TESTING APPLICATION STANDARD (TAS) 116-95

TEST PROCEDURE FOR AIR PERMEABILITY TESTING OF RIGID, DISCONTINUOUS ROOF SYSTEMS

1. Scope:

1.1 This protocol covers the determination of the air permeability characteristics of a rigid, discontinuous roof system.

1.2 The test procedures outlined herein shall be used to determine the air pressure difference (DP) and the air volume flow rate (Q) which occur across the rigid, discontinuous roof system when the air flow rate into a sealed chamber beneath the system is such that the moment incurred on the rigid components within the system is equal to 90 percent of the restoring moment due to gravity (M_g) of the rigid components.

1.3 The calculations outlined herein shall be used to determine the air permeability (C_d) for the system being tested.

1.4 All testing and calculations shall be conducted by an approved testing agency and all test reports, including calculations, shall be signed by a Registered Design Professional per F.S., Section 471 or 481.

2. Referenced Documents:

2.1 *The Florida Building Code, Building*.

2.2 *Application Standards*

TAS 108 Test Procedure for Wind Tunnel Testing of Air Permeable, Rigid, Discontinuous Roof Systems

2.3 *The British Standard BS5534–Appendix A.5.1.*
Method of Test for the Air Permeability Factor D of Unsealed Small Element Roof Assemblies

2.4 *ASTM Standards*:

E 380 Excerpts from the Standard Practice for Use of the International System of Units (SI) (the Modernized Metric System)

2.5 *Roof Consultants Institute:*
Glossary of Terms

3. Terminology & Units:

3.1 Definitions–For definitions of terms in this Protocol, refer to Chapter 2 and Section 1513 of the *Florida Building Code, Building* and/or the RCI Glossary of Terms. Definitions from the *Florida Building Code, Building* shall take precedence.

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

4. Significance and Use:

4.1 Use of this protocol is limited to manufacturers of rigid, discontinuous roof systems who desire to have their system(s) tested for wind characteristics in compliance with TAS 108. This limits the protocol's use to discontinuous roof system in which the unsealed, overlapping, rigid components have a length between 1.0 and 1.75 feet; an exposed width between 0.73 and 1.25 feet; and a thickness not greater than 1.3 inches.

4.2 The procedures and calculations outlined herein provide a means of determining the air permeability (C_d) for a rigid, discontinuous roof system. This value shall be listed in the system manufacturer's roof system assembly Product Approval for reference by the chief code compliance officer to determine whether the system is air permeable or air impermeable. The Authority Having Jurisdiction may nullify this testing requirement for systems which are generally considered air permeable.

4.3 The test criteria will be based on testing, under the provisions of this Protocol, of rigid, prepared roof coverings which are generally considered air impermeable (i.e. metal roof systems, and lap sealed, rigid prepared roof coverings). This crite-

ria shall be determined by September 1, 1994. Until that date, the Authority Having Jurisdiction shall judge as to whether a prepared roof covering is air permeable or air impermeable.

5. Apparatus

5.1 The pressure from beneath the system shall be generated in a sealed, rectangular plenum chamber having a depth not less than 2 feet. The chamber shall be airtight with the exception of an open upper face; a tapping for a pressure tube; and an air inlet pipe. The chamber shall be of sufficient dimensions to receive a wood deck on which the minimum number of rigid components, noted in Section 8.5, shall be installed. (See Figure 1, attached.)

5.2 The pressure tapping, noted in Section 5.1, shall be positioned on the chamber so as to avoid direct alignment with the air inlet pipe. The pressure tube shall be connected to a manometer or an electrical pressure transducer to measure the pressure within the chamber relative to that outside the chamber. The pressure tapping shall be fully sealed around the pressure tube.

5.3 The air inlet pipe shall be connected to an electric fan which is capable of producing a continuous air volume flow of 7 ft^3/s through the air inlet pipe. The connection between the air inlet pipe and the chamber shall be fully sealed around the perimeter of the air inlet pipe. The air inlet pipe shall be equipped with an air flow meter capable of measuring an air volume flow rate (Q) of not less than 9.0 ft^3/s and having an accuracy of 0.1 ft^3/s.

5.4 An airtight removable cover panel shall be used to check the air tightness of the plenum chamber, as noted in Section 5.3.

5.5 A weighing device with an accuracy of 0.05 lb shall be used to determine the average mass of the rigid components which make up the prepared roof covering.

6. Precautions

6.1 This Protocol may involve hazardous materials, operations and equipment. This Protocol does not purport to address all of the safety problems associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

7. Apparatus Checks— the following steps shall be conducted prior to any air permeability testing.

7.1 The pressure tube from the plenum chamber to the manometer device shall be checked for leakage by applying a constant pressure within the tube and clamping it off. Leakage shall be identified by any pressure drop recorded by a pressure measuring device. Any pressure tube which exhibits leakage shall be repaired or replaced.

7.2 The manometer, if utilized, shall be cross-checked against an electrical pressure transducer.

7.3 Airtightness Check

7.3.1 Close the top of the plenum chamber by attaching and sealing the edges of the cover panel so that the plenum chamber is air tight with the exception of the inlet pipe.

7.3.2 Supply air from the electric fan through the inlet pipe to induce a pressure difference between the inside and outside of the plenum chamber of not less than 10.5 pounds per square feet.

7.3.3 If this pressure can be maintained for a period of 1 minute with an air pressure flow rate not greater than 0.2 ft^3/s, the airtightness shall be considered satisfactory.

8. Test Specimen

8.1 Substrate

8.1.1 The substrate shall consist of APA $^{32}/_{16}$ span rated sheathing of $^{15}/_{32}$ inch thickness, attached with 8d common nails at 6 inch o.c. at panel edges and 12 inch o.c. at intermediate supports, and an underlayment. The underlayment shall consist of a No. 30 ASTM D 226, type II asphalt saturated an-

chor sheet, mechanically attached to the sheathing with approved nails and tin caps spaced in a 12 inch grid staggered in two rows in the field and 6 inch o.c. at laps. Over the anchor sheet, one layer ASTM D 249 mineral surfaced cap sheet shall be applied in a full mopping of ASTM D 312, type IV asphalt. Side laps (if any) shall be 6 inches and head laps (if any) shall be 2 inches, nailed 12 inches o.c. and 6 inches o.c., respectively.

8.1.2 The substrate, consisting of the wood deck and the underlayment, shall have 3 inch holes spaced 6 inches across its width in staggered rows spaced 6 inches along its length to allow for airflow into the system.

8.1.3 The substrate perimeter shall be completely sealed when placed in the plenum chamber.

8.2 Mortar (if a mortar set tile system assembly)

8.2.1 Mortar mix shall have a roofing Component Product Approval for use with the mortar set tile system and shall be in compliance with TAS 123.

8.2.2 Mortar shall be mixed using the mixing ratio specified in the mortar manufacturer's Product Approval.

8.2.3 Mortar flow shall be determined using a cone penetrometer test, in compliance with ASTM C 780 (Appendix A1), the results of which shall be $2^{1}/_{8} + {}^{1}/_{8}$ inch (55 + 3 mm) of penetration.

8.3 Adhesive (if an adhesive set tile system assembly)

8.3.1 Adhesive shall have a roofing component Product Approval for use with the adhesive set tile system which is being tested and shall be applied in compliance with the provisions set forth in that Approval.

8.4 Fasteners (if applicable):

8.4.1 Component attachment fasteners (i.e., nails, screws, tile straps, etc.) shall be those recommended in the prepared roof covering manufacturer's published installation instructions. Minimum nails shall be 12 gage ring shank, hot dipped galvanized roofing nails. Minimum screws shall be #8 diameter screw fasteners.

8.5 Battens (if applicable)

8.5.1 Horizontal Batten System

- Horizontal battens shall be of nominal 1 inch by 2 inch dimensional lumber and shall be spaced to provide a minimum 3 inch head lap, or to match the interlocking configuration of the component's profile.
- Horizontal battens shall be nailed to the wood test deck at 6 inch o.c. using 12 gage roofing nails.

8.5.2 Counter Batten System:

- Vertical battens shall be of nominal 1 inch by 4 inch lumber and shall be spaced 24 inches over the intermediate supports (trusses).
- Vertical battens shall be nailed to the wood test deck at 6 inches o.c. using 12 gage roofing nails.
- Horizontal battens (counter battens) shall be as noted in Section 8.5.1, nailed to the 1 inch by 4 inch vertical battens using 12 gage roofing nails of sufficient length to penetrate both battens.

8.5.3 If the system being tested is installed over battens, the battens shall be installed prior to drilling the 3 inch holes noted in Section 8.1.2.

8.6 Rigid components:

8.6.1 Rigid components shall meet the size requirements listed in Section 4.1.

8.6.2 Rigid components shall be attached or bonded in compliance with the system manufacturer's published installation instructions and the minimum requirements of the *Florida Building Code, Building*. For mechanically attached, direct deck applications, care shall be taken so as to avoid direct alignment of the fastening line for each course with the staggered rows of 3 inch holes in the substrate, noted in Section 7.1.2. For mortar or adhesive applications, care shall be taken to avoid mortar or adhesive application over these holes. If this is unavoidable due to the configuration/spacing of the rigid components within the system, the holes shall be cleared of excess mortar or adhesive prior to the material hardening.

8.6.3 The number of rigid components to be installed on the substrate, unsealed, shall be in compliance with Table 1, below.

TABLE 1
NUMBER OF COURSES AND NUMBER OF COMPONENTS PER COURSE

Component Type	Minimum Number of Courses	Minimum Number per Course
Single Lap	2	2
Plain Tiles (bonded or mechanically attached)	2	4
Slates	2	2

8.6.4 In addition to the number of components listed in Table 1, a sufficient number of components shall be provided to cover the perimeter area of the substrate. These components shall be completely sealed at all laps, front and side joints with approved adhesive.

9. Preliminary Measurements and Calculations:

9.1 Average mass, weight and restoring moment due to gravity (M_g):

9.1.1 Determine the mass of each rigid component to be installed and calculate the average mass.

9.1.2 Determine the average weight of the rigid components using the average mass and the following equation.

$$W = m \times \frac{1\ slug}{32.174\ lbm} \times g \qquad \text{where,}$$

W = average component weight (lbf);

m = average component mass (lbm); and,

g = 32.2 ft/s^2 = acceleration of gravity constant.

Note: 1 slug = 1 lbf s^2/ ft

9.1.3 Determine the restoring moment due to gravity (M_g) from the center of the exposed area about the head of the rigid component using the component's average weight and the following equation.

$$M_g = W \times l \qquad \text{where,}$$

M_g = restoring moment due to gravity (ft-lbf);

W = average component weight (lbf); and

l = moment arm (ft) (distance from center of exposed area to the head of the component)

9.2 Pressure to Induce Moment (p)

9.2.1 Determine the upward pressure required to induce the restoring moment due to gravity, determined above, using the following equation.

$$p = \frac{M_g}{b \times l_0 \times l} \qquad \text{where,}$$

p = pressure required to induct moment (lbf/ft^2);

M_g = restoring moment due to gravity (ft-lbf);

b = component cover width (ft);

l_o = component exposed length (ft)

= total length - headlap dimension; and

l = moment arm (ft) (distance from center of exposed area to the head of the component)

9.3 Effective Area (a):

9.3.1 Determine the effective area (a) (i.e., the area having unsealed components) across which the pressure difference will occur using the following equation.

$a = N \times b \times l_o$ where,

a = effective area (ft^2);
N = number of unsealed components;
b = component cover width (ft); and
l_o = component exposed length (ft),
= total length–headlap dimension.

10. Test Procedure:

10.1 Position the test specimen in the plenum chamber, insuring that both the substrate perimeter and the perimeter rigid components are completely sealed.

10.2 Supply air through the inlet pipe to the plenum chamber, gradually increasing the airflow until the manometer indicates a pressure difference (ΔP) equal to 90 percent of the pressure (p) determined in Section 9.2.

10.3 When the pressure difference (ΔP) reaches this point, record the pressure difference (ΔP) and the air volume flow rate (Q) and gradually reduce the air supply to zero.

10.4 Repeat this test procedure three times using the same test specimen. If any evidence of damage exists subsequent to any test, construct an additional test specimen for the additional test(s).

11. Calculations:

11.1 Determine the air permeability (C_d) using information gathered from preliminary calculations, testing procedures and the following equation.

$$C_d = \frac{Q}{a \times \sqrt{\frac{2 \times \Delta P}{\rho}}}$$ where,

C_d = air permeability (dimensionless);
Q = air volume flow rate (ft^3/s);
a = effective area (ft^2);
ΔP = pressure difference (lbf/ft^2); and
ρ = density of air = 2.377 x 10-3 slugs/ft^3.

11.2 Determine the average air permeability for the three tests conducted.

12. Report:

12.1 The final test report shall include the following:

12.1.1 The type, name, and manufacturer of the discontinuous roof system and the dimensions of the rigid components within the system.

12.1.2 A detailed report of the system installation prepared by a Registered Design Professional per F.S., Section 471 or 481 or Registered Roof Consultant, including a sketch of the installed system, indicating the sealed and unsealed components, and the published installation instructions provided by the system manufacturer.

12.1.3 Data and calculations for average mass (m); average weight (W); restoring moment due to gravity (M_g); pressure required to induce moment (p); and effective area (a).

12.1.4 Pressure difference (ΔP) and air volume flow rate (Q) readings at the point when the pressure needed to incur moment is attained.

12.1.5 Calculations and results for the air permeability (C_d) of the three tests and the average value.

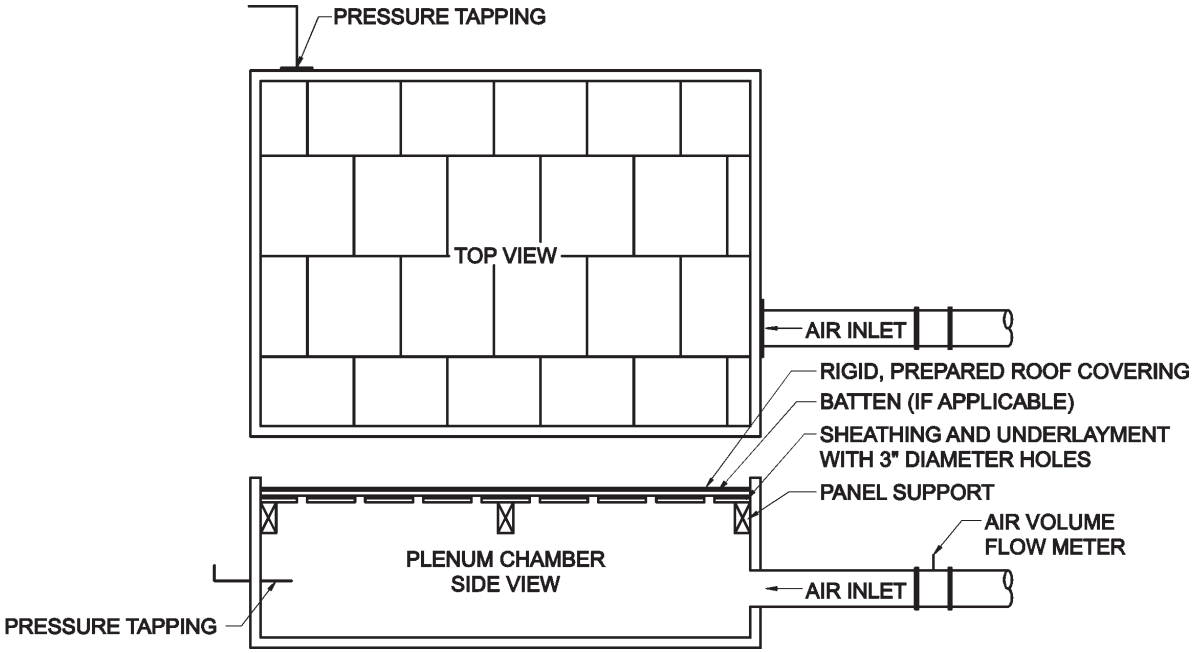

FIGURE 1
AIR PERMEABILITY TEST APPARATUS