Appendix B: Strain Gauge Plan

1 Overview

The strain gauge plan for the data collection exercise involving tanker J3857 was briefly described in the main report. The strain gauge plan was developed based upon an assessment of GRW's analysis of a static model of the tanker. In this finite element model, three different loading conditions were considered: a 1g forward acceleration, 1g lateral acceleration and a 1g vertical acceleration. In each load case, the body accelerations were resisted by the king pin and/or suspension. From the results of these simulations, TWI identified regions where large stresses acted normal to the circumferential seam welds. These regions in turn represent positions on the tanker where it is likely that fatigue damage may be most severe. Based on this review of the simulation results, the following strategy was employed for the strain gauge positions:

- Tanker bands B and G were the most densely instrumented. Along these bands, both circumferentially- and axially-oriented strain gauges were placed at multiple positions along the circumference. In particular, the regions near the cradle featured a cluster of four axial gauges and one circumferential (hoop) gauge so that a local biaxial stress could be calculated and linearly extrapolated back to the hypothetical crack plane.
- Tanker bands C and D were the next most densely instrumented. For these two bands, circumferentially-oriented gauges were not employed, but axial gauges at the same circumferential position having different longitudinal offsets from the welds were used to enable linear stress extrapolation back to the hypothetical crack plane.
- For the remaining circumferential seam welds, a single axial gauge was placed on the offside of the tanker where the cradle attached to the tanker. This allowed for strain data to be collected from the same position from each circumferential seam weld of the tanker.
- Two 'remote' axial gauges were placed on the tanker away from the circumferential seam welds and other local stress raisers. One was placed half-way between bands E and F and one was placed half-way between bands I and J. In both cases, the gauges were located on the offside, mid-height. The purpose of these two gauges was to provide additional model validation/calibration in regions where high strain gradients were not expected.

2 Details of Strain Gauge Placement

Figure B1 provides a legend for the coloured blocks that refer to strain gauge placements around the circumference of the tanker. In the top left of this figure, a black rectangle indicates a single, axially-oriented gauge positioned 5mm from the toe of the extrusion profile. The dimension of 5mm was chosen as this is the nominal tanker shell wall thickness. When or if an additional internal fillet weld was found to be present at a location, the 5mm offset was taken to be from the fillet weld toe. A solid red block indicates two, axially-oriented strain gauges, one 5mm from the toe of the extrusion profile and one 20mm offset from the first gauge (equivalently, 25mm offset from the toe of the extrusion profile). A black and red hatched rectangle indicates the placement of three strain gauges: two axially oriented, spaced similarly to the red block, and one circumferentially oriented. Finally, a yellow and black hatched rectangle indicates a single uniaxial gauge and a single circumferential gauge, both 5mm offset from the toe of the extrusion profile with 20mm between the gauges.

Based on this strain gauge legend, Figures B2-B11 provide illustrations of the strain gauge positions around the circumference for each circumferential seam weld. For both the offside and nearside, three main locations were considered around the circumference of the tanker: one at the bottom of the tanker, adjacent to the cradle supports (stiffeners, plate cradle and gusset cradle); one mid-height, primarily only used for the 'remote' gauges, and one at the top, near the valence welds. For the cradle and valence strain gauges, the gauges were always positioned 5mm off the attachment. Note that in Figures B2-B11, the cross-section shown is from the finite element model and is kept constant for each band for convenience and orientation; the various parts of the cradle and suspension shown in the figures may not look identical to that directly below any given weld. In Figures B2-B11, images of the instrumentation on the near side have been provided for reference. A detail of the precise positioning of the strain gauges on the offside cradle position for band B/10 is shown in Figure B12.

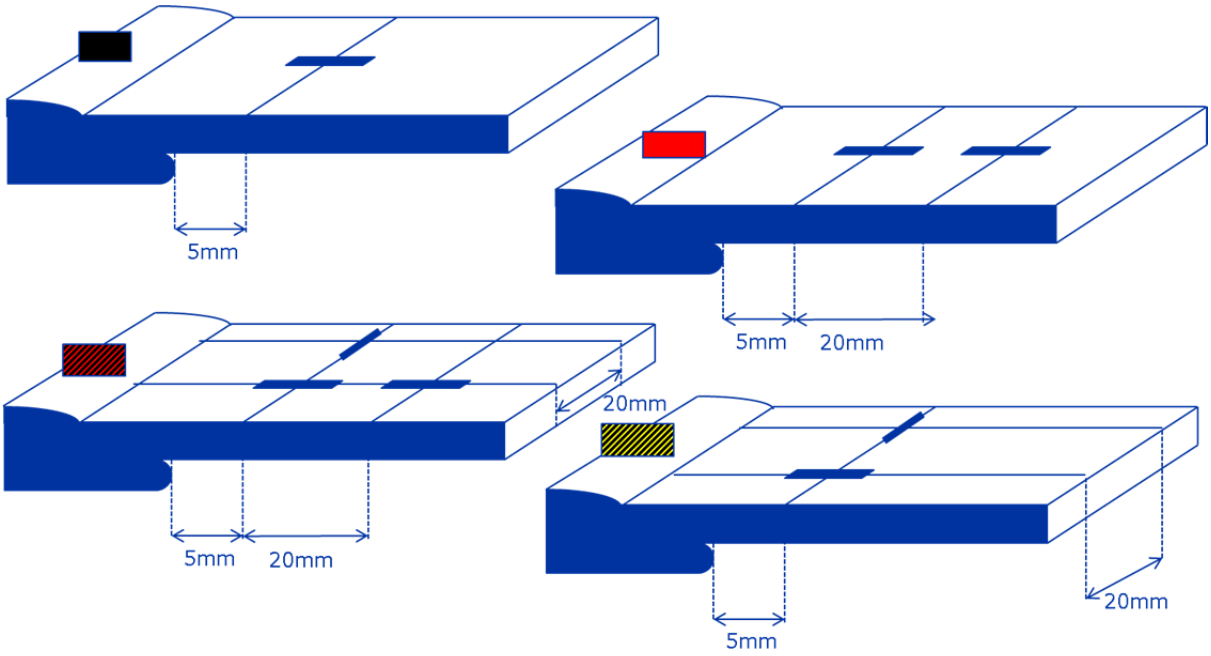

Figure B1 Strain gauge legend for the positions shown in Figures A2-A11.

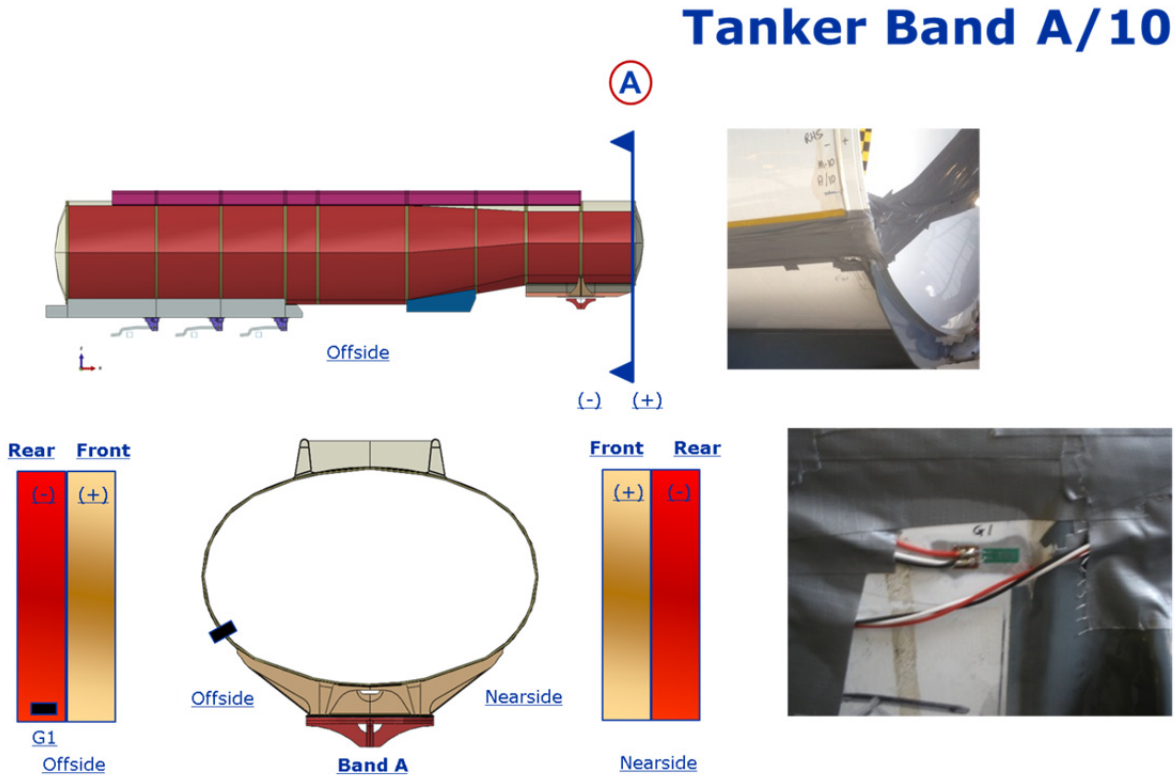

Figure B2 Illustration of the position of the single, axially-oriented strain gauge, G1, on band A/10 (-) on the near side.

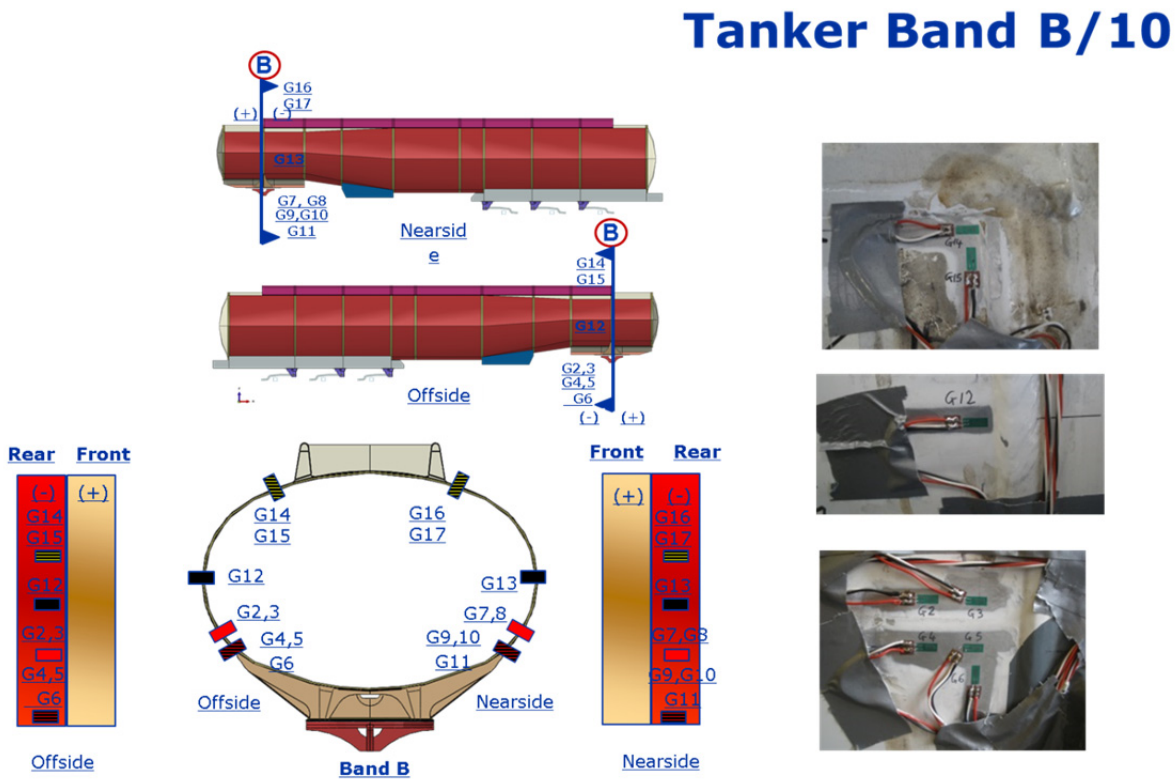

Figure B3 Illustration of the positions of strain gauges G2-17 on band B/10 (-).

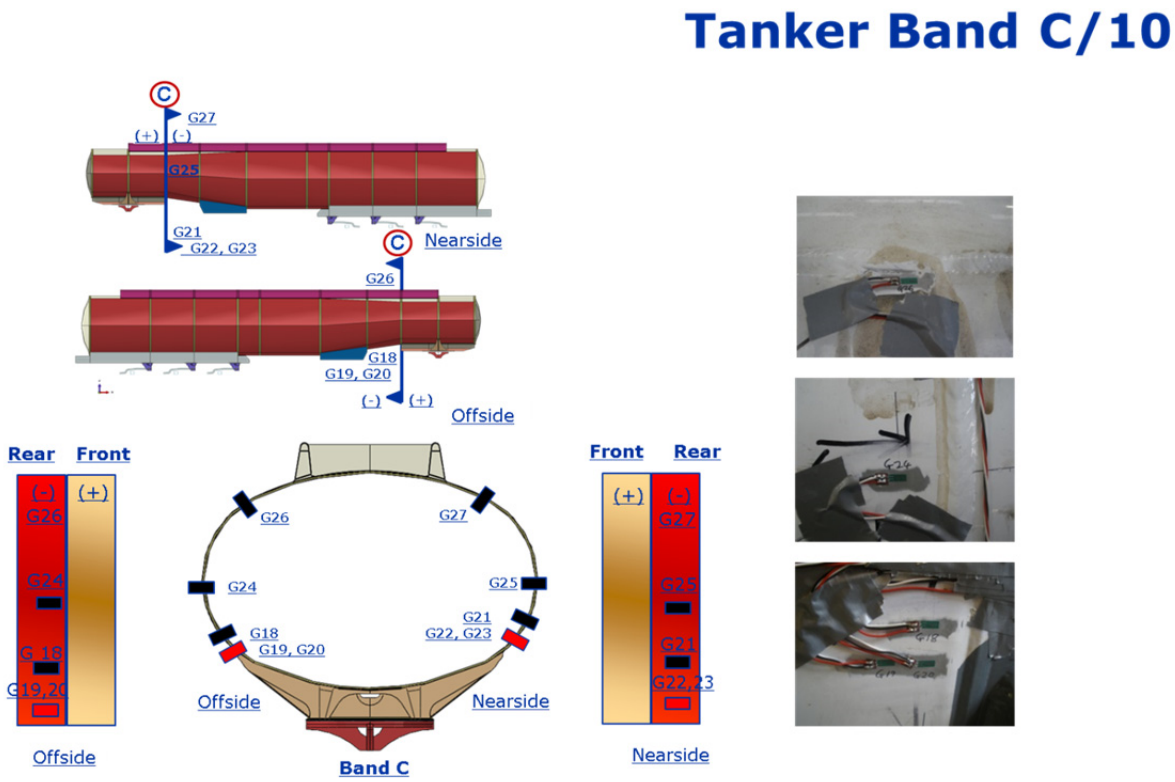

Figure B4 Illustration of the positions of strain gauges G18-27 for band C/10(-).

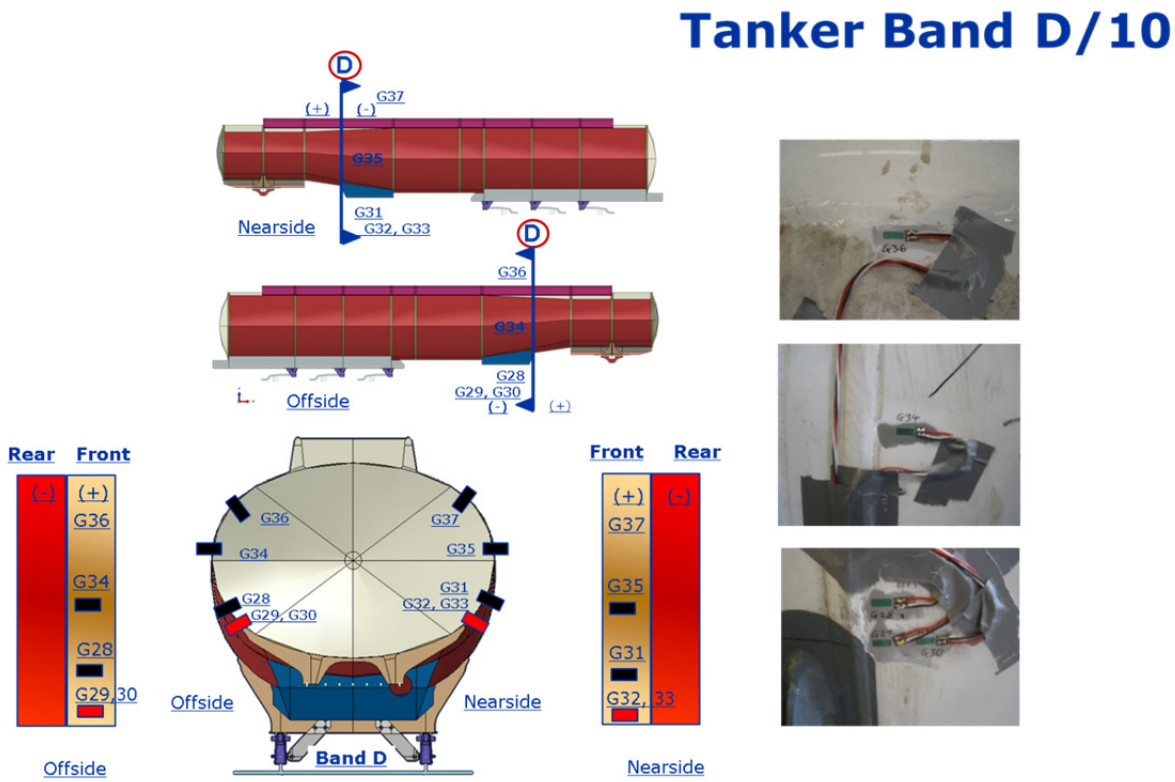

Figure B5 Illustration of the positions of strain gauges G28-37 for band D/10(+).

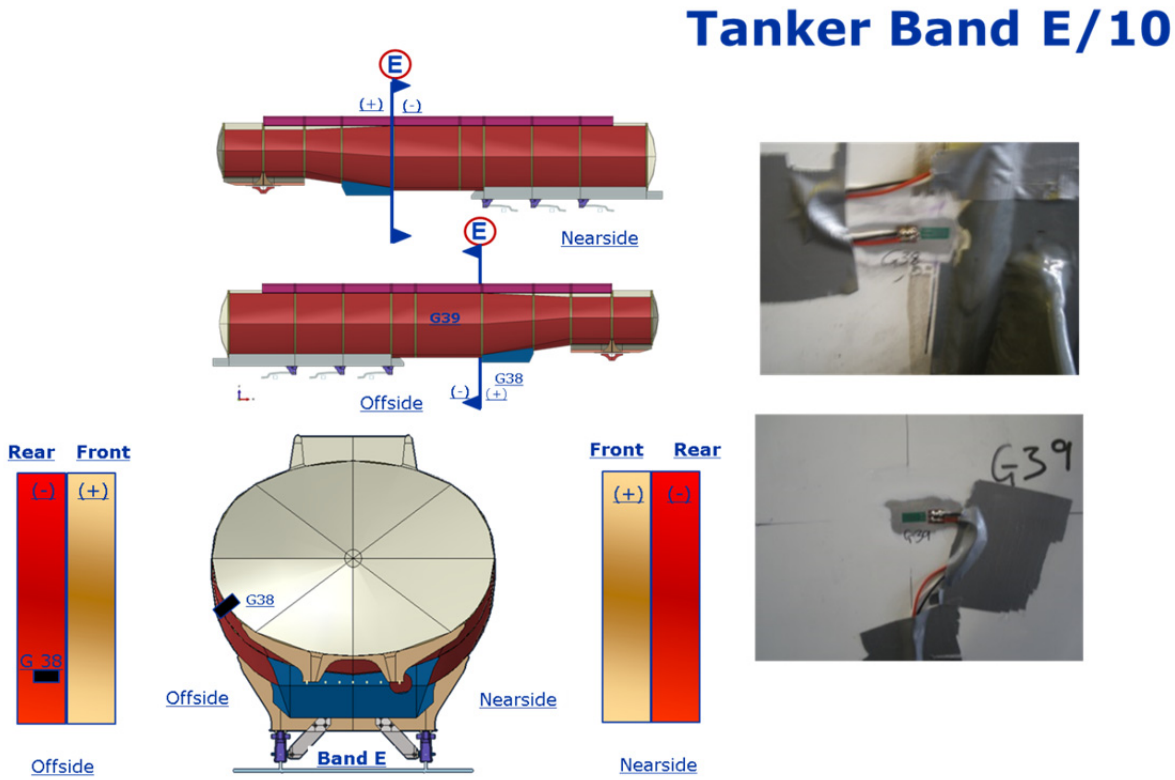

Figure B6 Illustration of the position of strain gauge G38 on band E/10(-) and the remote gauge G39, located midway between bands E and F.

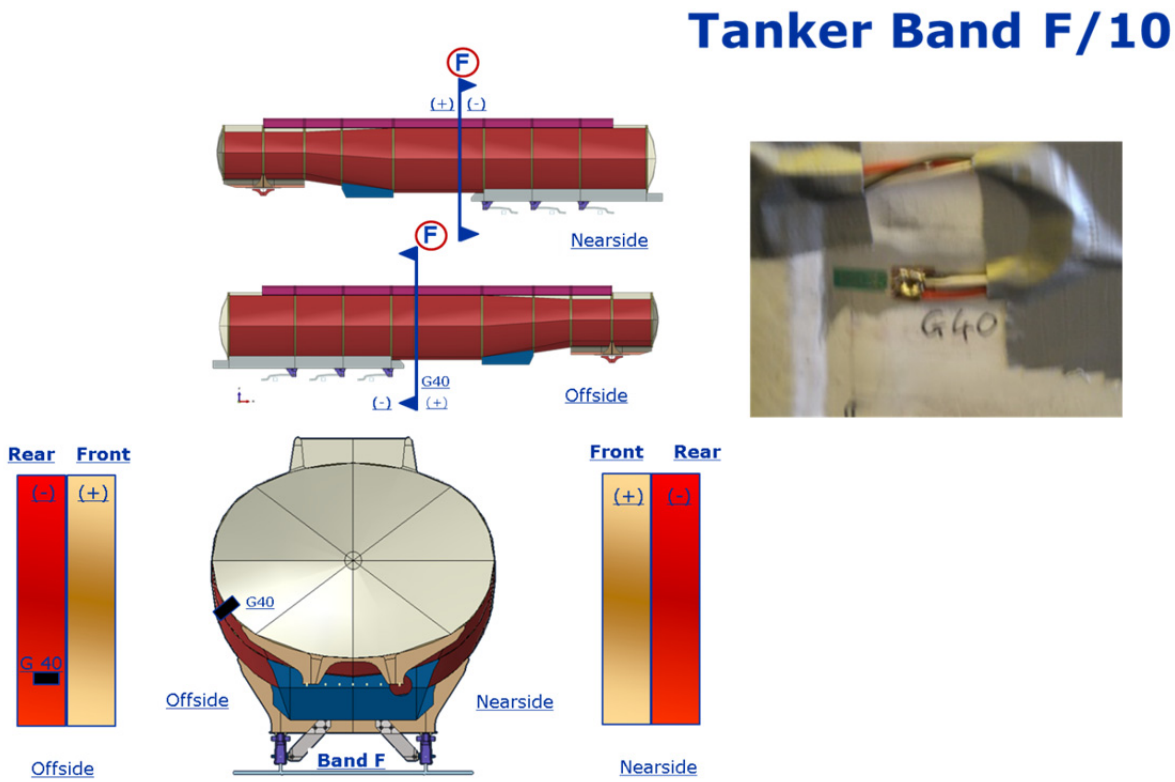

Figure B7 Illustration of the focussed gauge plan for band F/10(-).

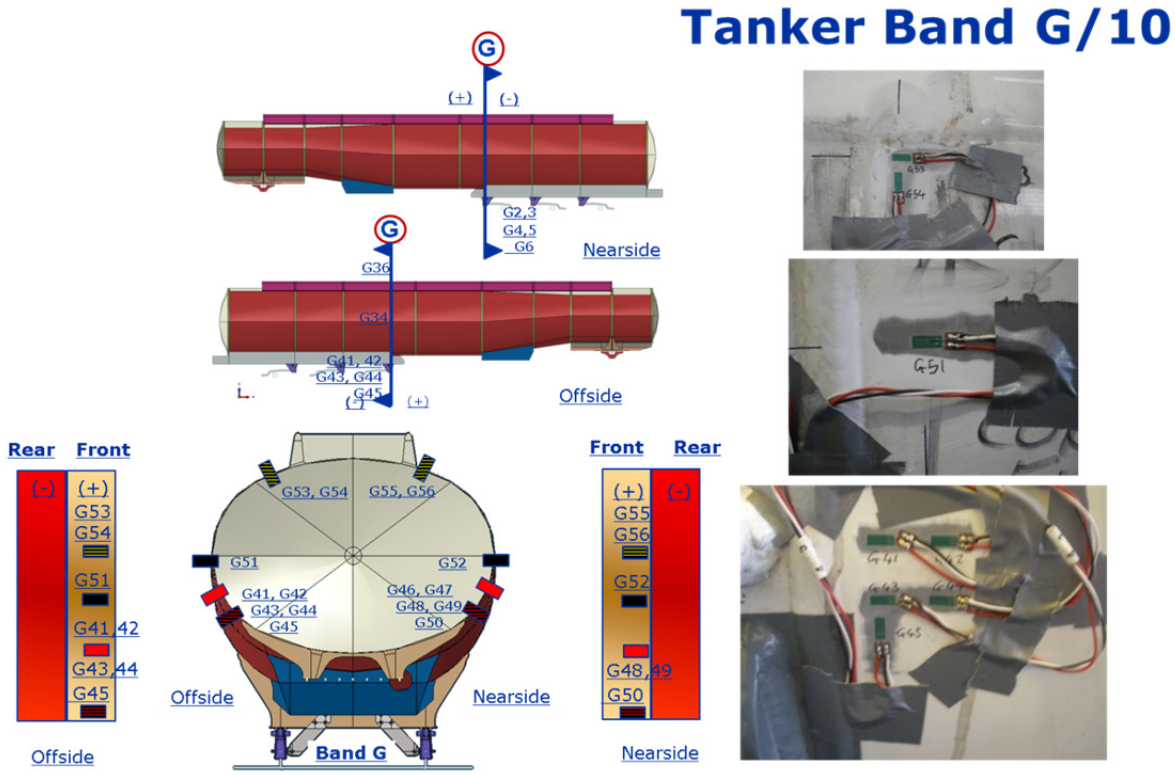

Figure B8 Illustration of the positions of strain gauges G41-56 on tanker band G/10(+).

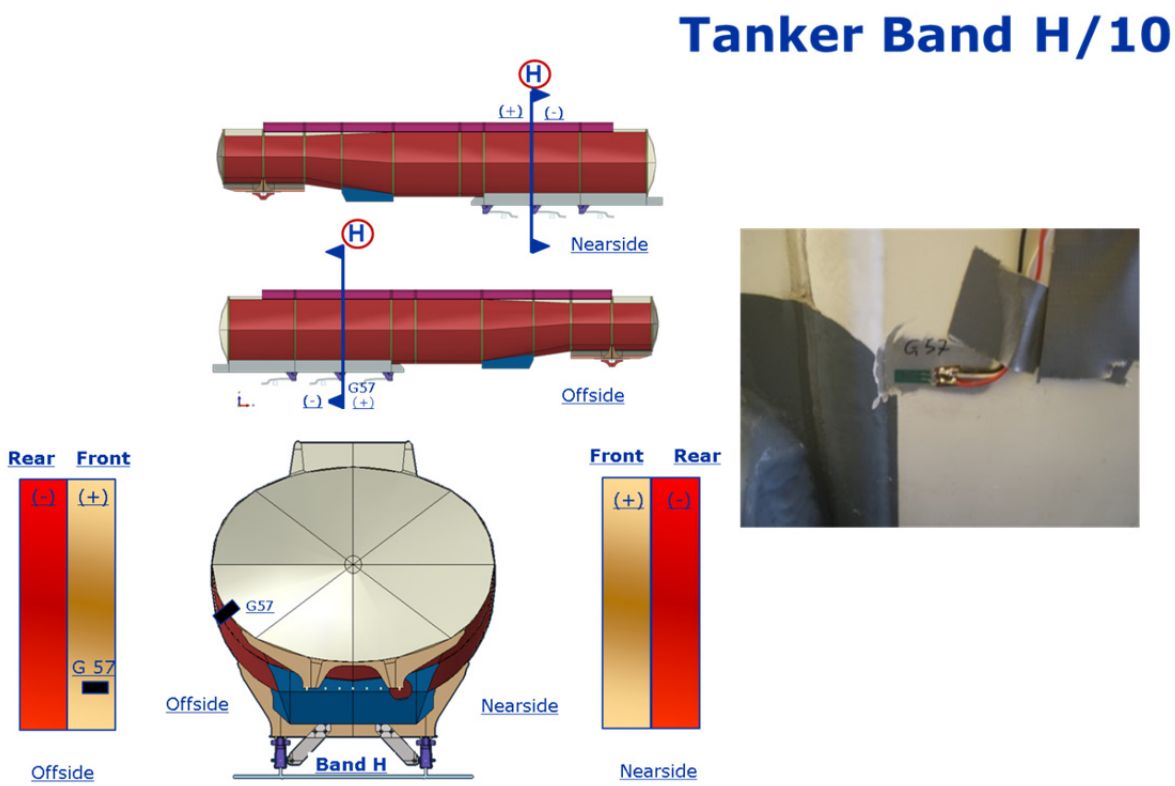

Figure B9 Illustration of the position of strain gauge G57 for band H/10(+).

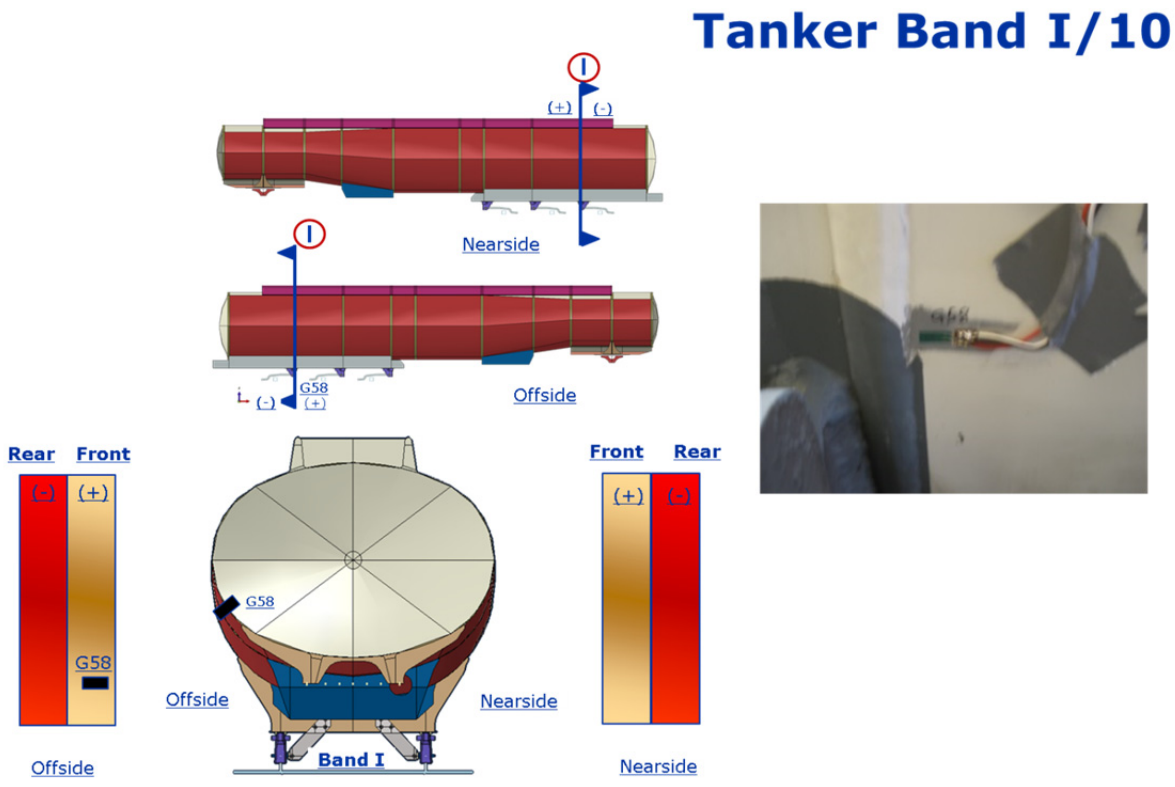

Figure B10 Illustration of the position of G58 for band I/10(+).

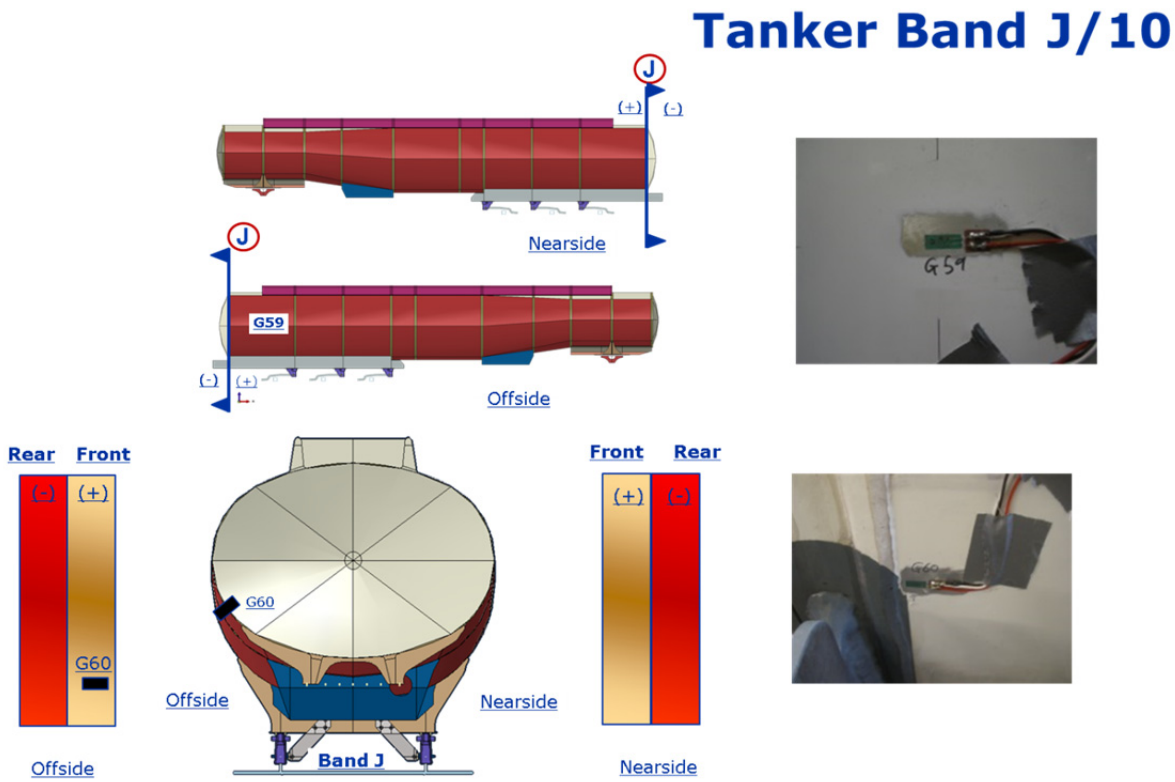

Figure B11 Illustration of the position of strain gauge G60 for band J/10(+) and the remote gauge G59 located between bands I and J.

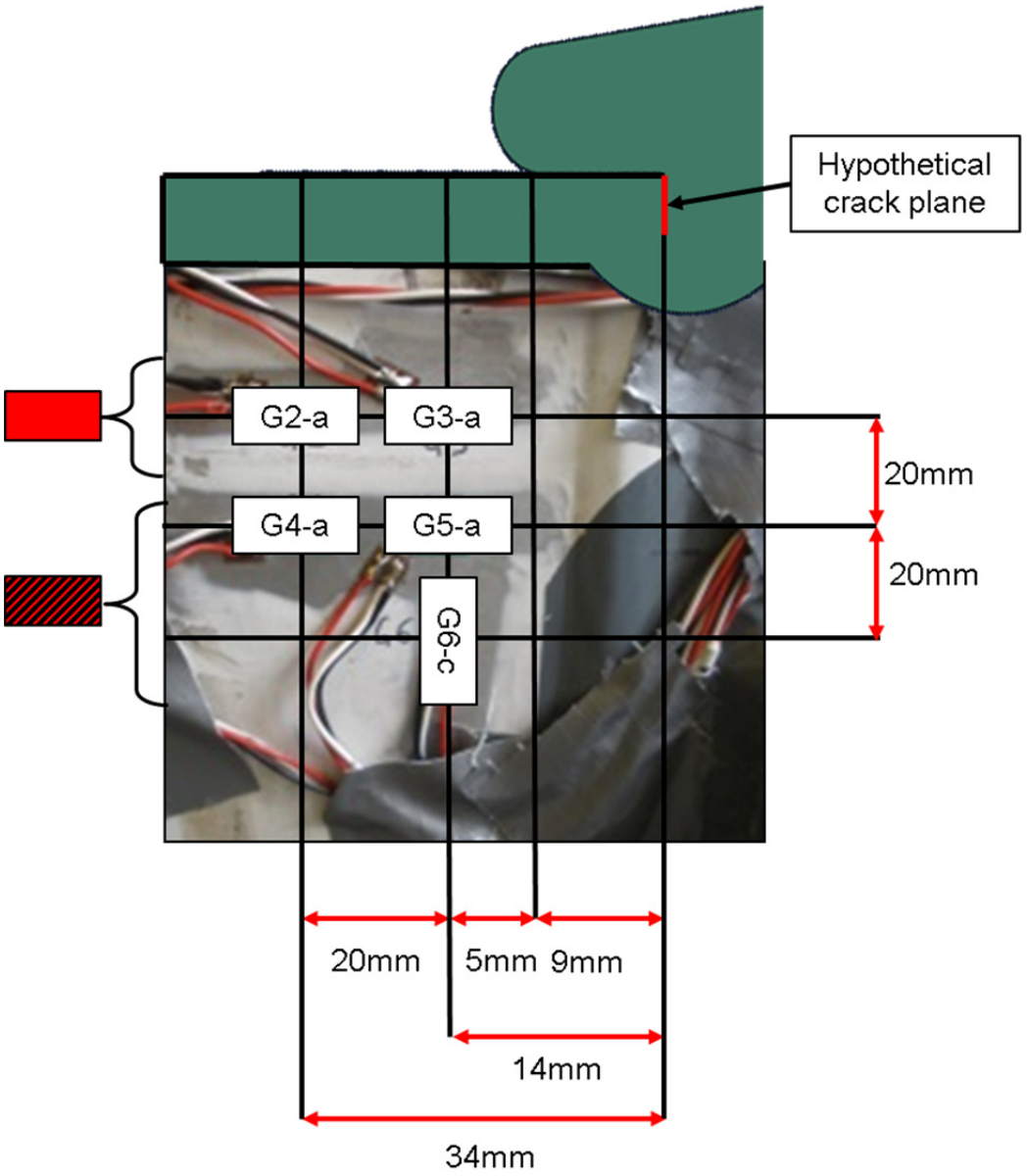

Figure B12 Illustration of the five-gauge assembly for local calculation and extrapolation of the stress taking into account biaxiality. The assembly shown is for the offside of band B adjacent to the cradle. The 9mm spacing is approximate and can vary from about 7.5mm to 9.0mm.