

TESTING APPLICATION STANDARD (TAS) No. 112-95

STANDARD REQUIREMENTS FOR CONCRETE ROOF TILES

- 1. Scope:** mixture in Portland Cement Concrete
- 1.1 This Protocol covers concrete roof tiles manufactured from Portland cement, water, and mineral aggregates, with or without the inclusion of other materials, see Section 5.3.
- C 979 Standard Specification for Pigments for Integrally Colored Concrete
- E 380 Excerpts from the Standard Practice for Use of the International System of Units (SI) (the Modernized Metric System)
- Note 1: Concrete roof tiles covered by this specification are made from lightweight or normal weight aggregates or both.
- Note 2: When particular features are desired, such as color, surface texture for appearance, or other special features, such properties should be specified by the purchaser. However, the local sellers should be consulted as to the availability of concrete roof tile having a desired feature.
- 2. Referenced Documents:**
- 2.1 *ASTM Standards:*
- C 33 Standard Specification for Concrete Aggregates
- C 67 Standard Methods of Testing Brick and Clay Tile
- C 150 Standard Specification for Portland Cement
- C 260 Standard Specification for Air-Entraining Admixtures for Concrete
- C 331 Standard Specification for Lightweight Aggregates for Masonry Units
- C 494 Standard Specification for Chemical Admixtures for Concrete
- C 595 Standard Specifications for Blended Hydraulic Cements
- C 618 Standard Specification for Fly Ash and Raw or Calcined Natural Pozzolan for use as a Mineral Ad-
- 3. Terminology & Units:**
- 3.1 Definitions—For definitions of terms used in this protocol, refer to Chapter 2 and Section 1513 of the *Florida Building Code, Building*; and/or the RCI Glossary of Terms. Definitions of the *Florida Building Code, Building* shall take precedence.
- 3.2 Definitions—The following terms are used in connection with concrete roof tiles:
- Batten lugs:* Protrusions on the underside of the tiles designed to engage over the upper edge of tiling battens.
- Flat profile tile:* Flat profile shaped tiles are defined as those tiles having a rise to width ratio equal to 0.00.
- Headlap:* The dimension by which the overlap of the nose end of the tiles covers the head end of the tow of tiles immediately under it.
- High profile tile:* High profile shaped tiles are defined as those tiles having a rise to width ratio greater than 0.20.
- Interlocking tile:* Those tiles with a system of ribs or grooves enabling the lateral joining of adjacent tiles in the same horizontal row, with the overlapping covering the underlapping.

<i>Length:</i>	The maximum overall dimension of the tiles as measured parallel to the interlock.
<i>Low profile tile:</i>	Low profile tiles are defined as those tiles having a rise to width ratio less than or equal to 0.20.
<i>Nail hole:</i>	A small opening passing partially or totally through the tiles to allow the penetration of a nail or screw for the purpose of fastening the tiles to a support.
<i>Noninterlocking tile:</i>	Those tiles without restrictive ribs, grooves or channels at the underlap and overlap.
<i>Nose lugs:</i>	A projecting on the underside of the nose of each tile, contoured to fit into the main water courses of the tiles immediately below, inhibiting the entry of wind driven rainch
<i>Profile:</i>	The contour of the top surface of the tiles when viewed from the nose end.
<i>Side lap:</i>	The width of the section of tiles containing the underlap.
<i>Thickness:</i>	Any vertical measurement of the cross section of the tiles excluding the lapping area, nose lugs, and weather checks.
<i>Width:</i>	The maximum overall dimension of the tiles as measured perpendicular to the length or water channel.
<i>Rise:</i>	The vertical distance from the underside of the batten lug to the highest point of the surface profile.
<i>Water course:</i>	The valley portions of profiled tiles along which water drains.

3.3 Units - For conversion of U.S. customary units to SI units, refer to ASTM E 380.

4. Classifications:

- 4.1 Concrete roof tiles manufactured in accordance with this specification are of the following types.
 - 4.1.1 *Type 1* Interlocking tiles:
 - Type 1a* High profile shaped tiles
 - Type 1b* Low profile shaped tiles
 - 4.1.2 *Type 2* Noninterlocking tiles:
 - Type 2a* High profile shaped tiles
 - Type 2b* Low profile shaped tiles
 - 4.1.3 *Type 3* Other tile:
 - Type 3a* Flat tile
 - Type 3b* Accessory tiles—shall include those tiles such as ridge, rake, hip, valley and all other tiles used in conjunction with those tiles listed in 4.1 above.

5. Material and Manufacture:

- 5.1 Cementitious materials—materials shall conform to the following applicable ASTM Test Standards:
 - C 150 Portland cements
 - C 595 Blended hydraulic cements
 - C 618 Fly ash and raw or calcined natural pozzolan for use as a mineral admixture in portland cement concrete.
- 5.2 Aggregates shall conform to the following applicable ASTM Test Standards, except that grading requirements do not apply:
 - 5.2.1 Normal weight—C 33 concrete aggregates
 - 5.2.2 Light weight—C 331 lightweight aggregates for concrete.
- 5.3 Other constituents—such as chemical and mineral admixtures established as suitable for use in concrete shall conform to

ASTM Test Standards where applicable, or shall be shown by tests or experience not to be detrimental to the durability of concrete.

6. Standard Methods of Sampling Concrete Tile:

- 6.1 Tile sampling shall be appropriate for one of the following three purposes:
 - 6.1.1 Resolution of quality disputes
 - 6.1.2 Third-party certification
 - 6.1.3 Specific order verification
- 6.2 Tile sampling for the purpose listed in 6.1 shall be taken according to Table 3. In the event the first fails, a second set of samples shall be taken and tested in accordance with the criteria listed in Table 3.
- 6.3 Sampling procedure:
 - 6.3.1 Buyer and Seller shall agree on the method of sampling prior to shipment. Whenever possible, the sampling method shall be such that all tiles in the consignment have equal chance of being selected on each trial. Select the required number of tiles at random throughout the consignment.

7. Standard Method of Testing Concrete Roof Tiles:

- 7.1 The following tests are required on concrete roof tiles
 1. *Dimensional*
 2. *Freeze Thaw*
 3. *Transverse Strength*
 4. *Permeability*
 5. *Water Absorption*
- 7.2 Testing for dimensional tolerances:
 - 7.2.1 Dimensions—The total variation in dimensions of tiles, when measured in accordance with test method C 67, shall not be more than ± 5 percent from the nominal dimensions specified by the supplier.

- 7.2.2 Weight—The total variation in weight of tiles, when measured in accordance with test method C 67, shall not be more than ± 10 percent from the nominal weight specified by the supplier.

7.3 Test of freeze thaw: (Section 7.3 shall not be required for the purposes of *Florida Building Code, Building requirements*).

- 7.3.1 Tiles shall be subjected to 50 cycles of the freezing and thawing test Method ASTM C 67, as modified in 7.2.2.
 - 7.3.1.1 A lot shall be rated as passing provided that a sample, from the same design, and same materials had passed the test within the previous 12 months.
- 7.3.2 Modify method ASTM C 67 Section 8.2 as follows: The test specimens shall consist of five whole tiles. The freezing trays and containers shall be of sufficient size and depth to allow the tiles to be completely submerged in water when placed horizontally.

Note: A large capacity freezer may be necessary to accomplish freezing in the manner specified in Test Methods C 67 for trays containing more than one tile. Custom trays may be necessary to enclose the tile(s) and minimize the volume of water required to completely submerge the tile(s).

- 7.3.2.1 The following alternate procedure may be used to perform the freeze-thaw test in a minimum time.

The test specimens shall consist of five whole tiles. The tiles shall be totally immersed in water at a temperature of $75 \pm 10^\circ$ F ($24 \pm 6^\circ$ C) for 24 hours. The tiles shall then be individually sealed in a plastic bag (10 mil (0.25 mm) polyethylene has proved suitable) or between pre-formed plastic trays with

at least 500 cc of water or a sufficient amount that will provide a layer of water between $\frac{1}{16}$ inch and $\frac{1}{8}$ inch (1- to 3-mm) thick surrounding the tile. When using the plastic bags, they should be evacuated to remove the air and then heat sealed to enclose the tile and the water. When using molded trays they should be clamped or otherwise sealed to encapsulate the tile and the water. At least one of the tiles in the sample under test shall be drilled at the mid-point of the top surface to a depth of the mid-plane of the tiles with a hole of $\frac{1}{16}$ inch (1 mm) with rapid setting epoxy type cement, such that the bead is at the mid-plane of the tile. The sealed tiles may be stacked in a freezer chamber provided that (a) the sample containing the thermocouple is at the center of the stack; and, (b) that at least $\frac{1}{2}$ inch (12 mm) space is provided between the tiles.

The stack of tiles shall be placed in the freezer and the temperature lowered until the thermocouple reads $1 \pm 5^\circ\text{F}$ ($-18 \pm 2^\circ\text{C}$). The tiles shall be maintained at this temperature for at least 30 minutes. The stack shall then be removed from the freezer and placed in the ambient environment ($75 \pm 5^\circ\text{F}$ ($24 \pm 6^\circ\text{C}$)) until the thermocouple reads $40 \pm 5^\circ\text{F}$ ($4 \pm 2^\circ\text{C}$). The tiles shall be returned to the freezing chamber and the cycle repeated. The use of a fan for increasing the flow of ambient air throughout the

stack of tiles may be allowed.

Note: The time to complete a cycle of freezing and thawing by this procedure will depend on the capabilities of the freezing chamber. It is the intent of this procedure to assure that the tiles remain in contact with a thin layer of water (or ice) during the test, and to assure that the water within the body of the tiles has been frozen and subsequently has thawed in the process of performing each cycle.

7.4 Transverse strength:

- 7.4.1 Apparatus: The transverse breaking strength of tiles shall be determined as described in the flexural test in Test Methods C 67 except as modified in 7.4.2 to 7.4.10.
- 7.4.2 Five tiles shall be tested after conditioned as listed in Section 7.4.11.
- 7.4.3 The span chosen for the test shall be 12 inches (30.5 cm) ± 5 percent or $\frac{2}{3}$ the length of the tile, whichever is greater. The span is measured between the centers of the lower support member. (See Figure 1, attached.)
- 7.4.4 The tile shall be tested in a three-point bending mode in a horizontal plane with the bottom surface of the tile resting on two lower support members and with the load being applied to the upper (exposed) surface of the tile by a third member moving in a direction perpendicular to the plane of the tile and at mid-span (that is, equidistant from each of the lower support members).
- 7.4.5 The two support members and the loading member shall be of metal or hardwood with 1 inch (25 mm) ± 5 percent wide faces. The faces shall be shaped (see note) to closely conform to the profile of the surface of the tile upon which they bear during the test (the profile may therefore be different for

each member depending on the profile and cross-sectional shape of the tile). The total height of the members shall not be more than 1 inch (25 mm) greater than the rise of the profile and, if hardwood, they should be backed up with steel bearing plates at least 1/2 inch (13 mm) thick. A rubber shim strip 3/16 inch (4.8 mm) ± 10 percent thick of hardness no greater than shore durometer 30 (A scale), and 1 inch (25 mm) ± 5 percent wide, shall be placed between the faces of the support and loading members and the surface of the tile. A schematic of the assembly for testing a typical “S” tile is shown in Figure 1.

Notes:

1. The intent of the defined loading system is: 1) to apply the bending force with a loading member that pushes against as much of the profiled surface of the tile as practical; 2) to support the tile on members that support as much of the profiled surface of the tile as is practical; and, 3) to ensure that the contact area of both the loading and support members be equally distributed on either side of the length centerline on the tile to avoid non-symmetrical loading.
2. For tile with complex profiles and cross-sections but with flat bearing surfaces which are at least 50 percent of the width of the tile which are also equally distributed on either side of the length centerline, flat support and loading members may be used to perform this test provided that they otherwise comply with the requirements of Sections 7.4.5, 7.4.6, 7.4.7. When sufficient flat bearing surfaces do not exist, wood blocks of appropriate thickness and profile and 1 inch (25 mm) wide, may be used to provide a surface that will permit load application using a flat loading member which otherwise meets the requirements of 7.4.5, 7.4.6 and 7.4.7, and causes the load to be applied to at least 50 percent of the width of the tile and equally distributed on either side of the length centerline of the tile.
3. Each wood block used to provide sufficient flat surface to allow loading and supporting with the flat bearing members shall have a length of at least 25 percent of the width of the tile. Such blocks shall be spaced no farther apart than 25

percent of the width of the tile to avoid concentrated loading. Loading support members shall be parallel to each other and be placed in the same alignment across the width of the tile, when viewed from the end of the tile, to avoid torsional loading.

7.4.6 The length of the support and loading members shall be no greater than the width of the tile.

7.4.7 Both of the support members and the loading member shall be free to rotate in the longitudinal and transverse directions of the test specimen and be adjusted so that they will exert no force in these directions. This may be spherically seated steel balls with appropriate supporting springs.

7.4.8 The tile shall be loaded uniformly and continuously, without shock, at a rate not to exceed 1000 lbf (4550 N)/min until fracture.

7.4.9 Record the load in pounds (kilograms) at the fracture of the five tiles and report the average of the five tests and the minimum individual result.

7.4.10 For tile with a width other than 14 inch (35.6 cm) the minimum values in Table 1 are to be adjusted proportionally to the change in width according to the following:

$$\frac{\text{width (inches)}}{14}$$

7.4.11 Conditioning procedure:

Prior to being tested for transverse breaking strength, the tiles shall be conditioned in one of the two following methods agreed on between the supplier and specifier. a) Dry Testing: Oven dry all tiles at 160°F ± 5°F (71°C ± 3°C) for 24 hours. Then allow to cool to room temperature prior to testing. b) Wet Testing: Submerge the tiles for 24 hours in water at a temperature of 75 ± 10°F (24 ± 6°C).

7.5 Permeability:

7.5.1 Apparatus: Provide a walled frame and stand, as shown in Figure 2, designed to closely surround the perimeter of the tile and provide for the horizontal support of the tile with the exposed surface uppermost, and for sealing around the perimeter. Any support flange or sealant material shall not protrude more than 1/2 inch (12 mm) onto the surface of either side of the tile. The height of the stand shall be sufficient to allow observation of the underside of the tile. The height of the perimeter frame wall should be at least 3 inches (75 mm) greater than the height of the tile profile to be tested.

7.5.2 Procedure: Seal the entire perimeter of the tile in the frame with suitable compound such as putty, mastic, or silicone sealant that will provide a water tight seal. Nail holes shall be similarly sealed. Sealant shall not protrude more than 1/2 inch (12 mm) onto the surface of either side of the tile. Place the frame and stand assembly on a nonabsorbent surface and adjust the stand so the tile is horizontal. Add water at $75 \pm 10^\circ\text{F}$ ($24 \pm 6^\circ\text{C}$) to a depth of $2 \pm 1/4$ inch (51 ± 6 mm) measured from the highest point of the upper surface of the tile. Maintain the depth of water for the 24 hour duration of the test and periodically observe the un-

derside of the tile and the surface beneath the stand for signs of water droplets.

7.5.3 Acceptance criteria: The tile shall have passed the test if, after 24 hours, no water droplets have fallen from the underside of the tile. If water droplets have fallen, the tile has failed the permeability test.

7.6 Method for determining water absorption:

7.6.1 Apparatus: The procedures and apparatus shall be in compliance with Section 6 of ASTM Test Standard C 140.

7.6.2 Procedure: Immerse the tile specimen in water at room temperature at 60 to 80°F (15.6 to 26.7°C) for 24 hours. Weigh the specimens while suspended by a metal wire and completely submerge in water. Remove the specimens from the water and allow to drain for 1 minute by placing them on $3/8$ inch (9.5 mm) wire mesh. Remove any visible surface water with a damp cloth and weigh to the nearest gram. Subsequent to saturation, dry all specimens in a ventilated oven at 212 to 239°F (100 to 115°C) for a minimum of 24 hours and continue until two successive weight measurements, at intervals of 2 hours, show a weight decrease less than or equal to 0.2

TABLE 1 TRANSVERSE BREAKING STRENGTH, MINIMUM LBF (N)				
Tile Profile	Dry Tile		Wet Tile	
	Average of Five Tiles	Individual Tile	Average of Five Tiles	Individual Tile
High Profile	400 (1780)	350 (1557)	300 (1334)	260 (1157)
Low Profile	300 (1335)	260 (1157)	225 (1001)	200 (890)
Flat Profile	250 (1122)	215 (956)	190 (845)	160 (712)

TABLE 2 TILE RATINGS AND MAXIMUM WATER ABSORPTION		
Weight Classification	W = Oven Dry Weights of Tile (lb/ft ³)	Max. Water Absorption lb/ft ³ -(kg/m ³)
Class I	$W \leq 105$	18 (288)
Class II	$105 < W < 126$	15 (240)
Class III	$W \geq 126$	13 (208)

Test	Quality Dispute	Third Party	0 to 250,000	Over 250,000
Freeze Thaw	5	5	*	*
Dimensional	5	5	5	5
Transverse	3	5	3	5
Permeability	3	3	3	5
Water Absorption	3	3	3	5

¹ Freeze Thaw Testing is only required for regions subject to freeze thaw.

² Annual test data available.

Number of Tiles	Number of Samples	Lot of Accepted	Lot Rejected
Less than 50	3	0	1
151-3,200	13	1	2
3,201-35,000	20	2	3
35,001-500,000	32	3	4
Over 500,000	50	5	5

Example: If 250,000 tiles were in a lot, then 32 samples would be taken for the retest of that specific test failed. If 3 of the 32 samples failed, the lot would be rated as passing; however, if 4 of 32 samples failed, the lot would have failed the specific test.

percent of the previously determined weight of the specimen.

Water absorption shall be calculated using the following formula:

$$A = \left[\frac{(E - C)}{E - F} \right] \times 62.4$$

where,

A = absorption (lb/ft³);

E = Mass of wet unit, (lb.);

C = Mass of dry unit, (lb.);
and

F = Suspended immersed weight of unit, (lb.)

Tile utilized in the high-velocity hurricane zone jurisdiction shall be rated and shall meet the absorption requirements noted in Table 2, below.

8. Texture and Color:

- 8.1 The texture and color of tiles should be specified by the purchaser and mutually agreed upon between purchase and supplier with reference to a sample of the type specified representing the possible range of shades and textures.

9. Inspection:

- 9.1 Inspection of the material covered by this specification shall be carried out by the authority having jurisdiction, without notice, during the period of the Product Approval.
- 9.2 The tiles, as delivered to the site, shall, by visual inspection by the building official, conform to the requirements set forth in this Protocol and shall conform to samples and test reports submitted to the authority having jurisdiction. Minor indentations, chips or surface cracks incidental to the usual method of manufactures, and not extending through the body of the tile, shall not be deemed grounds for rejection.
- 9.3 After tiles are placed in usage, the manufacturer or his agent shall not be held responsible for compliance of the tiles with the requirements of this specification for dimensional tolerances, or color.

10. Rejection and Rehearing:

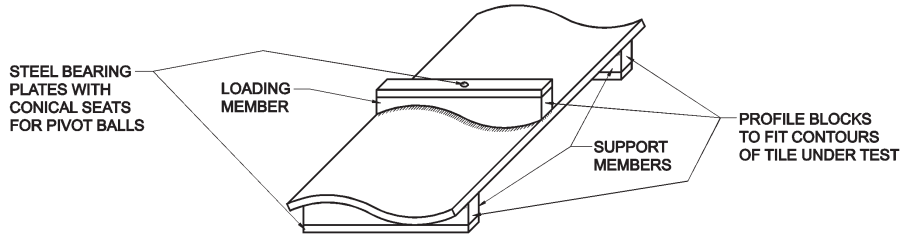
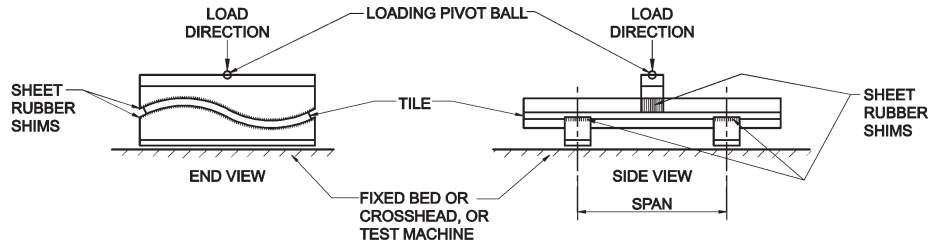
- 10.1 Material that fails to conform to the requirements of this specification may be rejected by the building official. Rejection should be promptly reported in writing to the supplier. In case of rejection, and if not specifically excluded in the purchase con-

tract, the supplier shall have the right to inspect the rejected lot and resubmit the lot after removal of the material not conforming to the specified requirements, provided this is done within 20 days after receipt of notice of the specific cause for rejection.

- 10.2 In the case the shipment fails to conform to the requirements for the type of tile specified, the manufacturer is permitted to sort it, and new specimens shall be selected by the purchaser from the retained lot and tested at the expense of the supplier. In the case the second set of specimens fails to meet the requirements, the entire shipment shall be rejected.

11. Certification:

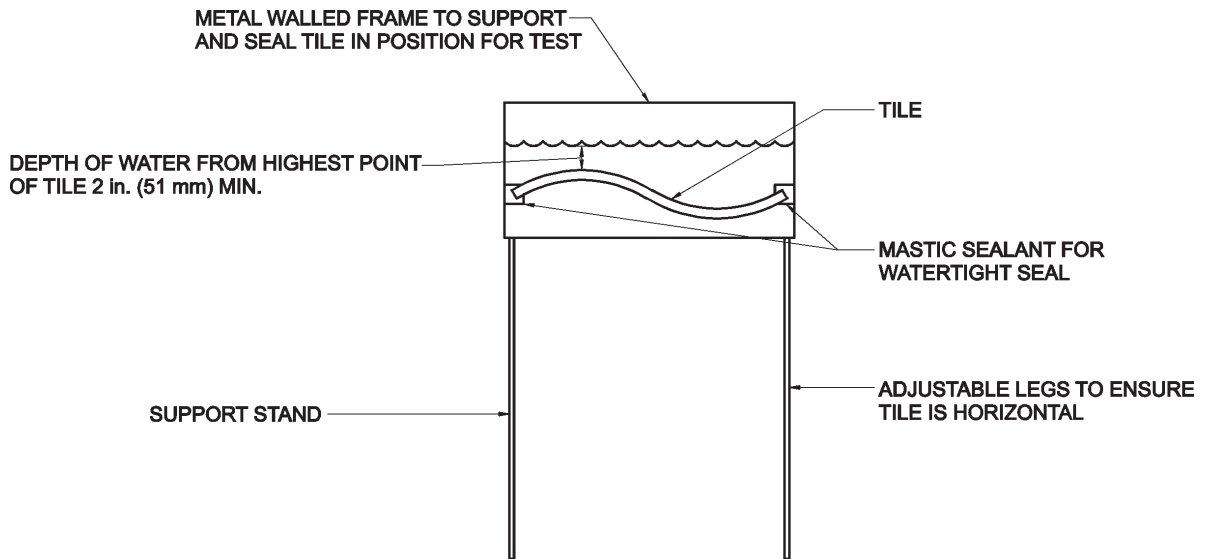
- ⋮
 - 11.1 The Authority Having Jurisdiction shall certify that the tile is in compliance with this protocol by the issuance of a Product Approval to the applicant. Tile forms part of a system that requires testing under additional protocols for usage in the high-velocity hurricane zone jurisdiction.



NOTE - SEE TEXT FOR DIMENSIONS

(POSITIONING SPRINGS FOR SUPPORT AND LOADING MEMBERS NOT SHOWN)

**FIGURE 1
TRANSVERSE STRENGTH TEST APPARATUS**



**FIGURE 2
PERMEABILITY TEST APPARATUS**

TESTING APPLICATION STANDARD (TAS) No. 112-95
Appendix A

CLARIFICATION OF TESTING FREQUENCY AND SAMPLING METHOD

1. Scope:

1.1 The purpose of this Appendix is to define frequency of testing and method of sampling.

4.3 The frequency of testing shall be per 250,000 tiles delivered or quarterly, whichever is more frequent.

2. Definitions:

2.1 *Domestic Manufacturers:* Those companies whose tiles are manufactured in the United States.

2.2 *Import Manufacturers:* Those companies whose tiles are manufactured outside the United States.

3. Domestic Manufacturers:

3.1 For tile lots in excess of 250,000 tiles, sampling shall be in accordance with Table 3 of TAS 112.

3.2 Tile samples shall be taken from tile inventories over 28 days old such that all tiles have an equal chance of being selected; or

3.3 Tile samples may be randomly selected from the manufacturing line and conditioned at the test lab for 28 days.

3.4 Testing shall be conducted quarterly. All sampling, testing and calculations shall be conducted by an approved testing agency. All test results, including calculations, shall be signed by a Registered Design Professional per F.S., Section 471 or 481.

4. Import Manufacturers:

4.1 For tile lots in excess of 250,000 tiles, sampling shall be in accordance with Table 3 of TAS 112.

4.2 Tile samples shall be randomly selected from tile shipments.

