CYCLONE TESTING STATION

**COLLEGE of SCIENCE and ENGINEERING**

**James Cook University**


# REPORT NO. TS1256

**22 April 2022**

## Simulated Wind Load Strength Testing of Acoustic Panels

**By**


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**for**

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NATA Accredited Laboratory Number 14937
Accredited for compliance with ISO/IEC 17025 - Testing.

# 1 Introduction

The aim of this test programme was to perform static and cyclic simulated wind load strength testing of Acoustic Panels manufactured by *Soundproof Warehouse Pty Ltd.* The test panels were loaded in accordance with the *AS 4040.2* static wind load strength and the *AS 4040.3* cyclic wind load strength test regimes. The testing was performed with the use of new test materials, supplied by the client.

The simulated wind load strength tests were conducted in the airbox testing facility located in the Wind Tunnel Building at James Cook University. The Cyclone Testing Station is a NATA accredited testing laboratory. All trials for this testing programme were performed in accordance with NATA requirements.

# 2 Test Programme

A programme of static and cyclic simulated wind load strength testing was conducted. A summary of the test programme is provided in Table 1.

**Table 1:** Test Programme Summary

<table>
<tr><th>Trial No.</th><th>Panel Size (mm)</th><th>Fastener Specification</th><th>Fastener Arrangement</th><th>Test Regime</th></tr>
<tr><td>SS1</td><td rowspan="2">2,400 × 1,200 × 61</td><td rowspan="2">M10 × 90 mm Gr 8.8 Bolts with nuts, flat washers and spring washers</td><td rowspan="2">12 bolts in total (six on each long side) through holes 20 mm in from edge of frame.</td><td>AS 4040.2 Static Wind Load Strength</td></tr>
<tr><td>C1</td><td>AS 4040.3 Cyclic Wind Load Strength for Walling Applications</td></tr>
</table>

# 3 Acoustic Panels, Fasteners, Supports and Installation Details

## 3.1 *Acoustic Panels*

The *Acoustic Panels* were stated to have been fabricated primarily from nominally 1.00 mm Base Metal Thickness (BMT) aluminium alloy skins encased in a frame. An average thickness of 0.95 mm was measured on the skins (based on three measurements taken from samples SS1 and C1). The total panel width is nominally 1,200 mm and its overall length is nominally 2,400 mm. The frame surrounding the acoustic panel skins was a “C section” aluminium extrusion with dimensions of 61 mm high with flanges 32 mm wide and 3 mm wall thickness. The outer skin of the panel was a solid aluminium sheet. The inner skin of the panel was perforated in an equilateral triangular pattern with nominally 2.45 mm holes spaced at nominally 6.05 mm centres. In between the skins were layers of acoustic insulation, specified to include mineral wool and a rubber compound sheet. Figure 1 is a photograph that shows the Acoustic Panel mounted in the test rig.

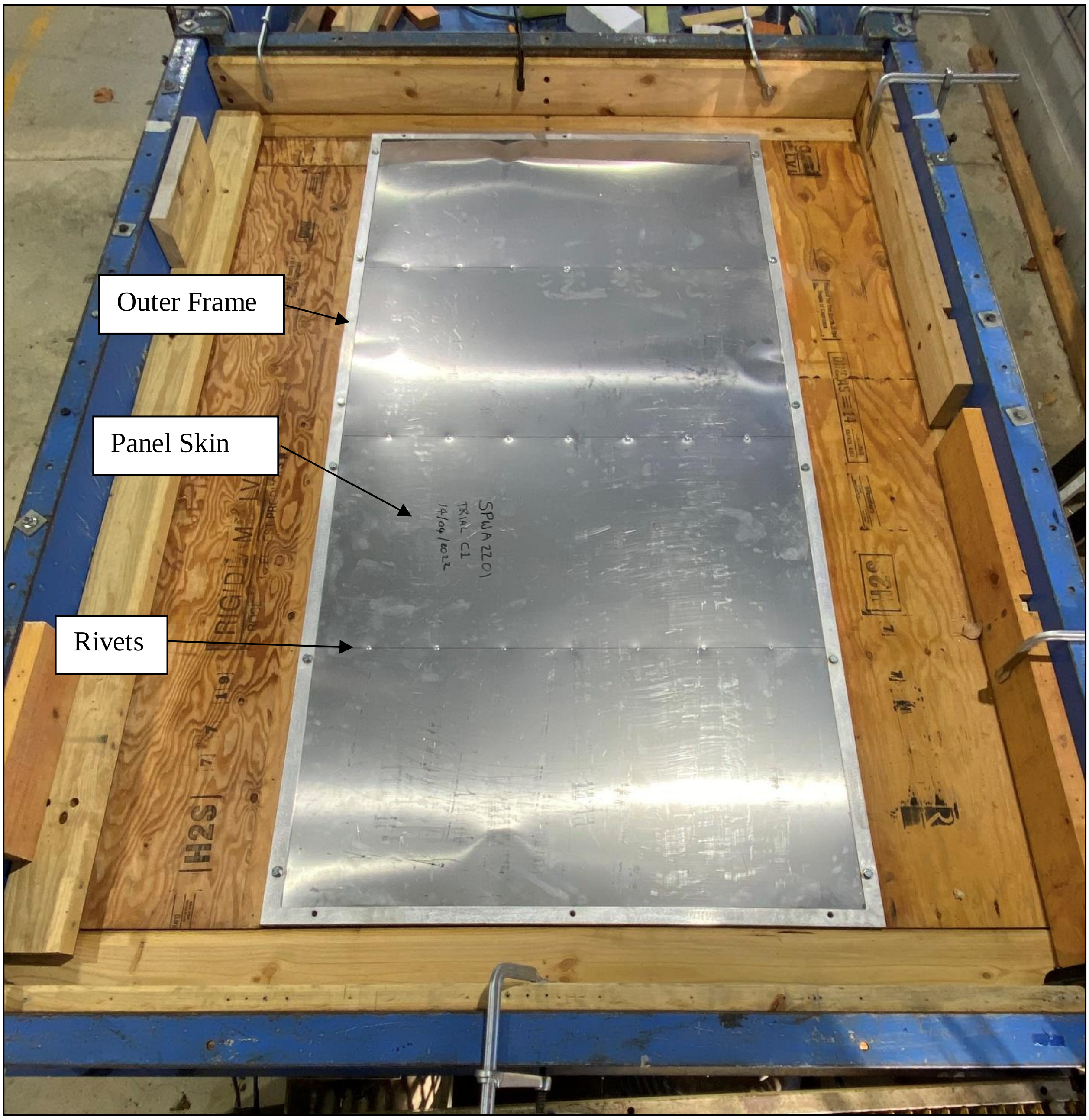


**Figure 1:** Photograph of an Acoustic Panel mounted in the airbox test rig.

The frame was fitted with tubes welded in place connecting the bolt holes in the flanges. The aluminium sheets forming the skins of the panel were drilled at the locations of the tubes. The connecting tubes provided the structural support for the skins at the edges of the panels. Three pressed channels were installed transversely across the panel at approximately 600 mm spacings providing support for a series of eight pop rivets fixing the skins to the channels in the interior region of the panel (as shown in Figure 1). The pop rivets were installed at approximately 150 mm spacing across the channels. Figure 2 is a photograph that shows the connecting tubes installed in the "C section" frame of the acoustic panel.

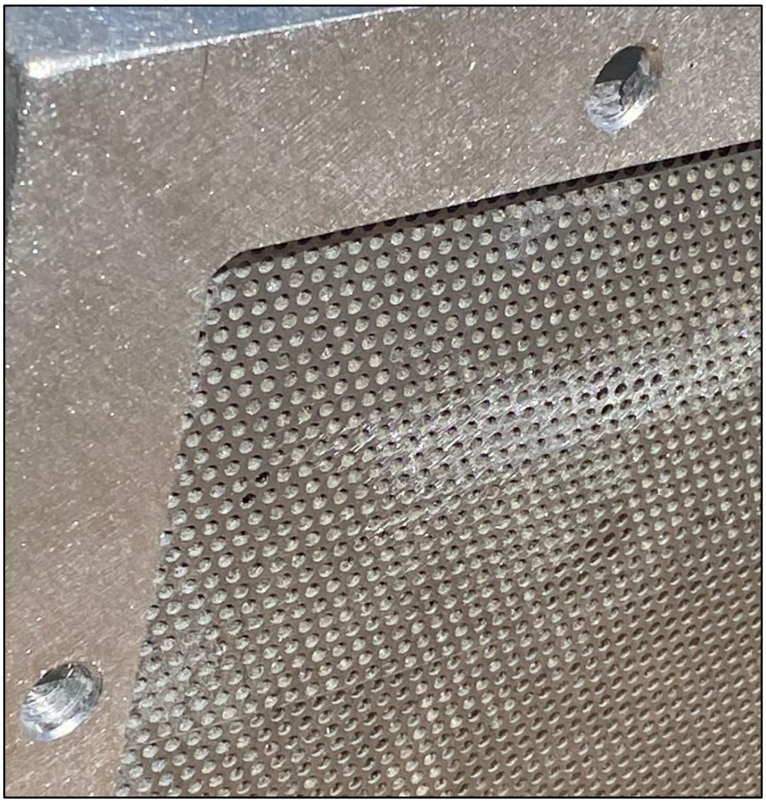

**Figure 2:** Photograph showing the connecting tubes in the "C section" frame of the panel.

### 3.2 Fasteners

The fasteners used to fix the panels to the supports were M10 × 90 bolts with a flat washer under the head, a flat washer and a spring washer were installed under the nut. Figure 3 shows a photograph of a typical bolt with nut and washers.


**Figure 3:** M10 × 90 mm bolt and nut with flat and spring washers

### 3.3 Support Details

The supports used for all trials in this test programme were 1.5 mm BMT C15015 purlins. Note that the strength of these supports was not being evaluated in this programme.

### 3.4 Installation

For both trials, the acoustic panels were bolted to the C15015 support members at six (6) locations on each long side of the panels. The C15015 support members were installed to run across the airbox test rig. No fasteners were installed in the top and bottom sections of the panel frames. Figure 4 shows a photograph of a typical installation of the acoustic panels in the test rig.

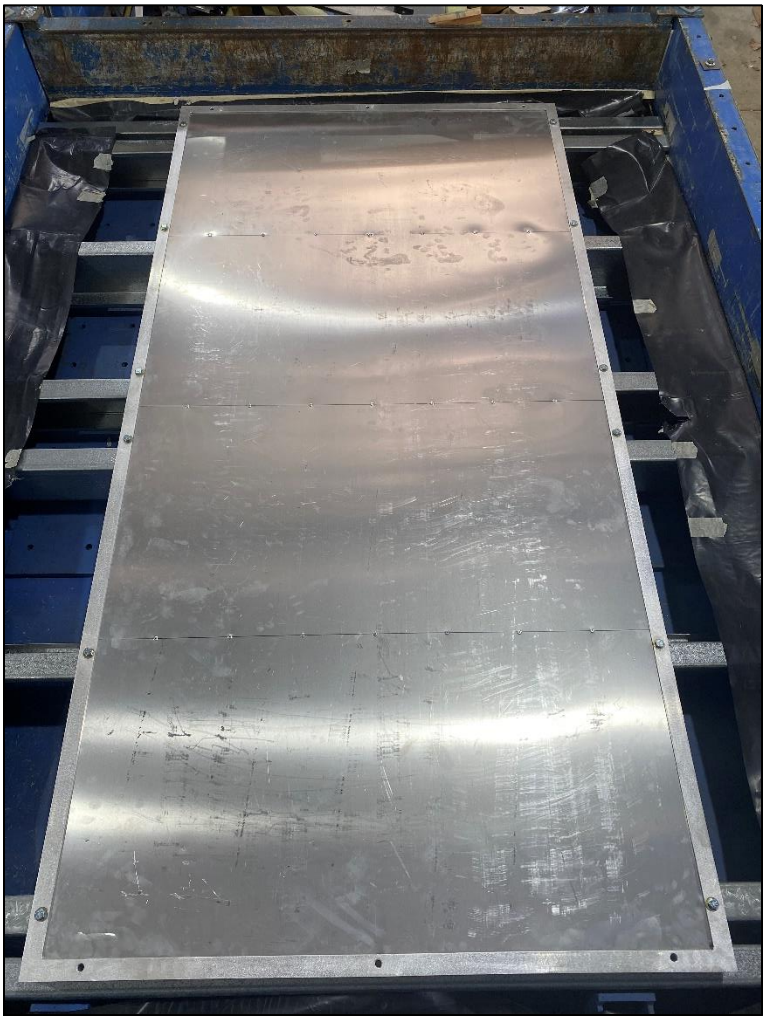

**Figure 4:** Photograph of a typical Acoustic Panel installation in the airbox test rig.

# 4 Test Apparatus and Procedure for Simulated Wind Load Tests

## 4.1 Test Set Up in Airbox Test Facility

The test specimens were installed in the Cyclone Testing Station's airbox test facility. The airbox is an open-topped pressure chamber with a maximum test width of 2040 mm and an adjustable length of up to 10 m. For this testing programme, the panel supports were set up to run across the width of the airbox and the spacing between supports varied according to the bolt hole spacings in the sides of the specimens.

## 4.2 Simulated Wind Load Strength Testing

A uniform pressure was applied to the internal face of the outer skin by one or two large centrifugal fan(s) blowing air into the airbox chamber. This pressure simulated the combined effect of both the outward pressure (suction) and the internal positive pressure acting on the panels. A pressure transducer measured the applied load on the test panels.

## 4.3 Allowance for Self-Weight of Panels

The wall system is normally mounted vertically, but were tested in a horizontal position Therefore, the indicated test pressure applied was adjusted to compensate for the self-weight of the panel system. All test pressure figures stated subsequently are net pressures that allow for the self-weight of the system.

## 4.4 Static Simulated Wind Load Strength Testing

### 4.4.1 General

The static simulated wind load strength testing was performed in accordance with *AS 4040.2-1992 (Incorporating Amendment No. 1), "Methods of Testing Sheet Roof and Wall Cladding, Method 2: Resistance to Wind Pressures for Non-Cyclone Regions"* as stipulated in Clause 5.5.2 of *AS 1562.1, "Design and installation of sheet roof and wall cladding, Part 1: Metal"*. The test specimen was subjected to increasing pressures in appropriate increments and each pressure was held constant for a period of 1 minute. This procedure was repeated until failure of the test specimen, or the maximum capacity of the airbox test rig was reached.

### 4.4.2 Acceptance Criteria

Clause 6.3 of *AS 4040.2* requires that the test pressure must be held for 1 minute. However, as the test method is for an Ultimate Limit State design criteria, the test specimen can show signs of distortion and permanent deformation and still be considered a successful outcome.

The last reading at which the test specimen was able to support the load for 1 minute was used to calculate the Ultimate Limit State design pressure.

## 4.5 Cyclic Simulated Wind Load Strength Testing

### 4.5.1 General

The cyclic simulated wind load strength testing was performed in accordance with *AS 4040.3-2018, "Methods of Testing Sheet Roof and Wall Cladding, Method 3: Resistance to Wind Pressures for Cyclone Regions*". Cyclic loading was achieved by opening and closing pressure dump valves.

### 4.5.2 *AS 4040.3* Fatigue Loading Sequence for Wall Systems

The cyclic loading sequence used in this test programme was performed in accordance with the cyclic testing regime specified in *clause 6.3* of *AS 4040.3-2018, "Methods of Testing Sheet Roof and Wall Cladding, Method 3: Resistance to Wind Pressures for Cyclone Regions*" for wall cladding. The test pressure ($P_t$) for Ultimate Strength Limit State is specified as being equal to the design pressure for Ultimate Limit State divided by a material capacity reduction factor. A material capacity factor of 0.9 was adopted (as recommended by *AS 4040.3-2018)*. The loading sequence is presented in Table 2, where $P_t$ is the test pressure.

**Table 2:** *AS 4040.3* Fatigue Loading Sequence

| No. of Cycles | Load |
|---|---|
| 8000 | 0 to 0.40 $P_t$ |
| 2000 | 0 to 0.50 $P_t$ |
| 200 | 0 to 0.65 $P_t$ |
| 1 | 0 to Ultimate Load |

For one test sample, *AS 4040.3-2018* specifies an Ultimate Load of 1.30 $P_t$ for the Single Load Cycle. If either two or three identical tests are performed, then the Single Load Cycle value to be applied reduces to either 1.20 Pt or 1.00 Pt, respectively, but all of the tests must support the smaller load. Note that the single load test cycle must be supported for 1 minute. For this test programme an Ultimate Load of 1.30 $P_t$ was used for the Single Load Cycle.

### 4.5.3 Acceptance Criteria

The test specimen, including the acoustic panel, its connections and immediate supporting members shall be subjected to the relevant fatigue loading sequence and must be capable of remaining in position notwithstanding any permanent distortion, fracture or damage that might occur in the sheet or fastenings, without loss of load carrying capacity.

### 4.5.4 Target Test Pressure

The target test pressure in this testing programme was approved by the client prior to performing the test.

# 5 Results

## 5.1 Static Simulated Wind Load Strength Testing

One static simulated wind load strength tests was performed. A summary of the static strength test result is provided in Table 3. For photographs of damage see Appendix A.

**Table 3:** Static Simulated Wind Load Strength Testing Results

| Trial No. | Date Tested | Max. Pressure Held for 1 Minute (kPa) | Max. Pressure Applied (kPa) | Observations |
|---|---|---|---|---|
| SS1 | 25 Mar 2022 | 6.23 | 6.23 | End of outer skin pulled away from tubes in surrounding frame. |

## 5.2 Cyclic Simulated Wind Load Strength Testing

One cyclic simulated wind load strength test was performed. A summary of the test result and observations is provided in Table 4.

**Table 4:** Cyclic Simulated Wind Load Strength Testing Results

| Trial No. | Date Tested | Test Pressure $P_t$ (kPa) | Proof Load Test Pressure 1.3 $P_t$ (kPa) | Results and Observations |
|---|---|---|---|---|
| C1 | 14 Apr 2022 | 4.47 | 5.80 | **Pass**. Slight crinkling of skin at center of ends of outer skin. |

# 6 Limit State Design Wind Capacities

## 6.1 Determination of Non-Cyclonic Ultimate Limit State Design Wind Capacities

The recommended Ultimate Limit State design wind capacities for the cladding for non-cyclonic regions can be determined by using an approach based on that specified in the Australian standard *AS 4040-1992, "Methods of Testing Sheet Roof and Wall Cladding"*. This standard specifies that the test pressure to be supported shall be equal to the Ultimate Limit State design wind pressure multiplied by the material variability factor from Table 5.1 in the Australian standard, *AS 1562.1-2018, "Design and Installation of Sheet Roof and Wall Cladding, Part 1: Metal"*. The material variability factor was dependent on the coefficient of variation of structural characteristics ($V_{sc}$) and the total number of units to be tested. An increase in the number of units to be tested results in a reduction of $k_t$ and an increase in the final design capacity.

As the tests were to evaluate the strength of a fabricated metal panel a coefficient of 10% may be assumed for the acoustic panel strength testing, as recommended in Note 2 of Table 5.1.

For walling test panels, each panel with perimeter fixings can be counted as a "unit to be tested". For this test programme, a single test specimen was set up to be tested. Therefore, a total of one (1) "units to be tested" can be counted and the material variability factor adopted was 1.46.

### 6.1.1 Recommended Non-Cyclonic Ultimate Limit State Design Wind Capacities

The Ultimate Limit State design wind pressure capacities can be back calculated from the static test results by dividing the lowest of the highest test pressure held for 1 minute by each specimen by the material variability factor. The recommended Ultimate Limit State design capacity for non-cyclonic regions is summarised in Table 5. Note that the design capacity is only applicable for the acoustic panel geometry, fastener types and support details, as used in this testing programme.

**Table 5:** Recommended Non-Cyclonic Ultimate Limit State Design Wind Capacity

| Panel Thickness (mm) | Panel Fixing Configuration | Recommended Non-Cyclonic Ultimate Limit State Design Wind Capacity (kPa) |
|---|---|---|
| 61 | Six M10 fasteners at each long side | 4.26 |

## 6.2 Determination of Cyclonic Ultimate Limit State Design Wind Capacities

The recommended Ultimate Strength Limit State design capacity for cyclonic regions was calculated by multiplying the test pressure ($P_t$) by the material capacity factor of 0.9.

### 6.2.1 Recommended Cyclonic Ultimate Strength Limit State Design Capacities

The Cyclonic Ultimate Strength Limit State design wind pressure capacity of the tested panel was calculated based on the rationale and variability factor outlined in Section 4.5. Table 6 provides a summary of recommended Ultimate Limit State design pressure for cyclonic regions. Note that the design capacity is only applicable for the panel geometry, fastener types and support details, as used in this testing programme.

**Table 6:** Recommended Cyclonic Ultimate Limit State Design Wind Capacities

| Panel Thickness (mm) | Panel Fixing Configuration | Recommended Cyclonic Ultimate Limit State Design Wind Capacity (kPa) |
|---|---|---|
| 61 | Six M10 fasteners at each long side | 4.02 |

## 7 Conclusions

A programme of static and cyclic simulated wind load strength testing was performed on *Acoustic Panels* manufactured by *Soundproof Warehouse Pty Ltd*.

The methods of testing (in accordance with *AS 4040.2* and *AS 4040.3* have been presented).

The static simulated wind load strength test result can be used to determine the Ultimate Limit State design wind capacity for non-cyclonic regions. Table 5 provides the recommended Ultimate Limit State design wind capacity for non-cyclonic regions, for the particular arrangement tested in this test programme.

The cyclic simulated wind load strength test result can be used to determine the Ultimate Limit State design wind capacity for cyclonic regions. Table 6 provides the recommended Ultimate Limit State design wind capacity for cyclonic regions, for the particular arrangement tested in this test programme.

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## Appendix A – Photographs of Damage after Static Simulated Wind Load Strength Testing

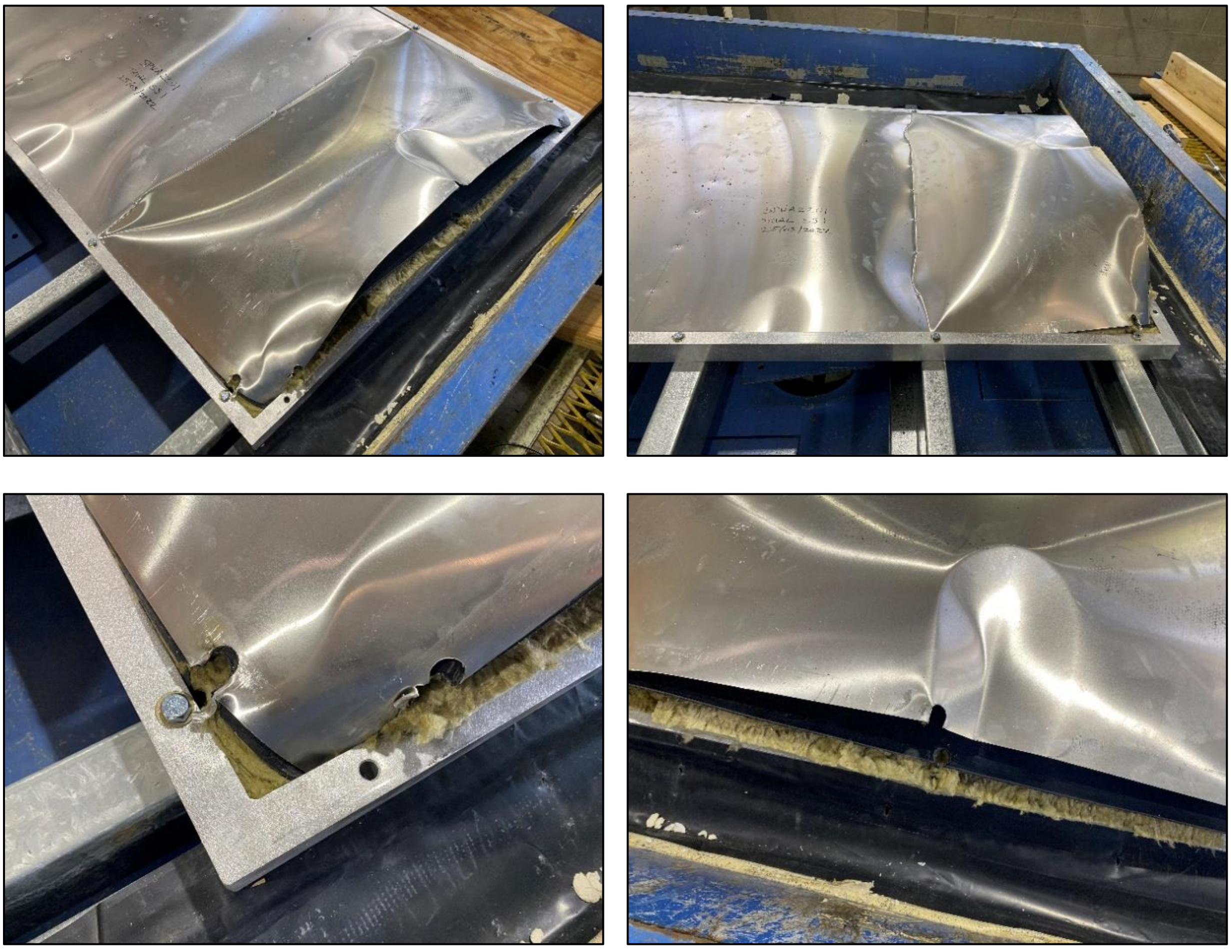

**Figure 5:** Typical damage after Trial SS1