TESTING APPLICATION STANDARD (TAS) 125-03

STANDARD REQUIREMENTS FOR METAL ROOFING SYSTEMS

1. Scope:

1.1 This Protocol covers the testing requirements for structural and non-structural (architectural) metal roofing systems and the approval process for all systems, which have successfully met the testing criteria.

1.2 All testing shall be conducted by a certified testing agency and all test reports, including calculations, shall be signed and sealed by a Professional Engineer.

2. Referenced Documents:

2.1 *The Florida Building Code, Building*.

2.2 *Underwriters Laboratories, Inc.*

UL 580 Tests for Uplift Resistance of Roof Assemblies

UL 1897 Standard for Roof Covering Systems Annual Roofing Materials and Systems Directory

2.3 *Application Standards*

TAS 201 Impact Test Procedures

TAS 100 Test Procedure for Wind Driven Rain Resistance of Discontinuous Roof Systems

TAS 100A Test Procedure for Wind and Wind Driven Rain Resistance and for Increased Wind Speed Resistance of Soffit Ventilation Strip and Continuous or Intermittent Ventilation System Installed at the Ridge Area

TAS 110 Testing Requirements for Physical Properties of Roof Membranes, Insulation, Coatings and Other Roofing Components

RAS 111 Standard Requirements for Attachment of Perimeter Wood Blocking and Metal Flashings

RAS 113 Standard Requirements for Job Site Mixing of Roof Tile Mortar

2.4 *ASTM Standards*

D 1079 Standard Definitions and Terms Relating to Roofing, Waterproofing and Bituminous Materials

E 1592 Structural Performance of Sheet Metal Roof and Siding Systems by Uniform Static Air Pressure Difference.

E 380 Excerpts from 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 used in this Protocol, refer to ASTM D 1079; and/or the RCI Glossary of Terms; and/or Chapter 2 and Section 1513 of the *Florida Building Code, Building* and/or T125-5.1 and T125-5.2 herein. The 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 The requirements outlined herein provide:

1. A means of establishing the criteria for water infiltration resistance; impact loading; and/or, uplift loading

of metal roofing systems for use within the High-Velocity Hurricane Zone jurisdiction; and,

2. A guideline for metal roofing system manufacturers in order to obtain a roof system assembly Product Approval.

5. Applicable Metal Roofing System Constructions

5.1 Structural Metal Roofing Systems

5.1.1 Structural Metal Roofing System - Any metal roof system, which is designed to act as a water shedding and waterproofing layer and is capable of spanning support joists or purlins without additional reinforcement or structural layers. No underlayment is included in a structural metal roofing system.

- Structural metal roof panels shall be not less than 24 gage.
- Deflection of structural metal roof panels shall not exceed L/240.
- Minimum roof decking uplift loads shall comply with ASTM E 1592, as noted herein.
- The resistance to uplift pressure of structural metal roof panels, as determined in compliance with ASTM E 1592, shall be subject to a margin of safety of 2.
- Metal roof decking shall be designed without an allowable increase in stresses of $^1/_3$ due to wind load.
- Structural metal roofing systems shall be tested in compliance with the requirements set forth in T125-7 of this Protocol as well as the physical property requirements set forth in TAS 110.

5.2 Non-Structural (Architectural) Metal Roofing Systems

5.2.1 Non-Structural (Architectural) Metal Roofing System - Any metal roof system which requires the support of an independent structural roof deck. A non-structural metal roofing system shall have a water shedding layer mechanically attached to the structural roof deck.

- Testing for uplift resistance for Non-Structural (Architectural) Metal Roof Assemblies shall be performed in accordance with UL 580 as modified herein, and shall be subject to a margin of safety of 2.
- The independent structural roof deck over which a non-structural metal roofing system is to be installed shall be in compliance with Chapter 22 (*High-Velocity Hurricane Zones*), for metal, or Chapter 23 (*High-Velocity Hurricane Zones*), for wood, of the *Florida Building Code, Building*.
- Wood decking, over which a non-structural metal roofing system is to be installed, shall be not less than $^{15}/_{32}$ in. thick. Minimum fastening for decking shall be in accordance with the *Florida Building Code (High-Velocity Hurricane Zone)*.
- Non-structural metal roofing systems shall be tested in compliance with the requirements set forth in T125- 7 of this Protocol as well as the physical property requirements set forth in TAS 110.

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. Testing Requirements:

7.1 General—All structural and non-structural metal roofing systems shall be subjected to the following testing unless otherwise noted.

7.2 Physical Property Testing

7.2.1 All structural and non-structural metal roofing systems shall be tested for the physical properties set forth in T125-20 of TAS 110.

7.3 Wind Driven Rain Testing

7.3.1 All structural and non-structural metal roofing systems shall be tested for resistance to wind driven rain in compliance with TAS 100 for slopes 2:12 and greater or TAS 114 Appendix G (FM 4471) for slope less than 2:12.

7.3.1.1 For systems with a valley assembly, testing in accordance with TAS 100 shall be required in addition to testing in accordance with TAS 114, Appendix G.

7.3.1.2 For system approvals including horizontal joints, a minimum of two horizontal joints shall be incorporated in the TAS 100 test and one horizontal joint in TAS 114 test of the test specimens.

7.3.2 All ridge ventilation systems shall be tested for resistance to wind driven rain in compliance with TAS 100(A).

7.4 Impact Testing

7.4.1 Structural Metal Roofing Systems

- All structural metal roofing systems having a thickness less than 22 gage shall be tested for impact resistance in compliance with TAS 201, as amended below. Structural metal roofing systems having a thickness greater than or equal to 22 gage shall be exempt from impact testing.

7.4.2 Non-Structural Metal Roofing Systems

- All non-structural metal roofing systems which are less than 26 gage in thickness shall be tested for impact resistance in compliance with TAS 201, as amended below.

7.4.3 TAS 201 Amendments for Metal Roofing Systems

- Panel thickness, finish, fasteners, sealing washers, and overall design shall be in compliance with Section 2222.4 (for structural) or Section 2222.5 (for non-structural) of the *Florida Building Code, Building*.
- The metal roofing system test specimen shall be constructed in compliance with the manufacturer's published installation instructions and the minimum requirements set forth in Section 2222.4 (for structural) or Section 2222.5 (for non-structural) of the *Florida Building Code, Building*. The requirements from the *Florida Building Code, Building* shall take precedence.
- Testing in compliance with TAS 203, as noted in T201-12.1 of TAS 201, is not required for either structural or non-structural metal roofing systems.

7.5 Air Pressure/Resistance Testing for Structural Metal Roofing Systems

7.5.1 All structural metal roofing systems shall be tested in compliance with ASTM E 1592, as modified in T125-9 of this Protocol. Not less than three (3) ASTM E 1592 tests shall be conducted for each metal roofing system.

7.5.2 The average maximum positive and negative pressures attained during the three (3) ASTM E 1592 tests of a particular structural metal roofing system shall be included in the manufacturer's Roof Assembly Product Approval for reference after a 2 to 1 margin of safety is applied.

7.6 Uplift Resistance Testing for Non-Structural Metal Roofing Systems

7.6.1 All nonstructural metal roofing systems shall be tested in compliance with UL 580, as modified in T125-8 of this Protocol. Not less than three (3) specimens shall be conducted for each metal roofing assembly.

7.6.2 A margin of safety of 2 to 1 shall be applied to all uplift resistance test results.

7.6.3 The maximum allowable design pressure for the two tested specimens representing a typical roof field installation as specified in T125-7.6.3 shall be established by applying a 2 to 1 margin of safety to the average tested pressure of the specimens. The established maximum allowable design pressure shall be listed in the Roof Assembly Product Approval.

The maximum allowable design pressure for the third specimen representing a typical roof corner condition as specified in T125-7.6.3 shall be established by applying a 2 to 1 margin of safety to the tested pressure of the specimen. The established maximum allowable design pressure shall be listed in the Roof Assembly Product Approval.

Extrapolation of either the field and/or corner maximum allowable design pressures listed in the Roof Assembly Product Approval shall not be permitted.

8. UL 580 (as modified for the *Florida Building Code, Building*):

8.1 Scope

8.1.1 The test method specified in this standard is intended to determine the average uplift resistance of roof assemblies consisting of the roof deck and roof covering materials. It is applicable to any type of roof assembly which is adaptable to the test equipment. Tests to evaluate other potential hazards of roof assemblies are not within the scope of these requirements.

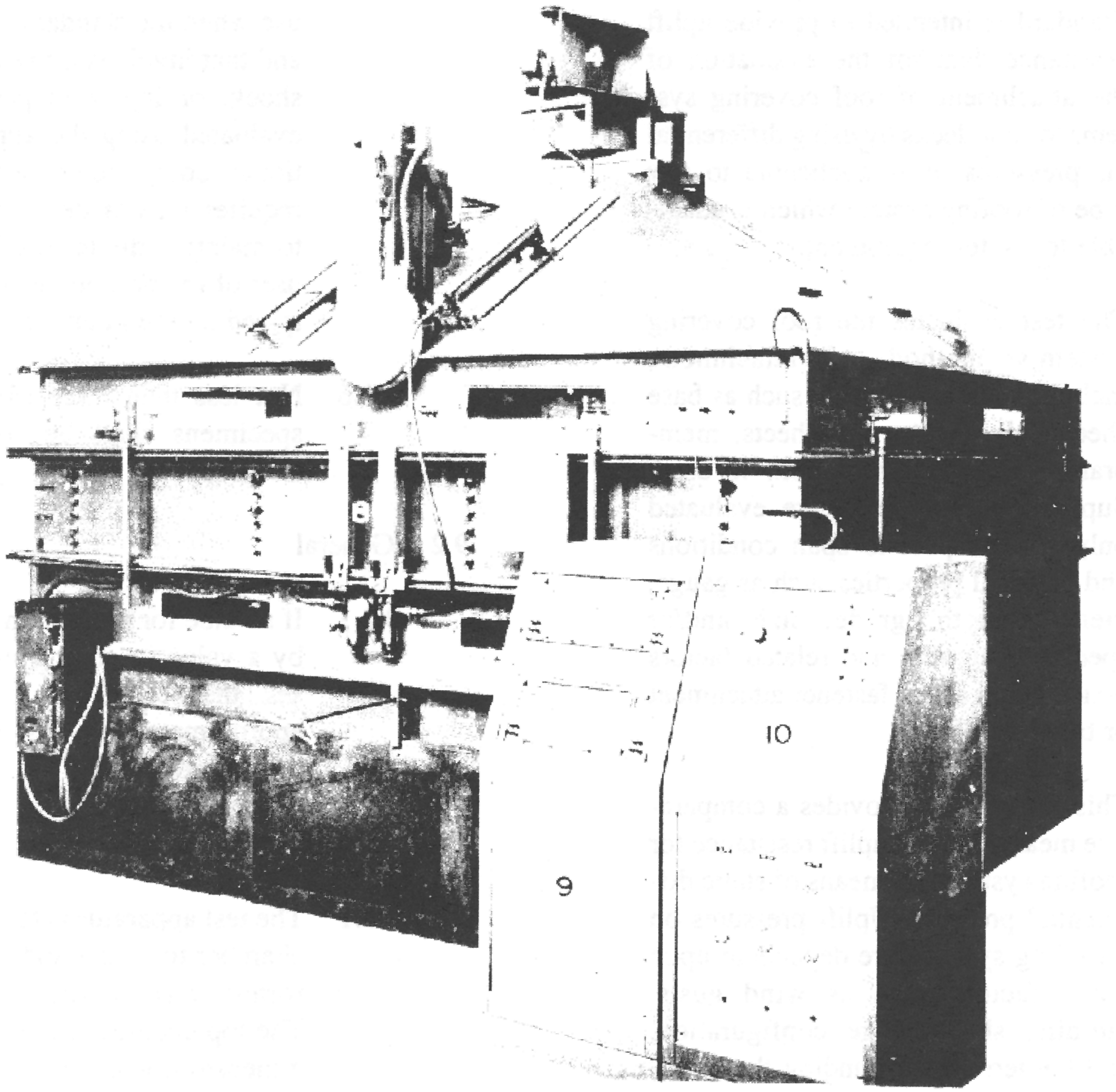
8.1.2 The purpose of this test is to evaluate the comparative resistance of roof assemblies to positive and negative pressures. Not less than three (3) test specimens shall be constructed and tested. Two test specimens shall simulate roof field installation conditions, and one test specimen shall simulate roof corner conditions.

8.1.3 The test evaluates the roof deck, its attachment to supports, and roof covering materials, if used. It does not evaluate roofs adjacent to chimneys, overhanging eaves, or the like, connections of the assembly to main structural supports (girders, columns, or the like), structural integrity of secondary supports (purlins, joists, bulb tees, or the like), or deterioration of roofing materials.

8.2 General

8.2.1 If a value for measurement is followed by a value in other units in parentheses, the second value may be only approximate. The first stated value is the requirement.

8.2.2 Any undated reference to a code of standard shall be interpreted as referring to the latest edition of that code or standard.



1. Pressure Chamber
2. Vacuum Chamber
3. Test Frame
4. Vacuum Blower
5. Slide Damper-Automatic
6. Slide Damper-Manual
7. Starters for Vacuum and Pressure Blowers
8. Pressure Manometers
9. Pressure Recording Equipment
10. Automatic Vacuum Controls

FIGURE 8-1
ASSEMBLED UPLIFT TEST APPARATUS FOR UL 580

8.3 Test Apparatus

8.3.1 The test apparatus is to consist of three sections: a top section to create a uniform vacuum, a center section in which the roof assembly is constructed, and a bottom section to create a uniform positive pressure. See Figure T125-8-1. Each section is to be sealed to maintain the specified pressures.

8.3.2 The inside dimensions of the test apparatus is to be a minimum of 10 by 10 feet (3.05 by 3.05 m).

8.3.3 The test chamber is to be capable of applying steady positive pressures on the underside of the test assembly and both steady and oscillating negative pressures, as specified, upon the top surface.

8.3.4 Recording equipment is to be provided to make a permanent record of the pressure levels developed in the test as a function of time.

8.3.5 T125-8.4 - T125-8.6 contain a specification of the presently used test apparatus. Design modifications may be made provided that the test results are equivalent to the results obtained from the specified apparatus.

8.4 Pressure Chamber

8.4.1 The pressure chamber is to be formed from C12 x 30 channels and is to measure 10 by 10 feet (3.05 by 3.05 m) by 9 inches (229 mm) deep. A $4^1/_2$ inch (114 mm) wide by $^1/_4$ inch (6.4 mm) thick steel plate is to be welded around the top of the chamber.

8.4.2 The floor of the pressure chamber is to be fabricated from $^1/_8$ inch (3.2 mm) thick sheet steel, welded at the seams and supported by five 3 by 8.5 inch (76 by 190 mm) steel shapes. The chamber is to be supported by an MC8 x 20 channel at each side and a W8 x 28 beam at each corner.

8.4.3 Several windows constructed of break-resistant glazing material are to be installed in the chamber walls to allow observation of the underside of the test assembly.

8.4.4 Flood lights are to be mounted in the chamber for illumination of the underside of the test assembly.

8.4.5 Air is to be admitted into the chamber through a 6 by 6 inch (152 by 152 mm) opening cut into the bottom of the chamber.

8.4.6 A steel baffle is to be placed over the air inlet opening for even distribution of air pressure. The baffle consists of two vanes with the lower vane measuring 22 by 22 inches (559 by 559 mm) and the upper vane measuring 16 by 16 inches (406 by 406 mm). The vanes are set at an angle of 30° from the horizontal.

8.4.7 Air to be provided by a blower attached to a 3 horsepower (2.2 kW output) electric motor that is capable of delivering 862 cubic feet (24.4 m^3) of air per minute at a static pressure of 24 inches (610 mm) of water.

8.4.8 The pressure blower starter controls are to be located on the side of the chamber for ease of access and rapid shut down.

8.4.9 The inlet pressure is to be controlled at the blower by a manually operated steel damper measuring 2 by 8 inches (51 by 457 mm) which is mounted in a sheet steel collar. The chamber pressure is to be controlled by an automatic relief damper measuring $4^3/_4$ by $11^3/_4$ inches (121 by 298 mm) located on the bottom of the chamber. The automatic damper is to be controlled by means of an adjustable weight system.

8.4.10 The air pressure is to be measured at five points by means of $^1/_4$ inch (6.4 mm) outside diameter copper tubing extending from the floor into the chamber at an angle of 45°

from the floor. Each of four tubes is to be diagonally located 42 inches (1067 mm) from a corner of the chamber. A fifth tube is to be located 18 inches (457 mm) from the center of the air inlet opening. The end of each tube is to be 7 inches (178 mm) above the chamber floor. The tubes are to be connected through $^1/_4$ inch valves into a manifold that, in turn, is to be connected to a manometer having a range of 0 - 25 inches of water (0 - 6221 Pa), graduated into 0.10 inch (24.9 Pa) increments.

8.5 Vacuum Chamber

8.5.1 The vacuum chamber is to be formed from C12 x 30 channels and is to measure 10 by 10 feet (3.05 by 3.05 m) by 12 inches (305 mm) high at the base. A $4^1/_2$ inch (114 mm) wide by $^1/_4$ inch (6.4 mm) thick steel plate is to be welded to the bottom of the channels. A reinforced hood, constructed from 0.105 inch (2.66 mm) thick steel with $2^1/_2$ by $2^1/_2$ by $^1/_2$ inch (64 by 64 by 12.7 mm) angles at the corners and $2^1/_2$ by $2\ ^3/_4$ inch (64 by 70 mm) T125-s at the center, is to be mounted on the base.

8.5.2 Several windows constructed of break-resistant glazing material are to be installed in the test chamber base to allow observation of the upper face of the test assembly.

8.5.3 The hood is to have a 30° slope from the horizontal at each side and is to have observation windows constructed of break-resistant glazing material in each wall.

8.5.4 The hood is to be terminated in a 24 by 24 inch (610 by 610 mm) metal platform constructed from $^1/_8$ inch (3.2 mm) thick steel plate. A 7 inch (178 mm) diameter opening is to be cut into the plate for the blower.

8.5.5 Negative pressure is to be provided by a blower and 3 horsepower (2.2 kW output) motor, which are to be mounted on top of the chamber with their shafts in a vertical position. The combination is to be capable of delivering 862 cubic feet (24.4 m^3) of air per minute at a static pressure of 11 inches (300 mm) of water.

8.5.6 The vacuum blower starter controls are to be located on a platform welded to the top of the hood.

8.5.7 The pressure in the vacuum chamber is to be controlled by an automatic damper measuring 18 by $2^1/_4$ inches (457 by 57 mm). The damper door is to be moved by means of an air motor hooked to an air line and controlled by pressure switches located in a control console.

8.5.8 An additional manually controlled sliding damper is to be located on the sloped wall of the chamber. It is to be constructed of $^1/_8$ inch (3.2 mm) thick steel plate and a screw gear which opens or closes the damper by turning. The damper is to measure 6 by 18 inches (152 by 457 mm).

8.5.9 Sheet metal baffles are to be located on the underside of the damper to prevent direct air flow onto the test assembly.

8.5.10 The air pressure to be measured at five points by means of $^1/_4$ inch (6.4 mm) outside diameter copper tubing extending from the floor into the chamber at an angle of 45° to the floor. Each of four tubes is to be diagonally located 18 inches (457 mm) from a corner of the chamber. The ends of these four tubes are to be 8 inches (203 mm) above the chamber floor. The fifth tube is to enter the chamber at a point 12 inches (305 mm) from the center of the exhaust opening, and its end is to be 6 inches (152 mm) below the opening. The tubes all are to be connected through $^1/_4$ inch valves into a manifold that, in turn, is to be connected to a manometer having a range of 0 -12 inches of water (0 - 2988 Pa) graduated into 0.10 inch (24.9 Pa) increments.

8.5.11 An additional $^1/_4$ inch (6.4 mm) outside diameter copper tube is to be connected from the manifold to an exterior junction for use of the pressure switches which control the automatic damper.

8.5.12 Flood lights are to be mounted in the chamber for illumination of the top surface of the test assembly.

8.5.13 Lifting hooks fabricated from $^5/_8$ inch (15 mm) diameter steel rod are to be welded at each corner of the hood.

8.6 Test Frame

8.6.1 The test frame is to be fabricated from C15 x 33.9 steel channels and measures 10 by 10 feet (3.05 by 3.05 m) by 15 inches (381 mm) deep. A $4^1/_2$ inch (114 mm) wide by $^1/_4$ inch (6.4 mm) thick steel plate is to be welded to the top and bottom of the channels at all four sides.

8.6.2 Machine nuts used for attaching assembly supports to the test frame are to be welded to all four sides of the test frame. The nuts are to be located 36 inches (914 mm) on center, beginning 18 inches (457 mm) from the frame center lines. Each line includes six $^5/_8$ inch (15 mm) diameter nuts spaced 2 inches (51 mm) apart.

8.6.3 A rubber gasket is to be cemented to the top flange of the test frame.

8.6.4 Lifting hooks fabricated from $^5/_8$ inch (15 mm) diameter steel rods are to be welded to each corner of the test frame.

8.7 Test Procedure

8.7.1 The test assembly shall be subjected to positive and negative pressures at the values and time

TABLE T125-1
TEST PRESSURES

TEST PHASE	TIME DURATION (MINUTES)	NEGATIVE PRESSURE		POSITIVE PRESSURE	
		psf (kPa)	INCHES (mm) OF WATER	psf (kPa)	INCHES (mm) OF WATER
Class 30 (not an obtainable rating)					
1	5	16.2 (0.79)	3.1 (79)	0.0 (0.00)	0.0 (0)
2	5	16.2 (0.79)	3.1 (79)	13.8 (0.66)	2.7 (69)
3	60	8.1- 27.7 (0.39-1.33)	1.5-5.3 (38-135)	13.8 (0.66)	2.7 (69)
4	5	24.2 (1.16)	4.7 (119)	0.0 (0.00)	0.0 (0)
5	5	24.2 (1.16)	4.7 (119)	20.8 (1.00)	4.0 (102)
Class 60 (not an obtainable rating)					
1	5	32.3 (1.55)	6.2 (157)	0.0 (0.00)	0.0 (0)
2	5	32.3 (1.55)	6.2 (157)	27.7 (1.33)	5.3 (135)
3	60	16.2- 55.4[a] (0.79-2.66)	3.1-10.7 (79-272)	27.7 (1.33)	5.3 (135)
4	5	40.4 (1.94)	7.8 (198)	0.0 (0.00)	0.0 (0)
5	5	40.4 (1.94)	7.8 (198)	34.6 (1.66)	6.7 (170)
Class 90 (maximum combined uplift pressure of 105 psf)					
1	5	48.5 (2.33)	9.3 (236)	0.0 (0.00)	0.0 (0)
2	5	48.5 (2.33)	9.3 (236)	41.5 (1.99)	8.0 (203)
3	60	24.2- 48.5[a] (1.16-2.33)	4.7-9.3 (119-236)	41.5 (1.99)	8.0 (203)
4	5	56.5 (2.71)	10.9 (277)	0.0 (0.00)	0.0 (0)
5	5	56.5 (2.71)	10.9 (277)	48.5 (2.33)	9.3 (236)

a Oscillation frequency as specified in T125-8.7.1.

duration specified in Table T125-1. Negative pressure is to be applied to the top surface of the assembly and positive pressure is to be applied to the bottom surface. During Phase 3 of the test, the oscillation frequency is to be 10 +/-2 seconds per cycle.

8.7.2 For a Class 90 (105 psf) rating the test pressure shall not exceed the specified values by more than 0.31 inches of water (77.2 Pa) for any test phase, the average pressure is not to vary by more than 0.25 inch of water (62.2 Pa) from the specified values.

8.7.3 Upon completion of each 60-minute oscillation phase and at the conclusion of each class level, the assembly is to be examined and observations recorded.

8.7.4 Subsequent to the completion of Phase 5 of the Class 90 test sequence, the test specimen may be subjected to additional static uplift pressures. Continuation of the test to increased pressure levels is the option of the manufacturer.

8.7.4.1 The positive pressure supplied from below shall be maintained at 48.5 psf (9.3 kPa).

8.7.4.2 The negative uplift pressure shall be supplied from above. The initial negative static uplift pressure shall be 63.5 psf. Subsequent pressure intervals shall increase in increments of 15 psf, with each pressure level held for one minute, until failure or until the desired uplift pressure is attained.

8.7.5 Vertical movement of the assembly during the tests is to be recorded.

8.7.6 Repairs or modifications, except to stop air leakage along the periphery, are not to be made to the assembly during the test.

8.8 Test Assembly Construction Features

8.8.1 The test assembly is to be representative of the construction for which classification is desired as to materials, workmanship, and details such as dimensions of parts, and shall be built under conditions representative of those in building construction. Properties of the materials and ingredients used in the test assembly together with their location and method of attachment are to be determined and recorded.

8.8.2 For non-structural metal roofing assemblies installed over wood decks, plywood shall be APA 42/20 span rated sheathing of a minimum thickness of $^{15}/_{32}$ in. Ends shall be butted, not blocked. All butt and side joints shall be left un-sealed, positive pressure shall freely flow through the deck. Minimum deck attachment shall be in compliance with the *Florida Building Code, Building*.

8.8.3 The dimensions of the test assembly are to be a minimum of 10 by 10 feet (3.05 by 3.05 m). The test assembly shall contain side and end joints if such occur in field installation. The test assembly shall consist of secondary bearing members, such as purlins and joists, to which the roof decking is fastened or on which insulation and roof coverings are applied.

8.8.4 The assembly components, including secondary members, are to be located to best represent field installations within the restraints provided by the test frame.

8.8.5 The periphery of the test assembly is to be sealed to prevent passage of air under pressure.

8.8.6 The test assembly is to be cured at room temperature for a period until representative field strength, humidity, and temperature are achieved.

8.8.7 Not less than three test specimens as described above shall be constructed and tested.

8.8.8 Proper Use of Film and Air Bags

8.8.8.1 Where plastic film is used to seal joints to allow pressurization of the interior or underside surface of the roof specimen it shall contact all surfaces of the panel and shall not interfere with the air passage to the specimen or the movement of adjacent parts. Film shall not bridge or otherwise block the gap at the base of a standing seam, as in Figure T125-9-3. Such bridging or blocking prevents lateral movement and proper pressurization of the specimen and yields non-conservative results whether it be a flat film sealed at the edges or an air bag.

- Longitudinal pleats that fit up into the rib on both sides of a clip, as in Figure T125-9-4 herein, ensure full contact and eliminate restraint.
- Multiple longitudinal air bags wider than the panel module, as in Figure T125-9-5 herein, provide the same effect without the need to perforate the air bag with the anchor fastener. Where either of these interferes with proper clip engagement, all seals must be limited to the perimeter of the test specimen.
- Multiple crosswise air bags, as in Figure T125-9-6 herein, do not make full contact and will hamper panel distortion. Plastic film must always lie between the panel and the crosswise support structure to provide continuous longitudinal contact. Other methods of sealing that demonstrate equivalent distortion as air pressure are acceptable.

8.9 Classifications

8.9.1 A Class 90 uplift classification shall be obtainable, having a maximum combined positive and negative pressure of 105 psf.

8.9.2 To obtain a Class 90 rating, the sample shall be subjected to the Class 30 and Class 60 tests, in that order, prior to the Class 90 test.

8.9.3 To obtain an increased maximum uplift resistance, the sample shall be subjected to the Class 30, Class 60 and Class 90 tests, in that order, prior to the static test.

8.9.4 The test assembly shall retain its structural integrity during or following the test without evidence of permanent damage. The following are examples of permanent damage.

- Buckling of rolled members that results in permanent loss of stiffness as determined by separate load tests comparing buckled and unbuckled members.
- Separation of components or permanent distortion that interferes with the function of the system or inability to carry additional load.
- Sidejoint disengagement.
- Failure of one or more fasteners of any type.
- Any permanent deformation of nonstructural roof systems exceeding 1.00 inch in diameter.

8.10 Interpretation of Results

8.10.1 The maximum allowable design pressure for the two tested specimens representing a typical roof field installation as specified in T125-7.6.3 shall be established by applying a 2 to 1 margin of safety to the average tested pressure of the specimens. The established maximum allowable design pressure shall be listed in the Roof Assembly Product Approval.

The maximum allowable design pressure for the third specimen representing a typical roof corner condition as specified in T125-7.6.3 shall be established by applying a 2 to 1 margin of safety to the tested pressure of the specimen. The established maximum allowable design pressure shall be listed in the Roof Assembly Product Approval.

Extrapolation of either the field and/or corner maximum allowable design pressures listed in the Roof Assembly Product Approval shall not be permitted.

9. ASTM E 1592:

9.1 Scope

9.1.1 This test method covers the evaluation of the structural performance of sheet metal panels and anchor-to-panel attachments for roof or siding systems under uniform static air pressure differences using a test chamber or support surface.

9.1.2 This test method is applicable to standing seam, trapezoidal, ribbed, or corrugated metal panels in the range of thickness from 0.012 in. to 0.050 in. (0.3 to 1.3 mm) and applies to the evaluation of single-skin construction or one layer of multiple-skin construction. It does not cover requirements for the evaluation of composite or multiple-layer construction.

9.1.3 Proper use of this test method requires knowledge of the principles of pressure and deflection measurement.

9.1.4 This test method describes optional apparatus and procedures for use in evaluating the structural performance of a given system for a range of support spacings or for confirming the structural performance of a specific installation.

9.1.5 The values stated in inch-pound units are to be regarded as the standard. The metric equivalents of inch-pound units are approximate.

9.1.6 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. For specific precautionary statements, see T125-9.7.

9.1.7 The text of this standard references notes exclusive of those from tables and figures. These notes and footnotes provide explanatory material and shall not be considered as requirements of the standard.

9.1.8 Not less than three (3) identical test specimens shall be constructed and tested.

9.2 Reference Documents

9.2.1 ASTM Standards:

A) 370 Test Methods and Definitions for Mechanical Testing of Steel Products.

B) 557 Method of Tension Testing Wrought and Cast Aluminum and Magnesium-Alloy Products

9.2.2 Aluminum Association Standard: Aluminum Formed-Sheet Building Sheathing Design Guide, Appendix B of specifications for Aluminum Structures, 1986 Edition

9.2.3 AISI Standards:

Load and Resistance Factor Specification for Cold-Formed Steel Structural Members, 1991 Edition Specification for the Design of Cold- Formed Steel Structural Members, 1996 Edition with the 1999 Addendum, Part I of the Cold Form Steel Design Manual

9.2.4 American Society of Civil Engineers: ASCE 7 Minimum Design Loads for Buildings and Other Structures. (Formerly ANSI A58.1)

9.3 Terminology - Descriptions of Terms Specific to This Standard.

9.3.1 Anchor, n - a fastener, bolt, screw, or formed device such as a clip that connects panels to the support structure.

9.3.2 Anchor Failure, n - any failure at the anchor device, including separation of the device from the panel, of the device itself, or of the connection to the structural support.

9.3.3 Crosswise Restraint, n - any attachment in the flat of a panel between structural elements that controls or limits pan distortion under pressure.

9.3.4 Failure, n - separation of components or permanent distortion that interferes with the function of the system or inability to carry additional load.

9.3.5 Interior Support, n - any support other than those at either extreme in a series of supports for a continuous panel.

9.3.6 Pan Distortion, n - displacement under load of normally flat portions of a panel profile as measured normal to the plane of the roof or wall surface.

9.3.7 Panel Deflection, n - displacement under load measured normal to the plane of the roof or wall surface of a longitudinal structural element as measured from a straight line between structural supports.

9.3.8 Permanent Deformation, n - the permanent displacement in any direction from an original position that remains after an applied load has been removed.

9.3.9 Reference Zero Load, n - nominal pressure applied to a specimen to provide a reference position free of variations from internal stresses or friction within the system assembly.

9.3.10 Rib Spread, n - panel distortion under load at the base of a rib or standing seam as measured crosswise to the rib in the plane of the roof or wall surface.

9.3.11 Span Length, n - the center-to-center distance between anchors or supports measured parallel to the longitudinal axis of the panel.

9.3.12 Specimen, n - the entire assembled unit submitted for testing, as described in T125-9.8.

9.3.13 Specimen Length, n - the distance from center to center of the end supports; the sum of individual span lengths.

9.3.14 Structural Element, n - the width of a panel profile as measured between center lines of repeating longitudinal stiffeners for continuously supported panels in a positive load test or the width between anchor attachments to repeating stiffener elements in a negative load test.

9.3.15 Test Load, n - the difference in static air pressure (positive or negative) between the inside and outside face of the specimen, expressed in pounds-force per square foot (lbf/ft^2) or pascals (Pa).

9.3.16 Test Panel Length, n - specimen length plus overhangs.

9.3.17 Ultimate Load, n - the difference in static air pressure (positive or negative) at which failure of the specimen occurs, expressed in pounds-force per square foot (lbf/ft^2) or pascals (Pa).

9.3.18 Unlatching Failure, n - disengagement of a panel seams or anchors that occurs in an unloaded assembly due to permanent set or distortion that occurred under a previous load condition.

9.3.19 Yield Load, n - that pressure at which deflection increases are no longer proportional to the increasing pressure. Yielding is not failure.

9.3.20 Zero Load, n - the absence of air pressure difference across the specimen.

9.4 Summary of Test Method

9.4.1 This test method consists of the following: (1) sealing the test specimen into or against one face of a test chamber; (2) supplying air to, or exhausting air from, the chamber at the rate required to maintain the test pressure difference across the specimen; and, (3) observing, measuring, and recording the deflection, deformations, and nature of any failures of principal or critical elements of the panel profile or members of the anchor system.

9.4.2 The increments of load application shall be chosen such that a sufficient number of readings will be obtained to determine the load deformation curve of the system.

9.4.3 End and edge restraint shall be representative of field conditions, and the unit shall contain sufficient individual components to minimize the effect of variations in material and workmanship.

9.5 Significance and Use

9.5.1 This test method provides a standard procedure to evaluate or confirm structural performance under uniform static air pressure difference. This procedure is intended to represent the effects of uniform loads on exterior building surface elements.

9.5.2 It is also permissible to develop data for load-span tables by interpolating between the test results at different spans

NOTE 1: When applying the results of tests to determine allowable design loads by application of a factor of safety, bear in mind that the performance of a wall or a roof and its components, or both, can be a function of fabrication, installation, and adjustment. The specimen must represent the actual structure closely. In service, the performance can also depend on the rigidity of supporting construction and on the resistance of components to deterioration by various causes, to vibration, to thermal expansion and contraction, etc.

9.6 Apparatus

9.6.1 The description of apparatus is general in nature; any equipment capable of performing the test procedure within the allowable tolerances is permitted. Major components are shown in Figure T125-9-1, herein.

9.6.2 Test Chamber - a test chamber, air bag, or box with an opening, a removable mounting panel, or one open surface in which or against which the specimen is installed. Provide at least two static pressure taps located at diagonally opposite corners to measure the chamber pressure such that the reading is unaffected by the velocity of the air supply to or from the chamber or any other air movement. The air supply opening into the chamber shall be arranged so that the air does not impinge directly on the test specimen with any significant velocity. A means of access into the chamber to facilitate adjustments and observations after the specimen has been installed is optional.

NOTE 2: The test chamber or the specimen mounting frame, or both, must not deflect under the test load in such a manner that the performance of the specimen will be affected. In general, select anchor support members sufficiently rigid that deflection under the test load will be negligible.

9.6.3 Air System-a compressed air supply, exhaust system, or controllable blower is to be provided to develop the required air pressure difference across the specimen. The system shall maintain an essentially constant air pressure difference for the required test period.

NOTE 3: It is convenient to use a reversible blower or separate pressure and exhaust systems to provide the required air pressure difference so that different test specimens can be tested for the effect of positive pressure or the effect of suction (negative pressure) without reversing the position of the test specimen. The use of the same specimen for both positive and negative testing is outside the scope of this test method. If an adequate air supply is available, a completely airtight seal need not be provided around the perimeter of the test specimen and the mounting panel, although it is preferable. However, substantial air leakage will require an air supply of much greater capacity to maintain the required pressure differences.

9.6.4 Pressure-measuring Apparatus - the devices to measure the test pressure difference shall operate within a tolerance of +/-2% of the design pressure, or within 0.1 in. (0.52 psf or 25 pa) of water pressure and be located as described in T125-9.6.1.

9.6.5 Deflection and Distortion Measurement Precision:

9.6.5.1 The means of measuring deflections of structural ribs between the reaction supports and movement of the ribs at the supports shall provide readings within a tolerance of +/-0.01 in. (0.25 mm).

9.6.5.2 The means of measuring pan distortion shall provide readings within a tolerance of +/- $^{1}/_{16}$ in. (1.5 mm).

9.6.5.3 The means of measuring rib spread shall provide readings within a tolerance of +/-$^{1}/_{16}$ in. (1.5 mm).

9.6.6 Reading Locations:

9.6.6.1 Support deflection gages or measuring devices so that readings are not influenced by movements of, or within, the specimen or member supports.

9.6.6.2 Minimum, measure the maximum deflection of the panel at the end span and the deflections of the supports of the end span.

9.6.6.3 Measure pan distortion in the middle of at least one panel flat (between structural elements) at a minimum of three locations. Additional reading locations are required to validate freedom from end restraint, as described in T125-9.8.2.2.

9.6.6.4 Rib spread readings are optional for measuring panel distortion for profiles with vertical rib faces. Measure rib spread at the base of the ribs in line with the anchors and at mid span, as required, to meet requirements of T125-9.8.2.2.

9.6.7 Reading Frequency:

9.6.7.1 In all cases except for rib spread, readings shall be taken at initial zero or preload, at each increment of load, and again at the zero or preload to determine permanent set. See T125-9.10.2.4 regarding the selection of zero load.

9.6.7.2 Rib spread readings shall be taken at each increment of load unless stipulated otherwise by the specifying authority.

9.7 Safety Precautions:

9.7.1 Take proper precautions to protect the operating personnel and observers in the event of any failure.

9.8 Test Specimens:

9.8.1 The test specimens shall be of sufficient size to determine the performance of all typical parts of the system. Conditions of structural support shall be simulated as accurately as possible, and the full length and width, including overhangs, shall be loaded. All parts of the test specimen shall be full size, using the same materials, details, and methods of construction and anchorage as used on the actual building. Except for positive load as in T125-9.8.2.2, any partial width sheets shall not be considered in figuring specimen width.

9.8.2 Specimen Width - edge seals shall not contain structural attachments that restrict deflection of the test panel any more than the normal gable condition.

9.8.2.1 For the evaluation of either bending capacity or anchor to panel attachment strength under negative load, the specimen width shall contain not less than three full panels and five structural elements with normal rake or gable supports at both edges. (See Figure T125-9-2, herein.)

9.8.2.2 For the evaluation of panel bending capacity in resisting positive pressure, the specimen width shall be as specified in T125-9.8.2.1 or be not less than 40% of the clear span and include not less than four structural elements with not less than one half the flat distance to the next adjacent nonincluded parallel rib, corrugation, or stiffener on each side.

9.8.3 Specimen Length - for negative (uplift) load tests (or any form of loading that tends to push panels away from the crosswise support), unless the test represents the full length used, the specimen length shall be sufficient to ensure that end seals or attachments do not restrict panel movement at the area under investigation.

9.8.3.1 For the evaluation of anchor to panel strength free of end influence, the arbitrary minimum specimen length, when both ends have crosswise restraint, is 24 ft (7.3 m). Shorter lengths are acceptable when only one end having crosswise restraint is a minimum of 8 ft (2.4 m) from at least one row of interior anchors. When both ends are free of crosswise restraint, the minimum specimen length is 10 ft (3 m) (see Table T125-1). When crosswise restraint is removed from both ends, the normal failure mechanism is the anchor connection to the seam. Other modes of failure or performance must be evaluated using one or both ends restrained.

9.8.3.2 For the evaluation of anchor to panel strength, the results are deemed to be free of end influence that the sample is outside the effect of the end condition as follows:

9.8.3.2.1 When a maximum mid-span panel distortion reading of an identical 24-ft (7.3-m) panel do not exceed (within the tolerance of the measurement) the maximum readings on the shorter setup; or

9.8.3.2.2 When maximum mid-span panel distortion reading does not exceed (within the tolerance of the measurement) the midspan distortion readings at least 4 ft (1.2 m) on both sides of at least one purlin.

9.8.3.3 For positive load tests, where the panels are supported to resist the applied load at each structural element in the midroof area as well as at the ends, the specimen length is not restricted.

9.8.4 Structural supports used in the test shall be of sufficient strength and rigidity to minimize deflection of the assembly. For supports used in positive pressure tests, due consideration must be given to the support.

9.8.5 End conditions that simulate eave or ridge flashing situations in which the panel terminates at or slightly beyond the purlin are considered to have crosswise restraint and influence distortion for some distance along the length of the panel. An open-end condition is one without crosswise restraint.

9.8.5.1 It is permissible to reinforce open-end conditions to prevent non-typical failures of clip to panel attachment or of web buckling caused by proximity of the free edge to the support. Acceptable reinforcement includes longitudinal stiffeners in the flats to prevent buckling of flats. Also acceptable are seam fasteners at the ends of ribs to prevent un-seaming from the free end. The reinforcement shall not restrict crosswise panel deformation nor cause the end seal to pull away from the pan as panels distort under load.

9.9 Calibration

9.9.1 The calibration of liquid column manometers, dial gages, and graduated scales or tape measures is not required for each test.

9.10 Procedure

9.10.1 Omit from the test specimen any unique influence from gravity, sealing, or construction material that does not occur during actual installation.

9.10.1.1 If the test panel orientation is either inverted or vertical, a gravity correction shall be made in the determination of the allowable superimposed loading. Tests run in an inverted position shall include data from pressure reversal or an upright specimen to demonstrate that unlatching will not occur in the normal orientation.

9.10.1.2 For negative load tests, the interior side of the specimen shall face the higher pressure. Support and secure the specimen by the same number and type of anchors normally used for installing the unit on a building, or if this is impractical, by the same number of other comparable fasteners located in the same way as in the intended installations.

9.10.1.3 If air leakage through or around the test specimen is excessive, tape or plastic film is acceptable to block any cracks and joints through which the leakage is occurring. Tape or film shall not be used to span a joint where it restricts differential movement between adjoining members. This caution applies specifically to the inside face of standing seam panels which tend to spread apart under pressure. See the instructions for proper film placement in the annex.

9.10.1.4 In cases in which it will not affect the results, it is permissible to apply a single thickness of polyethylene film no thicker than 6 mils (0.006 in.) (0.15 mm). The technique of application is important so that full load is permitted to be transferred to the specimen and the membrane does not prevent movement or failure of the specimen. Apply the film loosely, with extra folds of material at each corner and at all offsets, and recesses including the perimeter of the test specimen. The film shall not span any joint that will tend to separate under pressure. When the load is applied, there shall be no fillet caused by tightness of plastic film that will have a significant effect on the results.

9.10.2 Procedure - the following procedure is designed to produce a minimum of six points on the load-deflection curve. For precision in determination of the yield and ultimate strength, smaller increments are permitted to obtain additional points at the discretion of the test operator.

9.10.2.1 Check the specimen for proper adjustment, and close all vents in pressure-measuring lines.

9.10.2.2 Install the required deflection measuring devices at their specified locations.

9.10.2.3 At each increment of load, maintain pressure for not less than 60 seconds and until the dial gages indicate no further increase in deflection.

9.10.2.4 Apply a nominal initial pressure equal to at least four times but not more than ten times the dead weight of the specimen. If the applied loads are in the same direction as gravity on the test specimen, remove this pressure and record the initial reading at zero load. If applied loads are not in the same direction as gravity, use this nominal pressure as the reference zero and record the initial readings.

9.10.2.5 Unless otherwise specified, the first increment of load shall be nominally equal to one-third the anticipated ultimate load.

9.10.2.6 Reduce the pressure difference to zero and, after a recovery period of not more than 5 min at zero load, increase the pressure to reference zero (if used instead of zero) and take readings to determine permanent deformation for the first increment of load.

9.10.2.7 Proceed as above with successive increments that do not exceed one sixth the maximum specified test load until failure or the specified ultimate load is reached.

9.10.2.8 When the behavior of the specimen under load indicates that failure is imminent, it is permissible to remove the deflection measuring devices and to increase the load continuously until failure. In such cases, the yield point must be assumed to have been reached at or before the last recorded load.

9.10.2.9 After initial failure of one or more connections that leaves the majority of the specimen intact, it is permissible to provide external support to prevent further displacement of those locations and continue the loading to develop additional data.

9.11 Report

9.11.1 Report the following information:

9.11.1.1 Date of the test and issue of the report. State the location of the facility, name of the testing agency (if any), and names of the specific observers of the test. Cite the qualifications of any independent observers called in to certify the test procedure or results.

9.11.1.2 Identification of the specimen (manufacturer, source of supply, dimensions, model types, materials, and other pertinent information).

9.11.1.3 Detailed drawings of the specimen and test fixture, showing the dimensions of T125-profiles, purlin location, measurement locations, panel arrangement, installation and spacing of anchorage, sealants, and perimeter construction details. Note any modifications made on the specimen, including reinforcement in accordance with T125-9.10.2.9, to obtain the reported values, on the drawings.

9.11.1.4 Measured thickness and tensile yield strength of the material used in the test panels. Mechanical properties and thickness shall be measured after the removal of coatings in accordance with the appropriate standards for the material used, that is. Test methods A 370 for steel and method B 557 for aluminum. These values will be used to verify conformity with the product specification or make any required adjustment of allowable capacity within the range of a material specification and shall be made in accordance with the appropriate ASTM standard for the material involved.

9.11.1.5 Tabulation of the number of test load increments, zero load value and pressure differences exerted across the specimen at load increments, pertinent deflections at these pressure differences, and permanent deformations at locations specified for each specimen tested.

9.11.1.6 Plot of deflections and permanent set related to pressures applied.

9.11.1.7 Duration of the test loads including incremental loads.

9.11.1.8 Record of visual observations of performance and description of the location and type of failure experienced.

9.11.1.9 When the tests are made to check conformity of the specimen to a particular specification, an identification or description of that specification.

9.11.1.10 Statement that the tests were conducted in accordance with this test method or a full description of any deviations from this test method.

9.11.1.11 Statement that the panel and sealing method was observed by the testing engineer with comments concerning whether tape or file, or both, were used to seal against leakage, and whether, in the judgment of the test engineer, the tape or film could have influenced the results of the test.

9.11.2 If several essentially identical specimens of a component are tested, report the results for all specimens, with each specimen being identified properly, particularly with respect to distinguishing features or differing adjustments. A separate drawing for each drawing specimen will not be required if all difference between them are noted on the drawings provided.

9.12 Precision and Bias

9.12.1 This is a new procedure, and precision and bias of the test. Method is to be determined.

9.13 Keywords

9.13.1 Air bags, air seals, anchor strength, crosswise distortion; deflection; flexural capacity; rib spread; sheet metal roof and siding; single stain construction; standing seam; static air pressure; structural performance; test chamber; trapezoidal, ribbed, and corrugated panels; unlatching failure

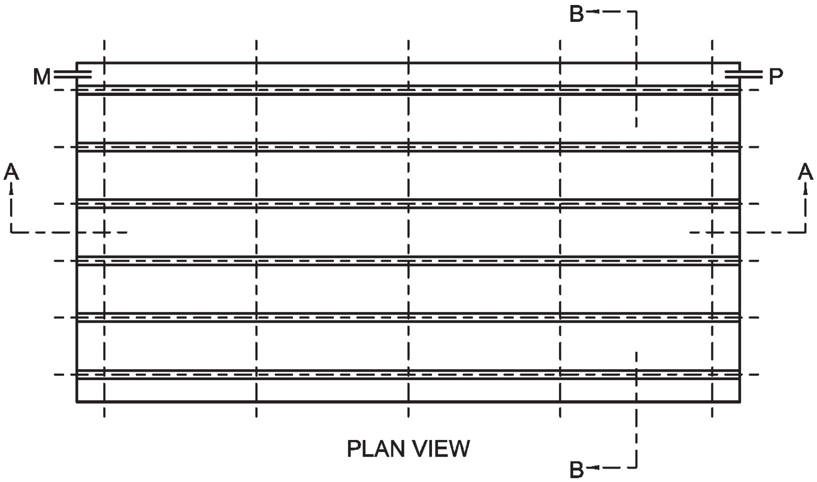
9.14 Proper Use of Film and Airbags

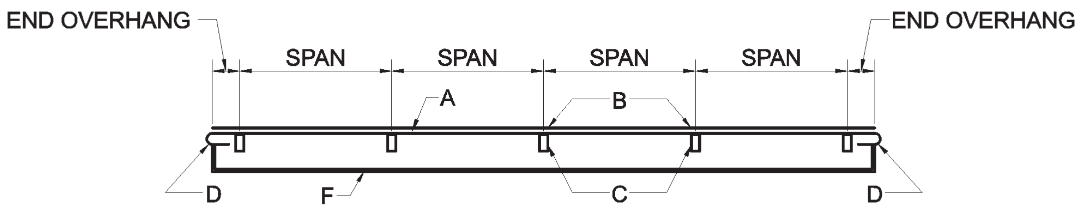
9.14.1 Where plastic film is used to seal joints to allow pressurization of the interior or underside surface of the roof specimen it shall contact all surfaces of the panel and shall not interfere with the air passage to the specimen or the movement of adjacent parts. Film shall not bridge or otherwise block the gap at the base of a standing seam, as in Figure T125-9-3. Such bridging or blocking prevents lateral movement and proper pressurization of the specimen and yields nonconservative results whether it be a flat film sealed at the edges or an air bag.

9.14.2 Longitudinal pleats that fit up into the rib on both sides of a clip, as in Figure T125-9-4 herein, ensure full contact and eliminate restraint.

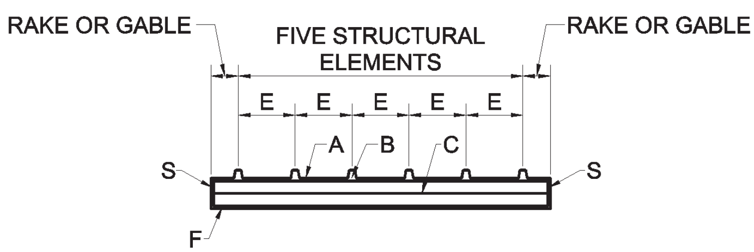
9.14.3 Multiple longitudinal air bags wider than the panel module, as in Figure T125-9-5 herein, provide the same effect without the need to perforate the air bag with the anchor fastener. Where either of these interferes with proper clip engagement, all seals must be limited to the perimeter of the test specimen.

9.14.4 Multiple crosswise air bags, as in Figure T125-9-6 herein, do not make full contact and will hamper panel distortion. Plastic film must always lie between the panel and the crosswise support structure to provide continuous longitudinal contact. Other methods of sealing that demonstrate equivalent distortion as air pressure are acceptable.





SECTION AA - PARALLEL TO PANEL LENGTH
(REFERENCE SECTION 7.2)



SECTION BB CROSSWISE TO PANEL LENGTH

A. Test Panels
B. Anchors
C. Crosswise Supports and Purlins
D. Flexible End Seal
E. Structural Element of Panel
F. Pressure or Vacuum Chamber
M. Manometer Locations
P. Air Supply or Exhaust
S. Flexible Side Seal

FIGURE 9-1
SCHEMATIC OF TEST APPARATUS FOR ASTM E 1592 UPLIFT TESTING

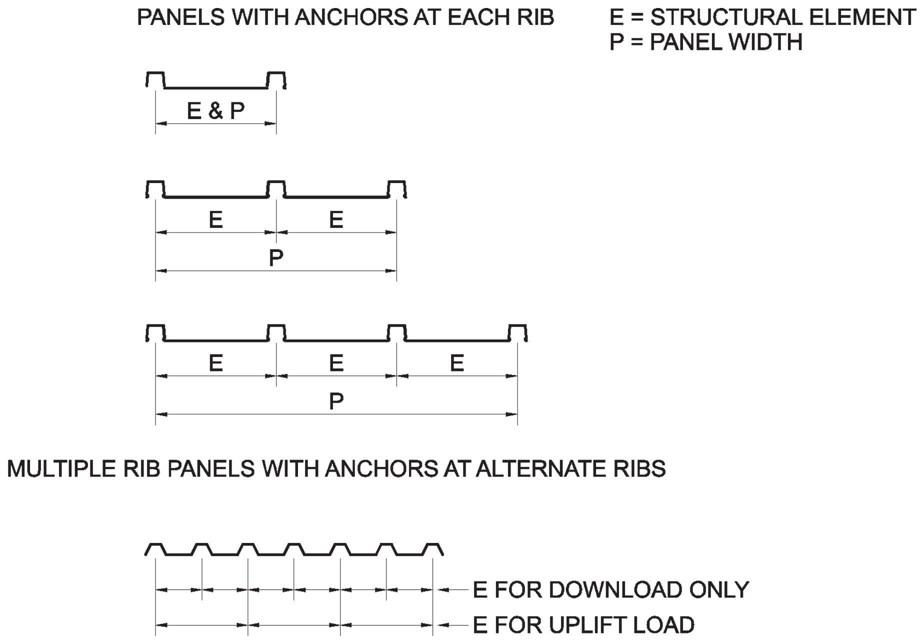


FIGURE 9-2
EXAMPLES OF STRUCTURAL ELEMENTS AND PANEL WIDTH FOR DIFFERENT PROFILES

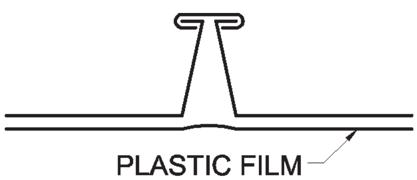


FIGURE 9-3
IMPROPER SEAL WHERE FILM SPANS CREVICE AT BASE OF RIB

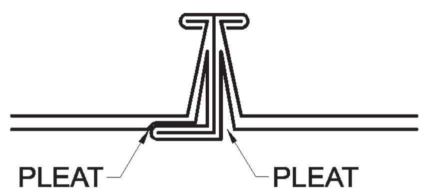


FIGURE 9-4
PLEATS MAKE CONTACT WITH METAL PANEL ON BOTH SIDES OF CLIPS

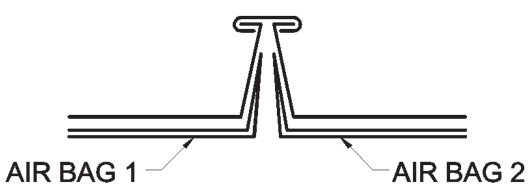


FIGURE 9-5
PROPER SEAL AT RIB WITH MULTIPLE LONGITUDINAL AIR BAGS

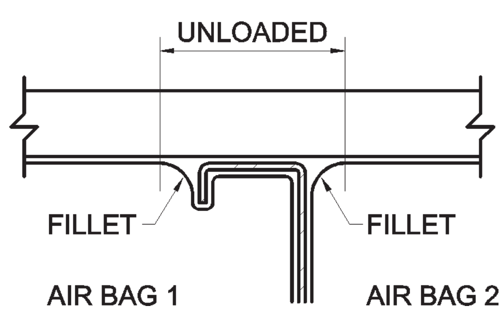


FIGURE 9-6
IMPROPER USE OF MULTIPLE AIR BAGS BETWEEN SUPPORT