



INTERNATIONAL ASSOCIATION OF PLUMBING AND MECHANICAL OFFICIALS
UNIFORM EVALUATION SERVICE

EVALUATION CRITERIA FOR

SINGLE SKIN STEEL ROOF AND WALL PANELS WITH CONCEALED FASTENERS

EC 011-2013

(Adopted – September 2013)

1.0 INTRODUCTION

1.1 Purpose: This Evaluation Criteria establishes the requirements for single skin steel roof and wall panels with concealed fasteners (herein referred to as “panels”) to be recognized in an evaluation report under the 2012 and 2009 *International Building Code*[®] (IBC) and the 2012 and 2009 *International Residential Code*[®] (IRC). Bases of recognition are IBC Section 104.11 and IRC Section R104.11.

This Evaluation Criteria provides guidelines for the calculation of strength, serviceability and testing of panels based on code provisions and for conditions where the codes do not address the necessary requirements.

1.2 Scope: This Evaluation Criteria provides a basis for calculating, testing and evaluating panels for positive and negative out-of-plane load capacities, section properties, and web crippling. In addition, standards are provided for optional fire resistance, hail resistance, wind-blown debris resistance, air and water infiltration resistance, drag resistance evaluation and clip/fastener attachment schedules.

The Scope of this Evaluation Criteria excludes the following items:

- a) In-plane shear resistance.
- b) Composite panel systems.
- c) Exposed fastener panels.
- d) Panel materials other than steel.

2.0 REFERENCED STANDARDS

2.1 Standards shall be applied consistently with the specific edition of the code(s) for which the Evaluation Report is prepared unless otherwise approved by IAPMO UES.

American Forest and Paper Association

NDS-2012 ANSI/AF&PA National Design Specification[®] (NDS) for Wood Construction (2012 IBC and IRC)

NDS-2005 ANSI/AF&PA National Design Specification[®] (NDS) for Wood Construction (2009 IBC and IRC)

American Concrete Institute

ACI 318-11 Building Code Requirements for Structural Concrete and Commentary (2012 IBC and IRC)

ACI 318-08 Building Code Requirements for Structural Concrete and Commentary (2009 IBC and IRC)

American Iron and Steel Institute

- AISI S100-07 North American Specifications for the Design of Cold-Formed Steel Structural Members
- AISI S100-07-S2-10 Supplement No. 2 to the North American Specification for the Design of Cold-Formed Steel Structural Members, 2007 Edition (2012 IBC and IRC)
- AISI S904-08 Standard Test Methods for Determining the Tensile and Shear Strength of Screws
- AISI S905-08 Test Methods for Mechanically Fastened Cold-Formed Steel Connections
- AISI S906-08 Standard Procedures for Panel and Anchor Structural Tests and the Commentary
- AISI S909-08 Standard Test Method for Determining the Web Crippling Strength of Cold-Formed Steel Beams

ASTM International

- ASTM A370-10 Standard Test Methods and Definitions for Mechanical Testing of Steel Products
- ASTM C1513-12 Standard Specification for Steel Tapping Screws for Cold-Formed Steel Framing Connections
- ASTM D1761-06 Standard Test Methods for Mechanical Fasteners in Wood
- ASTM E108-07a Standard Test Methods for Fire Tests of Roof Coverings
- ASTM E119-08a Test Methods for Fire Tests of Building Construction and Materials
- ASTM E283-04 Standard Test Method for Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen
- ASTM E331-00 (09) Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference
- ASTM C1513-12 Standard Specification for Steel Tapping Screws for Cold-Formed Steel Framing Connections
- ASTM E1592-05 Standard Test Method for Structural Performance of Sheet Metal Roof and Siding Systems by Uniform Static Air Pressure Difference
- ASTM E1646-95 (11) Standard Test Method for Water Penetration of Exterior Metal Roof Panel Systems by Uniform Static Air Pressure Difference
- ASTM E1680-95 (03) Standard Test Method for Rate of Air Leakage Through Exterior Metal Roof Panel Systems
- ASTM E1886-05 Standard Test Method for Performance of Exterior Windows, Curtain Walls, Doors, and Impact Protective Systems Impacted by Missiles(s) and Exposed to Cyclic Pressure Differentials
- ASTM E1996-09 Standard Specification for Performance of Exterior Windows, Curtain Walls, Doors, and Impact Protective Systems Impacted by Windborne Debris in Hurricanes

Factory Mutual

- FM 4471 (2010) Approval Standard for Class 1 Panel Roofs
- FM 4473 (2005) Specification Test Standard for Impact Resistance Testing of Rigid Roofing Materials by Impacting with Freezer Ice Balls

International Organization for Standardization

- ISO/IEC 17011:2004 Conformity Assessment -- General Requirements for Accreditation Bodies Accrediting Conformity Assessment Bodies
- ISO/IEC 17020:2012 Conformity Assessment -- Requirements for the Operation of Various Types of Bodies Performing Inspection
- ISO/IEC 17025:2005 General Requirements for the Competence of Testing and Calibration Laboratories

Underwriters' Laboratories

| | |
|------------|---|
| UL 263-03 | Standard for Fire Tests of Building Construction and Materials, with revisions through October 2007 |
| UL 790-04 | Standard Test Methods for Fire Tests of Roof Coverings |
| UL 2218-10 | Standard for the Impact Resistance of Prepared Roof Covering Materials |

3.0 DEFINITIONS

3.1 General: Terms not defined in this section, applicable codes, or referenced standards shall have the ordinary accepted definition for the context for which they are intended.

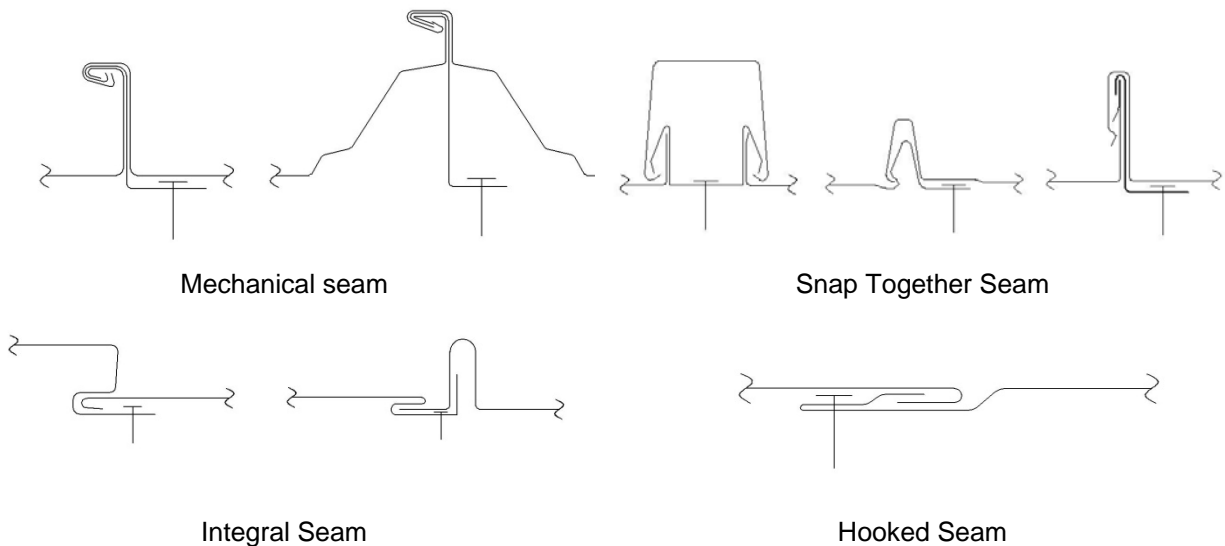
3.2 Definitions:

Analytical Theory: A mathematic equation or set of equations used to predict the load capacity of panels over a range of panel assembly conditions (i.e. panel gage, material grade, width, clip or fastener attachment spacing, etc.).

Clip: A mechanical device used to connect the panel to the support member through interlocking means or by the use of mechanical fasteners.

Concealed Fastener Panel: A single skin panel utilizing a clip or other fastener attachment method that is not exposed to the outside of the finished product. Figure 1 illustrates examples of typical concealed fastener panel types.

Figure 1: Examples of Concealed Fastener Panel Types



Exposed Fastener Panels: A panel that is attached to the substrate by driving fasteners through the exterior of the panel and into the support member. These panels are also commonly referred to as corrugated or through-fastened panels.

Negative Load: An out-of-plane load applied to the panel acting away from support members.

Positive Load: An out-of-plane load applied to the panel acting toward the support members.

Supporting member: A structural steel section, cold-formed steel structural section (e.g. cee, zee, hat), steel deck, dimensional lumber, wood structural panels (oriented strand board (OSB), or plywood) used as a base to securely fasten the panels down to.

4.0 BASIC INFORMATION

4.1 Panel Materials:

4.1.1 Permitted Roof Panel Materials: Roof panels shall be fabricated from cold-formed steel complying with the requirements of AISI-S100 Section A2, IBC Section 1507.4.3 or IRC Section 905.10.3 as applicable.

4.1.2 Permitted Wall Panel Materials: Wall panels shall be fabricated from cold-formed steel complying with the requirements of AISI-S100 Section A2 and IBC Section 1405.2.

4.1.3 Panel Material Properties: All steels used for testing shall have traceability back to mill certifications that clearly identify the grade designation, actual base metal thickness, yield strength, tensile strength and elongation. In absence of any of the required information, each coil of steel used to produce panel test samples shall be tested in accordance with ASTM A370.

4.2 Supporting Member Materials: Support members shall be of structural steel, cold-formed steel, lumber, wood structural panels, or concrete, complying with the requirements of the appropriate section of the IBC or IRC as applicable.

4.3 Fasteners: Fastening system shall be compatible with the material type, thickness and grade of the supporting members. Common fastener sizes for each panel shall be listed in the report.

4.4 Testing Laboratories: Testing laboratories shall be accredited for the applicable testing procedures in accordance with ISO/IEC 17025 by a recognized accreditation body conforming to ISO/IEC 17011. Testing at a non-accredited laboratory shall be permitted by IAPMO UES, provided the testing is conducted under the supervision of an accredited laboratory and the supervising laboratory issues the test report.

4.5 Test Reports: Test reports shall be in compliance with Test Report Requirements Procedure (ES-025) and submitted to IAPMO UES for generation of evaluation reports. Required and optional items to be included in the test reports are found in Table 1.

4.6 Test Product Requirements: Steel roof and wall components provided for tests under this Evaluation Criteria shall be representative of typical production and correlated by the testing laboratory or accredited inspection agency to the product specifications.

4.7 Panel Information: Panel and associated clip dimensioned drawings shall be submitted to IAPMO UES for each panel listed in the report. Panel installation instructions shall also be provided.

5.0 TESTING AND PERFORMANCE REQUIREMENTS

5.1 Panel Section Properties: Panel design base metal thickness and calculated section properties shall be in accordance with AISI S100.

5.2 Fastener and Connection Capacities: Any fastener and connection capacities listed in the report shall be based on one of the following:

5.2.1 Standard Calculations: In accordance with AISI S100, NDS, or ACI 318 for fasteners that may have their capacity determined using these standards.

5.2.2 Self-Drilling and Self-Tapping Fasteners: By testing in accordance with ASTM C1513 or AISI S904. The number of identical test specimens shall comply with AISI S100, Section F.

5.2.3 Approved Products: ASD or LRFD design capacities listed in an approved evaluation or acceptance report for the fastener.

5.2.4 Connections to cold-formed steel products: By testing in accordance with AISI S905.

5.3 Positive Load Capacities: Where applicable, determination of capacities for uniform positive loads from gravity and wind shall be based on a rational analysis, analyzing the panels as a beam. Panels shall be investigated for bending, shear, web crippling, combined bending and shear, and combined bending and web crippling in accordance with AISI S100 Chapters B and C. Alternatively, panels may be tested in accordance with AISI S906. For uniformly distributed loads, the effective moment of inertia, as a combination of gross and effective moments of inertia, shall be permitted to be used for determining deflection as follows:

$$I_{effective} = \frac{2I_{eff} + I_g}{3}$$

5.3.1 Web Crippling: For panels that rest on supports where web crippling is a mode of failure, web crippling shall be determined in accordance with the provisions of AISI S100. Alternately, any panel, including those that exceed the limitations of AISI S100, may be tested in accordance with AISI S909 to determine web crippling capacities, with the number of test specimens and determination of design values complying with AISI S100 Section F.

5.4 Negative Load Capacities:

Negative load capacities shall be based on the provisions of this section for a specific test assembly, an analytical theory describing the negative load capacity confirmed by a range of tested assemblies, or an assembly with an acceptable alternative clip. Testing shall be in accordance with ASTM E1592, along with the modifications stated in AISI S100 Section D6.2 and AISI S906 as referenced within.

5.4.1 Specific Test Assembly:

5.4.1.1 Roof or wall panel testing, the interpretation of results, and the development of a resistance factor and safety factor for a singular assembly shall be in accordance with Section D6.2 of AISI S100.

5.4.1.2 Design values for configurations between specific tested assemblies shall be permitted to be based on linear interpolation, provided the following conditions are met:

- a. Panels are the same design base steel thickness and cross sectional geometry.
- b. Assemblies use the same clips or the clip substitution conditions in this Evaluation Criteria are satisfied to justify the use of different clips.
- c. Assemblies use the same fasteners, unless particular fastener usage is not a limiting factor in the overall capacity of the tested assembly.
- d. Spacing of clips or fasteners in the tested assemblies shall not differ by more than 36 inches (915 mm).

5.4.2 Analytical Theory:

5.4.2.1 Roof or wall panel testing shall comply with the requirements of AISI S100, Section D6.2 as modified in this section of the Evaluation Criteria.

5.4.2.2 Number of test configurations shall not be less than three (3) and shall include the minimum and maximum condition for each variable in the analytical theory. Test programs shall also require assemblies with intermediate test configurations between the minimum and maximum conditions to develop the analytical theory unless justification is otherwise provided. Common variables comprising a configuration may include: panel cross-sectional geometry; design base steel thickness; grade of steel; clip or fastener attachment spacing; and fastener type.

5.4.2.3 Safety and resistance factors shall be determined in accordance with the procedures of AISI S100 Section F1.1 (b), the definitions for the variables defined by Section D6.2, and by the following:

$$\begin{aligned}
 P_m &= R_m \\
 V_P &= \text{Coefficient of variation of test results} \\
 &= \frac{1}{R_m} \sqrt{\frac{1}{n-1} \sum_{i=1}^n (R_i - R_m)^2} \geq .065 \quad (\text{Eq. 5.4-1})
 \end{aligned}$$

Where:

$$\begin{aligned}
 R_i &= \text{Test result } i \text{ of } n \text{ total results} \\
 &= S_{n(\text{test})} / S_{n(\text{calc})} \\
 S_{n(\text{test})} &= \text{Assembly strength from full scale tests, psf or Pa} \\
 S_{n(\text{calc})} &= \text{Assembly strength obtained from analytical theory, psf or Pa} \\
 R_m &= \text{Mean of all } R_i
 \end{aligned}$$

5.4.3 Alternative Clips: Alternative clips to the tested clip shall be permitted to be substituted, provided the conditions in this section of the Evaluation Criteria are satisfied.

5.4.3.1 Strength of the clip shall be permitted to be based on testing in accordance with Section 5.4.1 or 5.4.2. As an alternative to testing, for clips that can be rationally analyzed, capacities shall be permitted to be determined using the provisions of AISI S100, rational engineering mechanics and clip geometry.

5.4.3.2 The portion of the alternative clip that interlocks with the panel shall conform to the following requirements:

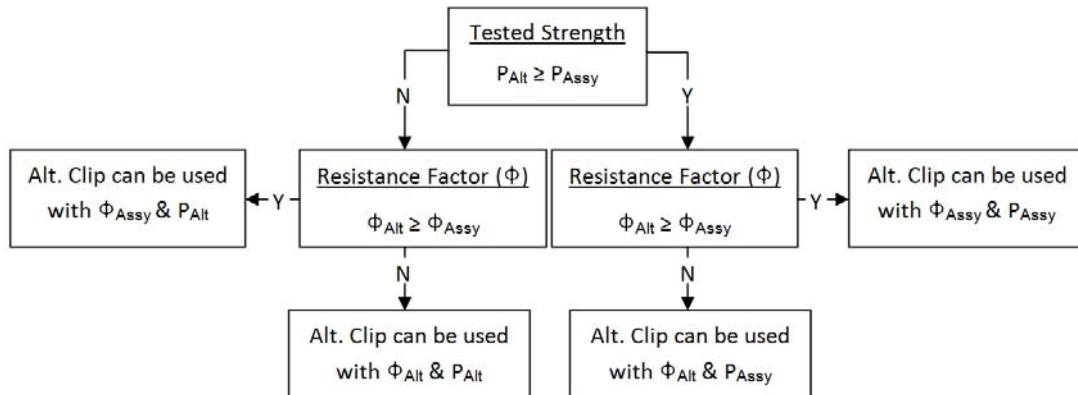
- a. Alternative clip shall have identical cross sectional geometry, perpendicular to the axis of the panel seam, to the tested clip.
- b. Length of the alternative clip shall be equal to or greater than the tested clip along the axis of the panel seam.
- c. If holes, embossments or other features exist in the portion of the clip that interlocks with the panel, the alternative clip shall have the same features as the tested clip.
- d. Design base steel thickness of the alternative clip shall be equal to or greater than the tested clip.
- e. Specified steel grade of the alternative clip shall have equal or greater yield and tensile strength than the tested clip.

5.4.3.3 The portion of the clip that does not interlock with the panel seam (i.e., clip base) shall be permitted to be used in accordance with the requirements shown in Figure 2.

5.4.3.4 Tensile testing of the clip portion that does not interlock with the panel seam (i.e., clip base) shall be performed in accordance with the provisions of AISI S905. Figure 3 illustrates an example of a typical test fixture. For the evaluation of alternative clips where the supporting member rotates (such as eccentrically loaded Cee & Zee purlins), clip base testing shall be performed utilizing representative supporting member sections to account for prying forces. Figure 4 provides an example.

For the purpose of testing, the clip's attachment to supporting members is permitted to utilize bolted connections, or other higher strength fasteners, to avoid fastener failures in these clip evaluation tests. The diameter and bearing surface of tested fasteners shall be representative of standard or full scale test fasteners. Alternative clip nominal capacities shall equal or exceed the maximum nominal clip capacities obtained through the full scale panel assembly tests.

Figure 2: Alternative Clip Capacity Flow Chart



P_{Assy} = Clip strength derived from full scale assembly testing (Section 5.4.1 & 5.4.2) and based on tributary area to the clip (psf).

P_{Alt} = Strength of the alternate clip based on testing (Section 5.4.3.4) and analyzed to the same tributary area associated with the clip from full scale assembly testing (psf).

Φ_{Assy} = Resistance factor for clip derived from full scale assembly tests.

Φ_{Alt} = Resistance factor for alternate clip.

Figure 3: Clip Test Fixture - Typical

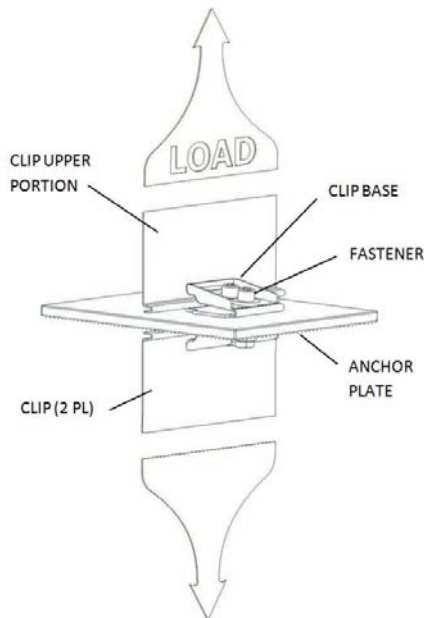
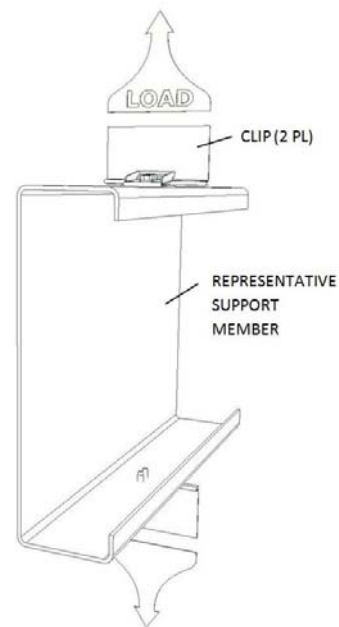
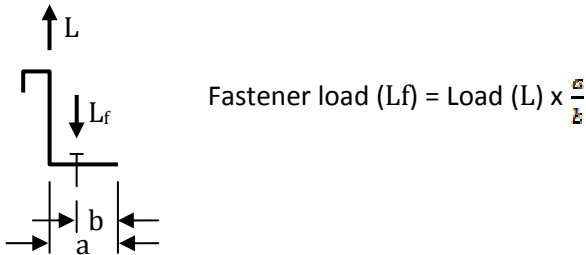


Figure 4: Flexible Support Members



5.4.4 Clip / Fastener Attachment Schedules (Optional): Attachment schedules shall report the panel assembly's calculated ASD or LRFD uplift loads based on various clip, fastener, and substrate combinations. Table 2 provides an acceptable attachment schedule format. In the determination of the ASD or LRFD loads specified in the attachment schedule, clip prying action shall be taken into account. Clip fastener locations are commonly installed off-center of the clip loading centerline, which under load creates a clip prying action that increases the loading of the fastener(s). Figure 5 shows an example of this prying action.

Figure 5: Prying Action on Fastener



5.5 Air and Water Infiltration Testing (Optional): If values are included in the Evaluation Report, air and water infiltration testing shall be performed in accordance with this section. If no air and water infiltration testing evidence is submitted, then the report shall indicate that the panels are not tested for air and water resistance and that air and water resistance is outside the scope of the report.

5.5.1 Roof Assemblies:

5.5.1.1 Air infiltration testing shall be performed in accordance with ASTM E1680.

5.5.1.2 Water infiltration testing shall be performed in accordance with ASTM E1646.

5.5.2 Wall Assemblies:

5.5.2.1 Air infiltration testing shall be performed in accordance with ASTM E283.

5.5.2.2 Wall panels may be tested for wind-driven rain in accordance with E331, subject to additional requirements in IBC Section 1403.2(Exception 2) or IRC Section R703.1.1 (Exception 2). Wall panels that are not tested shall comply with Statement 3 of Section 7.3.

5.5.3 All air and water infiltration testing shall be performed and evaluated utilizing the minimum test pressure differences defined in each of the above noted ASTM test specifications.

5.5.4 For all air and water infiltration testing performed at a given panel gage, panel width, and panel attachment spacing that passes the test requirements, all variations of the same panel design that have a heavier gage, narrower width, and/or reduced attachment spacing shall be considered passing due to their inherently stronger design. The same "passed" tested assembly attachment type shall be used when extending to additional variations.

5.6 Fire Ratings (Optional): If included, testing for fire ratings shall be performed in accordance with this section. If no fire rating evidence is submitted, the report shall indicate that the fire rating of the roof or wall panels is beyond the scope of the report as applicable.

5.6.1 Roof Panels: Class A, B, or C roof assemblies or roof coverings shall be tested in accordance with ASTM E108 or UL 790. Testing is not required for roof assemblies complying with the requirements of IBC Section 1505.2 Exception No. 2, or IRC Section R902.1 Exception No. 2, which are classified Class A roof assemblies by definition.

5.6.2 Wall Panels: The fire-resistance rating of building components or assemblies shall be tested in accordance with ASTM E119 or UL263.

5.7 Hail Resistance, Roof Panels (Optional): If included, hail resistance testing shall be performed in accordance with UL 2218 or FM 4473. If no hail resistance testing evidence is submitted, then the report shall indicate that the panels are not tested for hail resistance and that hail resistance is outside the scope of the report.

5.8 Wind Blown Debris Resistance, Wall Panels (Optional): If included, windblown debris resistance testing shall be conducted in accordance with ASTM E1886 and ASTM E1996 with the modifications in IBC Section 1609.1.2.2. If no wind borne debris resistance testing evidence is submitted, then the report shall indicate that the panels are not tested for wind borne debris resistance and that wind borne debris resistance is outside the scope of the report.

5.9 Drag Load Resistance, Roof Panels (Optional): If included, drag load resistance tables shall present the type and number of, fasteners required to appropriately fix concealed fastener panels to supporting members to resist drag load forces created by snow and gravity loads.

6.0 QUALITY CONTROL

6.1 IAPMO-UES approved inspections of manufacturing facilities are required for this product. Inspections by inspection agencies accredited for metal products in accordance with ISO/IEC 17020 by an accreditation body recognized as conforming to ISO/IEC 17011 are permitted.

6.2 Quality documentation complying with IAPMO UES Minimum Requirements for Listee's Quality Assurance System (ES-010) shall be submitted.

7.0 EVALUATION REPORT RECOGNITION

7.1 Each bundle of panels shall have a visible product identification label affixed to it. Labels shall include the manufacturer's name and address, IAPMO UES logo, and the evaluation report number, and shall clearly identify the panel type, steel specification by ASTM or other recognized specification, and steel gage or thickness as listed in the evaluation report.

7.2 Mandatory items shall be included and the optional items may be included in the evaluation report as shown in Table 1. Data supporting the mandatory and optional items that have found to comply with the requirements of this criteria shall be summarized in the evaluation report. Additional items may be included as determined appropriate by IAPMO-UES.

7.3 Evaluation report shall include the following or equivalent statements:

1. Metal panels used in roof applications shall be applied to a solid or closely fitted deck, except where the roof covering is specifically designed to be applied to spaced support members.
2. Calculations demonstrating compliance with this report shall be submitted to the code official for approval. The calculations shall be prepared by a licensed design professional where required by the statutes of the jurisdiction in which the project is to be constructed.

3. The evaluation report shall state that roof or wall panel resistance to air infiltration is outside the scope. Panels shall be permitted to be rated for resistance to air infiltration based on successful testing in accordance with Section 5.5.1.1 or 5.5.2.1.
4. Panels used on exterior walls shall be flashed in accordance with IBC Section 1405.3 or IRC Section R905.4.6 and have a water-resistant barrier behind them in accordance with IBC Section 1403.2 or IRC R703.1. Alternative means of weather protection shall be permitted based on successful testing in accordance with Section 5.5.2.2.
5. The evaluation report shall state the minimum allowable panel slopes for each listed panel type. The slopes shall not be less than minimums stated in IBC Section 1507.4.2 or IRC Section R905.10.2
6. The evaluation report shall include a statement that flashing requirements for roof assemblies, when applicable, shall comply with IBC Section 1503.2 and 1503.3 or IRC Section R903.2 and R903.3. Underlayment shall be installed in accordance with IBC Section 1507.4.5 where applicable wind conditions occur. Alternative means of weather protection shall be permitted based on successful testing in accordance with Section 5.5.1.2.
7. The evaluation report shall state that roof panels are limited to installations complying with IBC Section 1505.2 Exception No. 2, or IRC Section R902.1 Exception No. 2 as Class A roof assemblies or where nonclassified roofing is permitted by the IBC or IRC. Other classifications and installation methods shall be permitted based on successful testing in accordance with Section 5.6.1.
8. The evaluation report shall state that wall panels are limited to installations where non-fire-resistance-rated construction is permitted by the IBC or IRC. Wall panels shall be permitted in fire-resistance-rated wall assemblies based on successful testing in accordance with Section 5.6.2.
9. The evaluation report shall state that roof panel resistance to hail is outside the scope. Panels shall be permitted to be rated for resistance to hail damage based on successful testing in accordance with Section 5.7.
10. The evaluation report shall state that panel use as protection of glazed openings located in wind-borne debris regions is outside the scope. Panels shall be permitted to be used as impact-resistant coverings based on successful testing in accordance with Section 5.8.
11. Design of panel penetrations and other panel discontinuities shall be the responsibility of the design professional using rational engineering mechanics or in accordance with the manufacturer's installation instructions as approved by the building official.
12. For load combinations that include wind uplift, the nominal wind load shall be permitted to be multiplied by 0.67 provided the conditions in AISI S100, Appendix D6.2.1a (A through G) are satisfied. The evaluation report shall state whether or not conditions A and D to G have been satisfied for each panel listed in the report. Report shall also state that compliance with conditions B and C are the responsibility of the design professional.

Table 1: Required & Optional Evaluation Report Information

| Item | Required | Optional |
|--|----------------|----------|
| Section Properties (Section 5.1) | X | |
| Design Base Metal Thickness per Gage Callout (Section 5.1) | X | |
| Positive Load Test Results or Load Tables (Section 5.3) | X ¹ | |
| Negative Load Test Results or Load Tables (Section 5.4) | X | |
| Web Crippling (Section 5.3.1) | X ² | |
| Clip/ Fastener Attachment Schedule (Section 5.4.4) | | X |
| Air Infiltration Testing (Section 5.5) | | X |
| Water Infiltration Testing (Section 5.5) | | X |
| Fire Ratings (Section 5.6) | | X |
| Hail Resistance (Section 5.7) | | X |
| Wind Blown Debris Resistance (Section 5.8) | | X |
| Drag Load Resistance (Section 5.9) | | X |

Notes:

¹ - Shall be an optional report item if load resistance is calculated based on panel section properties.

² - Required if panel installation and supports conform to qualifications noted in Section 5.3.1

Table 2: Clip/ Fastener Attachment Schedule (Matrix) (Ref. 5.4.4)

| | |
|--|---|
| <p>Rows of available substrate and fastener combinations with allowable fastener pullouts (capacities determined in accordance with Section 5.2 of this criteria).</p> | <p>Columns of available panel attachment spans and maximum allowable panel uplift capacities at those spans based on testing and interpolation (as defined by Section 5.4).</p> |
| | <p>Matrix of allowable uplift loads based on uplift test data (above) and limited by fastener/substrate capacities at the left.</p> |