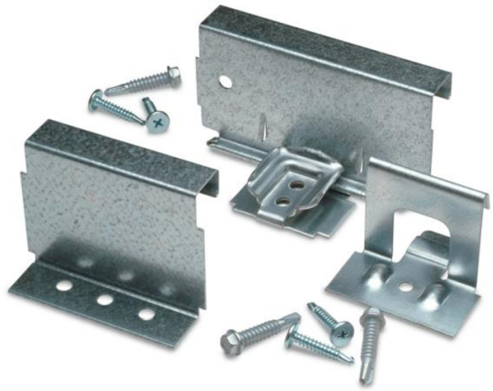
WHITE PAPER

Standing Seam Roof Clips Best Practices Guide



The information herein should be used as a guideline. The roof panel manufacturer or a structural engineer experienced in light-gauge cold-formed standing seam roof systems must be consulted for specific recommendations.

General Overview

Most standing seam panel installations require the use of specific fastening techniques to allow for thermal expansion and contraction while also safeguarding against attachment fatigue. This document focuses on clip-attached style standing seam roof systems, and addresses specific details and concerns for proper selection and use of the connection that anchors the roof panel to the roof panel support element.

Clips and Their Function

The primary function of the clip attachment is to enable dimensional change of the panel without fatigue of its fastening. Dimensional changes to the metal roof occur normally and frequently as a result of environmentally induced changes to the panels' temperature in a linear fashion. This "thermal cycling" occurs from season to season, day to night, hour to hour and even minute to minute as it results from fluctuations in the surface temperature of the panel. These fluctuations are caused by direct solar gain (warming), ambient air temperature changes, precipitation, and/or radiant nighttime cooling. These changes in panel temperatures may range more than 200°F in a season, 150°F in a single day, and 100°F within minutes as cloud cover inhibits direct sunlight and a cool rain begins. To varying lesser severity, thermal cycling occurs tens of thousands of times in a single year, and hundreds of thousands over the life of the roof. (For excellent historical information relating to metal roofing, see MCA's Technical Resource titled "Metal Roofing from (A) Aluminum to (Z) Zinc" by Rob Haddock. Chapter 1 covers history and materials while Chapter 5 covers profiles and profiling equipment).

A properly executed clip attachment enables thermal cycling while also eliminating fastener penetration of the weathering surfaces of the panel. Hence, such systems are considered premium technologies over face-fastened panel designs from a weathering and durability standpoint at a modest increase in cost. Of course the clip attachment must interact with the panel in such a way as to resist, primarily wind induced, design loads. Ideally, the interface also minimizes frictional resistance which can exacerbate "oil canning" and thermal noise.

A secondary function of clip attachment is the aesthetic enhancement of the architectural roof, since fastening of the roof panel is concealed.

These systems are further distinguished by exactly how they accommodate the thermal expansion/contraction of the panels along their length. Standing seam roof panel systems are often installed over structural decks. In other cases these types of roofs are also often installed over open structural framing. In some assemblies, compressible blanket insulation is used between the panels and structure. In other assemblies, rigid board insulation is used between the roof panels and deck material. In many others, there is no insulation at the roof-to-structure junction, but rather a ventilated attic, where the attic floor is insulated. Such variety of configurations also introduces a multiplicity of challenges to the clip requirements and connection interface.

Concealed Fastening Using Clips

Panel systems with hidden clips connect metal panels to the underlying roof sub-structure via an interface within the panel side joints from beneath the top panel surface, thus concealing them from view while accommodating both thermally-induced expansion/contraction as well as resistance to wind-induced uplift pressures. Panel side joints are designed, configured and proportioned to nest precisely with the side joint of the next (neighboring) panel. This interconnection of the panel edges is common with either a male-female interlock of varied geometry, or twin male edges with a separate female cap component. In either case, the “fit" of the clip-to-panel within the seam is critical. The clip must properly grasp the panel element(s) adequately and also introduce no interference within the panel-to-panel mating interface. The panel-to-panel nesting referenced is often carried out through the use of a custom power seaming device, sometimes in combination with a custom hand seaming tool, to accomplish in-place seam folding. Many of the available standing seam systems call for hand seaming (or crimping) at clips, followed by mechanical seaming for the full length of the panel.

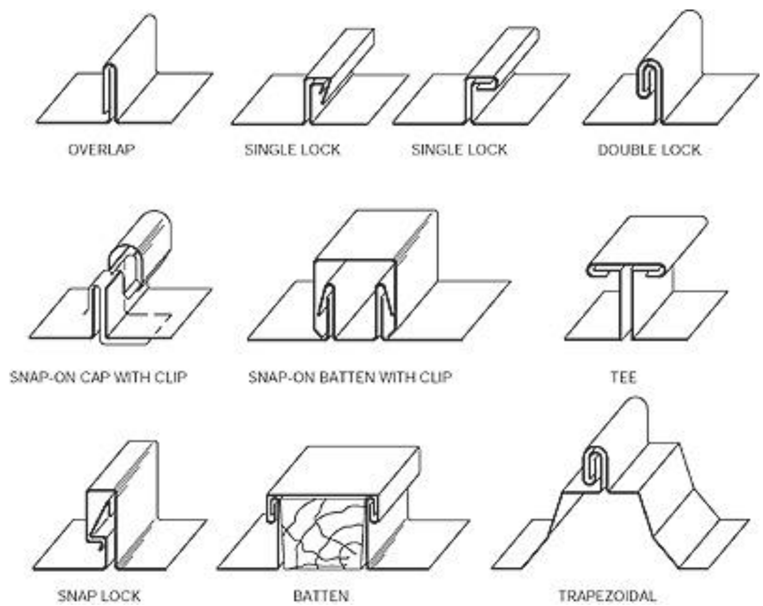
The "hand seaming at clips" procedure provides a temporary hold-down for the panels and greatly reduces the horsepower required for the mechanical seamer to power over a clip location. An infraction of these guidelines can completely downgrade the wind uplift capacity of the roof system and negatively influence the ability of the panel/clip assembly to respond to thermally-induced longitudinal expansion/contraction of the panels. Refer to the MCA’s *Roof Seaming Best Practice Guide*, August, 2015.

A further complication is that some panel systems contain seam sealant between the male and female seam components rendering the seam "hydrostatic" in its performance. In such cases, the clip may breach the seam sealant creating a conduit for moisture infiltration. There are, therefore, some clip designs where the clip is manufactured with an integral sealant. The intent of this precisely "proportioned and placed" clip sealant bead is to, upon the assembly of two mating side joint elements, "marry" with the sealant within the panel joint, providing a dependable, uninterrupted seam seal that can remain watertight while providing the serviceability of repeated thermal cycling as previously described.

Be aware that improper clip (or clip fit) destroys the concept of side joint seal continuity. Additionally, a clip misfit can result in aesthetically objectionable read-through, where the sheet metal is actually deformed and quite visible.

Panel Styles

Panel styles and seaming types vary depending on aesthetics preferences and load requirements. Some examples are shown below:

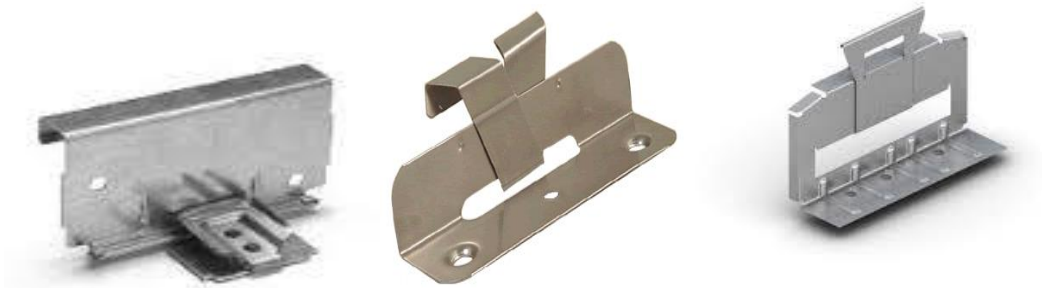


Common clip designs are of two types: one-piece and two-piece sliding. The one-piece clip is affixed directly to the building structure and is stationary. With most snap-fit seam types of panel system the one-piece clip engages the panel in such a way that allows the panel to move along the clip axis inhibited only by minimal friction. When the seam type is machine-folded around the clip, the connection is “fixed” and allows for only minimal differential movement of the roof panel through limited flexure of the clip and/or structure to which it is affixed. For short roof panel lengths, or flexible structures, this may be prudent as accumulated thermal movement of short panels is minimal.

Two-piece sliding clips involve two interlocking but connected components. With such a clip design, the top component engages and moves with the roof panel seam while the lower component is affixed to the structure. Differential movement takes place within the clip and between the two components. This clip type is commonly used on longer length panels and/or in flexible structures. Most clips of this design have some limitation as to the maximum dimension of panel movement.

One-Piece Clip Examples

Two-Piece Sliding Clip Examples



Both clip types are capable of providing some degree of thermal movement for the panel. These clip types are typical, but do not provide the following:

- A definable top flange stabilization (strutting) for panel structural support members (i.e. purlins). Lateral stability of purlin flanges should be accomplished via deliberate structural bracing
- A definable level of "in-the-plane-of-the roof" diaphragm stiffness

Panels will tend to migrate under the influence of drag loads which develop via naturally-accumulated gravity-induced live and dead loads (walking, snow, wind, etc.) Panels must be adequately fixed to the building structure at a single location to resist such forces. This can be accomplished through the use of “fixed clips” or by positively screw-fastening the roof panel at a specific “point of fixity”.

Proper Clip Selection Criteria

Items to consider when considering clip type:

- Clip must be perfectly proportioned and shaped for proper clip/panel interface (i.e. is the clip designed for the panel to which it is being applied?)
- Clip must be proportioned and shaped so there is minimal "read through" (panel transfer) as a result of the mechanical seaming or snap-fit process.
- Interchangeability between panels and clips should only be done after engineering evaluation done by a registered design professional and/or testing.
- Engineering design, frequently called a clip analysis, must be done to determine clip spacing for the various zones on a roof. (i.e. field of roof, leading/trailing edges and outside corner zones) This design or analysis should be done by a registered design professional if required by the local code and will determine the adequacy of clip travel and the movement capacity versus the maximum degree of expected longitudinal expansion/contraction. Lack of attention in this area can lead to panel buckling, clip damage, fastener distress and objectionable noise to room side. Also, fixed clips or a fixed connection point must be established both to control the direction of panel movement and to prevent panels from shifting, or "clutching" off the roof. This could require fixity to avoid expansion without contraction leaving the panel no slide capability.

It is important to note that standing seam roof system clips (designs and configurations) are specific to the dimensional characteristics and seam design of a particular metal panel profile and often the manufacturer.

For installed panels to perform properly, the clips, whether one or two-piece, must have a precise (non-binding) fit with the panel and consist of the proper material grade and gauge (or gauges for a two-piece clip). Additionally, in the case of the two-piece clips, the components should have a smooth interaction, devoid of excessive frictional resistance.

The clip component is critical to the performance of the panel, such that any clip deviation, no matter how subtle, can negate any behavioral claims that exist for the roof system. Using the proper clips on a standing seam roof panel system will allow for the preservation of manufacturer’s load handling claims and test results.

The wind uplift strength determination (or categorization) for standing seam panel systems with specific clips is documented by one or more of the following testing protocols:

- Factory Mutual FM4471
- Underwriters Laboratories UL580 and UL1897
- ASTM E1592

Today the ASTM E1592 protocol is the most recognized wind uplift assessment failure tool for testing of standing seam metal roof assemblies.

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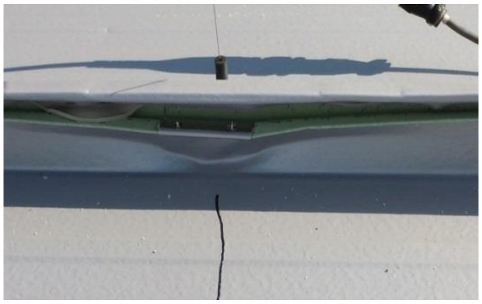
Examples of Clip Failure Modes



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Other reasons where clips can cause significant failure on metal roofs include:

- Improperly matched panels and clips
- Improper panel alignment
- Moveable tab is not centered to allow maximum clearance
- Improper raw material used while manufacturing clip
- Improper fastener selection regarding to dissimilar materials or corrosive environments
- If applicable, improperly placed and proportioned clip sealant compatible with panel sealant (see below note regarding sealant)

Note: When structural standing seam roof panels span over open framing, the levels of air infiltration/exfiltration resistance and water infiltration resistance are directly correlated to the following factors:

- Proper sealant for conditions within the panel (i.e. cold weather installations)
- Compatible sealant placement within the clip while
- Maintaining uninterrupted sealant continuity via bead alignment
- Fasteners used not suitable for clip design which may cause visual read through the panel. This may cause visual dimpling and/or erosion of the panel base metal or metallic coatings. Similar situations can occur if fasteners are not seated squarely.

Installation to Ensure Bead Continuity

If a clip hook (the panel capture segment of the clip), contains a pre-installed sealant bead, the installer must place a small "bud" of compatible sealant at each end of that sealant bead prior to setting the clip hook over the panel element. This set of sealant "buds" will marry into the panel sealant, protecting against a seal "skip".

Other Considerations

Clips must have enough travel in either direction, use a two-piece clip, or proper clearances to develop a “running fit relative to panel” (one piece clip) to address the computed amount of system in-place longitudinal expansion/contraction. Some two-piece panel clips have an integral centering devise that prevents an installation where the traveling hook element is “bottomed out” at the time of installation. This feature prevents “travel” limitations and in- service jamming.

When conducting a fastener pull out analysis for specific wind uplift pressures, include the pry effect administered to the fastener(s) via the leverage applied by the clip base.

Relating to seismic inspired building racking, sliding clips will not behave as a shear resisting in plane diaphragm. The system “floats” and therefore this style roof is usually not affected by lateral seismic activity.

Summary

There are many details that need to be considered when choosing the correct clip to achieve the required design loads and functionality. It is always recommended to consult with the panel manufacturer or design engineer to ensure proper clip selection or recommendations.

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