Appendix I-2: Macro and Microscopic Examination of Samples from GRW Tanker J2580

1 Samples from J2580

1.1 Description of sample

The received samples from J2580 are shown in Figures I19 and I20. These samples were taken from band H/8 offside and nearside and the approximate weld lengths were 1650mm and 1660mm, respectively. The offside sample was from an impacted area of the tanker, with the area of impact making up approximately 1150mm of the weld. From visual inspection of the impacted sample, a longitudinal crack in the circumferential weld was observed, with a length of over 300mm (Figure I21). Additionally, rupture of the weld joining the end dish to the extrusion band was observed.

1.2 Radiographic examination

After photography in the as-received condition, both welds were radiographed. The radiography reports are attached. Lack of fusion and isolated pores and cavities were found throughout the weld along with the longitudinal crack previously noted. The radiographic inspection interpretation report is attached.

1.3 Metallographic examination

A small amount of dye penetrant was used to pinpoint the ends of the longitudinal crack before a sample was removed incorporating this crack. The total length of the through-thickness flaw was 320mm. This sample was cut into two pieces as shown in Figure I22.

Sample W09-01 was then mechanically broken open to reveal the fracture faces (Figures I23 to I26). The lack of fusion defect was measured on the broken-open section and the total, continuous length was 230mm with very nearly a constant defect height of 1.0mm. It was not possible to measure the length of the initial lack of fusion defect from the section that was not broken open. However, the defect that led to the through-thickness rupture shows up on the radiographic inspection report and therefore the surface length of the initial flaw would have also been in excess of 100mm. However, without accurate measurement it is only possible to say conclusively that the initial lack of fusion defect that led to rupture was 1.0mm deep and at least 230mm long.

A 10mm section was removed from W09-02, near the centre of the crack and a macro section was produced (Figure I27).

This macro clearly reveals the following features:

- There is an initial lack of fusion defect located at the positioning lip (vertical up-stand located near the fusion line of the weld). The height of this lack of fusion is 1.0mm. The length of the lack of fusion defect is in excess of 100mm.
- The lack of fusion defect has the morphology of a surface-breaking flaw, because the material is unfused to the left of the defect (as oriented in Figure I27). See also Figure I28.
- As a result of the overload conditions (ie the topple test) the lack of fusion defect has ruptured through the circumferential seam weld.
- Measurements reveal that the misalignment in this macro section is approximately 0.5mm and the local weld cap height is approximately 1.0mm (see Figure I29).

1.4 Conclusions from examination

The conclusions from the post-mortem examination of the impacted section of band H/8 from tanker J2580 are as follows:

1 As with J3910, rupture of the fillet weld joining the end dish to the extrusion band was observed.
2 Additionally, a through-wall rupture of the circumferential seam weld arising from an initial manufacturing lack of fusion defect has been observed.
3 The length of the through-wall flaw was 320mm. The length of the initial defect that led to rupture was in excess of 230mm.

In the context of the ECA and FEA calculations of the main report, TWI analysed a GRW joint with 'average' joint geometry. For this average geometry, under the fuel oil, higher impact velocity simulation, the critical defect height was 1.1mm. The topple test involving tanker J2580 involved water as the contained fluid and a slightly lower impact velocity. However, correspondence with HSL has indicated that the local bending moment acting on the region in which the through-wall flaw was observed was very similar to the 'topple test' roll over moment that was employed to derive the 1.1mm critical defect height. However, the local joint geometry for J2580 where the rupture was observed contained a smaller weld cap height than the average joint geometry analysed. Based on the geometry parametric study that was undertaken, this would imply that the critical defect height for J2580 in the proximity of the through-wall rupture would be less than the critical defect height for the average joint geometry. Therefore, based on the results of the detailed FEA undertaken, it is expected that the 1.0mm lack of fusion defect would have led to rupture as it did in the topple test.

Correspondence with GRW has indicated that tanker J2580 is a so-called 'Period A' tanker with manufacture between 2006 and the middle of 2008. For a Period A tanker, the welding used a single wire semi-automated process with no specified (to-date) removal of the positioning lip.

Figure I19 J2580 Band H O/S sample (as-received).

Figure I20 J2580 Band H N/S sample (as-received).

Figure I21 J2580 Band H O/S sample longitudinal crack.

Figure I22 J2580 samples W09-01 and W09-02 (incorporating longitudinal crack).

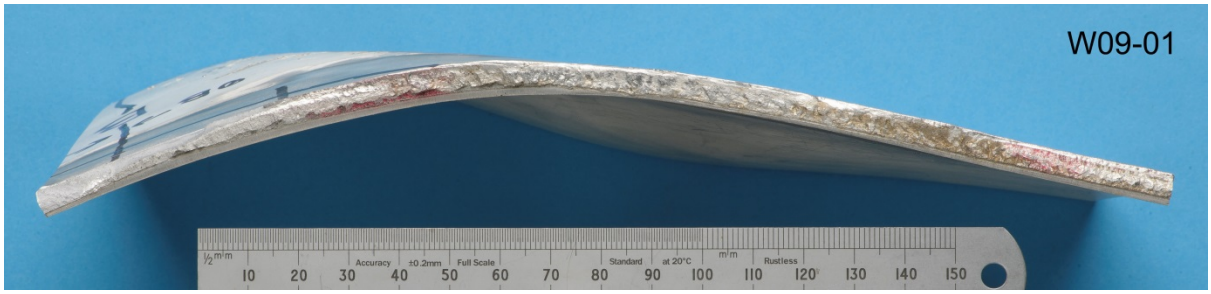

Figure I23 J2580 sample W09-01 fracture surface.

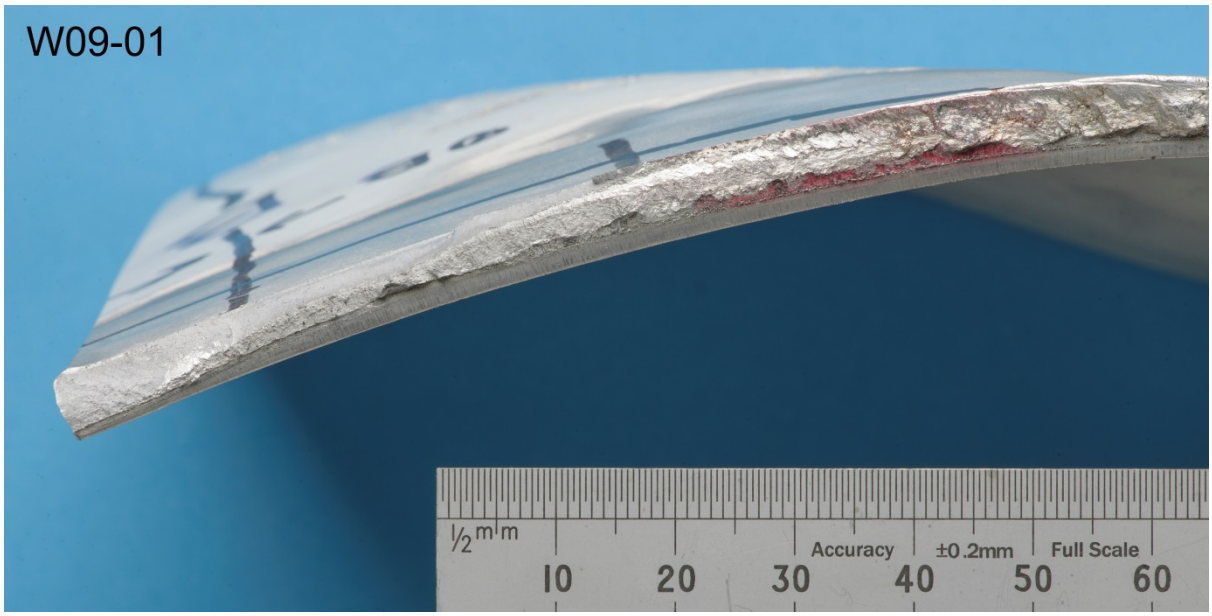

Figure I24 J2580 sample W09-01 fracture surface (left).

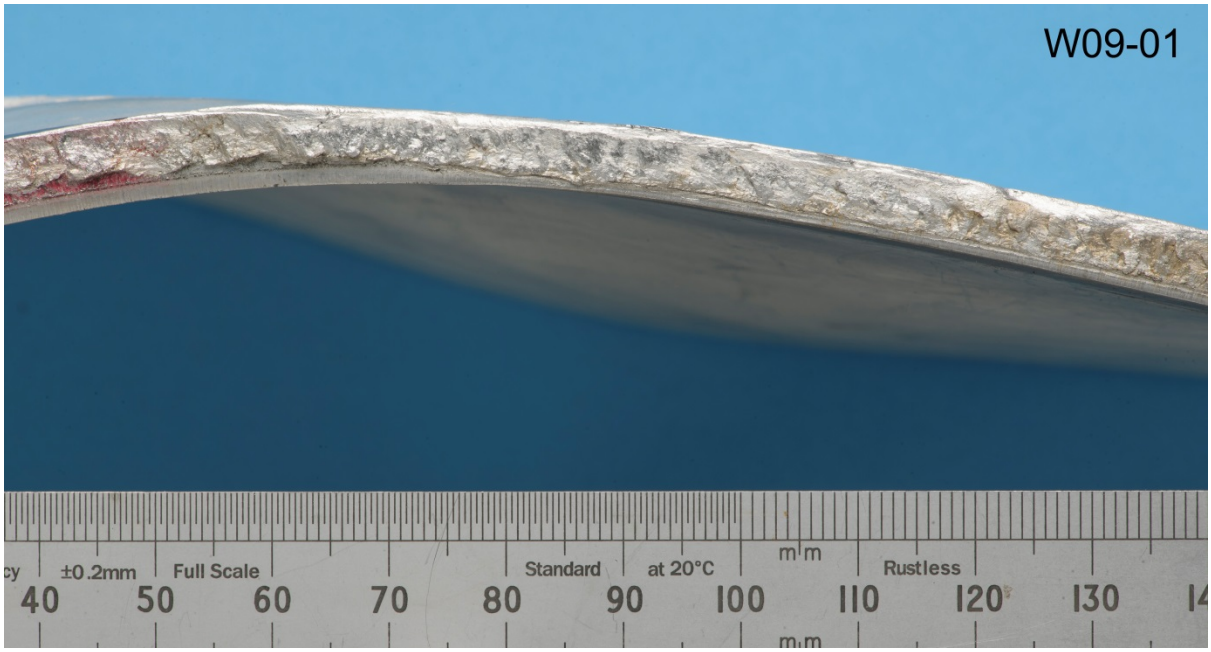

Figure I25 J2580 sample W09-01 fracture surface (centre).

Figure I26 J2580 sample W09-01 fracture surface (right).

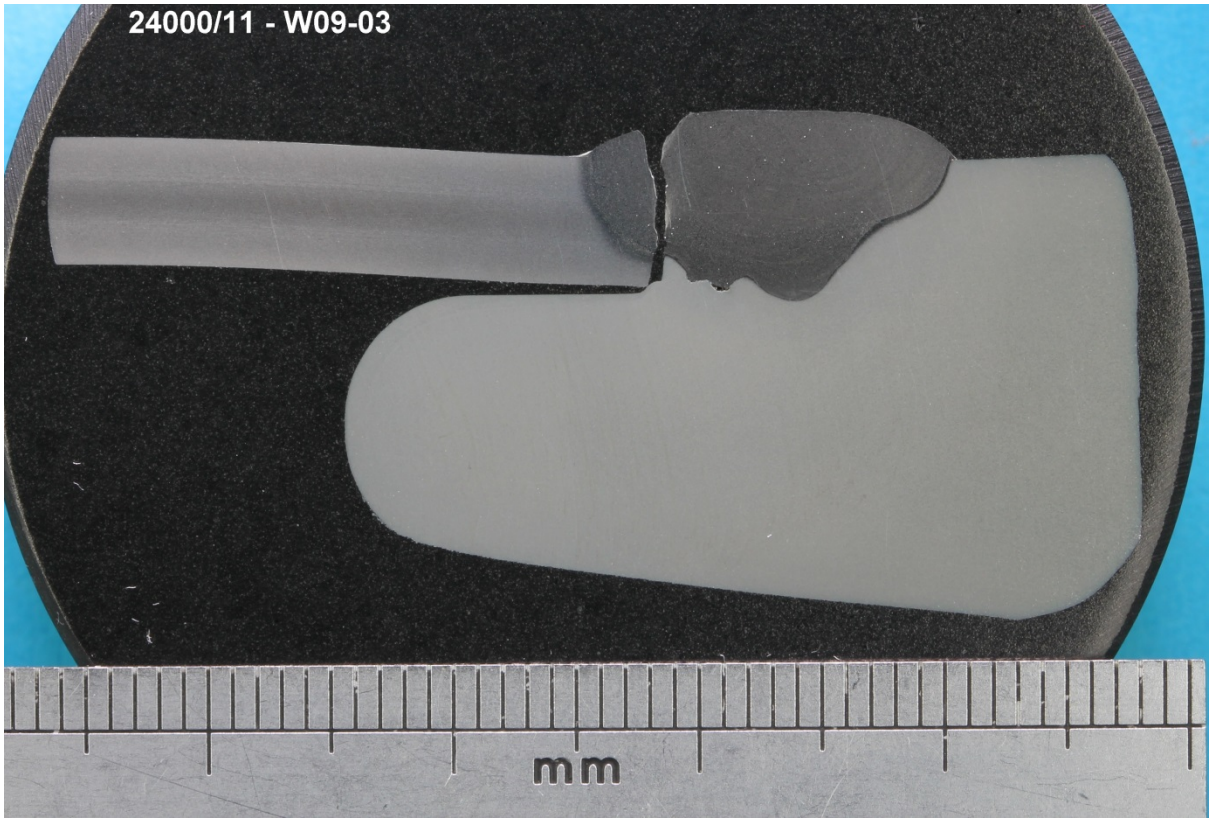

Figure I27 J2580 sample W09-03 macro.

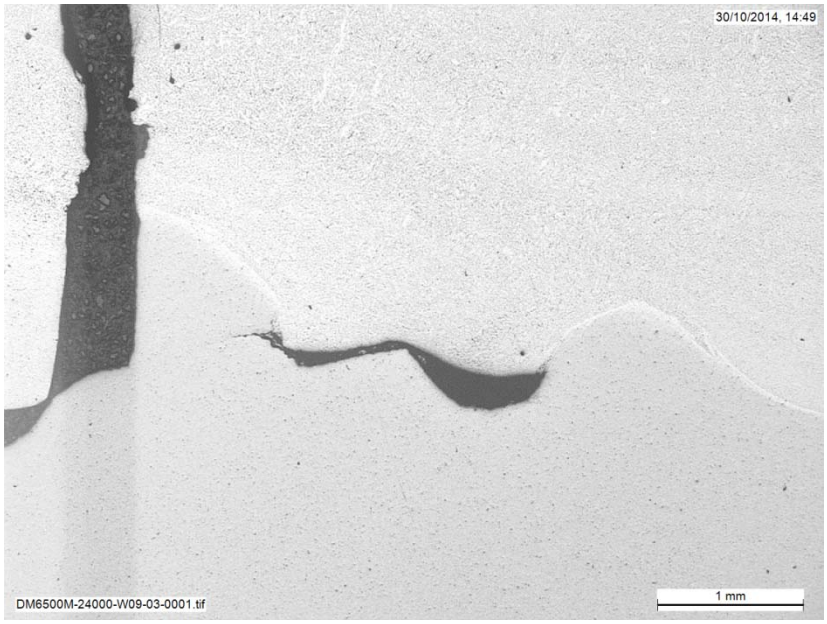

Figure I28 J2580 sample W09-03 macro. Focus on the initial lack of fusion at the positioner lip.

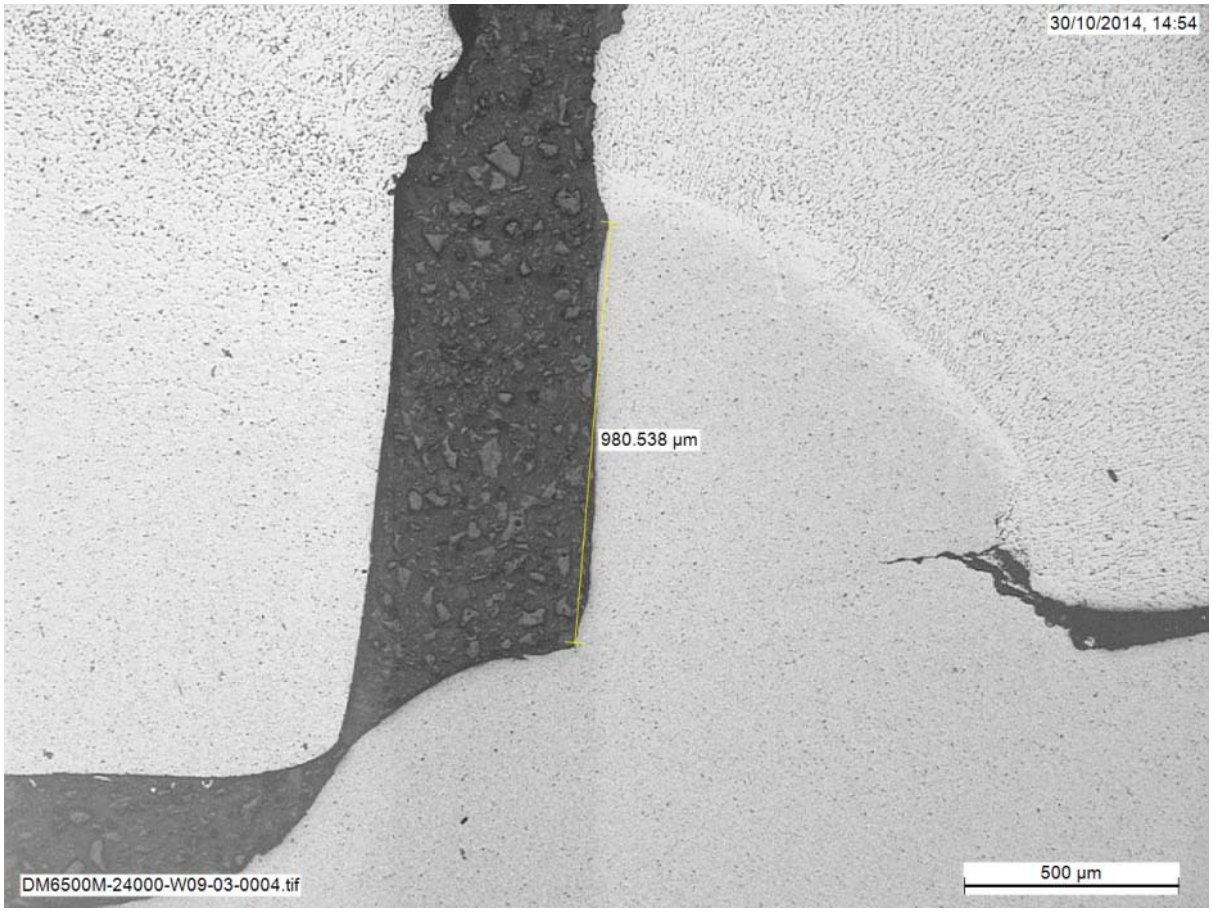

Figure I29 J2580 sample W09-03 macro. Measurement of the lack of fusion defect at the positioner lip. Initial height of the surface flaw is approximately 1.0mm.