



Designation: **E2634 – 16** **E2634 – 17**

## Standard Specification for Flat Wall Insulating Concrete Form (ICF) Systems<sup>1</sup>

This standard is issued under the fixed designation E2634; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

### 1. Scope

1.1 This specification is intended to apply to Insulating Concrete Form (ICF) Systems that will act as permanent formwork for cast-in-place reinforced concrete beams; lintels; exterior and interior, above and below grade bearing and non-bearing walls; foundations; and retaining walls. The specification is restricted to ICF Systems with a resultant uniform monolithic concrete core.

1.2 Products covered by the specification consists of molded expanded polystyrene (EPS) insulation panels that are connected by cross ties to form the ICF System.

1.3 This specification identifies test methods appropriate for establishing ICF System performance in their primary function as a stay in place concrete forming system. The use of ICF Systems covered by this specification shall be regulated by building codes that address fire performance, structural performance or both. The fire performance of the material shall be addressed through standard fire test methods established by the appropriate governing documents. The structural performance must be addressed through design of concrete structures in accordance with the appropriate Code requirements.

1.4 Details of manufacturing procedures are beyond the scope of this specification.

1.5 The values stated in SI units are to be regarded as standard. The values given in parentheses are mathematical conversions to inch-pound units that are provided for information only and are not considered standard. For conversion to metric units other than those contained in this specification, refer to **IEEE/ASTM SI 10**.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

### 2. Referenced Documents

2.1 *ASTM Standards:*<sup>2</sup>

**C203** Test Methods for Breaking Load and Flexural Properties of Block-Type Thermal Insulation

**C390** Practice for Sampling and Acceptance of Thermal Insulation Lots

**C475/C475M** Specification for Joint Compound and Joint Tape for Finishing Gypsum Board

**C578** Specification for Rigid, Cellular Polystyrene Thermal Insulation

**C645** Specification for Nonstructural Steel Framing Members

**C1002** Specification for Steel Self-Piercing Tapping Screws for Application of Gypsum Panel Products or Metal Plaster Bases to Wood Studs or Steel Studs

**C1363** Test Method for Thermal Performance of Building Materials and Envelope Assemblies by Means of a Hot Box Apparatus

**C1396/C1396M** Specification for Gypsum Board

**D635** Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position

**D638** Test Method for Tensile Properties of Plastics

**D732** Test Method for Shear Strength of Plastics by Punch Tool

**D1622/D1622M** Test Method for Apparent Density of Rigid Cellular Plastics

<sup>1</sup> This specification is under the jurisdiction of ASTM Committee E06 on Performance of Buildings and is the direct responsibility of Subcommittee E06.21 on Serviceability.

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<sup>2</sup> For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

- D1761 Test Methods for Mechanical Fasteners in Wood
- D1929 Test Method for Determining Ignition Temperature of Plastics
- D2863 Test Method for Measuring the Minimum Oxygen Concentration to Support Candle-Like Combustion of Plastics (Oxygen Index)
- E8/E8M Test Methods for Tension Testing of Metallic Materials
- E84 Test Method for Surface Burning Characteristics of Building Materials
- E90 Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements
- E119 Test Methods for Fire Tests of Building Construction and Materials
- E283 Test Method for Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen
- E331 Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference
- IEEE/ASTM SI 10 Standard for Use of the International System of Units (SI): the Modern Metric System
- 2.2 ISO/IEC Standards:<sup>3</sup>
  - ISO/IEC Guide 65 General Requirements for Bodies Operating Product Certification Systems
  - ISO/IEC Guide 17020 General Criteria for the Operation of Various Types of Bodies Performing Inspection
  - ISO/IEC Standard 17025 General Requirements for Competence of Test and Calibration Laboratories
- 2.3 Other Standards:
  - ACI 318 Building Code Requirements for Structural Concrete<sup>4</sup>
  - UL 1715 Fire Test of Interior Finish Material<sup>5</sup>
  - NFPA 286 Method of Fire Test for Evaluating Contribution of Wall and Ceiling Interior Finish to Room Fire Growth<sup>6</sup>
  - AISI NAS-01 North American Specification for the Design of Cold-formed Steel Structural Members, including 2005 Supplement<sup>7</sup>
  - ANSI/ASHRAE 90.1 Energy Standard for Buildings Except Low-Rise Residential Buildings<sup>8</sup>

### 3. Terminology

#### 3.1 Definitions:

3.1.1 *cross ties*—plastic or metal bridging comprised of flanges and webs that hold the EPS panels at a prescribed distance and provide resistance to the concrete pressure. The flanges may be used as attachment points for interior and exterior finishing materials.

3.1.2 *expanded polystyrene*—a type of foamed plastic formed by the expansion of polystyrene resin beads in a molding process.

3.1.3 *insulating concrete forms (ICFs)*—a structural stay-in-place concrete forming system, consisting of opposing EPS panels, held parallel by means of cross ties and serves to provide insulating characteristics. See Fig. 1.

3.1.4 *quality agency*—a quality agency is defined to be one that: (1) Maintains accreditation as a Certification Organization in accordance with ISO/IEC Guide 65 and as an Inspection Agency in accordance with ISO/IEC Guide 17020. The scope of accreditations shall be consistent with the type of product being inspected. (2) Has access to the facilities and trained technical personnel to verify that the grading, bonding, workmanship, and other characteristics of the products as determined by inspection,

<sup>3</sup> Available from International Organization for Standardization (ISO), ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, <http://www.iso.org>.

<sup>4</sup> Available from American Concrete Institute (ACI), 38800 Country Club Dr., Farmington Hills, MI 48331-3439, <http://www.concrete.org>.

<sup>5</sup> Available from Underwriters Laboratories (UL), 333 Pfingsten Rd., Northbrook, IL 60062, <http://www.ul.com>.

<sup>6</sup> Available from National Fire Protection Association (NFPA), 1 Batterymarch Park, Quincy, MA 02269-7471, <http://www.nfpa.org>.

<sup>7</sup> Available from American Iron and Steel Institute (AISI), 25 Massachusetts Ave., NW, Suite 800, Washington, DC 20001, <http://www.steel.org>.

<sup>8</sup> Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

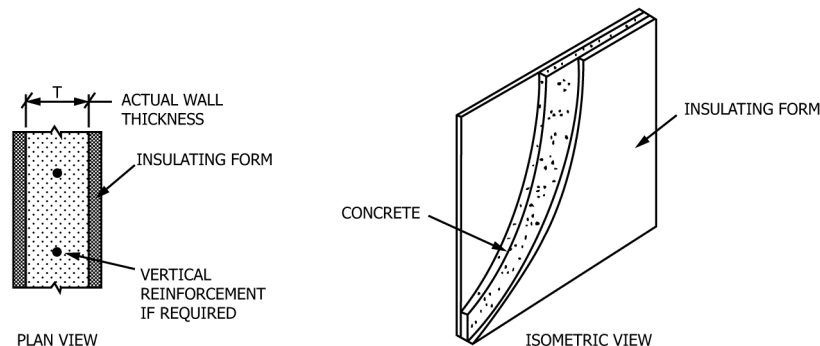


FIG. 1 Flat Wall ICF, Wall Assembly

sampling, and testing comply with all applicable requirements specified herein. (3) Has procedures to be followed by its personnel in performance of the inspection and testing. (4) Has no financial interest in, or is not financially dependent upon, any single company manufacturing the product being inspected or tested. (5) Is not owned, operated, or controlled by any such company.

3.1.5 *testing laboratory*—a testing laboratory is one that is accredited as complying with ISO/IEC Standard 17025. The scope of the laboratory's accreditation shall include the specific type of testing being performed.

#### 4. Classification

4.1 ICF Systems addressed by this specification are those which produce a cast-in-place uniform monolithic concrete core wall where the concrete design is in accordance with accepted design standards such as ACI 318.

#### 5. Materials and Manufacture

5.1 *EPS Panels*—All EPS panels are manufactured using molded EPS insulation, conforming to Specification **C578**.

5.2 *Cross Ties*—All components shall conform to manufacturing or performance standards as in accordance with **6.2**. Cross ties that are susceptible to UV degradation shall have a minimum of ~~6 months~~ months of ultraviolet (UV) protection against degradation of physical properties.

NOTE 1—UV protection includes but is not limited to UV stabilizers, protective coverings, or other suitable means.

#### 6. Physical Properties

6.1 *Expanded Polystyrene Qualification:*

6.1.1 These materials, including products into which recycled material is introduced, must comply with requirements in Specification **C578**, Table 1.

6.1.2 *Qualification to the Requirements of 6.1.3*—Data required in **6.1.1** must be submitted in accordance with either **6.1.3** or **6.1.4**.

6.1.3 Where the resin supplier provides to the quality agency sufficient test data in compliance with **6.1.1** for each resin grade (base formula) and for each Specification **C578** Type intended for application use, the ICF System owner must provide reports of tests demonstrating compliance with flexural strength tested in accordance with Test Methods **C203**, Method I, Procedure B, and density requirements tested in accordance with Test Method **D1622/D1622M** of each grade and each Specification **C578** Type intended for application use for each recognized manufacturing plant/location.

6.1.3.1 *Exception*—Oxygen index tests in accordance with Test Method **D2863** need only be conducted on one Specification **C578** Type per supplier resin grade (base formula).

6.1.3.2 *Exception*—Thermal resistance tests need only be conducted at  $23.8 \pm 2.8$  °C ( $75 \pm 5$  °F).

6.1.4 Where the resin supplier does not provide, to the quality agency, sufficient test data showing compliance with all requirements of **6.1.1** for each resin grade (base formula) and for each Specification **C578** Type intended for application use, the ICF System owner must provide reports of tests to demonstrate full compliance with **6.1.1** for each Specification **C578** Type intended for application use at one manufacturing location.

6.1.4.1 *Exception*—Oxygen index tests in accordance with Test Method **D2863** need only be conducted on one Specification **C578** Type per supplier resin grade (base formula).

6.1.4.2 *Exception*—Thermal resistance tests need only be conducted at  $23.8 \pm 2.8$  °C ( $75 \pm 5$  °F).

6.1.4.3 *Exception*—Where products manufactured with any one of the resin grades (base formula) already quality under **6.1.4**, the ICF System owner must provide reports of tests demonstrating compliance with flexural strength tested in accordance with Test Methods **C203**, Method I, Procedure B, and density requirements tested in accordance with Test Method **D1622/D1622M** of each grade and each Specification **C578** Type intended for application use for each recognized manufacturing plant/location.

6.1.5 *Surface Burning Characteristics*—The EPS shall be tested in accordance with Test Method **E84** in the maximum thickness and density intended for use. The maximum Flame Spread Index shall be 75 and the maximum Smoke Development Index shall be 450.

6.1.5.1 *Exception*—The maximum Flame Spread Index shall be 25 when the product is intended for use in non-combustible construction.

6.2 *Cross Tie Qualification:*

6.2.1 *General*—These materials, including products into which recycled material is introduced, must comply with requirements of **6.2.2 – 6.2.6** of this specification which establish the base line properties of the cross ties.

6.2.2 *Rate of Burning*—Plastic Ties shall be tested in accordance with Test Method **D635**. The plastic shall meet minimum CC2 Classification as defined by Test Method **D635**, X2.1.2.

6.2.3 *Ignition Temperature*—Plastic Ties shall be tested in accordance with Test Method **D1929**, Procedure B. The minimum Ignition Temperature shall be 350 °C (662 °F).

6.2.4 *Fastener Capacity*—Shall be tested in accordance with modified Test Methods **D1761** on a minimum of ten specimens.

6.2.4.1 Lateral Load Strength test specimens shall consist of full-thickness ICF panels, with the fastener for which recognition is sought, screwed into the cross-tie flange in a manner representative of the end-use configuration. The test shall be conducted

with an eccentricity equal to the embedment depth of the cross tie below the surface of the EPS. Where cross ties are flush to the EPS no eccentricity is required. Pilot holes for screws shall not be predrilled into the specimen.

#### 6.2.4.2 Analysis:

(1) *Plastic Cross Ties*—The allowable lateral load strength of the connection shall not exceed 75 % of the average proportional limit load, or the average ultimate load divided by a factor of 3.2, whichever is lower. The factor of 3.2 assumes a maximum coefficient of variation (COV) of 15 %. Where the COV is greater than 15 %, the allowable load shall be computed using the following equation:

$$F_{all} = F((1 - 2COV)/2.24) \quad (1)$$

where:

$F_{all}$  = allowable load, N,  
 $COV$  =  $s/F$  = coefficient of variation in a test series,  
 $s$  = standard deviation in a test series, and  
 $F$  = average ultimate load in test series, N.

(2) *Metal Cross Ties*—The allowable lateral strength of the connection shall be determined in accordance with AISI NAS-01, Chapter F.

6.2.4.3 *Withdrawal Load Strength (Plastic or Metal Cross Ties)*—Test specimens shall consist of full-thickness ICF panels, with the fastener for which recognition is sought, screwed into the cross-tie flange in a manner representative of the end-use configuration. Pilot holes for screws shall not be predrilled into the specimen.

(1) The ultimate load shall be determined for each test specimen.

(2) The allowable withdrawal load strength of the connection shall be determined based on the average ultimate load divided by a safety factor of 5.

6.2.5 *Cross Tie Tensile Strength*—The integrated cross tie assembly shall be tested in accordance with modified Test Method **D638** for plastic cross ties and modified Test Methods **E8/E8M** for metal cross ties. Modification of Test Method is to test the actual cross tie assembly with load rate of 25 mm (1 in.) per minute. The minimum tensile strength of the cross tie assembly shall be equivalent to 32.3 kN/m<sup>2</sup> (675 lb/ft<sup>2</sup>) of wall surface.

6.2.5.1 *Exception*—Where the manufacturer can substantiate satisfactory concrete formwork capability through analysis or testing, a reduced minimum tensile strength may be acceptable.

6.2.6 *Cross Tie Shear Strength*—The minimum shear strength of the plastic material determined from Test Method **D732** shall be greater than the value calculated by multiplying the web tributary area by the minimum shear strength of the cross tie assembly and dividing by the minimum vertical cross sectional area of the portion of the cross tie that passes through the concrete cavity. **Fig. 2** indicates the tributary area associated with the web cross sectional area that is subjected to the shear strength.

### 6.3 System Qualification:

6.3.1 *Room Corner Fire Test*—The minimum thickness of the complete assembly of EPS, cross tie material, and concrete with thermal barrier attached, but excluding exterior finishing. The tested thermal barrier shall remain in place for a minimum of 15 min when tested in accordance with UL 1715 or NFPA 286 with the following conditions of acceptance applied to the NFPA 286 test method.

6.3.1.1 Additionally, during the 40 kW (2276 Btu/min) exposure, the interior finish shall comply with Item (1). During the 160 kW (9120 Btu/min) exposure, the interior finish shall comply with Item (2). During the entire test, the interior finish shall comply with Items (3) and (4):

- (1) During the 40 kW (2276 Btu/min) exposure, flames shall not spread to the ceiling.
- (2) During the 160 kW (9120 Btu/min) exposure, the interior finish shall comply with the following:
  - (a) Flame shall not spread to the outer extremity of the sample on any wall or ceiling.
  - (b) Flashover, as defined in NFPA 286, shall not occur.
- (3) The peak rate of heat release throughout the NFPA 286 test shall not exceed 800 kW (45 600 Btu/min).
- (4) The total smoke released throughout the NFPA 286 test shall not exceed 1000 m<sup>2</sup> (10 764 ft<sup>2</sup>).

6.3.2 *Gypsum Wallboard Attachment Test*—The ICF system shall be tested in accordance with the test method contained in **Annex A1** and meet the requirements.

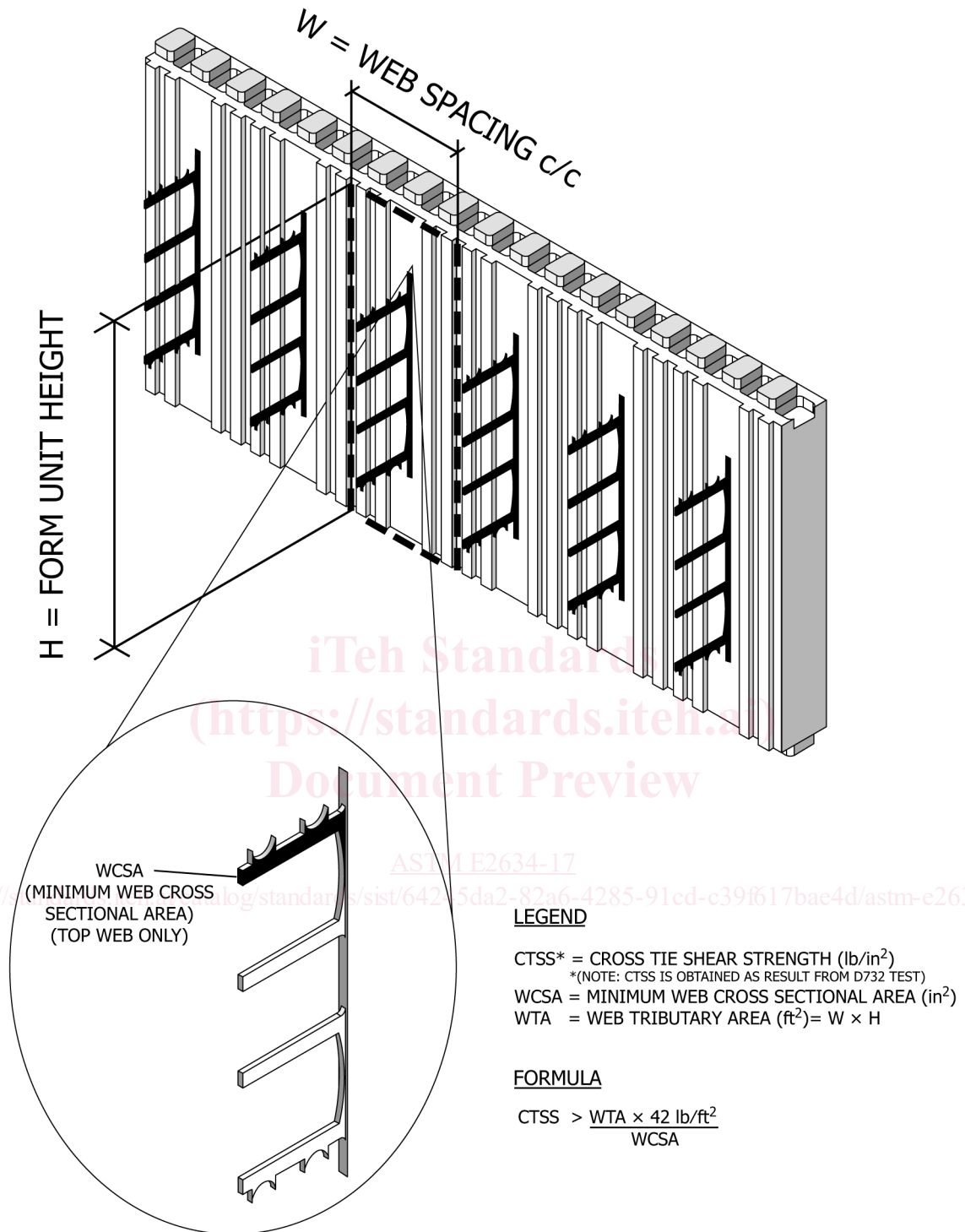
## 7. Dimensions and Permissible Variations

7.1 The length of the ICFs shall be within  $\pm 4.2$  mm/m (0.05 in./ft) of the intended length.

7.2 The height of the ICFs shall be within  $\pm 1.6$  mm (0.06 in.) of the intended height.

7.3 Any mold ejection damage of the ICFs shall be limited to 4.8 mm (0.19 in.) indentation and 1.6 mm (0.06 in.) protrusion from the flat surface of the EPS.

7.4 The cross ties embedded in the EPS panels shall be spaced center to center within  $\pm 6.4$  mm (0.25 in.).



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**LEGEND**

- CTSS\* = CROSS TIE SHEAR STRENGTH (lb/in<sup>2</sup>)  
 \*(NOTE: CTSS IS OBTAINED AS RESULT FROM D732 TEST)
- WCSA = MINIMUM WEB CROSS SECTIONAL AREA (in<sup>2</sup>)
- WTA = WEB TRIBUTARY AREA (ft<sup>2</sup>) =  $W \times H$

**FORMULA**

$$\text{CTSS} > \frac{\text{WTA} \times 42 \text{ lb/ft}^2}{\text{WCSA}}$$

FIG. 2 Tributary Area Associated with the Web Cross Sectional Area that would be Subjected to the Shear Strength

## 8. Workmanship, Finish, and Appearance

8.1 The EPS panels shall be free from defects in workmanship. Defects in the ICFs consist of, but are not limited to, the following:

8.1.1 The EPS panels shall have warping limited to 6.4 mm (0.25 in.) as measured at the center of the panel.

8.1.2 The total number of voids on the EPS panels shall not exceed the average of 1 per 0.093 m<sup>2</sup> (1 per ft<sup>2</sup>) with dimensions larger than 3.3 by 3.3 by 3.3 mm (0.13 by 0.13 by 0.13 in.).

8.1.3 The cross ties shall be properly formed and free from damage after molding.

8.1.4 The EPS panels shall have proper fit between the top and bottom interlocking mechanism.

8.1.5 The EPS panels dimensions shall conform to 7.1, 7.2, 7.3, or 7.4, or a combination thereof.

8.1.6 The EPS panels shall have no crushed or depressed areas on any surface exceeding 3.3 mm (0.13 in.) in depth on more than 10 % of the total surface area.

## 9. Sampling

9.1 Sampling of the test specimens shall be in accordance with Practice C390, where practical, and shall be truly representative of the standard manufactured product, including typical color. Test specimens of products shall be sampled at the manufacturing facility by an accredited testing laboratory or accredited inspection agency. Instead of sampling at the manufacturing facility, a sampling at a warehouse or distribution center is permitted, provided the testing laboratory or quality agency samples the materials and correlates the sampled materials with the finished product specification.

## 10. Number of Tests and Retests

10.1 *General*—Any time significant changes, to manufacturing process or material specifications that affect the physical properties or system qualification requirements, occur qualification tests related to the significant change shall be required.

10.2 *Testing*—Qualification tests shall be conducted or witnessed by a quality agency as defined in 12.1. All test results are to be certified by the quality agency.

10.3 *Sample Size*—Where the number of test specimens is not specified in the applicable test method or this specification, a minimum of three specimens shall be tested.

## 11. Specimen Preparation

11.1 *Test Specimens*—Materials and fabrication procedures of specimens shall be as typical of intended production as can be obtained at the time of manufacturing qualification specimens. Tests in accordance with this specification shall be conducted on intended thicknesses and densities of representative specimens unless noted otherwise.

## 12. Independent Inspection and Certification

12.1 A quality agency shall be retained by the ICF System owner for the purpose of certifying the ICF for compliance with this Specification, through monitoring of the quality assurance and the production process on a random unannounced basis. The quality agency shall establish or approve and monitor procedures for quality assurance.

## 13. Quality Control Manual

13.1 A quality control manual subject to the approval of the quality agency, shall be written and maintained by the ICF System owner manufacturer for each product and for each manufacturing facility. This quality control manual shall include provision for quality assurance.

## 14. Quality Assurance

14.1 *Quality Assurance in Quality Control Manual*—This portion of the quality control manual shall include subject matter necessary to the quality-assurance program including the following:

14.1.1 Material Specifications, including incoming material inspection and acceptance requirements.

14.1.2 Quality assurance, inspection, testing, and acceptance procedures.

14.1.2.1 Sampling and inspection frequencies shall be devised to encompass all variables that affect quality of the finished product. Increased frequencies shall be used in connection with new or revised facilities. A random sampling scheme shall generally be used for specimen selection.

14.1.3 Procedures to be followed upon failure to meet specifications or upon out of control conditions shall be specified. Included shall be re-examination criteria for suspect material and material rejection criteria.

14.1.4 Finished product marking, handling, protection, and shipping requirements as they relate to the performance quality of the product shall be defined.

14.2 *Inspection Personnel*—All manufacturing personnel responsible for quality control shall demonstrate to the quality agency that they have knowledge of the inspection and test procedures used to control the process of the operation and calibration and the maintenance and interpretation of quality control records.