



Member of the FM Global Group

Examination Standard for Skylights

Class Number 4431

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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 skylights. Skylights are also referred to as roof lights. For purposes of this standard, skylights and roof lights shall be considered as the same product and shall be referred to as skylights.
- 1.1.2 Testing and certification criteria shall include, but are not limited to, performance requirements, marking requirements, examination of manufacturing facility(ies), an audit of quality assurance procedures, and a surveillance program.

1.2 Scope

- 1.2.1 This standard sets the performance requirements for skylights under simulated laboratory conditions. They shall be examined for their ability to limit fire propagation on the topside and/or through the assembly, wind resistance, hail resistance, windborne debris and UV exposure. The standard also examines the ability of the skylights to withstand the effects of temporary live loads such as those imposed by foot traffic and snow.
- 1.2.2 Skylights are normally installed in the plane of the roof but they can be installed in numerous orientations and configurations including what are commonly referred to as north lights or saw tooth applications.
- 1.2.3 This standard is intended to qualify skylights when their slope is less than or equal to 45° from the horizontal. This standard does not qualify skylights when installed vertically in a north light or saw tooth configuration. When oriented vertically, as would be the case in a north light or saw tooth configuration, the skylight shall be considered as an exterior wall panel. For the certification requirements of exterior wall panels, see FM 4881, *Examination Standard for Class 1 Exterior Wall Systems*.
- 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 This standard does not qualify automatic heat and smoke vents. For the certification requirements of heat and smoke vents, see FM 4430, *Examination Standard for Heat and Smoke Vents*.

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 skylights for the purpose of obtaining certification. Skylights having characteristics not anticipated by this standard may be certified if performance equal, or superior, to that required by this standard is demonstrated.

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 for certification; 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 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

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;
- satisfactory field experience;
- 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.

American National Standard Institute (ANSI)

- ANSI/IEEE/ASTM SI 10, *American National Standard for Metric Practice*
- ANSI/FM 4473, *Impact Resistance Testing of Rigid Roofing Materials by Impacting with Freezer Ice Balls*
- ANSI/FM 4474, *Simulated Wind Uplift Resistance of Roof Assemblies Using Static Positive and/or Negative Differential Pressures*

American Society for Testing and Materials (ASTM International)

- ASTM E108, *Standard Test Method for Fire Tests of Roof Coverings*

FM Approvals LLC (FM)

- FM 4350, *Examination Standard for Windstorm Resistant Fenestrations*
- FM 4430, *Examination Standard for Heat and Smoke Vents*
- FM 4470, *Examination Standard for Single-Ply, Polymer-Modified Bitumen Sheet, Built-Up Roof (BUR) and Liquid Applied Roof Assemblies for Use in Class 1 and Noncombustible Roof Deck Construction*
- FM 4880, *Examination Standard for Class 1 Fire Rating of Building Panels or Interior Finish Materials*
- FM 4881, *Examination Standard for Class 1 Exterior Wall Systems*

1.9 Terms and Definitions

For purposes of this standard, the following terms apply:

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

Heat and Smoke 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.

Light Band – for purposes of this standard, a light band is identical to a wall light.

North Light – see Saw Tooth.

Roof Light – for purposes of this standard, a roof light is identical to a skylight.

Saw Tooth – a type of skylight that is normally installed facing north and has a vertical component and a sloped component. For purposes of this standard, the vertical component of this type of arrangement will be considered a skylight.

Thermoplastic – materials that soften when heated and harden when cooled. This process is reversible provided that the material is not heated sufficiently to decompose. Examples are polyvinyl chloride (PVC), expanded or extruded polystyrene (EPS), polycarbonate, polyethylene terephthalate (PET), polymethyl methacrylate (PMMA), polypropylene and polyethylene.

Thermoset – materials that cure or set irreversibly when heated during manufacture. Examples are polyurethane, polyisocyanurate, fiberglass reinforced plastic (FRP), phenolic foam, melamine and unsaturated polyester (UP).

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. They are installed in the plane of the roof and are limited to installations where the slope is less than or equal to 45° from the horizontal.

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

Wall Light – similar to a skylight except they are installed vertically, usually near the top of a building's exterior. In addition to emitting light, they also serve as an exterior wall component.

Deck - The structural component of the roof assembly to which the roof system is secured.

2 GENERAL INFORMATION

2.1 Product Information

- 2.1.1 Skylights are manufactured in a variety of profiles and materials. These products can be constructed as single or multi-layered panels, be translucent or transparent and single or multi skinned panels. Plastic skylights can be constructed of either thermoplastic or thermoset materials and are designed to admit light while maintaining the building envelope. Skylights shall be considered inoperable and can span the entire length of a roof.
- 2.1.2 As defined in this standard, skylights are installed in the plane of the roof and are limited to installations where their slope is less than or equal to 45° from the horizontal.
- 2.1.3 Skylights may have a corrugated or troughed surface and be provided in shapes such as, but not limited to, domes and pyramids. Unlike heat and smoke vents, skylights often cover large areas of a roof, and can run the entire length of a building.

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, 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 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:
- 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. Any decision to use data generated using prototypes is at the discretion of the certification agency.
- 2.3.4 It is the manufacturer's responsibility to provide any necessary test fixtures, such as those which may be required to evaluate the skylights.

3 GENERAL REQUIREMENTS

3.1 Review of Documentation

- 3.1.1 The requirements of this standard shall be used to measure and describe the performance of skylight systems to simulated fire testing, resistance to wind loading, resistance to hail, the effects of temporary live loads such as those imposed by foot traffic and the deleterious effects caused from everyday exposure to sunlight. As an option, these systems can also be examined for their resistance to windborne debris.
- 3.1.2 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 investigation shall define the limits of the Certification.
- 3.1.3 Drawing(s), formulation(s) and specifications identifying materials, formulations and construction details shall be provided to the certification agency for each configuration tested (i.e., itemized percentage of combustible material types per unit length).
- 3.1.4 A drawing(s) shall be provided to the certification agency indicating the size and location of the markings as they will be shown on the product.
- 3.1.5 The manufacturer shall also provide to the certification agency copies of all brochures, sales literature and specification sheets relating to the skylight(s) submitted for testing.

3.2 Markings

- 3.2.1 Marking on 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, size, rating, capacity, etc., as appropriate.
 - when the products are provided with a safety cage, a note that the safety cage meets the requirements of OSHA Regulation 29 CFR 1910.23(e)(8) and 1926.501 or comparable international standard having jurisdiction.

When hazard warnings are needed, the markings should be universally recognizable.

- 3.2.2 The model or type identification shall correspond with the manufacturer's catalog designation and shall uniquely identify the certification agency's mark of conformity.
- 3.2.3 The certification agency's mark of conformity shall be displayed visibly and permanently on the product as appropriate and in accordance with the requirements of the certification agency. The manufacturer shall exercise control of this mark as specified by the certification agency and the certification scheme.
- 3.2.4 All markings shall be legible and durable.

3.3 Manufacturer's Installation and Operation Instructions

- 3.3.1 The manufacturer shall:
- prepare instructions for the installation, maintenance, and operation of the product;
 - provide facilities for repair of the product and supply replacement parts, if applicable; and

- provide 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.

3.4 Calibration

- 3.4.1 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.
- 3.4.2 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

Tests of alternate constructions may be waived if considered less hazardous than those previously tested.

4.1 Spread of Flame Test for Skylights from an Exterior Ignition Source

4.1.1 Requirement

All skylights shall be subjected to a fire test to evaluate their ability to limit flame spread in accordance with a modified version of ASTM E108 Class A and Class B. The Spread of Flame test shall also be used to evaluate the material's propensity to melt and drip and its ability to maintain its structural integrity. The modifications are as follows:

The width of the test samples for the Spread of Flame test shall be minimum 3 ft (0.91 m) wide, up to a maximum of 6 ft-8 in. (2 m) wide. Skylights having widths less than 3 ft (0.91 m) shall be allowed and tested at the greatest width for which certification is desired. The length of the test samples shall be minimum 8 ft (2.4 m). Skylights having lengths less than 8 ft (2.4 m) shall be allowed and tested at the greatest length for which Approval is desired. Ratings available shall be Class A and Class B only. There is no Class C rating as with ASTM E108.

4.1.2 Test/Verification

Two (2) tests shall be conducted on each candidate submitted for certification. Each test with a continuous exposure period of ten (10) minutes. The samples will be tested at the maximum slope for which certification is desired. The minimum slope allowed during the testing is 0.25 in 12 (2.4°). The maximum slope allowed during the test is 5 in 12 slope (23°). The rating shall indicate the maximum slope at which the material was successfully tested and for which it is certified. The one minute timed wind speed average velocity measured on the calibrated deck shall be 1056 ft/min \pm 44 ft/min (5.4 m/sec \pm 0.22 m/sec) and the two minute average flame temperature shall be 1400 °F \pm 50 °F (760 °C \pm 28 °C) for Class A and B testing.

4.1.3 Conditions of Acceptance for the Spread of Flame Test

Class A rating:

- each test sample shall not propagate flame more than 6 ft (1.8 m) from the flame exposed end;
- any particles that melt, drip or otherwise fall off during the test shall not be flaming or glowing upon contact with the floor.

Note: Skylight test samples that measure less than 6 ft (1.8 m) in length shall be granted a Class B rating if flames propagate the entire length of the sample provided particles that melt, drip, or otherwise fall off during the test are not flaming or glowing when making contact with the floor.

Class B rating:

- each test sample shall not propagate flame to the end of the test sample, 8 ft (2.4 m) from the flame exposed end;
- any particles that melt, drip or otherwise fall off during the test shall not be flaming or glowing upon contact with the floor.

When skylights do not maintain their structural integrity, the manufacturer shall provide a screen or similar mechanism to keep the plastic dome or lid from interfering with the sprinkler's operation.

In addition, a note shall be added to the certification listing to alert the end user that if a sprinkler is installed directly under such a skylight, steps need to be taken to prevent the skylight from interfering with the sprinkler’s operation.

4.2 Simulated Hail Resistance Test Using Freezer Ice Balls

4.2.1 Requirement

All skylights shall be subjected to a simulated hail impact test using freezer ice balls . Four (4) ratings are available: Very Severe (VSH), Severe Plus (SH+), Severe (SH) and Moderate (MH). The minimum rating required for Certification MH. Each rating consists of the following specifications:

Table 1

<i>Hail Rating</i>	<i>Nominal Ice Ball Diameter, in. (mm)</i>	<i>Kinetic Energy, ft-lbs (J)</i>
VSH	2.0 (51)	53 – 58 (72 – 79)
SH+	2.0 (51)	26.8 – 29.5 (36.4 – 40)
SH	1.75 (44)	14.9 – 16.5 (20.3 – 22.4)
MH	1.5 (44)	7.8 – 8.6 (10.4 – 11.6J)

4.2.2 Test/Verification

Two (2) test samples of each profile shall be subjected to either the VSH, SH+, SH or MH impact energy . One sample shall be exposed to ultraviolet (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 a minimum of five (5) times for SH+, SH or MH impact energy and subjected to three to five (3-5) ice ball impacts at corner, edge and center areas of the test sample for VSH impact energy. Additional impacts shall be conducted at the discretion of the certification agency, when the test sample includes changes in profile separate from the initial three (3) impact areas, such as corrugations or other points that may prove susceptible to hail damage.

4.2.3 The test samples shall be considered to meet the test criteria if:

SH+, SH and MH ratings:

- no through openings shall develop
- cracking and thin breaks examined under 10X magnification shall be permitted

VSH rating:

- no through openings, cracking or thin breaks examined under 10X magnification shall be permitted to develop.

4.3 Simulated Impact Test for Skylights

4.3.1 Requirement

All skylights shall be subjected to an impact test in order to determine the product's ability to resist anticipated live loads and other possible loads such as foot traffic. Skylights 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 certification.

4.3.2 Test/Verification

The test shall be conducted on the minimum thickness of each profile for which certification is desired. The test shall be conducted at the maximum span that the particular profile and thickness are to be certified.

4.3.2.1 The impactor consists of a cylindrical canvas bag having a diameter of 12 in. (300 mm) filled with dry sand having a total assembly weight of 100 lbs (45.5 kg) \pm 4 oz. (113.4 g). The bag is tied to ensure that the sand cannot escape, and a ring or similar device is attached to the top of the bag to facilitate a quick release mechanism used to drop the impactor. The skylight is secured to a suspended substrate sufficient to provide stiffness to prevent any flexibility from affecting the test results. The 1st impact is located within a 12 in. (300 mm) diameter circle located at the test sample's center point. The impactor is 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 is released such that it falls freely under gravity onto the surface of the test sample. The impactor shall not be removed for a period of five (5) minutes after the impact. The 2nd impact shall be located within a 12 in. (300 mm) diameter circle from the end support of the test sample.

4.3.2.2 The test sample shall be considered to meet the test criteria if no through opening develops through which a four (4) inch (102 mm) diameter sphere can pass however the specimens shall be permitted to develop cracks and thin breaks. 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.

4.4 Simulated Wind Uplift Resistance Test for Skylights

4.4.1 Requirement

All skylights 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. The minimum rating shall be 60 lbs/ft² (2.9 kPa). Additional ratings shall be in increments of 15 lbs/ft² (0.75 kPa).

4.4.2 Test/Verification

Testing for wind uplift resistance for skylights shall be in accordance with ANSI/FM 4474, *Test Method for Evaluating the Simulated Wind Uplift Resistance of Roof Assemblies Using Static Positive and/or Negative Differential Pressures* with the following modifications:

- 1) The test shall be conducted on the minimum thickness material of each profile for which certification is desired. The test shall be conducted at the maximum span that the particular profile and thickness are to be certified.
- 2) Skylights that measure < 5 x 9 ft (1.5 x 2.7 m) in size shall be permitted to be tested on the 5 x 9 ft (1.5 x 2.7 m) simulated wind uplift pressure test apparatus without limitation in wind

uplift rating. Skylights that measure > 5 x 9 ft (1.5 x 2.7 m) in size shall be tested on the 12 x 24 ft (3.7 x 7.3 m) simulated wind uplift pressure test apparatus.

4.4.3 The test sample shall be considered to meet the test criteria if:

- all fasteners, plates, clips and other items used to secure the skylight to the roof remain firmly embedded into or through roof decks or other structural substrates to which they are being fastened to or through;
- fasteners, plates, clips and other items used to secure the skylight curb to the test frame shall remain fully engaged and do not pull through, become dislodged, disconnected or disengaged;
- skylights shall not separate, delaminate, break or crack (other than thin breaks).

4.5 Windborne Debris Ratings (Optional)

4.5.1 Requirement

4.5.1.1 As an option, skylights shall be permitted to be certified for resistance to large or small windborne debris in accordance with Examination Standard 4350, *Windstorm Resistant Fenestrations*. Tests shall be conducted on the minimum thickness of each profile for which certification is desired.

4.5.1.2 The test method offers two (2) levels of impact - Large Debris (LD) or Small Debris (SD). Products that meet the criteria of the large windborne debris impact shall be deemed to have also met the criteria for the small windborne debris impact

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

4.5.1.4 The SD impact test consists of impacting a test sample with a series of impacts. Each impact of the small windborne debris consists of ten (10) steel balls 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 predetermined locations.

4.5.1.5 Subsequent to either windborne debris impact test, the sample 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 ($P^{\text{outward}} / P^{\text{inward}}$) shall be either (-1.4) or (-2.0).

4.5.2 Test/Verification

4.5.2.1 Three (3) separate samples shall be tested per the Test Method for Windstorm Resistant Fenestration Systems Impacted by Windborne Debris for either LD or SD 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).

4.5.2.2 To obtain certification for Wind Zones HM-LD and HM-SD:

For either LD Impact Resistance [Wind Zone HM-LD] or SD Impact Resistance [Wind Zone HM-SD], 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.

4.5.2.3 To obtain certification for Wind Zones HM-LD(FL) and HM-SD(FL):

For either LD Impact Resistance [Wind Zone HM-LD (FL)] or SD Impact Resistance [Wind Zone HM-SD (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 windborne debris (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.

5 OPERATIONS 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 certification agency'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 may be part of the certification agency's surveillance requirements 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 provided from, location(s) disclosed as part of the certification examination. Manufacture of products bearing a certification mark is not permitted at any other location prior to disclosure to the certification agency.

5.3 Manufacturer's Responsibilities

- 5.3.1 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*.