



**INTERNATIONAL ASSOCIATION OF PLUMBING AND MECHANICAL OFFICIALS
UNIFORM EVALUATION SERVICES**

EVALUATION CRITERIA FOR

**Metal Roof Attachment Methods for Photovoltaic Module Mounting
Systems, Snow Retention Systems, and Other Accessories"**

EC 029 - 2018

(Approved November 2018; Reapproved March 2025)

1.0 INTRODUCTION

- 1.1 Purpose:** The purpose of this evaluation criteria is to establish requirements for seam clamps, attachment roof-mounted brackets, and accessory brackets/components used to attach accessories, including solar modules, solar PV (photovoltaic) mounting systems, and rail-type snow retention systems to metal roofs to be independently reviewed and recognized in an evaluation report issued by a certification body. This criteria provides for recognition under the 2024, 2021, 2018, 2015, and 2012 *International Building Code*[®] (IBC[®]) and the 2024, 2021, 2018, 2015, and 2012 *International Residential Code*[®] (IRC[®]). The basis for recognition is contained in 2024, 2021, 2018 and 2015 IBC Section 1709.1; 2012, IBC Section 1708.1; IRC Section R301.1.3; and 2024 IBC Section 104.2.3 (2021, 2018, 2015 and 2012 IBC Section 104.11) and 2024 IRC Section R104.2.3(2021, 2018, 2015 and 2012 IRC Section R104.11).

1.2 Scope:

- 1.2.1** This Evaluation Criteria establishes the testing requirements and procedures, the documentation required for review, and the analysis methods used to determine allowable loads for roof-mounted seam clamps, roof-mounted brackets, accessory brackets, accessory brackets/components for solar PV mounting, and snow retention systems on exposed fasteners, and standing seams. Roof-mounted attachments may use either penetrating mechanical attachment methods or non-penetrating mechanical clamping methods. The criteria focuses on their ability to resist in-plane loads (downslope), perpendicular downward loads (perpendicular to the roof surface), and perpendicular uplift loads, as applicable. Other load types are not addressed in this document.

1.3 Definitions:

- 1.3.1 PV mounting systems:** Also referred to as PV racking systems or solar PV mounting systems, these are structural components used to securely attach solar modules to metal roofs.

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- 1.3.2 Seam Clamps:** Seam clamps are devices that connect to the standing seams of metal roof panels and provide attachment points for roof-mounted ancillary systems, such as rooftop PV mounting systems and snow retention systems. Seam clamps are designed to clamp securely onto the standing seams of metal roofs without penetrating the metal so that the roof remains watertight. Wind and dead loads applied to PV mounting systems are transferred through the seam clamps and into the roof. Snow loads on the snow guards are transferred through the seam clamps to the roof panels.
- 1.3.3 Brackets:**
- 1. Attachment Brackets:** Devices mechanically fastened through the sheet metal into the underlying roofing substrate or directly to the metal roofing sheet, providing attachment points for roof-mounted ancillary systems.
 - 2. Accessory Brackets/Components:** Brackets or components that connect to attachment brackets or seams using standing seam clamps, rather than directly to the roof. These components are used to secure solar modules, PV mounting systems, snow retention systems, or other ancillaries to a metal roof or structure.
- 1.3.4 Roof-mounted Snow Retention Systems:** Snow retention systems, also known as snow guard systems, are composed of multiple individual snow guards or continuous snow guard assemblies designed to restrain quantities of snow and ice from sliding down the slope of the roof. These systems include primary snow guard elements, clips, cross-members, seam clamps, and/or brackets/components.
- 1.3.5 Snow guards:** Snow guards are individual devices or assemblies designed to retard or restrain the movement of snow or ice.
- 1.3.6 Cross-members:** Structural members (rods, bars, or other shapes) installed perpendicular to the expected direction of sliding snow, providing a barrier against snow and ice movement. Cross-members are the primary components of rail- or fence-type snow retention systems.
- 1.3.7 Snow Clip:** Components mounted to cross-members to increase the effectiveness of the snow retention system by retarding movement of snow or ice beneath the cross-member.
- 1.3.8 Rail-Type Snow Retention System:** A snow retention system composed of rail- or fence-type cross-members and brackets. Snow clips may also be incorporated into the cross-members to increase the overall snow retention effectiveness.
- 1.3.9 Standing Seam Metal Roof System: Also referred to as a Standing Seam Metal Roof,** this is a roofing system composed of shaped metal panels interconnected via raised edges that are bent and folded together, forming a vertical standing seam. The panels may be fastened to the building structure with attachment clips that are integrated into the standing seam, leaving few or no exposed fasteners.
- 1.3.10 Exposed Fastener Metal Roof System: Also referred to as an exposed fastener metal roof,** this is a metal roofing system where the fasteners used to secure the roof panels are visible on the surface of the roof. These fasteners penetrate through the metal panels and attach directly to the underlying substrate below. Exposed fastener metal roofs have exposed fastener heads that are not concealed or hidden by another layer of material.

1.3.11 Snow retention system design load (RS_{DL}): The component of the maximum seasonal weight of snow acting in the direction of sliding snow down the slope of the roof. RS_{DL} is determined by the following equation:

$$RS_{DL} = W_{Smax} \cdot \sin(s_r^\circ)$$

W_{Smax} = maximum seasonal weight of snow on a roof

s_r° = angle of the roof in degrees

The quantity and weight of snow restrained by the snow retention system shall be determined by a qualified design professional. The design shall be based on the ground snow load for the location of the building and other factors influencing snow and ice build-up and weight contained in ASCE/SEI 7. These factors may include wind exposure and thermal factors, applicable warm and cold roof factors, roof slope, unbalanced loads, aerodynamic shading, snow surcharge, and drifting and shielding action. Additional information concerning standard practices for the design of snow retention systems may be found by consulting the Metal Construction Association.

Note: Due to the probability of water and ice on the roof surface, the force of friction acting to restrain the snow from sliding from the roof is assumed to be zero.

1.3.12 Roof System: the part(s) of the roofing structure below the roof covering, consisting of different components including truss, beam (wood or metal), rafter, strut, purlin, or board.

2.0 REFERENCED STANDARDS

2.1 The following standards, referenced in this criteria, shall be applied consistently with the provisions of the applicable edition of the code(s) noted herein unless otherwise approved by the certification body:

2012, 2015, 2018, 2021, 2024 IBC International Building Code®

2012, 2015, 2018, 2021, 2024 IRC International Residential Code®

ASTM A370 Standard Test Methods and Definitions for Mechanical Testing of Steel Products

ASTM A90-21 Standard Test Method for Weight [Mass] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings

ASTM A370-24 Standard Test Methods and Definitions for Mechanical Testing of Steel Products

ASTM A924-24	Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process
ASTM D7147	Standard Test Method for Testing and Establishing Allowable Loads of Joist Hangers
ASTM E4-21	Standard Practices for Force Verification of Testing Machines
ASTM E8	Standard Test Methods for Tension Testing of Metallic Materials
ASTM E575-05(2018)	Standard Practice for Reporting Data from Structural Tests of Building Constructions, Elements, Connections, and Assemblies
ISO/IEC 17011-2017	Conformity assessment- General requirements for accreditation bodies accrediting conformity assessment bodies
ISO/IEC 17025-2017	General requirements for competence of testing and calibration laboratories
ISO/IEC 17065-2012	Conformity assessment -- Requirements for bodies certifying products, processes and services
ASCE/SEI 7	Minimum Design Loads and Associated Criteria for Buildings and Other Structures
UL 2703	Mounting Systems, Mounting Devices, Clamping/Retention Devices, and Ground Lugs for Use with Flat-Plate Photovoltaic Modules and Panels

3.0 BASIC INFORMATION

The following information shall be provided for review and evaluation:

- 3.1 Product Description:** Complete information pertaining to components, including dimensional drawings, material specifications, and the manufacturing processes. Materials shall comply with an appropriate recognized national standard(s).
- 3.2 Installation and Use Instructions:** Complete information pertaining to product installation and use. The same installation instructions published for use in the field for product installation shall be observed by the laboratory for specimen preparation before testing.
- 3.3 Packaging and Identification:** Method(s) of packaging and product identification, which shall include, at a minimum, the manufacturer's or report holder's name and address, product name and identification number, mark of the certification body, and the evaluation report number.
- 3.4 Justifying Documentation:** Complete justification for the product's acceptability for the stated use in accordance with the applicable codes, standards, and related criteria, including this criteria, and reports of testing and analysis prescribed therein and otherwise appropriate to justify recognition and approval.
- 3.4.1 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, provided the testing is conducted under the supervision of an accredited laboratory, the testing complies with all of the requirements of the applicable standards, the product specimens comply with the minimum criteria for acceptance, and the supervising laboratory issues the test report.
- 3.4.2 Test Reports:** Test reports shall include all of the applicable information required by this criteria, the applicable test standard, and ASTM E575, as appropriate.

3.4.3 Product Sampling: Sampling of the components for tests under this criteria shall be conducted at the manufacturing locations by an accredited testing laboratory or inspection agency. Alternatively, the specimens may be submitted to the laboratory by the manufacturer, provided the manufacturer attests that the submitted samples are representative of normal production and of the product being evaluated. The accredited testing laboratory or accredited inspection agency shall compare the samples taken to the normal product specifications and shall conclude that the products comply.

4.0 TEST AND PERFORMANCE REQUIREMENTS

A test plan shall be submitted to the evaluation entity to include the proposed roof test panel specimen. Each manufacturer-specific roof panel configuration, material, and thickness sought for recognition in an evaluation report shall be tested. Any intermediate ribs that may be used as attachment points shall also be tested. The panel, when it includes a standing seam, shall be mated as prescribed by the roof panel manufacturer in a typical installation, exclusive of any attachment clips. If the panel standing seam is normally machine seamed on site, the provider shall furnish the roof panels in a seamed condition, using the same type of seaming machinery, methods, tools, and equipment as would be used in actual field assemblies. Adjustment factors shall be detailed in the test plan, as applicable. Deflection limits unique to each attachment of accessories shall be detailed in the test plan, including the disengagement of any accessory system bracket/component to the cross-member or object it is attached to and the displacement limitations of the parts. Variations to the load application and vector direction, assemblies, failure modes, and others deemed important to the purpose of this evaluation criteria, etc., shall be detailed.

Attachments brackets which are fastened to roofing sections, where structural performance is not influenced by the geometry of the roof panels may be tested and evaluated based on strength, material and thickness of the roof panel, if the roof panel shape does not affect the performance of the attachment bracket, and the bracket is intended to fasten through the panel. Evidence shall be submitted to demonstrate that the roof panel geometry does not influence attachment bracket performance values.

The attachment brackets, clamps, and accessory brackets/components used for the attachment of accessories to metal roofs shall be tested. The testing methods in Section 4.1 or 4.2 may be used, as applicable. Testing shall reflect the worst-case support conditions, as appropriate. Brackets, clamps, and accessory brackets/components shall be tested with an apparatus that transfers load into the bracket or component in a similar load path and bearing area.

4.1 Seam Clamp, Attachment Bracket, and Accessory Bracket/Component - Load Test Procedures and Analysis

4.1.1 The following information shall be provided for the standing-seam or exposed fastener metal roof panels and roof system components, as applicable:

(a) The uncoated base-metal thickness. The base-metal thickness may be calculated by converting the zinc or 55 percent AlZn coating weight to a zinc or 55 percent AlZn coating thickness and subtracting it from the overall measured thickness. The coating weight shall be determined in accordance with ASTM A90 or ASTM A924 for zinc and A792 for 55 percent AlZn.

(b) Specified minimum yield strength and minimum tensile strength. Verification of strength values shall be in accordance with ASTM E8 as specified in ASTM A370.

The tensile strength of the steel used in testing shall be within 10 percent of the minimum material strength specified in the approved quality documentation.

- (c) Detailed scaled drawings of the roof panels, including standing seam side joint and exposed fastener metal roof panels side rib, are required to verify the dimensions of the seam and the placement of the fasteners in the test setup. These details shall be included in the test report.

4.1.2 The following test setup shall be used to determine the seam clamp or attachment bracket strength or be used to determine the strength of accessory brackets or components used to attach accessories to metal roofing. This method is not applicable to accessory brackets that develop strength by attachment to the underlying roof substrate, such as wood, steel, or other materials.

- (a) The test setup shall include the seam clamps, attachment brackets, and/or accessory brackets/components corresponding to the roof-mounted accessories, such as snow retention, solar PV modules, and snow retention systems installed in accordance with the manufacturer's published instructions. The clamps and attachment brackets shall be fastened to a metal roof with a standing seam or exposed fastener using identifiable configurations representative of field conditions.
- (b) The number of specimens (setups) tested shall comply with the requirements of Section 4.1.4 of this criteria.
- (c) For seam clamps, the holding strength of seam clamps is dependent on setscrew installation torque. Each clamp setscrew shall be torqued to a maximum of 93 percent of the minimum torque indicated by the installation instructions, and the values shall be recorded.
Gouging or breaching of the corrosion-protective coating shall be avoided as shown in Figure 1 of this criteria.
- (d) A testing machine complying with the requirements of ASTM E4 that is capable of operating at a constant rate of motion, or constant rate of loading, shall be used. The rate of loading shall be controlled, or a constant rate of motion or rate of loading shall be maintained. The applied loads shall be recorded to a precision of one percent of the anticipated ultimate load.
- (e) Devices used to measure the components of a system shall be calibrated in accordance with ASTM E4. The devices used to measure displacement of the clamp relative to the seam or the displacement limitation of any component, shall provide a precision of ± 0.03 inch (0.8 mm). The devices used to measure the thickness of the metal roofing material shall be accurate to within ± 0.0005 inch (0.01 mm). The devices used to measure fastener dimensions shall provide a precision of ± 0.005 inch (0.1 mm).
- (f) A test apparatus, as shown in Figure 2, for downslope or in-plane testing, or Figure 3 for perpendicular downward or perpendicular uplift testing of this criteria shall be used to investigate the holding strength of the seam clamps to the standing seam or attachment bracket to the exposed fastener roof. The seam clamps or the attachment brackets may be in line with and assembled with applicable accessory brackets/components. The testing apparatus shall consist of a minimum $\frac{1}{8}$ -inch-thick (3.175 mm) steel plate measuring approximately 20 inches by 30 inches (508

mm by 762 mm) (Figure 2) or 12-inches by 12-inches (305mm by 305 mm) (Figure 3), a testing fixture that is measured to specifications. The plate shall be reinforced as necessary with a steel angle, tube, or channel to prevent its buckling, warping, or twisting when under tension loads parallel but offset from its surface. The test fixture, depicted in Figure 2, shall be securely anchored to the test table along the 20-inch (508 mm) dimension, and sufficiently braced to the table to prevent excessive deflection during the test.

- (g) For in-plane and downslope testing, the roof panel test specimen shall consist of a minimum 30-inch (762 mm) long section along the seam, rib, or vertical length of the sample of a manufacturer-specific panel side joint (standing seam) and adjacent tributary area of two adjoining metal roof panels. For perpendicular uplift and perpendicular downward testing, the test specimen shall consist of a minimum of 7-1/2-inches (190.5 mm) section along the seam, rib, or vertical length of the sample. Each manufacturer-specific roof panel configuration, material, and thickness sought for recognition in an evaluation report shall be tested. Any intermediate ribs that may be used as attachment points shall also be tested. The total width of the specimen shall be a minimum of 12 inches (305 mm) and a maximum of 20 inches (508 mm). For standing seam roofs, the panel standing seam shall be mated as prescribed by the roof panel manufacturer in a typical installation, exclusive of any attachment clips. If the panel standing seam is normally machine seamed on site, the provider shall furnish the roof panels in a seamed condition, using the same type of seaming machinery, methods, tools, and equipment as would be used in actual field assemblies. Attachment bracket testing, which is not inclusive to the manufacturer specific profile, shall meet the requirements of Section 4.0 of this criteria.
- (h) The test specimen shall be attached to the test apparatus so that the seam or rib of the testing sample lies parallel to the direction of the test load for in-plane or downslope testing and perpendicular to the direction of the test load for perpendicular uplift or perpendicular downward testing to model the loading condition. Figures 2 and 4 of this criteria depict these loading conditions
- (i) The test specimen shall be fastened to the plate using fasteners installed adjacent to the panel seam, in sufficient quantity and spacing to prevent movement of the panels during the test.
- (j) A metallic scale with 1-millimeter increments shall be located at each seam clamp, attachment bracket, or accessory bracket/component on the test panel to measure the movement of the clamp or travel along the loading direction.

4.1.3 The test procedure shall comply with the following:

- (a) Test loads shall be applied in the direction of the intended load path of the seam clamp or attachment bracket and shall be applied to simulate the load path associated with the PV mounting system, the cross-member, other ancillaries, and its attachment to the clamp, attachment bracket, or accessory bracket/component. The test load path shall be applied to induce maximum torsion of the setscrew connection in the seam clamp or attachment bracket, or accessory bracket/component attached to the roof panel.
 - a. PV Mounting System – The test load shall be applied along the path where the seam clamp/attachment bracket supports the mounting system.

- b. Snow Retention – For a single cross-member system, the test load shall be applied where the seam clamp supports the single cross-member. For a multiple cross-member system, the test load shall be applied where the seam clamp (or bracket portion) supports the uppermost cross-member.
 - c. Other brackets and clamps – The test load shall be applied where load transfers between the bracket/clamp and the roof deck/standing seam and means of attachment to the bracket or clamp.
 - d. Other accessory brackets/components – The test load shall be applied where the load transfers from the accessory/component to be attached and the seam clamp/attachment bracket. The seam clamp/attachment bracket may or may not be in the test setup as applicable.
- (b) An initial load, or preload, is permitted to be applied to seat the seam clamps or attachment brackets attached to the standing seam or rib of the test roof panel. This preload shall not exceed 10 percent of the expected average ultimate load and is removed before loading the specimen to failure. Preloads are applicable for the primary loading direction only.
- (c) The test load shall be applied at a uniform rate between 0.10 and 0.25 inch (2.54 to 6.5 mm) per minute until failure or ultimate load. Loads shall be recorded with a precision of ± 1 percent of the ultimate load during the application of test loads.

4.1.4 Evaluation of test data shall comply with the following:

Test results shall be evaluated based on the average value from the test data from not fewer than three identical specimens, provided the deviation of any individual test result from the average value obtained from all tests does not exceed 15 percent. If deviation from the average value exceeds 15 percent, more tests of the same kind shall be performed until the deviation of any individual test result from the average value obtained from all tests does not exceed 15 percent, or until at least three additional tests have been done. No test result shall be excluded unless a rationale for its exclusion is given.

Allowable loads shall be determined from the lesser of the values in accordance with Section 5.0 of this criteria. Allowable loads shall be determined by taking the average ultimate load of the tests divided by a safety factor of 2.0, provided that each test is within 15 percent of the average. The safety factor shall be adjusted appropriately for variations in results exceeding this percentage.

Fastener loads for screws and bolts shall not exceed published allowable load values recognized in national standards referenced by the codes or recognized in a current and approved evaluation report.

4.1.5 Failure modes: The following shall indicate that the peak load for a given test specimen has been reached:

Downslope or in-plane testing failure modes for Seam Clamps

- A. Disengagement of the clamp from the panel seam
- B. Clamp displacement of more than 8 mm (0.315 inch)
- C. Breakage or fracturing of clamps or fasteners
- D. Stripping or other failure of any related fasteners
- E. Fracturing of any area of panel seam

F. Buckling or any other structural or severe cosmetic damage to panel seam

Perpendicular downward or perpendicular uplift test failure modes for Seam Clamps

- A. Separation of the clamp from the seam
- B. Breakage of any part of the clamp
- C. Tearing or otherwise yielding of the seam
- D. Any other yielding of clamp-to-seam connection

Downslope or in-plane testing failure mode for brackets and accessory brackets/components

- A. Displacement limitation of any components as detailed in the test plan
- B. Yielding/disengagement of bracket-to-substrate connection or bracket-to-sheeting connection
- C. Visible, permanent deformation of the bracket or assembly, including bending, tearing, and fracturing
- D. Buckling or any other structural or severe cosmetic damage to the panel
- E. Stripping or other failure of any related fasteners

Downward or perpendicular uplift testing failure mode for brackets, accessory brackets/components

- A. Mounting bolt strips from the bracket
- B. Yielding of bracket-to-substrate connection or bracket-to-sheeting connection
- C. Visible permanent deformation of the bracket or assembly, including bending or tearing
- D. Fastener holding bracket in place pulls out 1 or more threads (Sheeting Only Attachment)

4.2 Alternative Load Test Procedures and Analysis for attachment brackets and accessory bracket/components: ASTM D7147 may be used as an alternative to testing attachment brackets or accessory brackets/components in accordance with Section 4.1 of this criteria. This method is not applicable to determining the performance of only seam clamps. The information in Section 4.1.1 of this criteria shall be provided.

4.2.1 The following test set up shall be used to test the strength of attachment brackets or accessory brackets/components used to attach accessories to metal roofing.

- (a) The minimum number of specimens (setups) tested shall be four (4).
- (b) When seam clamps are to be included as part of an assembly, and the holding strength of seam clamps is dependent on setscrew installation torque, each clamp setscrew shall be torqued to a maximum of 93 percent of the minimum torque indicated by the installation instructions, and the values shall be recorded. Gouging or breaching of the corrosion-protective coating shall be prevented as shown in Figure 1 of this criteria.

4.2.2 The test procedure shall comply with ASTM D7147 and the following:

- (a) Test loads shall be applied in the direction of the intended load path of the bracket assembly and shall be applied to simulate the load path associated with the load path for which recognition is sought and its attachment to the bracket assembly.

The location(s) of the applied test load shall be determined in the test plan and provided to the evaluation entity for review.

- (b) An initial load, or preload, is permitted to be applied to seat attachment brackets if they are to be included in the assembly and are attached to the standing seam, rib, or pan of the test roof panel. This preload shall not exceed 10 percent of the expected average ultimate load and is removed before loading the specimen to failure. Preloads are applicable for the primary loading direction only.
- (c) The test load shall be applied at a uniform rate in accordance with the standard until failure or ultimate load. Loads shall be recorded with a precision of ± 1 percent of the ultimate load during the application of test loads.
- (d) Assemblies that use clamping devices for attachment of the PV mounting system shall establish an allowable displacement measurement in the test plan. This limiting displacement will be used to determine allowable loads, and the allowable loads that correlate with this displacement and the displacement limit will be included in the evaluation report.

4.2.3 Evaluation of test data shall comply with the following:

4.2.3.1 Accessory Brackets that rely on strength from attachment to the roof covering only and do not develop strength by attachment to the underlying roof substrate:

- (a) Test results shall be evaluated based on the average value from the test data from not fewer than four identical specimens, provided the deviation of any individual test result from the average value obtained from all tests does not exceed 15 percent. If deviation from the average value exceeds 15 percent, more tests of the same kind shall be performed until the deviation of any individual test result from the average value obtained from all tests does not exceed 15 percent, or until at least three additional tests have been done. No test result shall be eliminated unless a rationale for its exclusion is given.
- (b) Allowable loads shall be determined from the lesser of the values in accordance with Section 5.0 of this criteria. Allowable loads shall be determined by taking the average ultimate load of the tests divided by a safety factor of 3.0, provided that each test is within 15 percent of the average. The safety factor shall be adjusted appropriately for variations in results exceeding this percentage. Adjustment factors shall be applied as detailed in the approved test plan.

4.2.3.2 Accessory Brackets that develop strength by attachment to the underlying roof:

- (a) Allowable loads for the accessory brackets shall be determined in accordance with ASTM D7147 Sections 13 through 15, including strength to account for the difference between the published nominal values of specific gravity and the tested values for the lumber used in the test set-up. The moisture content of dimension lumber specimens used in testing may be less than 11 percent, provided the results are adjusted in accordance with the standard. For structural composite lumber, structural glued laminated wood, and wood I-joists, the moisture content shall be in accordance with Section 10.2 of ASTM D7147.

4.2.4 Failure Modes: Failure Modes shall be as defined in Section 4.1.5.

4.3 Snow Retention Cross-Member Calculations: The strength and stiffness of the snow retention system cross-members shall be determined by analysis in accordance with the applicable code. The analysis shall be based on the sectional and material properties of the cross-members and shall account for material durability. Allowable loads shall not permit permanent deformation or permanent deflection of the cross-members. The analysis shall reflect the worst-case support conditions of the cross-members, including multiple spans, simple spans, and cantilevers, as appropriate.

4.4 Snow Retention Cross-member, Attachment Bracket, and Component Testing: When the strength and stiffness of the snow-guard system cannot be determined by calculation, testing of the system shall be required. A testing plan documenting all material elements and each snow-guard retention system configuration shall be submitted to the evaluation agency for approval prior to testing. If a splice is to be used to join adjacent cross-members, testing shall be performed with the splice placed mid-span of the cross-member. Testing shall reflect the worst-case support conditions of the cross-members, including multiple spans, simple spans, and cantilevers, as appropriate. Attachment brackets that hold cross-members in place shall be pull tested with an apparatus that represents cross-members transferring load into the bracket. A minimum of three replicate specimens shall be tested for each combination of variables that affect the performance of the system.

4.6 Fire Classification (optional): Attachment Bracket, Seam Clamp, Attachment Bracket/Component and Components that are part of a rooftop-mounted PV system and contain a photovoltaic module for which recognition is sought, shall comply with Section 1505.9 of the IBC and be tested in accordance with UL 2703.

4.7 Weather Resistance: Attachment brackets that penetrate metal roofs shall be tested in accordance with ASTM E2140. The specimens shall include each product and each waterproofing methodology to be recognized in the code report. The assembly shall resist the required water pressure head without observed water leakage.

5.0 DETERMINATION OF ALLOWABLE LOADS

5.1 Attachment Bracket, Accessory Bracket/Component or Seam Clamp: Roof-mounted brackets and clamps attached to metal standing seam roof panels, or exposed fastener panels, and roof decks used to attach accessories shall be rated for allowable direct load capacity for which recognition is sought. The allowable loads for the systems shall be based on the allowable load for the weakest element in the system as follows:

- (a) Allowable load determined for any attachment bracket, accessory bracket/component and fastening in the system based on test results described in Section 4.1 or 4.2, as applicable, of this criteria.
- (b) Allowable load determined for any attachment bracket, any seam clamp based on testing and analysis in accordance with Section 4.1 of this criteria, when a seam clamp is used to attach to a specific roof system.
- (c) Allowable load for fasteners attached to substrates in accordance with code compliant analysis.
- (d) Allowable load determined for the cross-member, based on the analysis described in Section 4 of this criteria.

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- 5.3** The material strength properties of the products used in testing shall not be greater than 110 percent of the minimum strength properties allowed for the manufactured product as specified in the manufacturer's quality management system.
- 5.4** Allowable loads for non-manufacturer-specific test assemblies shall include the measured test material thickness, material strength, and coating, and when applicable, the thickness, material strength, and coating of the underlying substrate. The evaluation report shall specify any limitations related to any panel geometries and shapes and substrate characteristics that would have a negative effect on the allowable loads as they were detailed in the test plan.
- 5.5** Load duration factor adjustments are not permitted to be used to determine the capacity of the snow retention system.

6.0 QUALITY CONTROL

- 6.1** **The manufacturer's** Quality Management System shall comply with the IAPMO UES minimum requirements for manufacturer's quality management systems (IAPMO ES-010).
- 6.2** Inspections of manufacturing facilities by an approved certification or inspection agency is required for these products. The inspection agency shall be accredited in accordance with ISO/IEC 17020; the certification agency shall be accredited in accordance with ISO/IEC 17065.

7.0 EVALUATION REPORT RECOGNITION

- 7.1** Evaluation reports shall include the general information required in Section 3.0 of this criteria and allowable loads in accordance with Section 5.0 of this criteria.
- 7.2** The evaluation report shall state that:
- 7.2.1** The roof-mounted seam clamps, attachment brackets, or accessory brackets/components used to attach accessories such as PV mounting systems or snow retention systems to metal roofs shall be structurally compatible with the metal roof. This compatibility shall be determined by an independent engineering review. The evaluation report shall specify the metal roof with which the components are structurally compatible, by including the brand name (where applicable per Section 4 for non-manufacturer-specific profiles), profile, profile thickness, material and coating, based on testing. Galvanic compatibility shall be determined using engineering judgement, recommendations from the snow retention system and the metal roof manufacturers, the building configuration, and in-service environmental conditions.
- 7.2.2** Environmentally exposed system components, including attachment fasteners, shall be fabricated from corrosion-resistant metals having a service life expectancy at least equivalent to the roof itself.
- 7.2.3** Linear thermal expansion of the system shall be considered and accommodated by system design. Thermal cycling of the metal roof system shall not be impeded by the system or accessories.
- 7.2.4** Seam clamp set screws and applicable attachment fasteners shall be installed to the torque specified in the evaluation report using a calibrated torque installation device. The calibration certificate shall be available at the job site for review.

- 7.2.5** Design wind, dead, and snow load forces imposed on metal roof r assemblies, panels and their connections are assumed to be accounted for in the structural design and attachment of the roof panels. The installation of the products and systems attached to the products listed in the evaluation report, including snow and PV mounting systems and associated equipment, may impart new loads, such as downslope drag loads or concentrated point loads, not accounted for during the original roof structural design and attachment of the roof panel design. Snow retention systems shall not be used where the Roof Slope Factor, C_s , for unobstructed slippery surfaces is used in roof structure design in accordance with Section 7.4 of ASCE/SEI 7.
- 7.2.6** Attachment Bracket, Accessory Bracket/Component or Clamp, PV Mounting Systems, and snow retention systems shall be installed in accordance with the manufacturer's installation instructions.
- 7.2.7** All attachment brackets that require penetration of the approved roof covering shall be flashed in accordance with Section 1503 of the IBC and the manufacturer's installation instructions for the roof covering.
- 7.2.8** A statement shall be included in the evaluation report that states which load directions were considered for each product evaluated and the displacement limitation used to determine allowable loads.
- 7.2.9** A statement if the optional fire resistance testing is not performed: The attachment of the brackets/systems evaluated has not been evaluated for fire performance.
- 7.2.10** Special inspections may be required when deemed necessary by building officials in accordance with Section 1705.1.1 of the IBC.

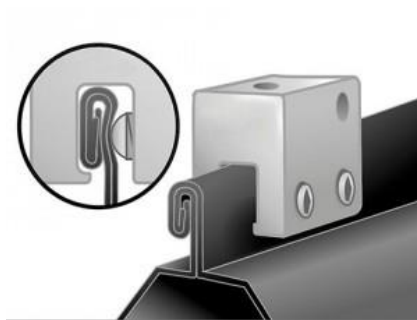
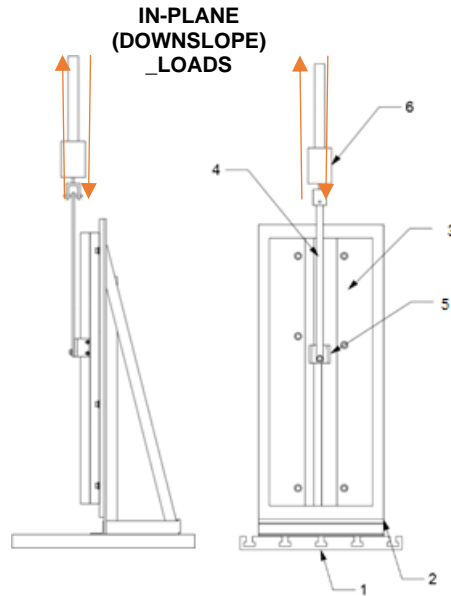
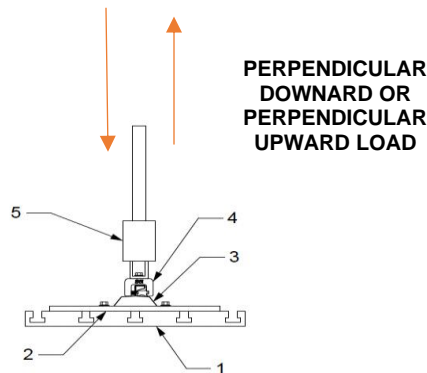


Figure 1: An example of round-point non-penetrating setscrews used to secure a snow-retention seam clamp to metal roof panels.

**Notes:**

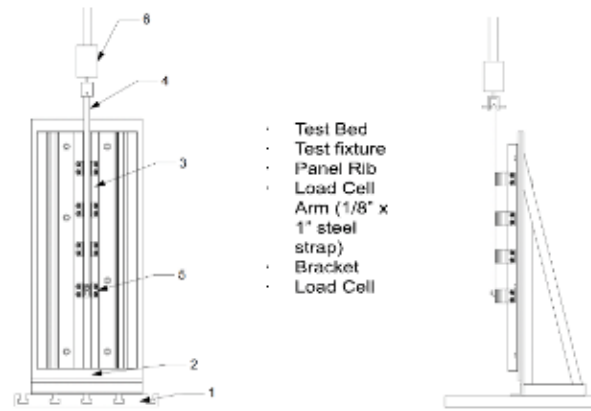
1. Test bed
2. Test fixture
3. Two steel or aluminum roof panels joined with a specific side joint (standing seam) configuration. The standing seam shall be of a type and configuration suitable for its intended use
4. Load cell arm
5. Seam clamps from a roof-mounted rail-type snow retention system attached to the standing seam. The clamp shall be tested and installed with the minimum end distance. For rail-type snow retention systems, the bracket shall be included in the test such that the load cell arm is located at the position of the top rail of the rail-type system (not shown in Figures 1 and 2).
6. Load cell

FIGURE 2 — TEST APPARATUS FOR IN-PLANE (DOWNSLOPE)_LOADS ON SEAM CLAMP

**NOTES:**

1. Test Bed
2. Test Fixture
3. Standing seam
4. S-S! Clamp
5. Load Cell

FIGURE 3 — TEST APPARATUS FOR PERPENDICULAR DOWNWARD OR PERPENDICULAR UPWARD TESTING ON SEAM CLAMP

**Notes:**

1. Test bed
2. Test fixture
3. Roof panel rib. The exposed fastener roofing shall be of a type and configuration intended for use with the roof-mounted rail-type snow retention system.
4. Load cell arm
5. Attachment bracket attached to the exposed fastener rib. The attachment bracket shall be installed and tested with the minimum end distance. For rail-type snow retention systems, the accessory brackets/components shall be included in the test such that the load cell arm is located at the position of the top rail of the rail-type system (not shown in Figures 1 and 2).
6. Load cell

FIGURE 4 — TEST APPARATUS FOR IN-PLANE (DOWNSLOPE) LOADS ON ATTACHMENT BRACKET

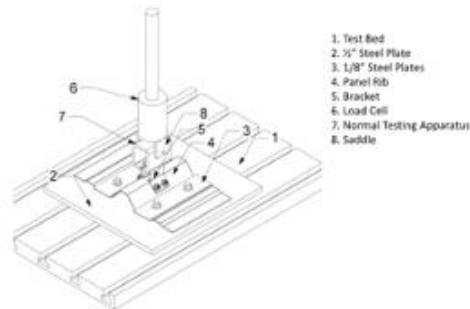


FIGURE 5 — TEST APPARATUS FOR PERPENDICULAR DOWNWARD OR PERPENDICULAR UPWARD LOAD ON ATTACHMENT BRACKET