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Evaluation of Rupture Panels M1, M2, and M3

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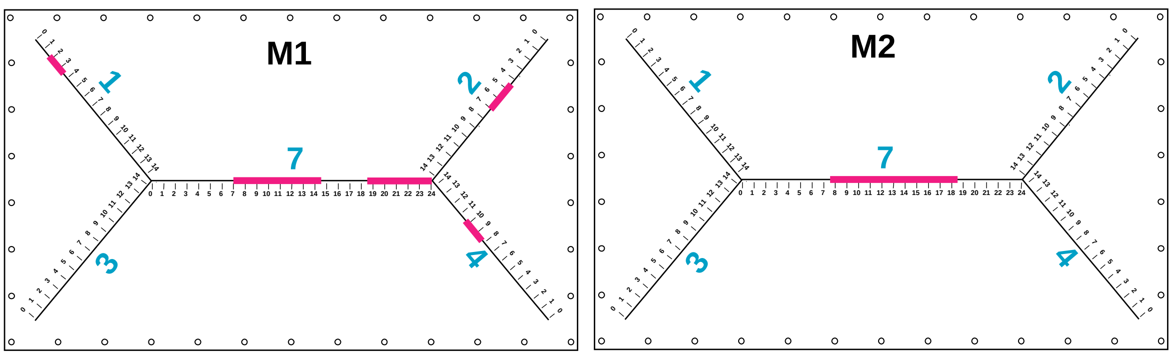
In December 2012, four rupture panels, from **Q42T**, **Q22T**, **Q22B** and **Q45B**, have been found leaking during inspection. Three of these panels, which have only been in service since April 2012, belong to the most recently purchased lots in 2011. These three panels are:

Lab ID	Panel ID
M1	AAA02-101378-OA-0427
M2	AAA02-101378-OA-0434
M3	AAA02-101378-OA-0326

The locations where the leaks occurred along the scored lines in each panel are illustrated in **Figure 1**.



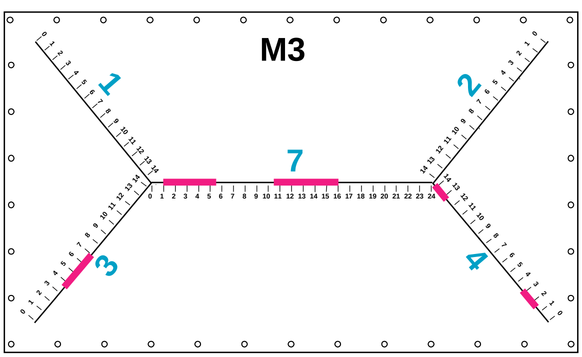


Figure 1 The locations where the leaks occurred along the scored lines in each panel are marked with red lines. For the lots purchased in 2011, the panel ID was stenciled on the opposite of the scribed side.

We had studied two brand new panels (**N1** & **N2**) from the 2011 lots in April 2012[1,2]. The conclusion was that the cracks will develop in the panels since the unscored depth in many locations along the scored lines was less than 100 μm as illustrated in **Figures 6** and **7** in **Ref. 1** and **Figure 2** in **Ref. 2**. Coincidentally, the predicted failure sites, as shown in the **Figure 7** in **Ref. 1**, are strikingly similar to the actual leak locations found in panels **M1** and **M3** as shown in **Figure 1**.

Fatigue Crack Initiation

Figure 2 below shows the progression of fatigue crack development as affected by the flopping of the panel. As shown in **Figure 2a**, the bottom surface of the panel was plastically deformed inward due to the flopping of the panel during service. The fatigue crack developed and grew as shown in **Figure 2b**, and the curvature of the kink at the bottom surface shortened. In the final stage as shown in **Figure 2c**, the kink sharpened to a point that causing the crack to penetrate through the whole unscored thickness. Thus, to minimize the flopping of panel during service will help to reduce the tendency of fatigue crack initiation and growth.

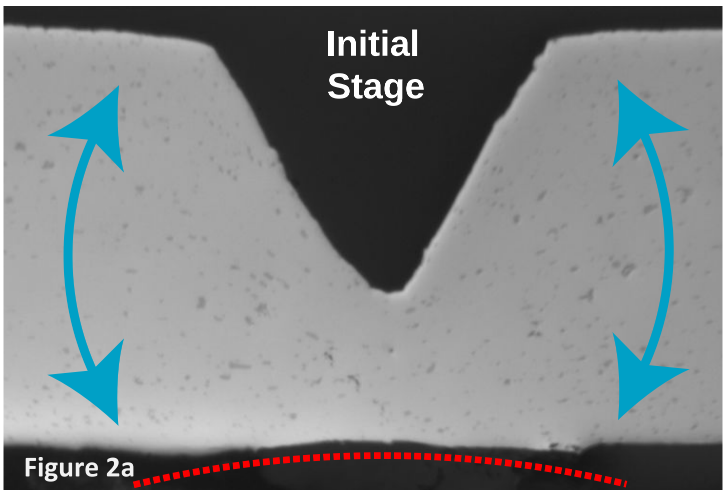


Figure 2a

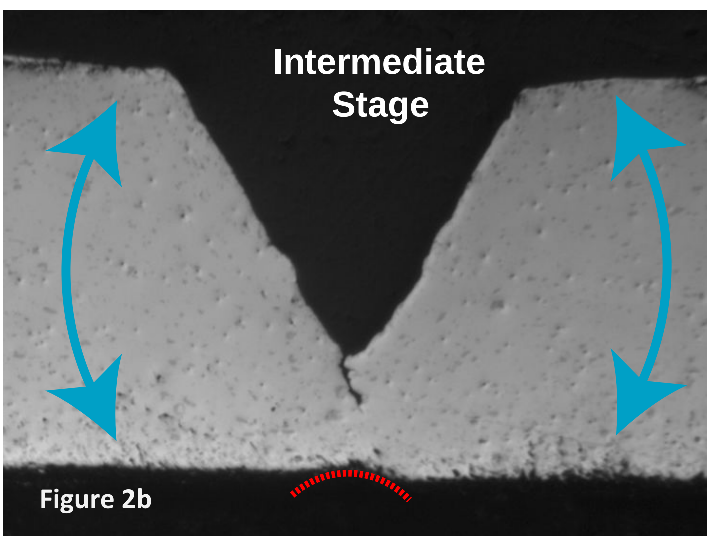


Figure 2b

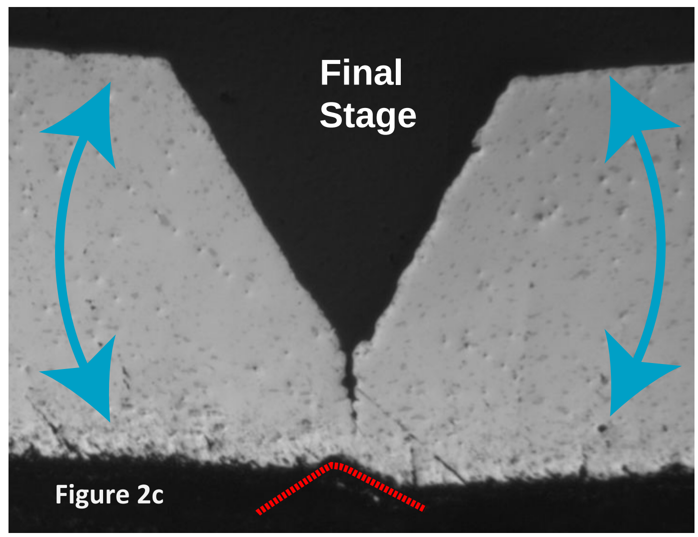


Figure 2c

Figure 2 shows the progression of the fatigue crack growth, and the evidence of the flopping of the rupture panel during service.

Scored Depth Measurements

Figures 3 and **4** summarize the scored depth measurements for panel **M1** and **M2**, respectively. Since the results are consistent with all data we have reported previously [1,2,3,4], the **M3** panel was not measured.

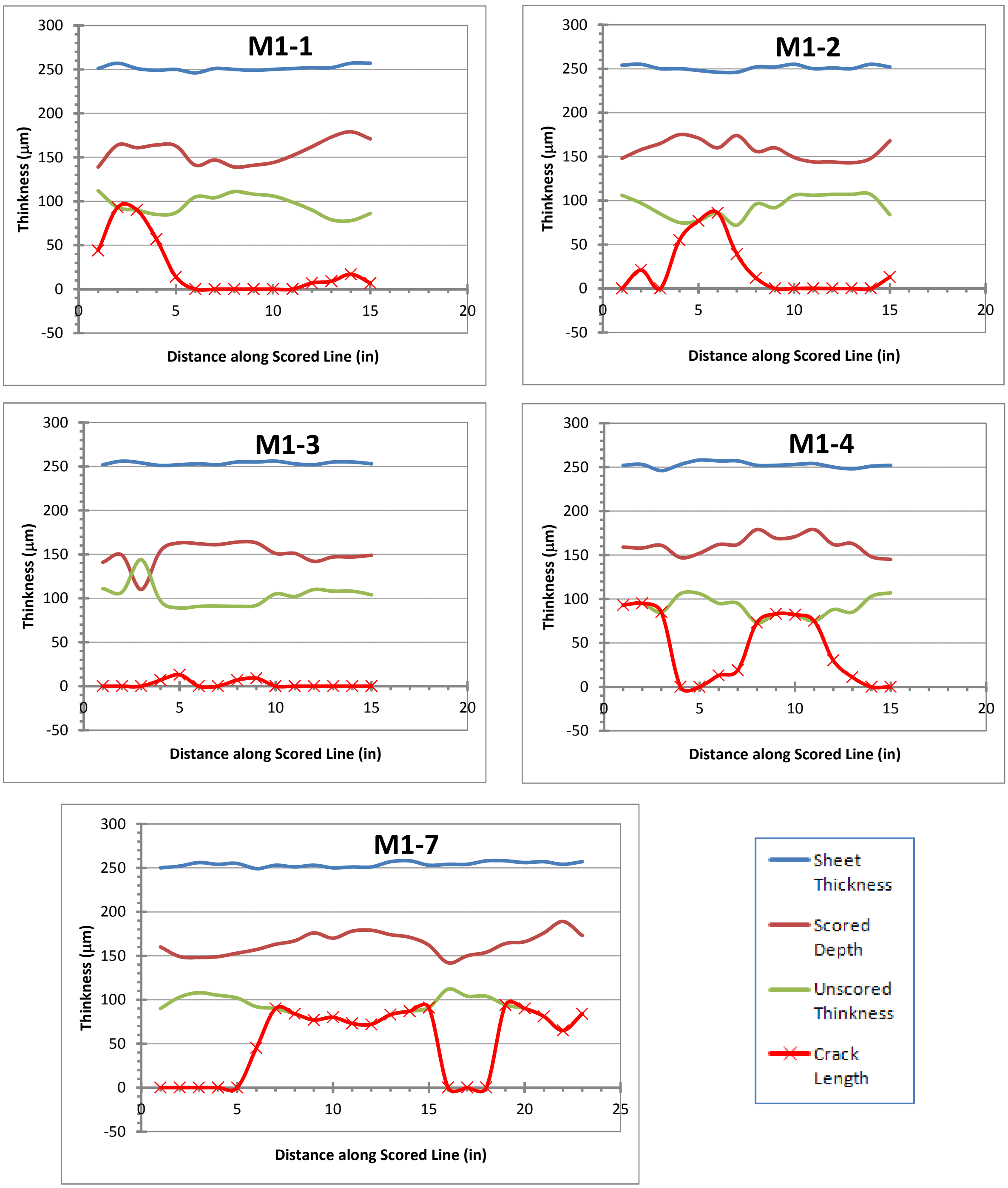


Figure 3 The results of the scored profile measurements for panel **M1**.

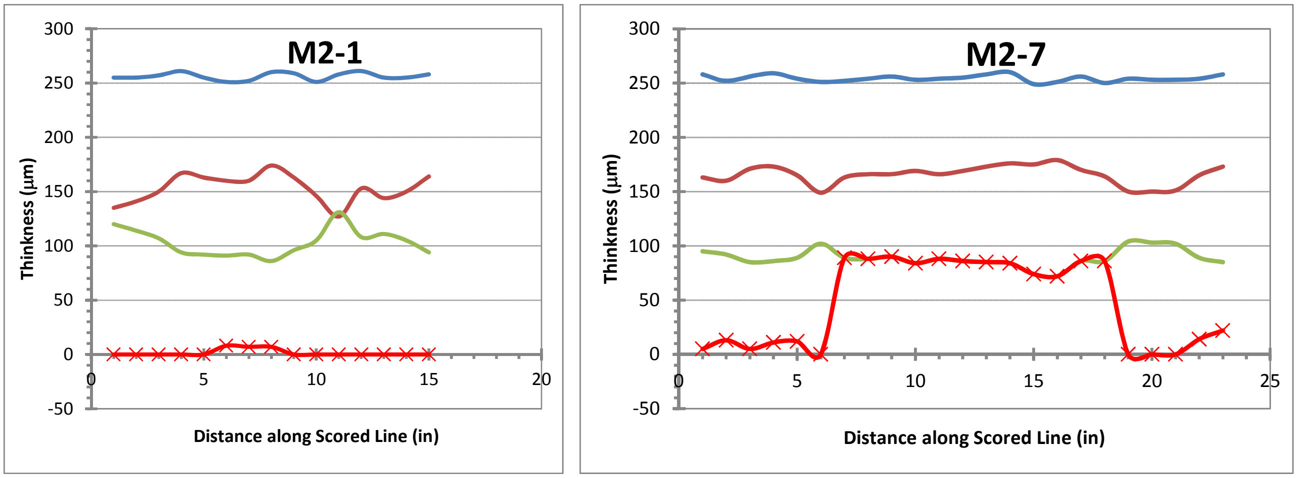


Figure 4 The results of the scored profile measurements for panel **M2**.

The scored profiles in these two panels have the same sharp V-shape, flat bottom, and round bottom as reported in **Figure 4** in **Ref. 1**. The fatigue cracks occurred in most locations where the scored depths are less than 100 µm and the scored profiles have a sharp V-shape. However, if the unscored depth is less than 100 µm, the flat bottom shape can still develop fatigue crack as observed in several locations.

The panel **M2** only has the **Scored Line 7** leaked. As shown in **Figure 4**, the **Scored Line 1** shows that most scored depths are around and above 100 µm. Although some fatigue cracks did initiate, but they had not yet grown substantially. Similar condition could be seen at the panel **M1** at the **Scored Line 3** as shown in **Figure 3**.

These results are consistent with our previous finding that the fatigue crack tends to initiate and grow at the locations where the unscored depth falls below 100 µm, and eventually causes the rupture panel to leak.

<u>Conclusions</u>

- The failure of the three newly acquired 2011 rupture panels reaffirm our previous finding that the fatigue crack tends to initiate and grow at the locations where the unscored depth falls below 100 µm.
- Three methods can be used to increase the service life of the rupture panel. These are:
    1. using different aluminum alloy, such as AA5052-O or AA5052-H32, with better fatigue strength,
    2. scoring with a flat or a rounded bottom profiles,
    3. reducing the flopping of rupture panel during service.

References

1. Report by Tien Shen dated 4/13/2012, entitled “Evaluation of Rupture Panels Q25T, Q23T & New Panel S/N 0424”.
2. Report by Tien Shen dated 4/25/, entitled “Evaluation of New Rupture Panels”.
3. Report by Tien Shen dated 2/29/2012, entitled “Failure Analysis of Rupture Panels Q32B & Q35B”.
4. Report by Tien Shen dated 3/14/2012, entitled “Additional Measurements of Rupture Panels”.