

# **SHEET METAL ROOF TEST REPORT**

## **Introduction**

The time tested performance of the double lock standing seam and batten seam metal roofing is demonstrated by thousands of squares successfully installed by SMACNA contractors over the last century. With the proliferation of pre-manufactured roof systems and the specification requirements of UL Standard 580 and Factory Mutual performance criteria, the SMACNA Architectural Sheet Metal Committee determined it was necessary to test the performance of the metal roof geometries depicted in the Architectural Sheet Metal Manual.

The roof specimens were assembled in accordance with the SMACNA Architectural Sheet Metal Manual. Testing was performed at the Construction Consulting Laboratories in Carrollton, Texas. All tests were witnessed by members of the Architectural Sheet Metal Committee of SMACNA.

It was the intent of the Committee to subject the metal roofing to performance tests as severe or more severe than those required by the industry.

The test specimen evaluated one inch high double lock standing seams and 1 1/2 inch batten seams. Transverse seams were used in unsealed flat lock form and in soldered form.

Although the SMACNA manual does not have criteria for air leakage control, at the onset air infiltration and exfiltration measurements were attempted but difficulties with the technique and chamber calibration made the results unreportable. It was apparent, however, that fascia edge conditions contribute more air leakage than roof surface seams.

Each metal roofing system was subjected to a static-pressure/water-penetration test. This test is similar to tests performed on curtain walls and is a severe test of metal roof seam performance. In another test the effects of dynamic wind loads induced by a slipstream of air generated by a turboprop engine were evaluated while a constant spray of water was introduced over the surface of each metal roof specimen. The metal roof specimens were also subjected to structural load tests. Severe incremental positive and negative (uplift) loads were induced onto the outer surface of the metal roofing in an attempt to demonstrate the ability of SMACNA metal roof configurations to resist (static pressure) uplift loads exceeding those imposed by the UL 90 classification requirements.

# METAL ROOF DESCRIPTION

The systems were constructed as follows: (see diagrams)

<b>Test Specimen</b>	6 ft by 19 ft 5 inches
<b>Roof Pitch</b>	4/12
<b>Seam Height</b>	1 inch standing; 1 1/2 inch batten
<b>Pan Width</b>	20.75 inches at center, 15.25 at rakes
<b>Seaming</b>	double lock standing seam or batten seam conforming to SMACNA's Architectural Sheet Metal Manual
<b>Fasteners</b>	2 inch wide cleats at 12 inch centers, nailed with 2 ring shank nails per clip
<b>Underlayment</b>	Rosin saturated building paper, 5 lbs per 100 sf lapped 2 inches and nailed approximately 36 in. o.c.  <b>Over</b> 30 lb. felt, lapped 2 inches and nailed 24 inches o.c. <b>Over</b> 1/2 plywood, APA Rated, anchored with #12 fasteners 18 inches o.c. <b>Over</b> 3.5 inch thick isocyanurate insulation with perlite board laminated, anchored with #12 fasteners 5 inches in length <b>Over</b> 22 gage 1.5 inch steel deck, Type F, welded to structure 12 inches o.c. at edges and 18 inches at center supports, laps fastened with #12 screws

Maximum sheet length used was 120 inches. Transverse seams were used to provide pan-lengths as indicated on diagrams. Edge conditions were flashed with cleated 5 inch fascia, lapped 4 inches at the rake and continuous at the eave and ridge. The panels and associated flashings were fabricated and tested in each of the following metals.

## **16 oz. Copper**

1. Standing Seam
2. Batten Seam

## **24 gage Galvanized Steel**

1. Standing Seam

## **0.032 inch Aluminum**

1. Standing seam

## **0.015 inch Terne-Coated Stainless Steel**

1. Standing Seam

## **STATIC WATER PENETRATION TEST**

The static water penetration test is similar to ASTM E331-86, which is used for curtain walls. This test subjects the specimen and chamber to a constant vacuum pressure equivalent to a 2 inch water head pressure. Water is uniformly sprayed on the roof at a rate of 5 gallons per hour per square foot of surface. This test simulates what could be expected in a severe storm condition with high winds and rapidly changing exterior pressures.

An observer would remain inside the test chamber for the 15 minute duration of the test to observe and record any water leakage through the system.

<b>Duration of test</b>	<b>15 minutes</b>
<b>Vacuum on inside of chamber</b>	<b>10.4 psf (2 inches of water)</b>

### **Results**

All systems passed. No uncontrolled water infiltration was observed for any of the metal types or systems with the exception of the eave and rake junction with the chamber on the TCS roof system. This was attributed to imperfect connections of the fascia junction.

## **DYNAMIC WATER PENETRATION TEST**

For this test the roof system is subjected to dynamic loading and water exposure similar to what the roof would go through in a rainstorm. The test is similar to the Architectural Aluminum Manufacturers Association (AAMA) Standard 501.1-83 for metal curtain walls.

In this test, water is applied to the exterior of the test specimen at a minimum rate of 5 gallons per hour per square foot of roof surface while an 80 to 85 mile an hour slipstream of air is applied. The slipstream of air flow is produced by a turboprop engine positioned approximately 20 feet from the eave of the specimen.

An observer inside the chamber inspects the interior of the specimen during the test and the exterior of the system is inspected after the test.

**Duration of test**

**15 minutes**

**Dynamic load produced by an airstream induced from a turboprop engine in combination with 5 gpm per square foot water spray**

### **Results**

All roof systems passed. No uncontrolled water infiltration was observed for any of the metal types or systems with the exception of the eave and rake junction with the chamber on the TCS roof system. This was attributed to an imperfect connection of the fascia junction.

No system damage or deformation occurred.

## UNIFORM STRUCTURAL LOAD AND DEFLECTION TESTS

For this test series, a second pressure chamber was applied over the metal roof specimen but was not in contact with it. Vacuum and blower pumps and ducting were connected to the chambers to create negative pressures (uplift pressures) on the top of the roof and positive pressures (downward loads) on demand.

All systems were tested in load intervals, both positive and negative, of 20 psf, 40 psf, 60 psf, and 90 psf. Each load level was applied, held for ten seconds then released to atmospheric level. All systems were subjected to negative loads of 125 psf. The galvanized steel, aluminum, terne-coated stainless steel and the copper batten seam system were subjected to a 150 psf uplift load. The terne-coated stainless steel and the copper batten seam systems were taken as high as 190 psf uplift load in an attempt to take the systems to structural failure. Deflection recordings were taken at the standing seam and at the midpoint of the panels.

**Table of Maximum Loads**

<u>Material Type</u>	<u>Seam Style</u>	<u>Max. Load</u>
Aluminum	Standing	150 psf
Copper	Standing	190 psf
Copper	Batten	190 psf
Galvanized	Standing	150 psf
Terne-Coated Stainless	Standing	190 psf

### Comments

1. The maximum load associated with a UL Standard 580 class 90 rating is 105 psf.
2. The centers of the pans deflected as much as 3/4" at loads up to 125 psf.
3. Upon removal of the top pressure chamber close inspection of metal systems revealed no permanent deformation or damage or loosening of fasteners.
4. The capacity of the pressurization apparatus was exceeded before structural failure of the roof system occurred.

## CONCLUSIONS

From these tests one can conclude that the correct installation of the SMACNA details on custom fabricated metal roofing will perform adequately when subjected to simulated storm conditions.

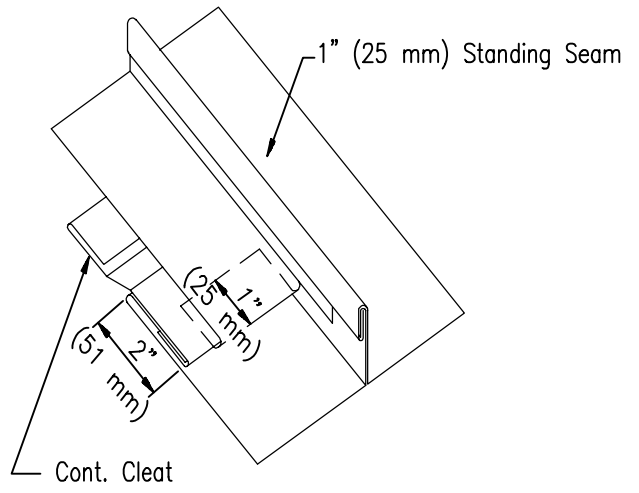
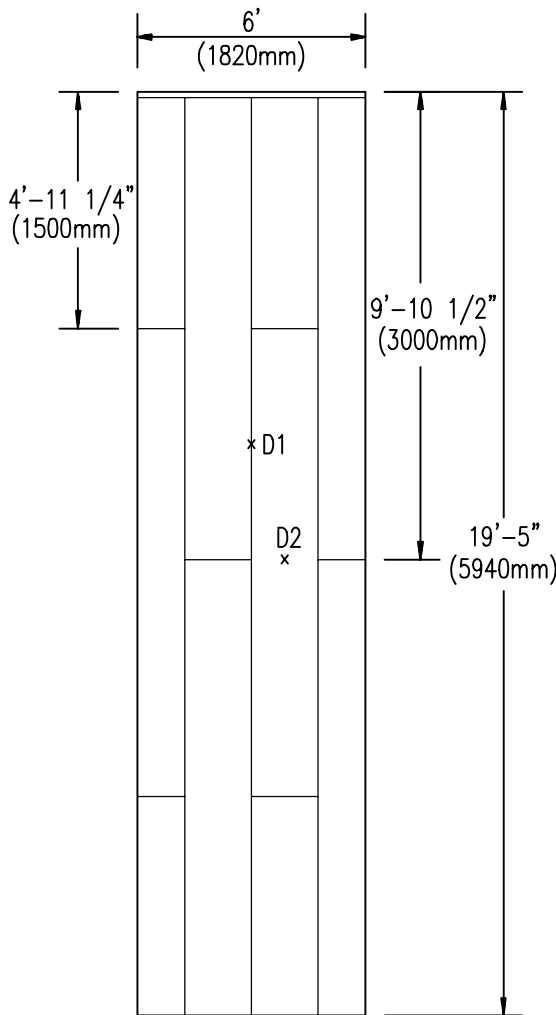
The SMACNA roof assemblies were tested in loading situations superior to the demands of the UL 90 requirements. We did not test the roof systems with Underwriters Laboratories because this would have locked the particular geometry and makeup to precisely what was tested. Since our systems are for customized architectural roofs that allow the designer to work within a series of variables, we tested what was felt to be the more vulnerable extremes.

In general, thin architectural metal roofing will work in concert with the metal decking and continuous nailable substrate to resist both positive and uplift pressures applied to the roof system.

- From the tests we found the critical areas of metal roof design to be the transitions or edge conditions. Special care must be taken at the edge conditions to seal the roof underlayments to the vertical walls and to tightly fit the metal roof to the edge conditions.
- Roofing felts are a necessary secondary barrier for the metal roofing system and should not be eliminated.
- The transverse seams should be as detailed on the Architectural Sheet Metal Manual with full closure and continuous cleating from standing seam to standing seam. Sealant at the corners of the fold will prevent moisture from entering behind the panels.

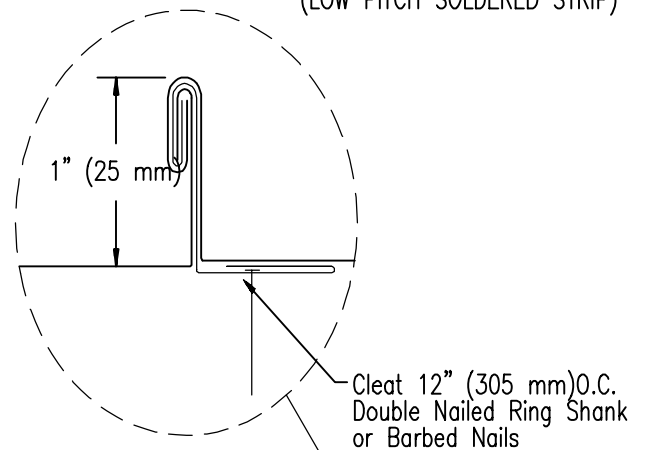
The SMACNA systems that have had such a satisfactory service record are supportable by laboratory tests.

DIMENSIONS WERE ADJUSTED TO FIT TEST CHAMBER



**TRANSVERSE JOINT**

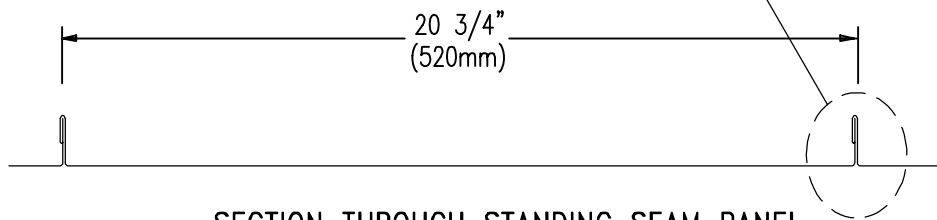
SMACNA FIGURE 6-5  
DETAIL 3A WAS USED ON TCS.  
(LOW PITCH SOLDERED STRIP)



**PLAN**

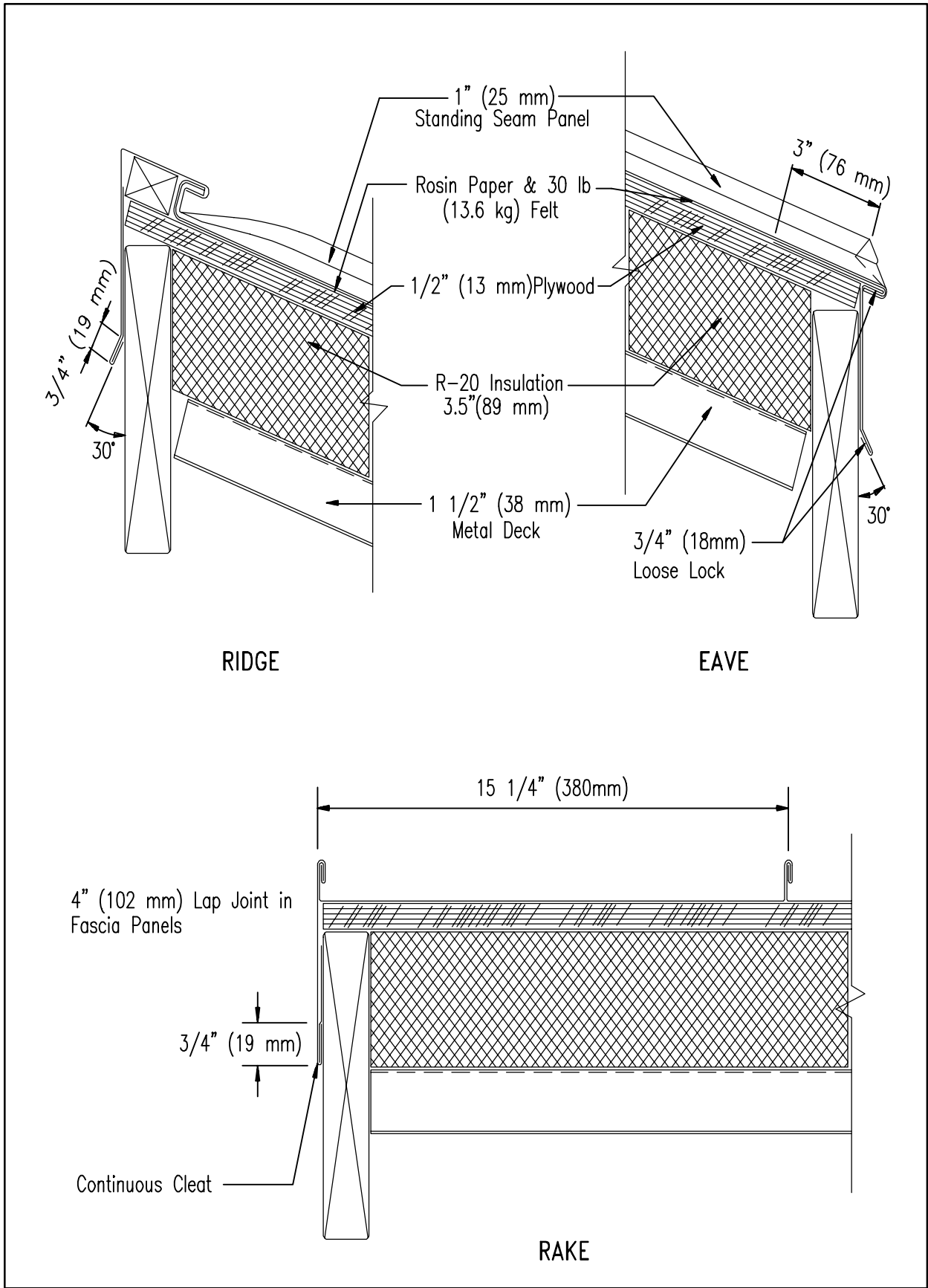
Roof Slope 4:12

D1 & D2 ARE METAL DEFLECTION MEASUREMENTS



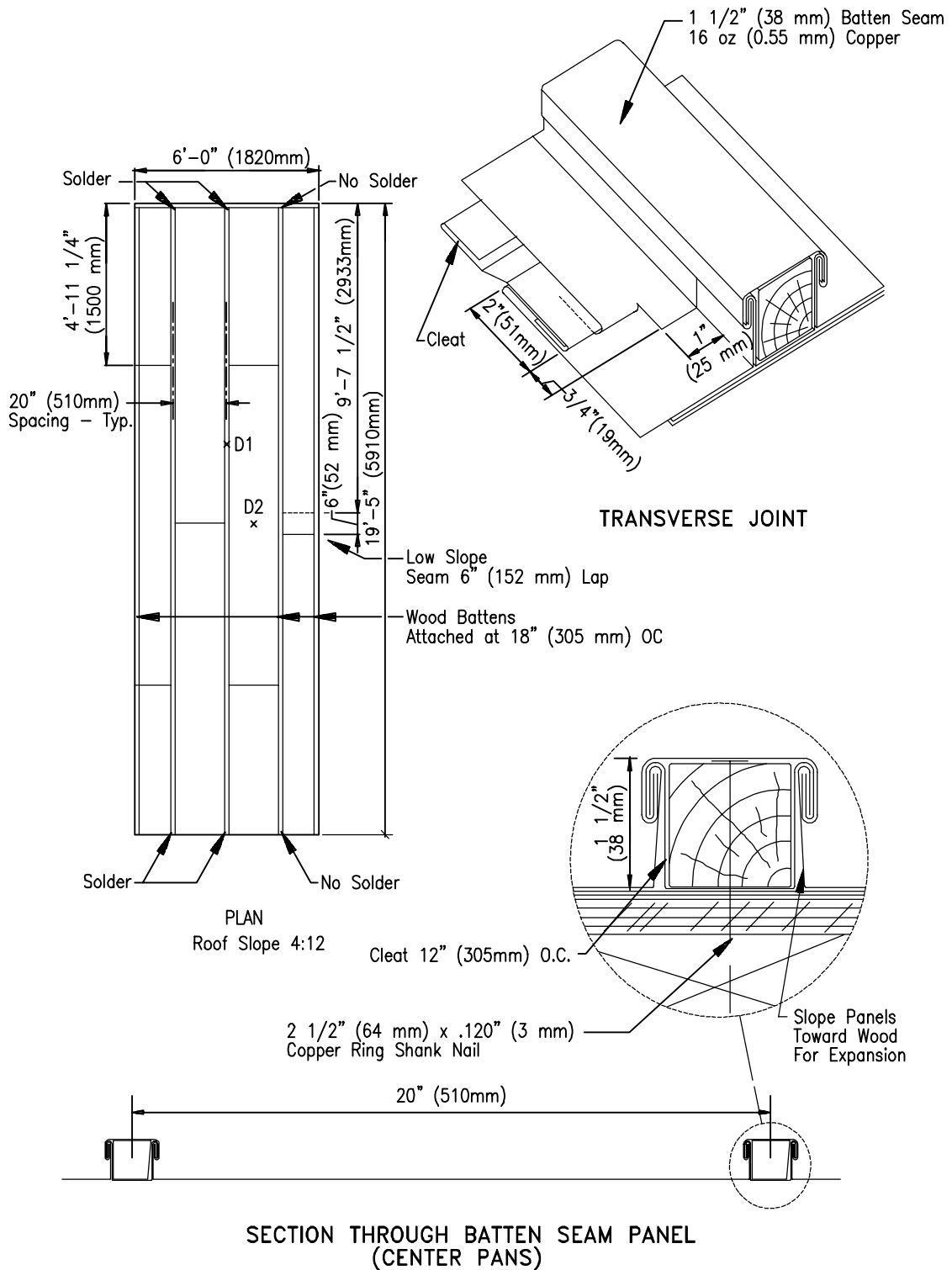
**SECTION THROUGH STANDING SEAM PANEL  
(CENTER PANS)**

**SHEET METAL ROOF TEST REPORT FIGURE 1**



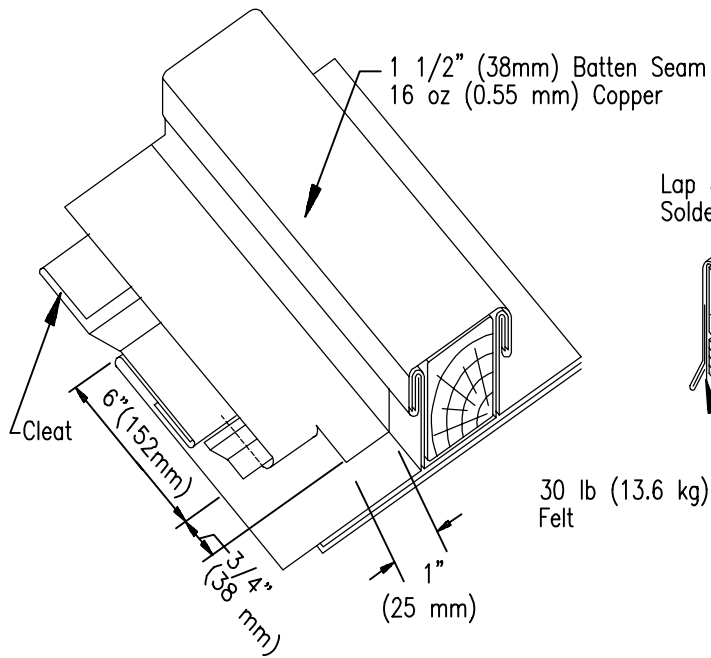
**SHEET METAL ROOF TEST REPORT FIGURE 2**



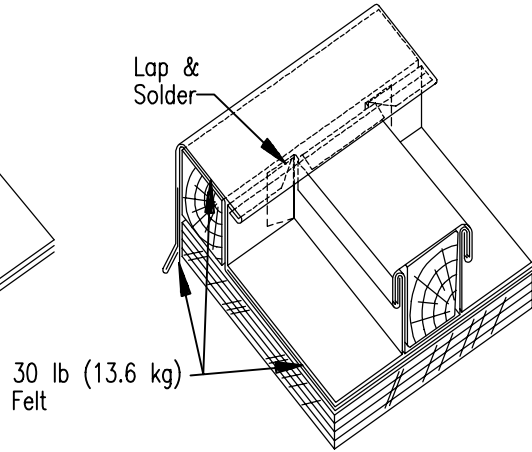


- NOTES: 1. Dimensions were adjusted to fit test chamber.  
 2. D1 and D2 are metal deflection measurement points.

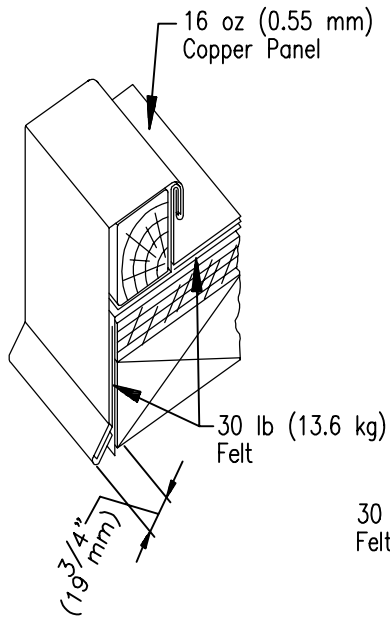
**SHEET METAL ROOF TEST REPORT FIGURE 3**



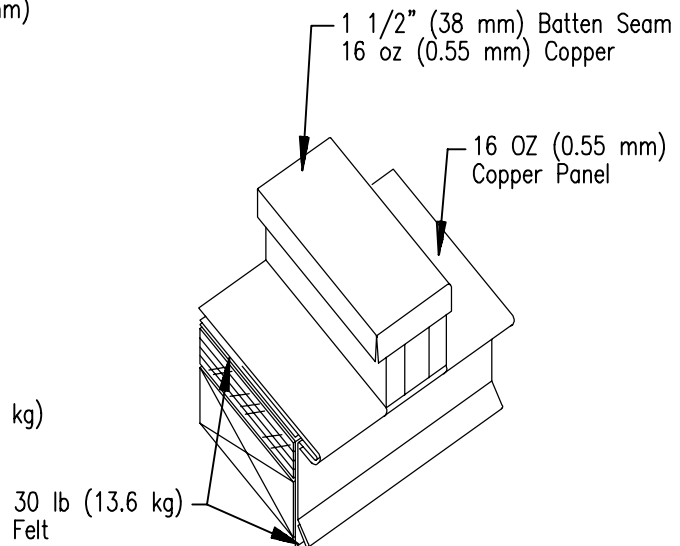
**TRANSVERSE JOINT**  
(Low Pitch)



**RIDGE**  
(Hip Similar)



**GABLE**



**EAVE**