subjected to any other tests prior to or subsequent to this test. Samples intended for use in Zone TCM shall be impacted by either the large missiles or small missiles (windborne debris) in accordance with the Test Method for Fenestration Systems Impacted by Windborne Debris prior to being subjected to this test.

For systems intended for use in Zone TC, one (1) sample shall be tested in accordance with Procedure

A. Upon completion of the test, the sample shall show no signs of cracking or any other signs of failure.

For systems intended for use in Zone TCM, see the acceptance criteria for the Test Method for Fenestration Systems Impacted by Windborne Debris (Paragraph 4.2.1). All three (3) samples that are impacted for windborne debris shall be subjected to the Structural Test Method for Fenestration Systems Exposed to Cyclic Air Pressure Differentials, Procedure A. Upon completion of the Structural Test Method for Fenestration Systems Exposed to Cyclic Air Pressure Differentials test, each sample shall continue to meet the acceptance criteria for the Test Method for Fenestration Systems Impacted by Windborne Debris.

Certified systems for use in Zone TCM shall also have one (1) additional sample examined in accordance with the Structural Test Method for Fenestration Systems Exposed to Cyclic Air Pressure Differentials, Procedure A. This sample shall not be impacted by simulated windborne debris. Upon completion of the test, the sample shall show no signs of cracking or any other signs of failure.

Systems intended for use in Zone NTC shall be tested in accordance with the Structural Test Method for Fenestration Systems Exposed to Cyclic Air Pressure Differentials, Procedure B.

4.1.3 Structural Test Method for Fenestration Systems Exposed to Cyclic Air Pressure Differentials (Procedure B)

A. Requirement

In order to qualify as certified windstorm resistant fenestration systems, all systems shall be tested in accordance with the Structural Test Method for Windstorm Resistant Fenestration Systems Exposed to Cyclic Air Pressure Differentials. This test method (Procedure B) is intended only for use in areas not prone to hurricane force winds (Zone NTC). Systems that are intended for use in areas that are prone to hurricane force winds (Zone TCM and TC) shall be examined in accordance with Procedure A as shown in Paragraph 4.1.2.

This test method consists of sealing the test specimen into or against one face of a test chamber, supplying air to or exhausting air from the chamber according to a specific test loading program (a total of 1056 cycles) at various pressure levels across the specimen, and observing, measuring and recording the nature of any distress or failure of the specimen. The inward pressure level, P^{inward}, that is used during the test shall be at the discretion of the test sponsor. The tests shall be conducted such that the ratio of the outward pressure to the inward pressure ($P^{outward}$/ P^{inward}) shall be either (-1.4) or (-2.0).

B. Test/Verification

The fenestration system shall be tested per the Structural Test Method for Windstorm Resistant Fenestration Systems Exposed to Cyclic Air Pressure Differentials, Procedure B. Samples intended for use in Zone NTC are not required to be subjected to any other tests prior to or subsequent to this test.

For systems intended for use in Zone NTC, one (1) sample shall be tested. Upon completion of the test, the sample shall show no signs of cracking or any other signs of failure.

4.1.4 Structural Test Method for Windstorm Resistant Fenestration Systems Exposed to Cyclic Air Pressure Differentials

4.1.4.1 This test method is intended to evaluate the structural performance of windstorm resistant fenestration systems. It is consistent with several well known test methods. The method consists of sealing a test specimen into or against one face of a test chamber and supplying air to or exhausting air from the chamber according to a specific test loading program.

4.1.4.2 This test method offers two (2) different loading sequences. They shall be referred to as Procedure A and Procedure B. In each case, the test specimen size, apparatus, arrangement, pressure coefficients and basic procedure are identical. The number of cycles, pressure levels used and sequence of pressure applications varies depending on the exterior wall system's intended use.

4.1.4.3 Procedure A shall be used to qualify fenestration systems that are intended to be used in areas that are prone to hurricane force winds (Zones TCM and TC). The test method consists of a total of 9000 pressure cycles. It is conducted in accordance with several well known test methods such as ASTM E1886, SBCCI STD 12 and FBC TAS 203-94.

4.1.4.3.1 When a fenestration system is being qualified for use in areas that are also prone to the impact of windborne debris (Zone TCM), the test specimen shall be subjected to the Test Method for Windstorm Resistant Fenestration Systems Impacted by Windborne Debris prior to being subjected to this procedure.

4.1.4.4 Procedure B shall be used to qualify fenestration systems that are intended to be used in areas that are not prone to hurricane force winds (Zone NTC). The test method consists of 1056 pressure cycles. It is conducted in accordance with ASTM E1233, Table X1.2.

4.1.4.5 The inward pressure level, P^{inward}, that is used during the test shall be at the discretion of the test sponsor. The tests shall be conducted such that the ratio of the outward pressure to the inward pressure ($P^{outward}$ / P^{inward}) shall be either (-1.4) or (-2.0). The minimum pressure levels used in the test program shall be [$P^{outward}$; P^{inward}] -42 lbs/ft2 and +30 lbs/ft^2 (-2.0 kPa and +1.45 kPa) when the pressure coefficient of (-1.4) is used and -60 lbs/ft^2 and +30 lbs/ft^2 (-2.9 kPa and +1.45 kPa) when the pressure coefficient of (-2.0) is used.

4.1.4.6 Test Apparatus and Arrangement

4.1.4.6.1 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.

4.1.4.6.2 Test Chamber - the test chamber consists of a box shaped device with one side open onto which the specimen is installed. It shall incorporate a pressure tap to measure the pressure difference across the specimen. The tap shall be located such that it is not affected by the velocity of the air supplied to or exhausted from the chamber. The air supply opening into the chamber shall be arranged so that the air does not impinge directly on the test specimen with any significant velocity. The test specimen mounting frame shall be of sufficient size so as not to deflect under the test load in a manner that will affect the performance of the test specimen.

4.1.4.6.3 Air System - the air system shall consist of a controllable blower, a compressed air supply, an exhaust system or a reversible controllable blower designed to provide the maximum air pressure differential across the specimen. The system shall provide an essentially constant air pressure difference for the required test period.

4.1.4.6.4 Pressure Measuring Apparatus - the pressure measuring apparatus used to measure the test pressure difference shall be capable of having a tolerance of ±2% of its maximum rated capacity or ±2 lbs/ft^2 (±100 kPa), whichever is less and a response time less than 50 ms. Examples of acceptable apparatus are mechanical pressure gauges and electronic pressure transducers.

4.1.4.6.5 Pressure Recording Device - a pressure recording device shall be interconnected with the air pressure system and pressure measuring device such that the number of cycles, pressure levels and cycle times are recorded.

4.1.4.7 Test Specimen

4.1.4.7.1 Each test specimen shall be of sufficient size and configuration to determine the performance of all components of the system. The conditions of structural support shall simulate, as accurately as possible, the actual structural conditions of a building. The distance between structural supports incorporated into the test specimen shall be the maximum support spacing granted in the certification.

4.1.4.7.2 The test specimen shall be subjected to both inward and outward acting cyclic pressures as shown in Table D-1 or Table D-2. The specimen shall incorporate the same number and type of fasteners and anchors normally used when installing the system on a building.

4.1.4.7.3 When a fenestration system is being qualified for use in areas that are not subject to the impact of windborne debris, (Zone TC and NTC), only a single test specimen needs to be examined.

4.1.4.8 Test Procedure

4.1.4.8.1 Each test specimen shall be fitted onto or against the test chamber. The air pressure used shall be in accordance with either Procedure A (Zones TCM and TC) or Procedure B (Zone NTC). Air shall be supplied to or exhausted from the system until the test pressure has been achieved. The duration of each air pressure cycle shall not be less than one (1) second or more than five (5) seconds. The dwell time between successive cycles shall be no more than one (1) second.

4.1.4.8.2 If the test specimen is such that the specified air pressure cannot be maintained, then any cracks or joints through which air leakage is occurring shall be sealed with tape or other effective means. As an alternate, the entire specimen can be covered with a single thickness of polyethylene film no thicker than 0.002 in. (0.05 mm). 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 at the corners and all offsets or recesses.

4.1.4.8.3 Interruptions for equipment maintenance and repair shall be permitted.

4.1.4.8.4 The test specimen shall be permitted to be removed, reversed and reinstalled in the chamber between the inward acting and outward acting pressure cycles.

4.1.4.8.5 Procedure A

Apply the cyclic loads in accordance with Table 1. P denotes the inward acting (positive) pressure and –P denoted the outward acting (negative) pressure. The outward pressure shall be a ratio (-1.4 or -2.0) of the inward pressure as described in 4.1.4.5.

Table 1

Loading Sequence	*Loading Direction*	*Air Pressure Cycles*	*No.ofAir Pressure Cycles*	*Outward Pressure Values Multiplied by a Ratio of -1.4*	*Outward Pressure Values Multiplied by a Ratio of -2.0*
1	Inward	0.2 P^{inward} - 0.5 P^{inward}	3500	NA	NA
2	Inward	0.0 P^{inward} - 0.6 P^{inward}	300	NA	NA
3	Inward	0.5 P^{inward} - 0.8 P^{inward}	600	NA	NA
4	Inward	0.3P P^{inward} - 1.0P P^{inward}	100	NA	NA
5	Outward	0.3$P^{outward}$ - 1.0$P^{outward}$	50	-0.4P/-1.4P	-0.6P/-2.0P
6	Outward	0.5$P^{outward}$ - 0.8$P^{outward}$	1050	-0.7P/-1.1P	-1.0P/-1.6P
7	Outward	0.0$P^{outward}$ - 0.6$P^{outward}$	50	0.0P/-0.8P	0.0P/-1.2P
8	Outward	0.2$P^{outward}$ - 0.5$P^{outward}$	3350	-0.3P/-0.7P	-0.4P/-1.0P

4.1.4.8.6 Procedure B

Apply the cyclic loads in accordance with Table 2. P denotes the inward acting (positive) pressure and –P denoted the outward acting (negative) pressure. The outward pressure shall be a ratio (-1.4 or -2.0) of the inward pressure as described in 4.1.4.5.

Table 2

Loading Sequence	*Loading Direction*	*Air Pressure Cycles*	*No.of Air Pressure Cycles*	*Negative Pressure Values Multiplied by a Ratio of -1.4*	*Negative Pressure Values Multiplied by a Ratio of -2.0*
1	Inward	0.0 P^{inward} - 0.6P P^{inward}	12	NA	NA
2	Inward	0.0P P^{inward} - 0.8 P^{inward}	1	NA	NA
Repeat positive loading sequence 1 and 2 an additional four (4) times prior to loading sequence 3					
3	Inward	0.0P P^{inward} - 1.0 P^{inward}	1	NA	NA
4	Outward	0.0$P^{outward}$ - 0.6$P^{outward}$	12	0.0/-0.8P	0.0P/-1.2P
5	Outward	0.0$P^{outward}$ - 0.8$P^{outward}$	1	0.0P/-1.1P	0.0P/-1.6P
Repeat negative loading sequence 4 and 5 an additional four (4) times prior to loading sequence 6					
6	Outward	0.0$P^{outward}$ - 1.0$P^{outward}$	1	0.0P/-1.4P	0.0P/-2.0P
Repeat the loading sequence 1 through 6, in the order designated an additional seven (7) times.					

4.1.4.9 Performance Requirements

4.1.4.9.1 Both an inward acting (positive) and outward acting (negative) wind load rating shall be assigned based on the maximum pressure levels successfully maintained. The ratings shall be based on the inward acting pressure rating in increments of 5 lbs/ft^2 (0.25 kPa). The pressure ratings shall be stated in multiples of +P, -1.4P or +P, -2P as applicable.

4.1.4.9.2 For windstorm resistant fenestration systems that are being qualified for use in areas that are not subject to the impact of wind debris (Wind Zones TC and NTC), the test specimen shall show no signs of cracking or any other signs of failure.

4.1.4.9.3 For windstorm resistant fenestration systems that are being qualified for use in areas that are subject to the impact of wind debris (Wind Zone TCM), see the Performance Requirements for the Test Method for Windstorm Resistant Fenestration Systems Impacted by Windborne Debris.

4.1.4.9.4 In addition to meeting the performance requirements stated in Paragraph 4.1.4.9.3, a separate sample, not impacted by windborne debris, shall meet the criteria for a Wind Zone TC certification. This is to ensure that windstorm resistant fenestrations systems that are certified for use in Wind Zone TCM meet the cyclic wind criteria when not impacted by windborne debris.

4.2 WINDBORNE DEBRIS RATINGS

4.2.1 Test Method for Windstorm Resistant Fenestration Systems Impacted by Windborne Debris

A. Requirement

In order to qualify as a certified windstorm resistant fenestration system for use in Zone TCM, the system shall be tested for either large missile or small missile impact resistance in accordance with the Test Method for Windstorm Resistant Fenestration Systems Impacted by Windborne Debris. These systems are intended for use in areas prone to hurricane force winds and where windborne debris resistance is required.

The large missile impact test consists of impacting a test specimen with a series of impacts. The large missile is an 8 ft (2.4 m) long nominal wooden 2 x 4 weighing 9 lbs (4 kg) traveling at a speed of 50 ft/sec (15.25 m/s). Each sample shall be subjected to two (2) impacts at predetermined locations.

The small missile impact test consists of impacting a test specimen with a series of impacts. Each impact of the small missile consists of ten (10) steel balls with each steel ball weighing 0.07 oz (2 g) traveling at a speed of 130 ft/sec (39.6 m/s).

Subsequent to the missile impact test, either large or small missile, the specimen shall be subjected to Structural Test Method for Windstorm Resistant Fenestration Systems Exposed to Cyclic Air Pressure Differentials (Procedure A). The inward pressure level, P^{inward}, that is used during the test shall be at the discretion of the test sponsor. The tests shall be conducted such that the ratio of the outward pressure to the inward pressure ($P^{outward}$ / P^{inward}) shall be either (-1.4) or (-2.0).

B. Test/Verification

Three (3) separate samples shall be tested per the Test Method for Windstorm Resistant Fenestration Systems Impacted by Windborne Debris for either large missile or small missile impact resistance. Following the Test Method for Windstorm Resistant Fenestration Systems Impacted by Windborne Debris, each sample shall also be subjected to the Structural Test Method for Windstorm Resistant Fenestration Systems Exposed to Cyclic Air Pressure Differentials (Procedure A).

To obtain certification for either large missile impact resistance [Wind Zone TCM-LM] or small missile impact resistance [Wind Zone TCM-SM], upon completion of the cyclic pressure test (which follows the impact test), all three (3) samples shall not develop any openings more than 5 in. (125 mm) in length or any through openings through which a 3 in. (75 mm) diameter solid sphere can freely pass.

To obtain certification for either large missile impact resistance [Wind Zone TCM-LM (FL)] or small missile impact resistance [Wind Zone TCM-SM (FL)], upon completion of the cyclic pressure test (which follows the impact test), all three (3) samples shall have no penetration of the impact protective system by the missile (for the impact test) and during the cyclic test, shall not develop any openings more than 5 in. (125 mm) in length or 1⁄16 in. (1.6 mm) in width through which air can pass.

4.2.2 Introduction

4.2.2.1 This test method is intended to evaluate the performance of windstorm resistant fenestration systems located in geographical areas that are subject to the impact of windborne debris (Zone TCM). The test method is based on several known test methods such as ASTM E1996, SBCCI STD 12 and FBC TAS 201-94 with several modifications incorporated. The modifications are basically a compilation of the existing test methods such that the resulting test method incorporates the most critical item from each test method. This should allow a manufacturer to meet all the major building codes by conducting a single set of tests.

4.2.2.2 Two (2) levels of performance requirements have been provided. This is done to assist the manufacturer in gaining acceptance of the product(s) by local jurisdictions that utilize a building code that exceeds the minimum acceptance criteria of the certification agency (most notably the Florida Building Code).

4.2.2.3 Two (2) different levels of missile impact are offered:

The large missile impact test consists of impacting a test specimen with an 8 ft (2.4 m) long wooden 2 × 4 weighing 9 lbs (4 kg) traveling at a speed of 50 ft/sec (15.25 m/s). Each sample shall be subjected to two (2) impacts at predetermined locations.

The small missile impact test consists of impacting a test specimen with ten (10) steel balls with each steel ball weighing 0.07 oz (2 g) traveling at a speed of 130 ft/sec (39.6 m/s). Each sample shall be subjected to three (3) impacts at predetermined locations.

4.2.2.4 Following the impact test, each sample shall be subjected to Structural Test Method for Windstorm Resistant Fenestration Systems Exposed to Cyclic Air Pressure Differentials, Procedure A.

4.2.3 Test Apparatus and Arrangement

4.2.3.1 Large Missile Impact Device - 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.

4.2.3.1.1 The large missile cannon shall be used to deliver the large missile. The cannon consists of a 4 in. (100 mm) internal diameter pipe that is approximately 12 ft (3.7) in length mounted onto a support frame. Compressed air is supplied to the cannon and monitored by a pressure gauge. A remote firing device and valve shall be used to fire the missile.

4.2.3.1.2 The large missile shall consist of an 8 ft ±4 in. (2.4 m ± 100 mm) long wooden 2 × 4, (Southern Yellow Pine or Douglas Fir) weighing 9 ±0.25 lbs (4100 ± 100g). The 2 × 4 shall be free of knots and splits within 12 in. (300 mm) of the impact end. A shabot shall be permitted on the trailing edge to facilitate launching. If used, the shabot's weight shall be considered in determining the missile's total weight.

4.2.3.1.3 A timing system shall be provided. It shall be capable of measuring the speed of the missile within a tolerance of 1 ft/sec (0.3 m/s).

4.2.3.1.4 The test sample shall be mounted vertically within or onto a test frame. The test frame shall be of sufficient size, strength and be adequately anchored to withstand the anticipated forces of the impacting missile without resulting in noticeable damage or excessive deflection. The mounting frame shall either be integral with the cyclic air test chamber or capable of being installed on the test chamber used in the Structural Test Method for Windstorm Resistant Fenestration Systems Exposed to Cyclic Air Pressure Differentials.

4.2.3.2 Small Missile Impact Device - 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.

4.2.3.2.1 The small missile cannon shall be used to deliver the small missile. The cannon consists of a 1 in. (25 mm) internal diameter pipe that is approximately 4 ft (1.2 m) in length mounted onto a support frame. Compressed air is supplied to the cannon and monitored by a pressure gauge. A remote firing device and valve shall be used to fire the missile.

4.2.3.2.2 The small missile shall consist of ten (10) steel balls fired simultaneously with each steel ball weighing 0.07 oz (2 g).

4.2.3.2.3 A timing system shall be provided. It shall be capable of measuring the speed of the missile within a tolerance of 1 ft/sec (0.3 m/s). Only the speed of one (1) steel ball needs to be monitored in order to determine the projectile speed.

4.2.3.2.4 The test sample shall be mounted vertically within or onto a test frame. The test frame shall be of sufficient size, strength and be adequately anchored to withstand the anticipated forces of the impacting missile without resulting in noticeable damage or excessive deflection. The mounting frame shall either be integral with the test chamber or capable of being installed on the test chamber used in the Structural Test Method for Windstorm Resistant Fenestration Systems Exposed to Cyclic Air Pressure Differentials.

4.2.4 Test Specimen

The test specimen shall be of sufficient size and configuration to determine the performance of all components of the system. The conditions of structural support shall simulate, as accurately as possible, the actual structural conditions of a building. The distance between structural supports incorporated into the test specimen shall be the maximum support spacing granted in the certification.

4.2.5 Test Procedure

4.2.5.1 Large Missile Impact

4.2.5.1.1 When ready for testing, the large missile cannon shall be positioned such that each test specimen receives a series of two (2) impacts of the large missile. The end of the cannon shall be located approximately 14 ft (4.3 m) away from the face of the test specimen. The first missile shall impact the test specimen within a 5 in. (125 mm) radius circle located at the center of the test specimen. The second missile shall impact a corner of the test specimen within a 5 in. (125 mm) radius circle centered no more than 6 in. (150 mm) away from any supporting members.

4.2.5.1.2 The large missile shall impact the surface of the test specimen with a speed of 50-52 ft/sec (15.2-15.8 m/s) which is approximately 34 miles/hour (55 km/hr).

4.2.5.2 Small Missile Impact

4.2.5.2.1 When ready for testing, the small missile cannon shall be positioned such that each test specimen receives a series of three (3) impacts of the small missile. The end of the cannon shall be located at an appropriate distance from the test panel such that the missiles are distributed over a maximum spread of 2 ft2 (0.2 m2). The series of impacts shall be located at the center of the test specimen, along the edge of the center of the long dimension of the test specimen and at one corner of the test specimen.

4.2.5.2.2 The small missile shall impact the surface of the test specimen with a speed of 130-132 ft/sec (39.6-40.2 m/s) which is approximately 90 miles/hour (146 km/hr).

4.3 HAIL RESISTANCE RATING

4.3.1 Simulated Hail Resistance Test Using Freezer Ice Balls

A. Requirement

All certified windstorm resistant fenestration systems shall be subjected to a simulated hail impact test in accordance with the Simulated Hail Resistance Test Using Freezer Ice Balls. Two (2) ratings are available: Severe (SH) and Moderate (MH). The test is based on ANSI/FM 4473 with variations as noted below. 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). The impact speeds are 101.8 ft/sec (31.0 m/sec) and 92.5 ft/sec (28.2 m/sec), respectively . Other impact energies that result in a greater impact energy in order to meet other jurisdictional requirements shall be permitted.

B. Test/Verification

One (1) test specimen shall be subjected to either the Severe or Moderate impact energy in accordance with the Simulated Hail Resistance Test Using Freezer Ice Balls.

The test specimen shall be the maximum size for which certification is desired and shall be representative of the samples being considered for certification. The test specimen shall be placed over 1⁄2 in. (13 mm) thick plywood if necessary.

The ice balls shall be molded 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. They shall meet the criteria listed in Table 3 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 3

Nominal Ice Ball Diameter in. (mm)	Mass in Pounds (g)
1.5 (38)	0.0584 (26.5)
1.75 (45)	0.0928 (42.1)

Each sample shall be impacted ten (10) times with six (6) of the impacts occurring within six 6 in. (150 mm) of the edges of the sample. The specimen shall be considered to meet the test criteria if there is no sign of cracking or splitting.

5 MANUFACTURER'S REQUIREMENTS

5.1 DEMONSTRATED QUALITY CONTROL PROGRAM

5.1.1 A quality assurance program is required to assure that subsequent products 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 may be documented in the certification report.
- Continued conformance to this standard is verified by the certifier's surveillance program.
- Quality of performance is determined by field performance and by periodic re-examination and testing.

5.1.2 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.

5.1.3 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.

5.1.4 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.

5.1.5 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 certification report, may be required to be reported to, and authorized by the certification agency prior to implementation for production.
- Records of all revisions to all certified products shall be maintained.

5.2 SURVEILLANCE AUDIT

5.2.1 An audit of the manufacturing facility is part of the certification 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 ensure a uniform product consistent with that which was tested and certified.

5.2.2 Certified products or services shall be produced or provided at or from the location(s) audited by the certification agency and as specified in the certification report. Manufacture of products bearing the certification agency's mark of conformity is not permitted at any other location without prior written authorization by the certification agency.

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 the certification agency.

5.4 PRODUCT MODIFICATIONS

The manufacturer shall notify the certification agency of changes in product construction, components, raw materials, physical characteristics, coatings, component formulation or quality assurance procedures prior to implementation.

6 BIBLIOGRAPHY

ISO/IEC 17025, General Requirements for the Competence of Testing and Calibration Laboratories.