

		MATERIALS EVALUATION REPORT Materials Engineering Department			
 Rolls-Royce	Rolls-Royce Corporation 450 S. Meridian Street Indianapolis, Indiana 46225-1103, USA	REPORT NO. 16FA8-071PR	REV. Initial	DATE 1/5/2017	PAGES 1 of 23
TITLE METALLURGICAL INVESTIGATION OF A COMPRESSOR DIFFUSER, P/N 23064637, INSTALLED IN AN M250 C47B ENGINE, S/N CAE847731		SIGN <i>Signature on File</i>			
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IDENTIFICATION

Report Request ID: 11681
 Traceability ID Number: Not Applicable
 Part Name: Compressor Diffuser Assembly
 Part Number: 23064637
 Part Serial Number: GY27720R
 Processes: Not Applicable
 Part Time: Unknown
 Engine Model: M250-C47B
 Engine Serial Number: CAE847731
 FPA Number: Not Applicable
 Supplier: Not Applicable
 Supplier Location / Vendor Code: Not Applicable
 Evaluations: Failure Analysis

1 Foreword

The compressor diffuser assembly, P/N 23064637, was installed in an M250-C47B engine, S/N CAE84773. The helicopter reportedly departed a remote landing site with four persons onboard. During climb out at approximately 50 to 100 feet AGL, a series of bangs were reportedly heard, followed by descent. During teardown, the diffuser was reportedly found separated. The diffuser was reportedly overhauled at 98 hours prior to the event, though the specific overhaul procedures performed on the component were not available at the time of this investigation. The subject compressor diffuser was submitted to the Rolls-Royce Corporation Materials Laboratory in Indianapolis, IN for detailed metallurgical investigation.

		Date
		1/5/2017

2 Summary of Findings

- 2.1 A portion of the aft plate near the inboard rim separated from both the remaining aft plate and the airfoil plate at the inboard aft braze joint. The separation extended around approximately 40% of the circumference. The braze surface on the airfoil plate in this region exhibited ductile dimples consistent with tensile overload.
- 2.2 The separated portion of the aft plate was a detail distinct from the remaining aft plate and was not consistent with the configuration of the component definition, which specified the aft plate as a single detail.
- 2.3 The braze gaps between the airfoil plate and the aft plate and the braze coverage in the inboard aft joint did not meet the component definition requirement.
- 2.4 The exposed surfaces of the braze alloy at the inboard aft braze joint exhibited evidence of corrosion.
- 2.5 The forward face of the aft plate near the outboard aft joint and the aft face of the aft ring plate both exhibited thermal spray coating, which is not specified by the component definition.
- 2.6 The compositions of the diffuser aft plate, airfoil plate, and braze material were consistent with the materials specified by the component definition.

3 Results and Discussion

3.1 Visual Examination

Figure 1 and Figure 2 show the forward and aft sides of the compressor diffuser in the as-received condition. Figure 3 shows a representative schematic of the compressor diffuser, which includes the location of the airfoil plate, aft plate, and applicable braze joints, as specified by the component definition. Figure 4 through Figure 7 show radial views of the aft side of the compressor diffuser over approximately 360°. The inboard rim of the compressor diffuser at the 0° position (see bottom image of Figure 4) exhibited separation at the inboard aft braze joint between the airfoil plate and the aft plate, which extended around approximately 40% of the circumference, starting counter-clockwise from the 300° position to the 80° position (see region A in Figure 2). The inboard rim of the compressor diffuser at the 90° and 180° positions (see bottom images of Figure 5 and Figure 6, respectively) exhibited no evidence of voids or debonding at the inboard aft braze joint, but the inboard rim at the 270° position (see bottom image of Figure 7) exhibited a crack through the inboard aft braze joint.

A portion of the aft plate was also separated from the remainder of the diffuser on the aft face at the 0° position approximately 0.65 inch outboard of the inner diameter, as shown in Figure 8. The separation on the aft plate extended around approximately 33% of the circumference, starting counter-clockwise from the 300° position to the 60° position (see region B in Figure 2). This portion (hereafter known as the aft ring plate) was a detail distinct from the remaining aft plate and encompassed the entire circumference of the inboard rim. The aft ring plate was a part of the assembly, but did not meet the configuration of the engineering drawing, which specified the aft plate as a single detail.

The compressor diffuser was sectioned radially at planes 1 and 3, as shown in Figure 2. The aft ring plate hung loose from the diffuser segment at plane 1, but was still joined to the segment near plane 3. The aft ring plate was pulled from the segment near plane 3, and the braze coverage at the inboard aft joint was visually inspected between the circumferential locations at planes 1 and 3. Figure 9 shows representative images of braze coverage on the airfoil plate at the inboard aft joint.

The areas of braze coverage were calculated using image analysis software. The braze coverage did not meet the component definition requirement, and the braze land of the airfoil plate also exhibited oxidation.

3.2 Fractography / Scanning Electron Microscope Examination

3.2.1 Location of Examinations

The braze surface on the airfoil plate was examined using optical microscopy and the scanning electron microscope (SEM) at the 0° circumferential location of the inboard aft joint (see location D in Figure 2) where the joint exhibited separation between the aft ring plate and the airfoil plate.

3.2.2 Results

The braze surface on the airfoil plate at the aft inboard joint exhibited ductile dimples consistent with tensile overload. Figure 10 shows representative SEM images of the ductile dimples on the braze surface on the airfoil plate at the inboard aft joint.

3.3 Metallographic Examination

3.3.1 Sectioning Plan

The compressor diffuser was sectioned radially for metallographic evaluation at planes 1, 2, and 3, as shown in Figure 2.

3.3.2 Results

Metallographic evaluation was performed on the cross-sections of the compressor diffuser (planes 1 through 3). Figure 11 shows the metallographic cross-section through the inboard aft joint at a circumferential location where the aft ring plate appeared separated from the airfoil plate (see plane 1 in Figure 2). The braze gap could not be measured due to the separation of the aft ring plate from the assembly, but the thickness of braze alloy that adhered to the airfoil plate did not meet the component definition requirement. Braze alloy coverage on the braze land also did not meet the component definition requirement. The aft ring plate surface in the unfilled portion of the braze gap also displayed oxidation (see Figure 12). The aft face of the aft ring plate exhibited thermal spray coating, which is not specified by the component definition. Figure 13 shows the metallographic cross-section through the outboard aft joint. The braze gap was completely filled, but its thickness did not meet the component definition requirement. The forward face of the aft plate exhibited thermal spray coating near the outboard aft joint, but no coating is specified by the component definition.

Figure 14 shows the metallographic cross-section through the inboard aft joint at a circumferential location where the braze joint appeared completely bonded (see plane 2 in Figure 2). Braze alloy coverage on the braze land met the component definition requirement, but the braze gap did not meet the component definition requirement. The surface of the bridged braze alloy exposed to the unfilled portion of the braze gap also displayed oxidation (see Figure 15). The aft face of the aft ring plate exhibited thermal spray coating, which is not specified by the component definition. Figure 16 shows the metallographic cross-section through the outboard aft joint. The braze gap was completely filled, and its thickness met the component definition requirement. The forward face of the aft plate exhibited thermal spray coating near the outboard aft joint, but no coating is specified by the component definition.

Figure 17 shows the metallographic cross-section through the inboard aft joint at a circumferential location bordering the region where the aft ring plate appeared separated from the airfoil plate (see plane 3 in Figure 2). The braze gap could not be measured due to the separation of the aft ring plate from the assembly, but the thickness of braze alloy did not meet the component definition requirement. Separation of the braze gap was potentially due to sample preparation. Braze alloy coverage on the braze land did not meet the component definition requirement. Surfaces in the unfilled portion of the braze gap, as well as surfaces where the aft ring plate separated from the braze alloy, displayed oxidation (see Figure 18). The aft face of the aft ring plate exhibited thermal spray coating, which is not specified by the component definition. Figure 19 shows the metallographic cross-section through the outboard aft joint. The braze gap was completely filled, but its thickness did not meet the component definition requirement. The forward face of the aft plate exhibited thermal spray coating near the outboard aft joint, but no coating is specified by the component definition.

3.4 Hardness

Hardness measurements were not conducted on the compressor diffuser.

3.5 Chemistry

Semi-quantitative energy dispersive spectroscopy (EDS) analysis determined the compositions of the diffuser aft plate, airfoil plate, and braze material were consistent with the materials specified by the component definition.

Semi-quantitative energy dispersive spectroscopy (EDS) analysis determined the darkened layer on the exposed surfaces of the braze material (see locations G1 and G2 in Figure 18) was consistent with corrosion.

4 Revision History

Issue	Change Summary	Date
Initial	Not applicable	5 Jan 17

5 Figures and Tables

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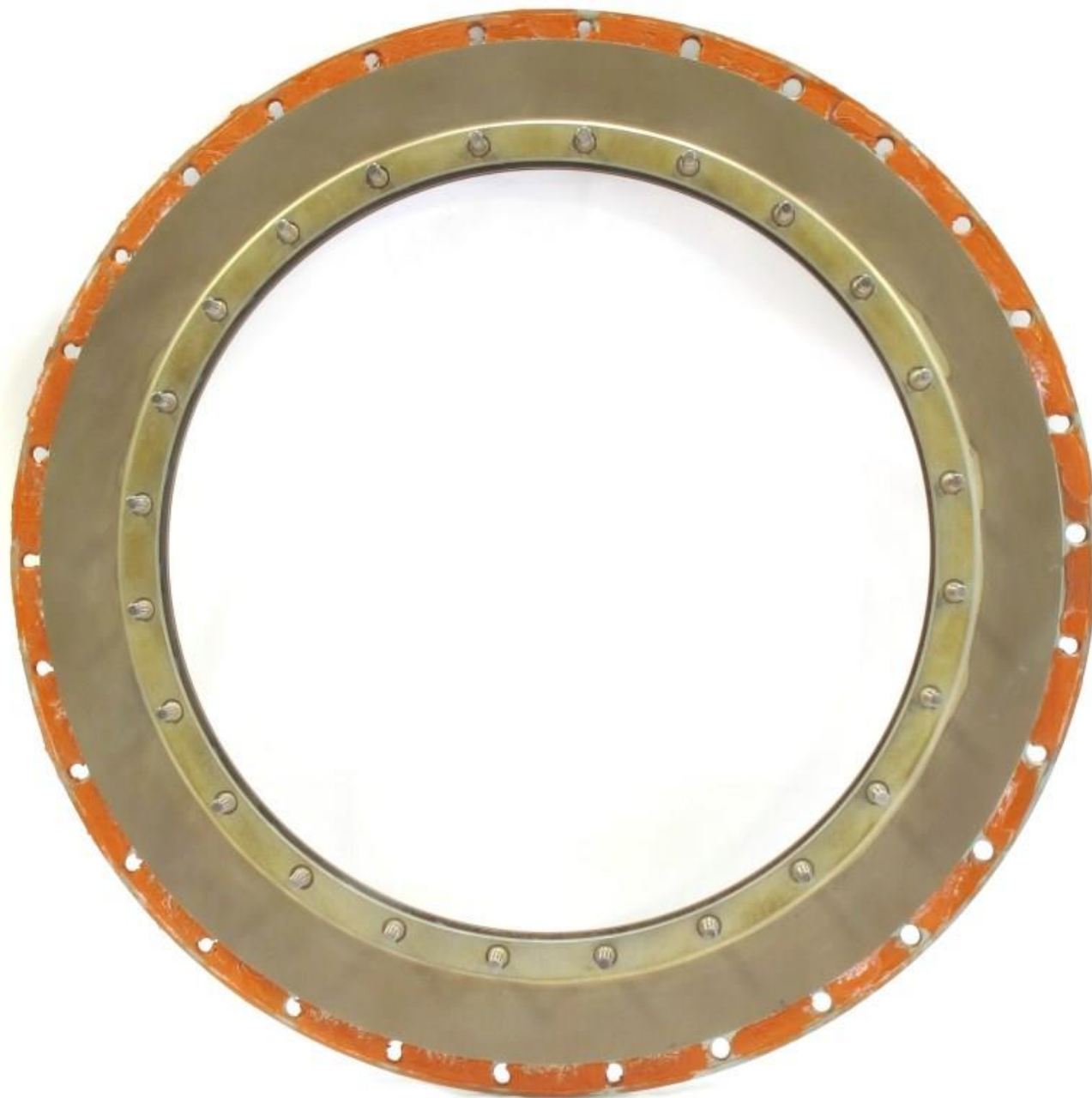


Figure 1. Forward side of the compressor diffuser in the as-received condition.

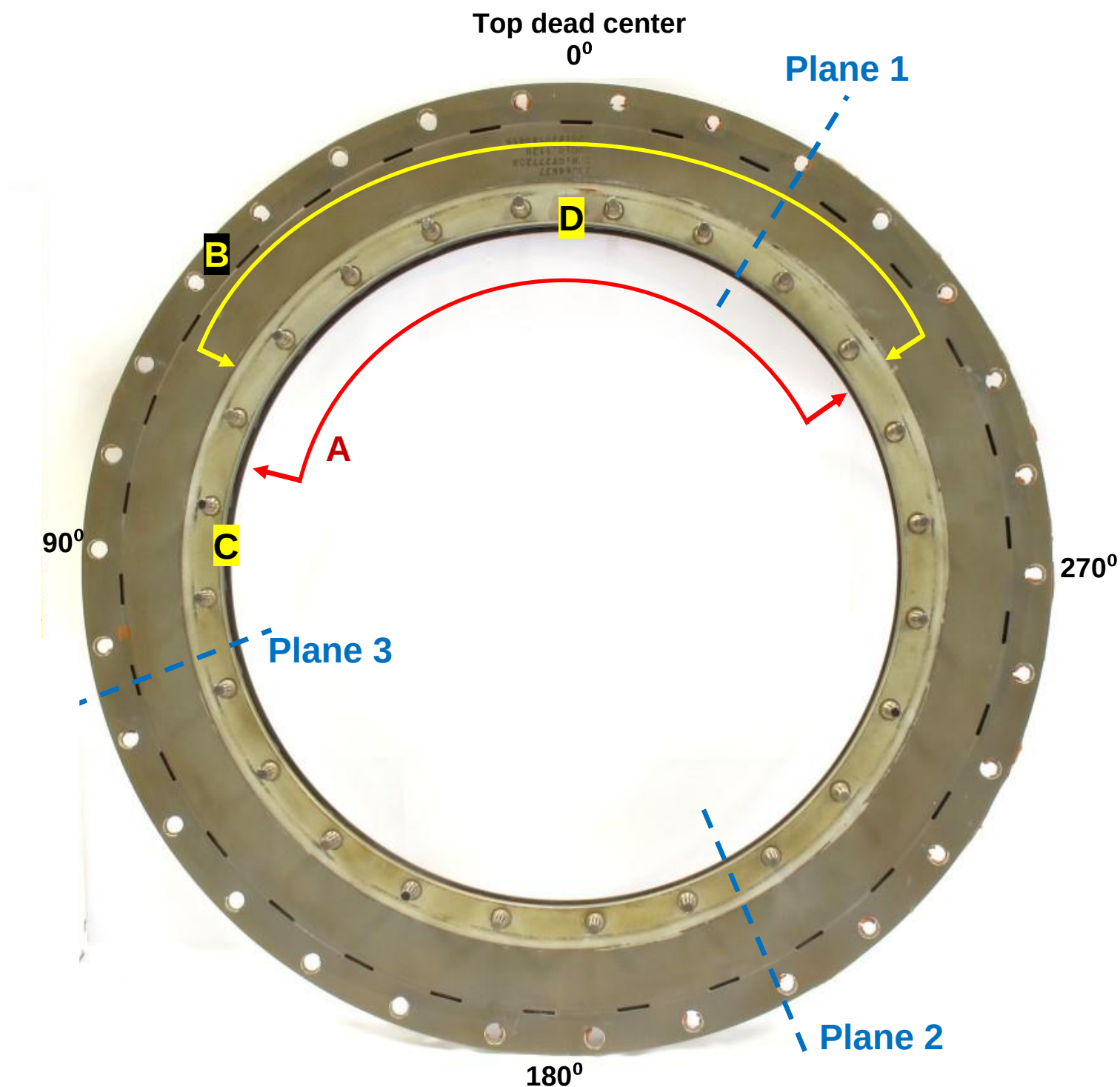


Figure 2. Aft side of the compressor diffuser in the as-received condition. Region A marks the circumferential extent of the separation at the inboard aft braze joint between the airfoil plate and the aft plate (see Figure 4), and region B marks the circumferential extent of separation on the aft face of the aft plate (see Figure 8). The braze coverage at locations C and D are shown in more detail in Figure 9. Blue dotted lines mark planes 1 through 3 selected for metallographic evaluation (see Figure 11 through Figure 19).

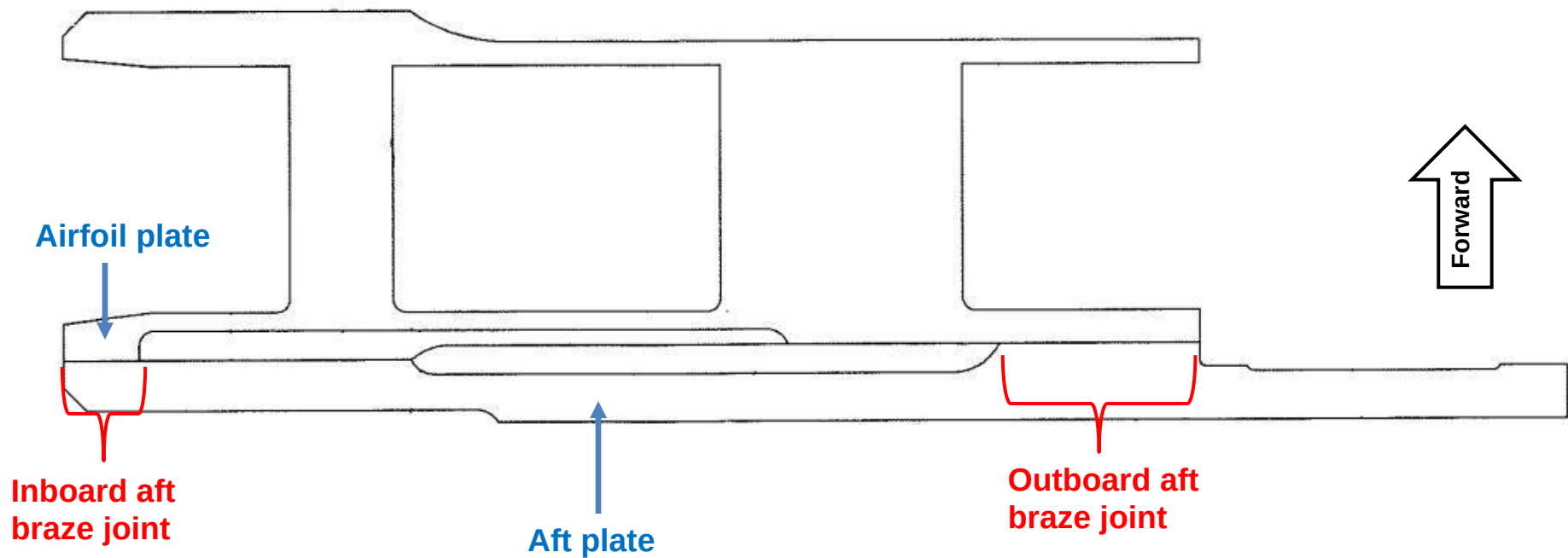


Figure 3. Schematic showing the location of the airfoil plate, aft plate, and applicable braze joints of the compressor diffuser as specified by the component definition. Schematic not to scale.

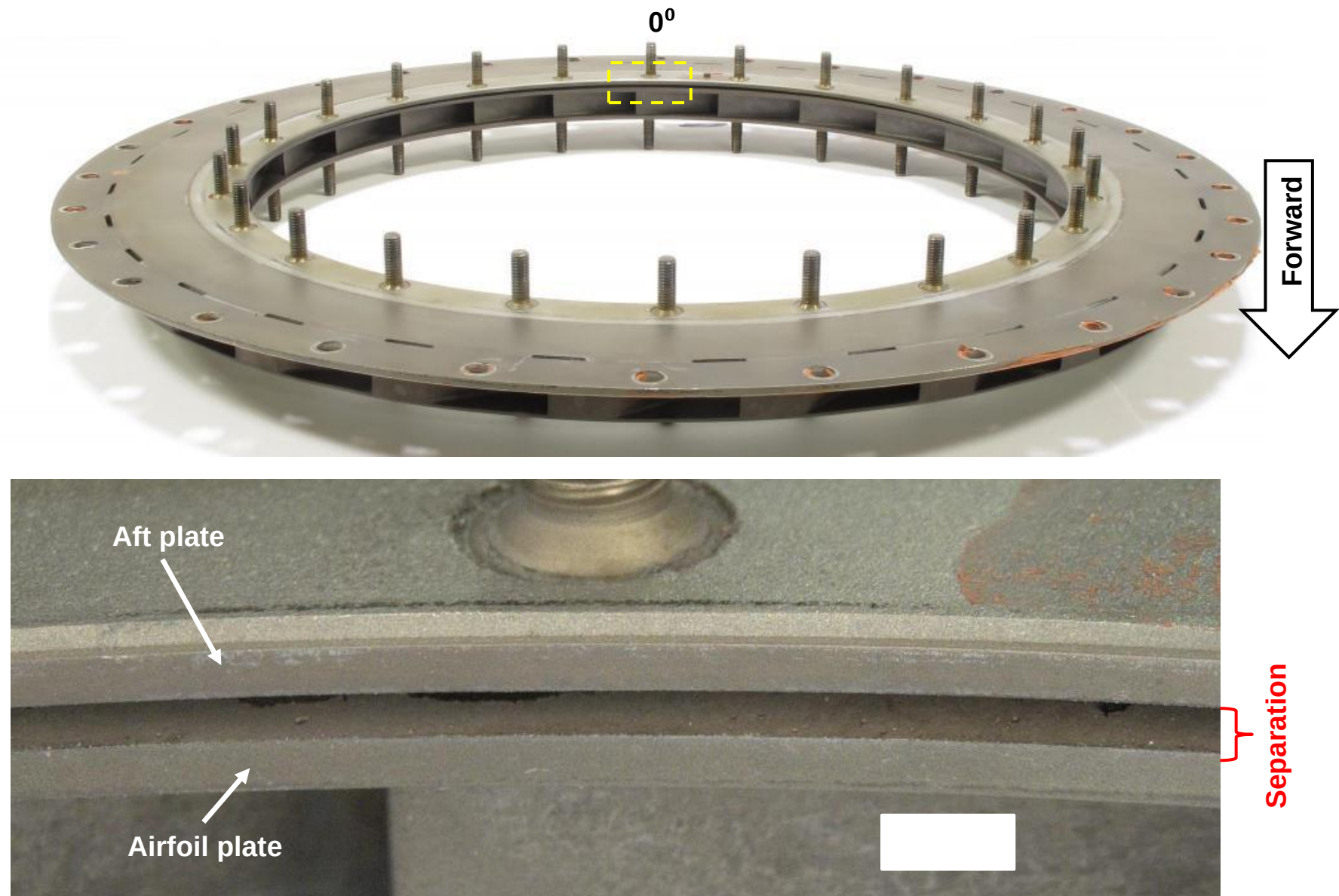


Figure 4. Radial views of the aft side of the compressor diffuser. The bottom image shows a detailed view of the inboard rim at the 0° position, which exhibited separation at the inboard aft braze joint between the airfoil plate and the aft plate.

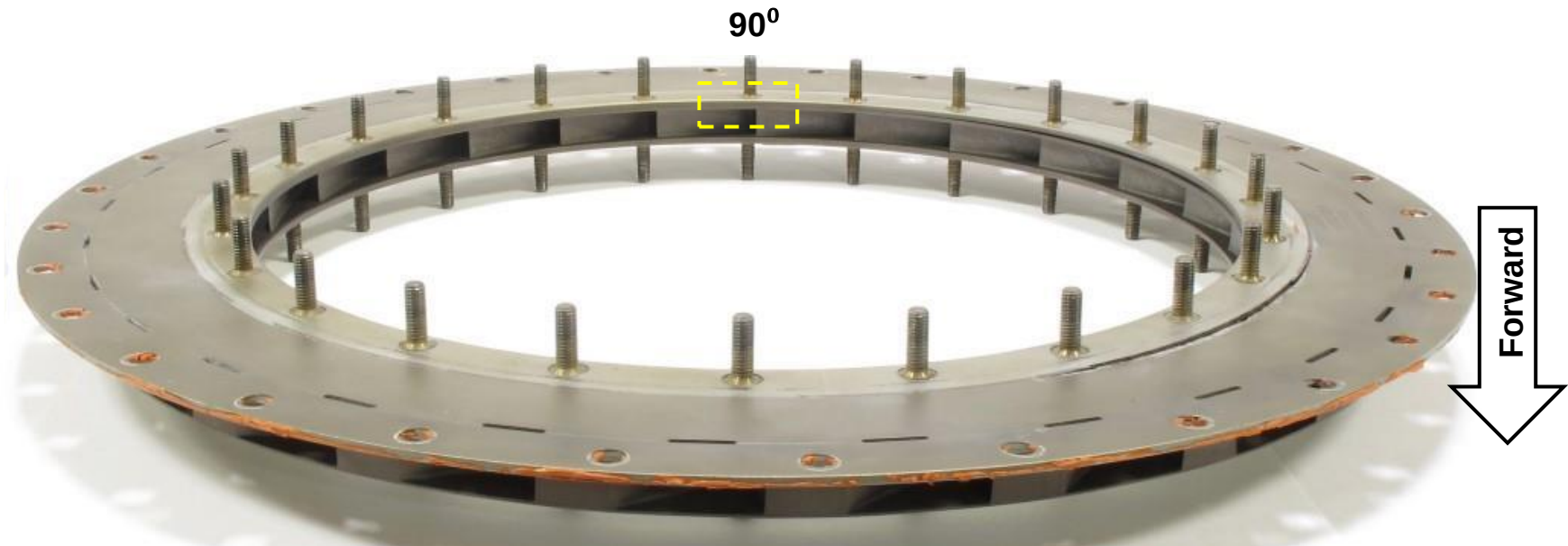


Figure 5. Radial views of the aft side of the compressor diffuser. The views are rotated approximately 90° from Figure 4. The bottom image shows a detailed view of the inboard rim at the 90° position, which exhibited no evidence of voids or debonding at the inboard aft braze joint.

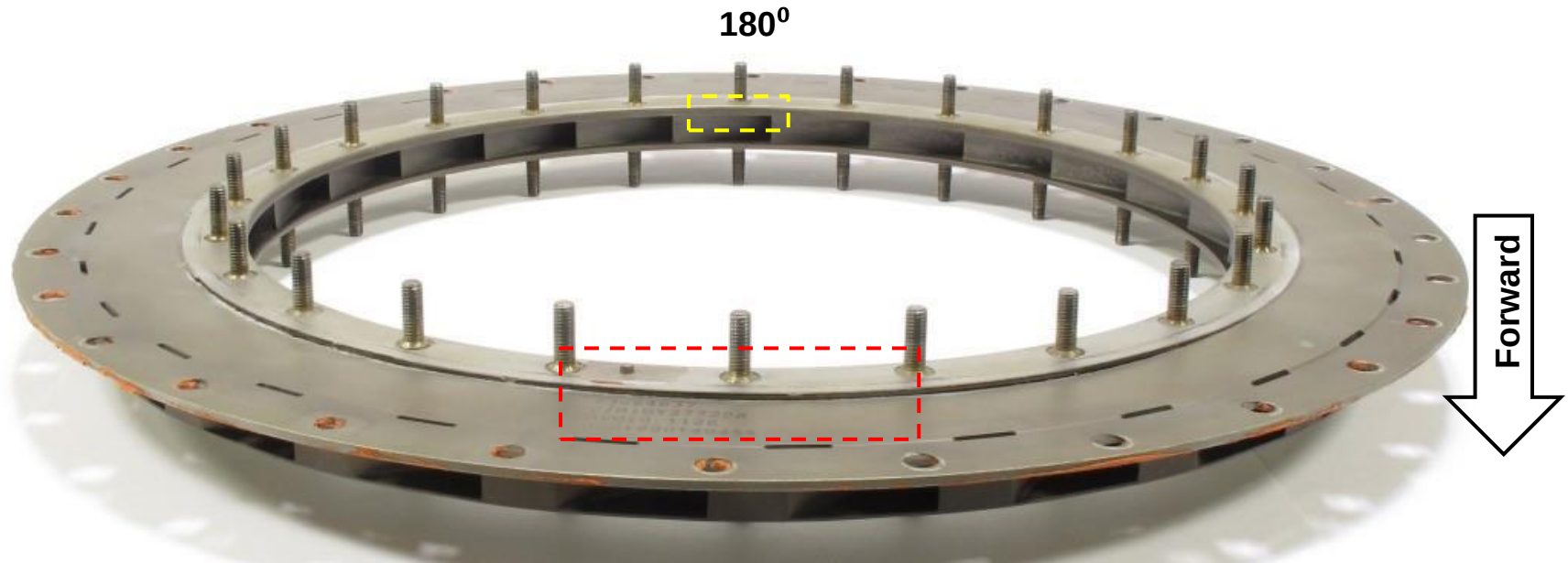


Figure 6. Radial views of the aft side of the compressor diffuser. The views are rotated approximately 90° from Figure 5. The bottom image (yellow boxed area) shows a detailed view of the inboard rim at the 180° position, which exhibited no evidence of voids or debonding at the inboard aft braze joint. The red boxed area is shown in more detail in Figure 8.

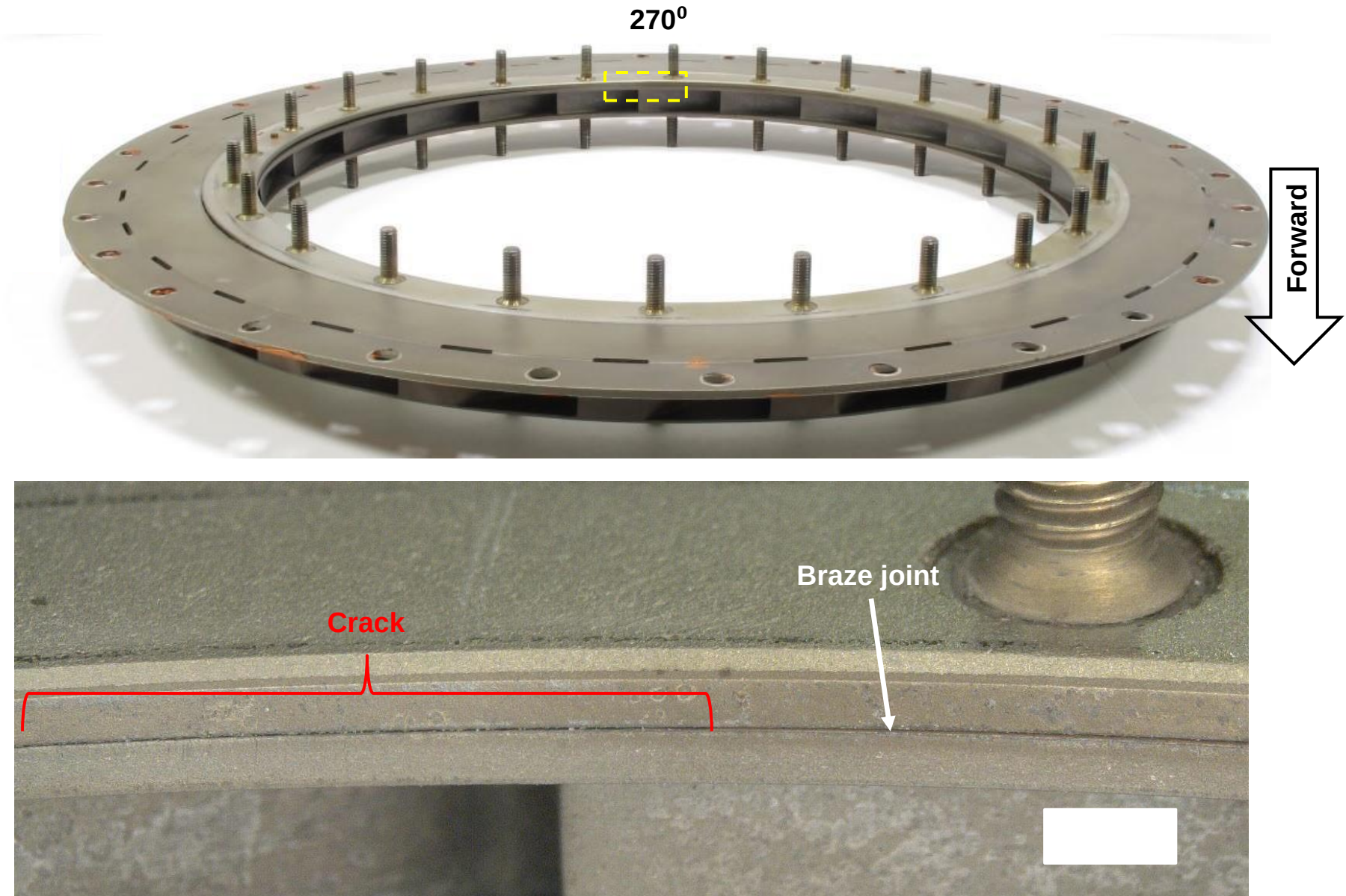


Figure 7. Radial views of the aft side of the compressor diffuser. The views are rotated approximately 90° from Figure 6. The bottom image shows a detailed view of the inboard rim at the 270° position, which exhibits a crack through the inboard aft braze joint (red bracket).

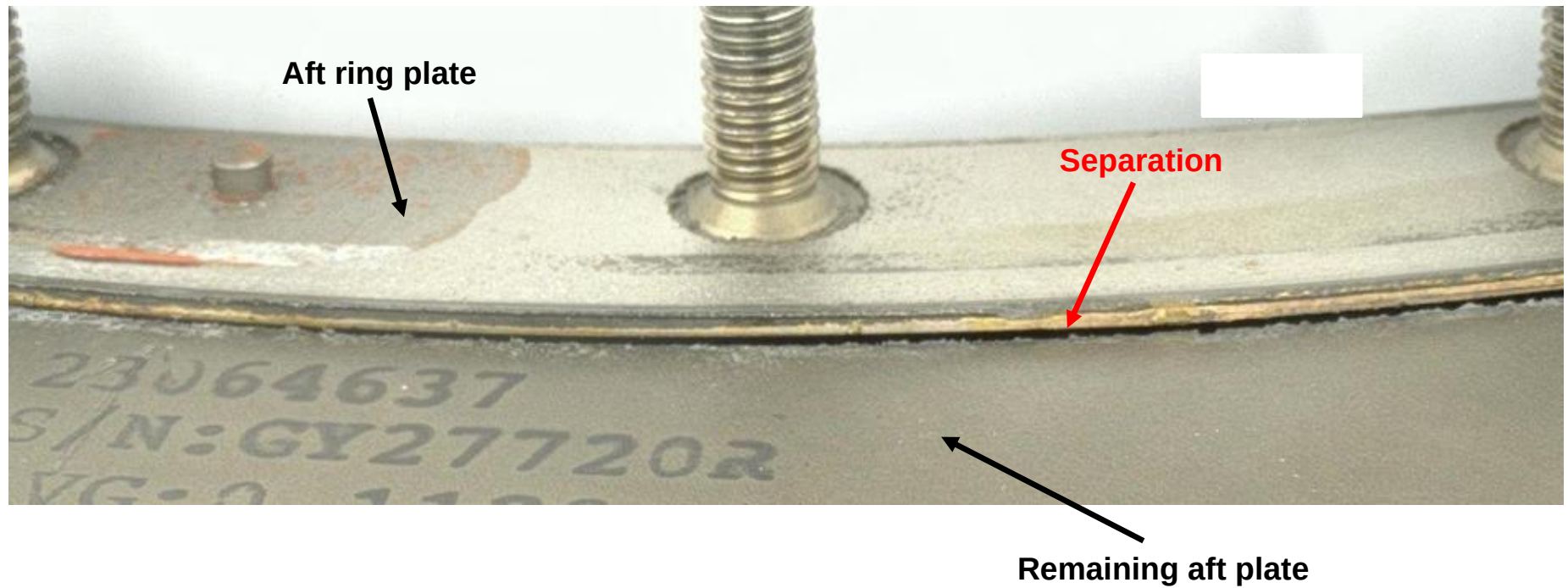


Figure 8. A detailed view of the aft face of the inboard rim at the 0° position, which exhibited separation between the aft ring plate and the remaining aft plate.

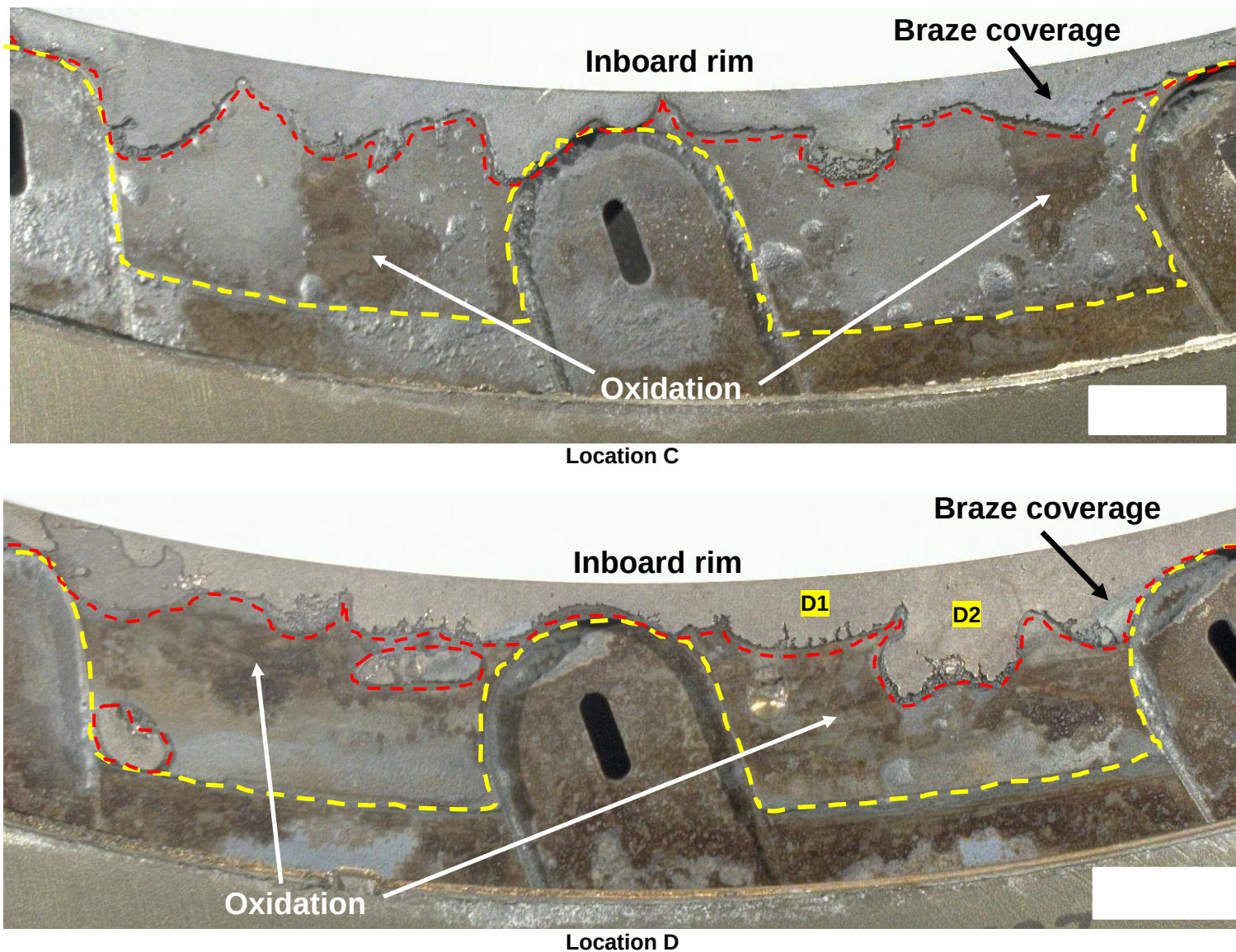


Figure 9. Detailed views of the airfoil plate at the inboard aft joint (see locations C and D in Figure 2) after removal of the the aft ring plate. Braze coverage did not meet the component definition requirement, and the braze land exhibited oxidation. The red dotted lines mark the area of the braze coverage, and the yellow dotted lines mark the inner extremity of the braze land. Locations D1 and D2 are shown in more detail in Figure 10.

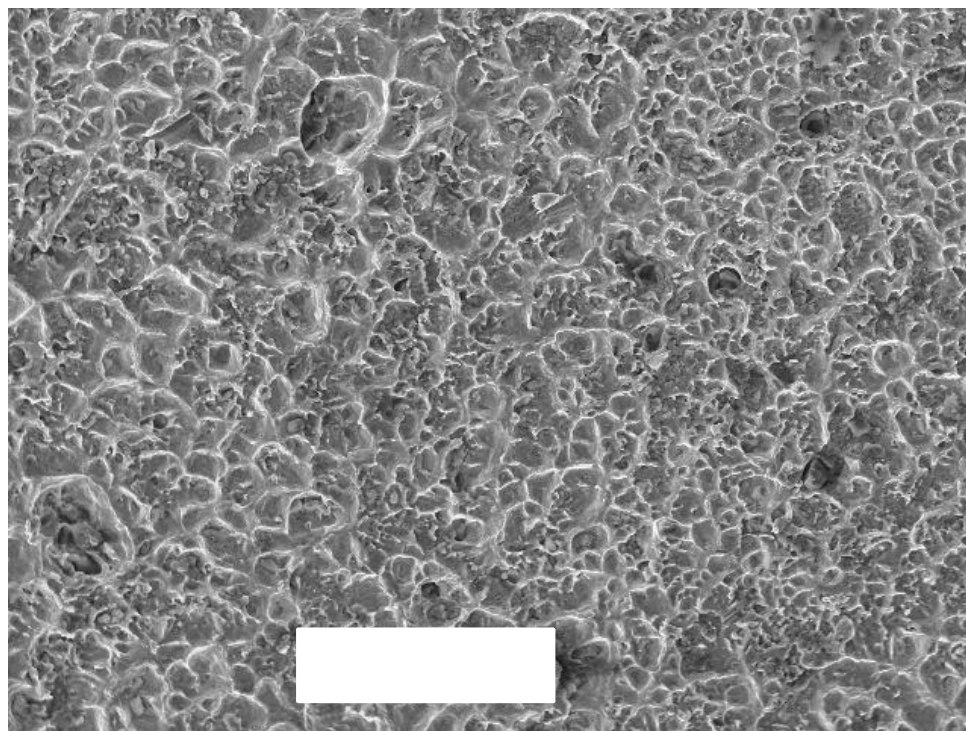
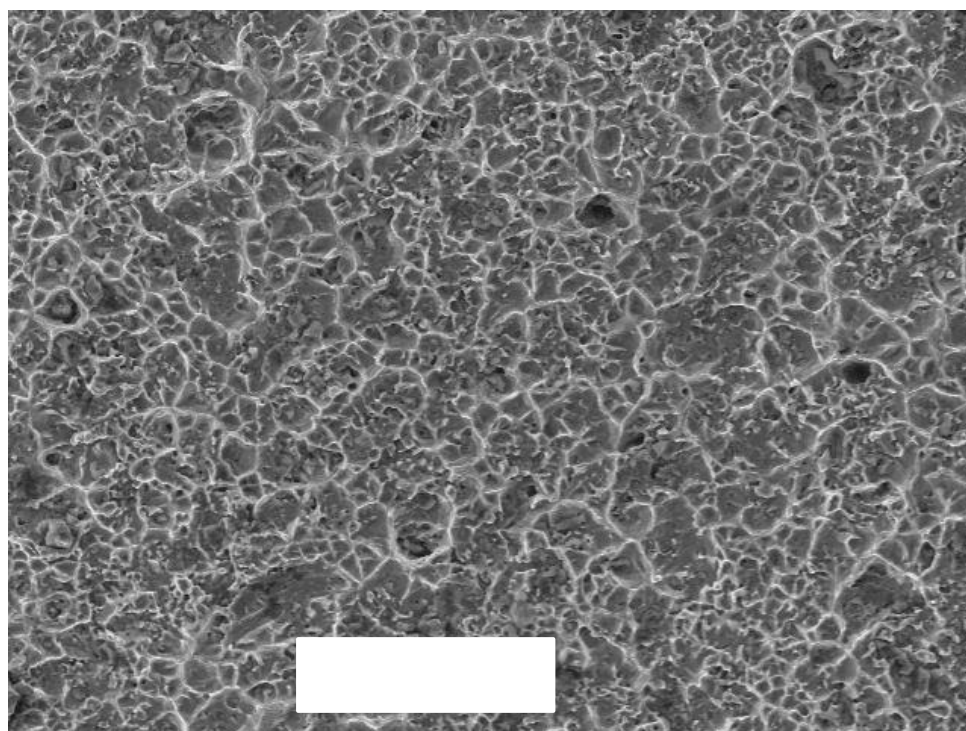
**Location D1****Location D2**

Figure 10. Secondary electron SEM images showing the braze surface on the airfoil plate at the inboard aft joint (see locations D1 and D2 in Figure 9), which displayed ductile dimples consistent with tensile overload.

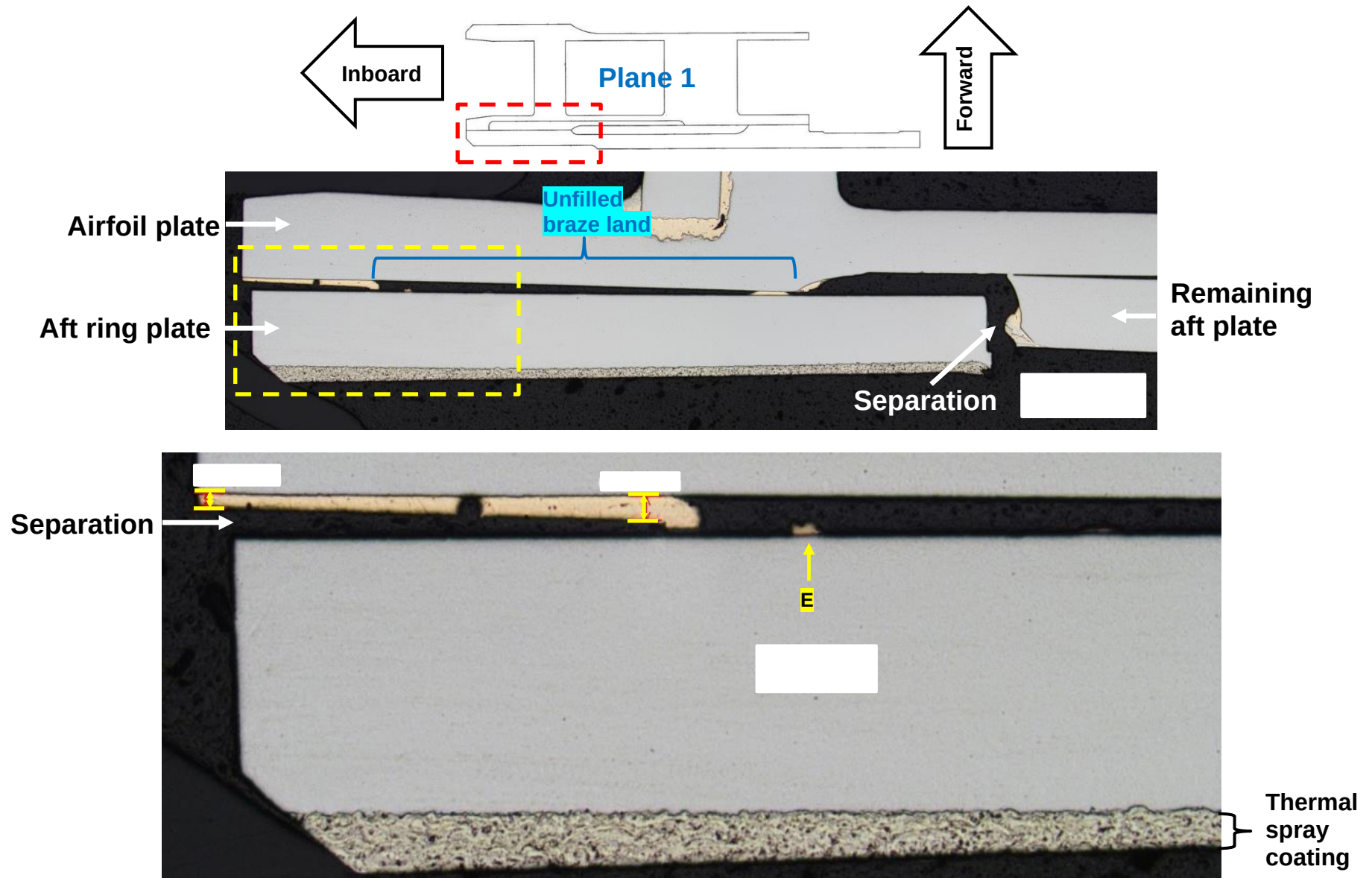


Figure 11. Photographs showing the metallographic cross-section through the inboard aft joint (see plane 1 in Figure 2). The braze alloy did not cover the entire braze land. The braze gap could not be measured since the aft ring plate was separated from the assembly, but the thickness of braze alloy that adhered to the airfoil plate did not meet the component definition requirement. Location E is shown in more detailed in Figure 12. Unetched.

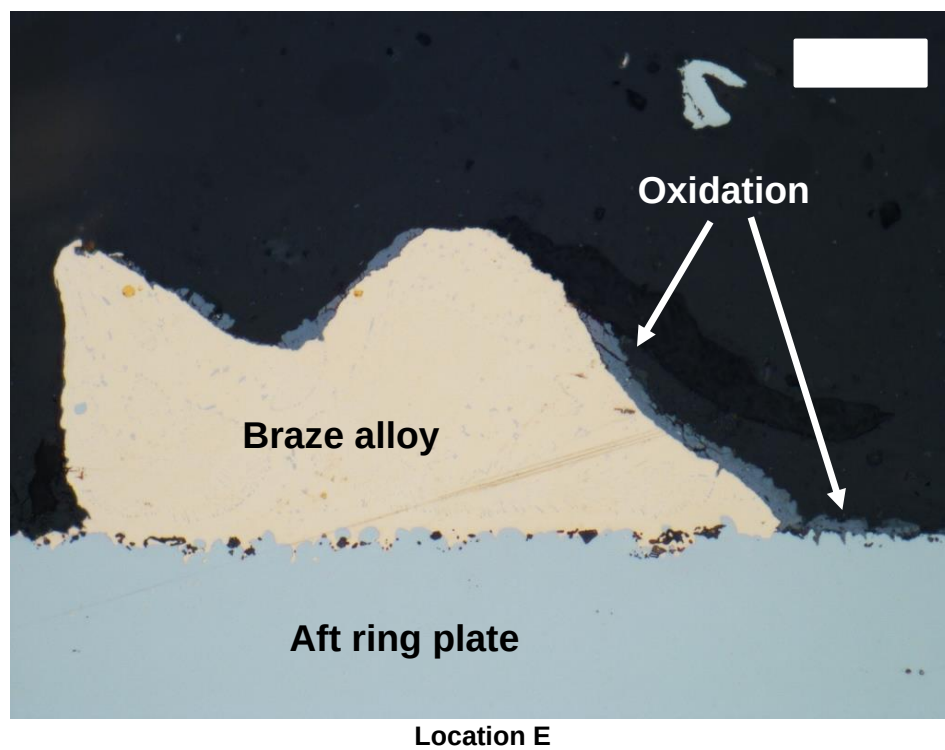


Figure 12. A representative metallographic cross-section through the aft ring plate in the unfilled portion of the the inboard aft joint (see location E in Figure 11), which exhibited oxidation. Unetched

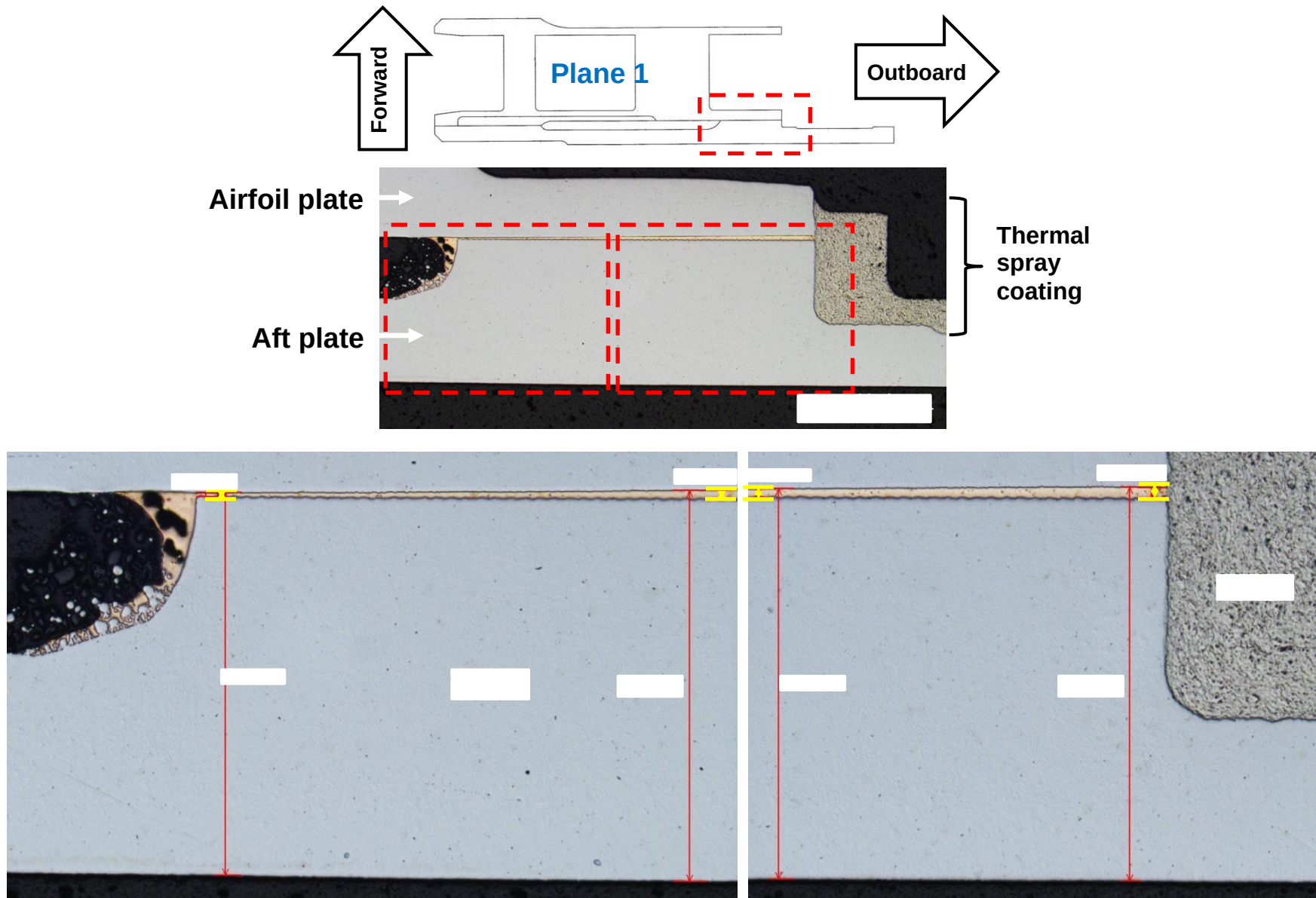


Figure 13. Photographs showing the metallographic cross-section through the outboard aft joint (see plane 1 in Figure 2). The braze gap was completely filled, but its thickness did not meet the component definition requirement. Unetched

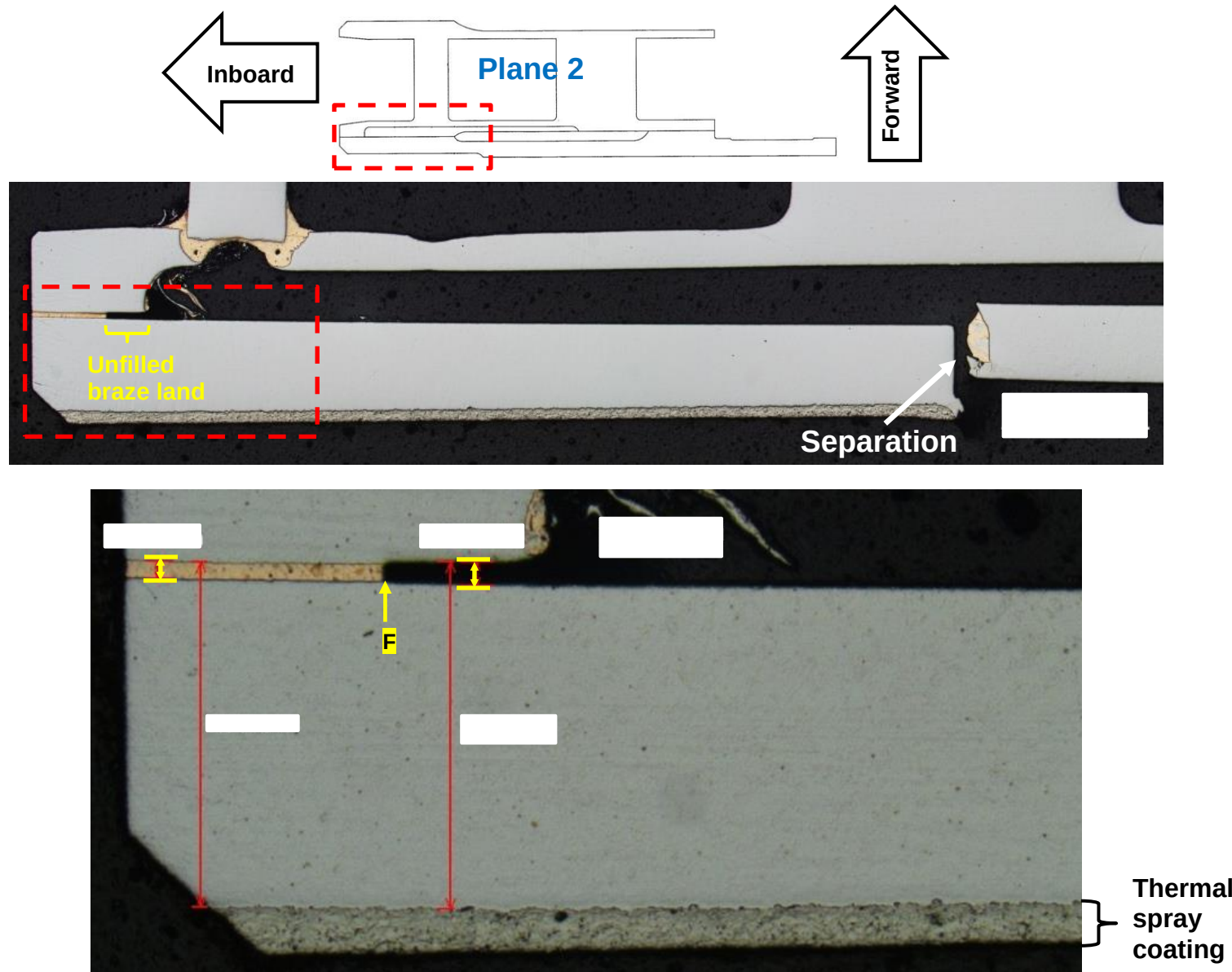


Figure 14. Photographs showing the metallographic cross-section through the inboard aft joint (see plane 2 in Figure 2). Braze alloy bridged the braze gap, but did not cover the entire braze land. The braze gap did not meet the gap requirement specified by the component definition. Location F is shown in more detailed in Figure 15. Unetched

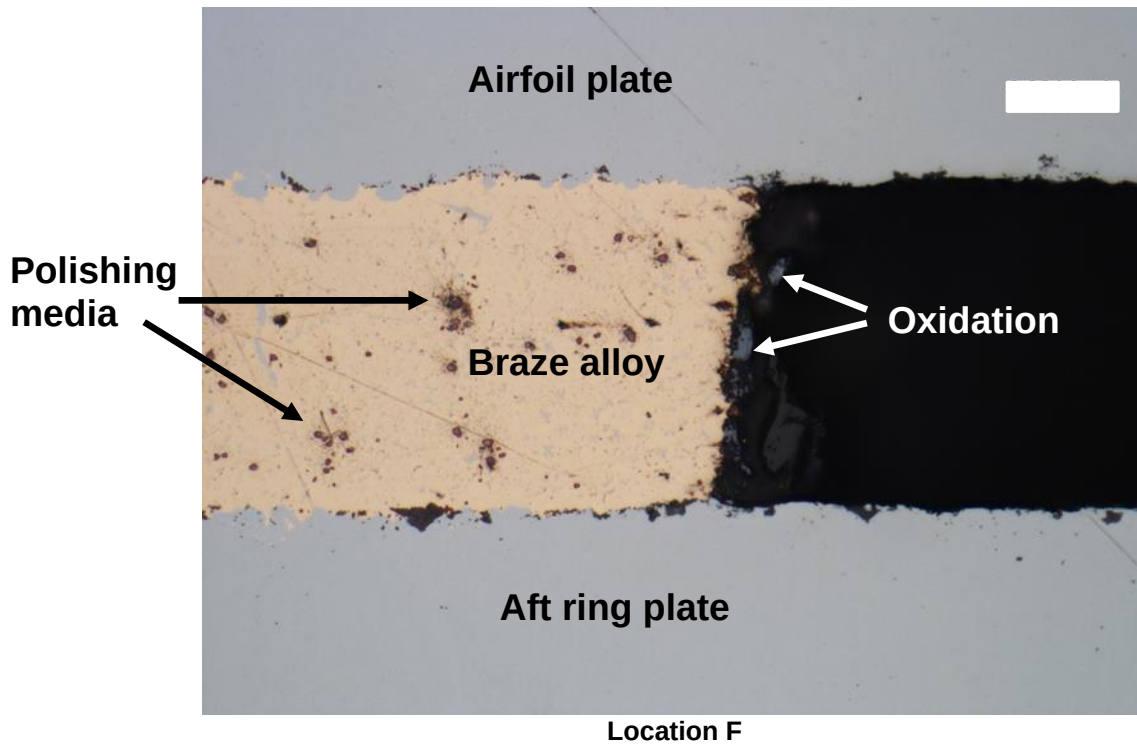


Figure 15. Detailed view of the metallographic cross-section through the inboard aft joint (see location F in Figure 14). The surface of the bridged braze alloy exposed to the unfilled portion of the braze gap exhibited oxidation. Unetched

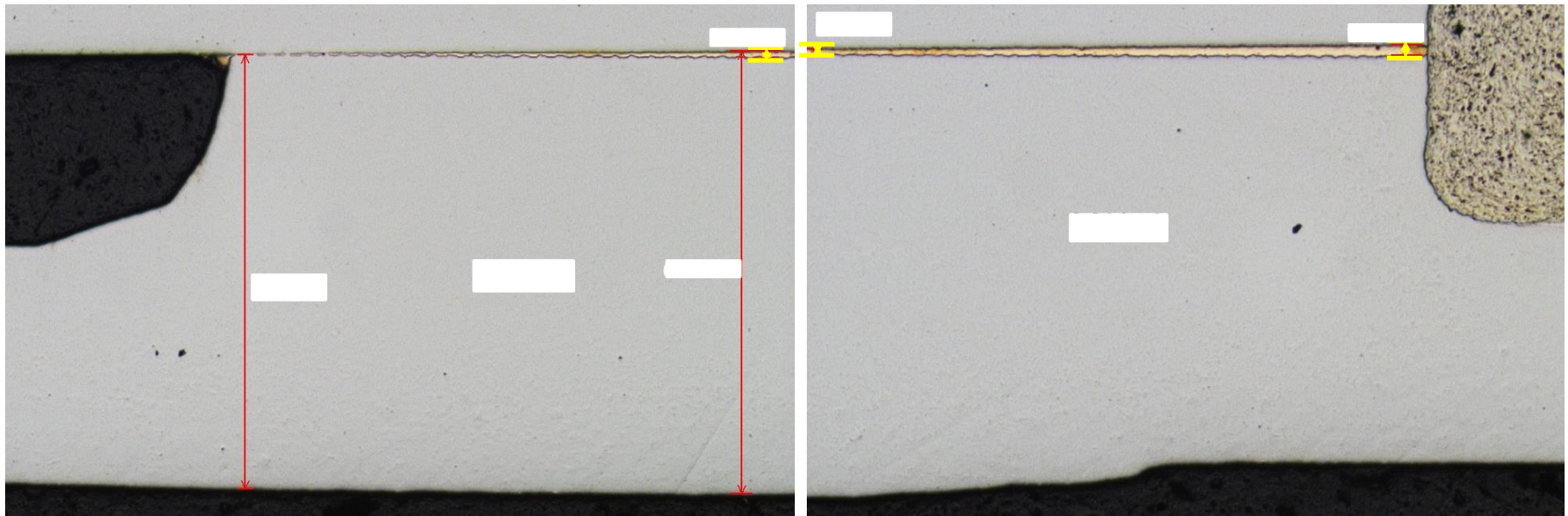
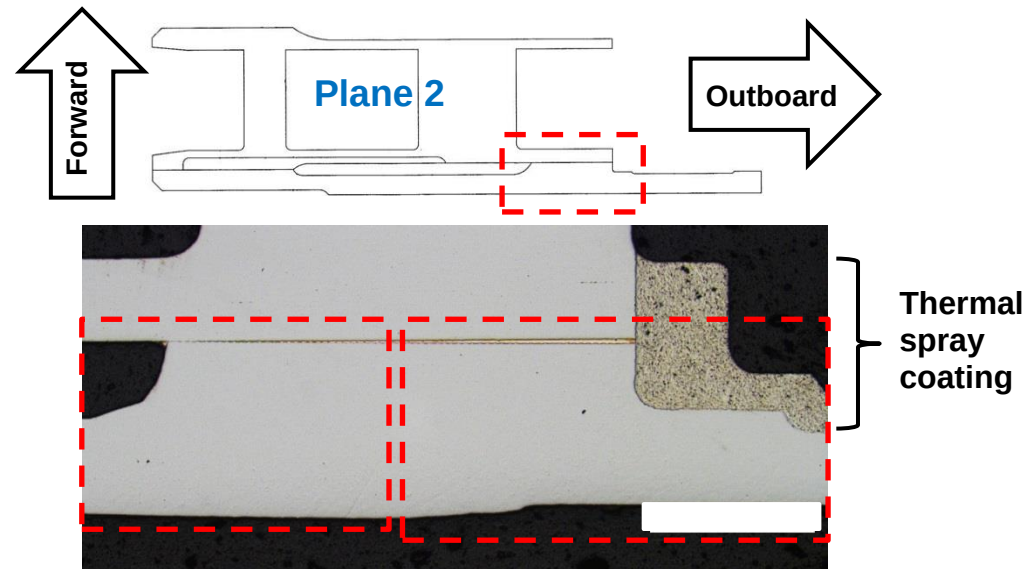


Figure 16. Photographs showing the metallographic cross-section through the outboard aft joint (see plane 2 in Figure 2). The braze gap was completely filled, and its thickness met the component definition requirement. Unetched

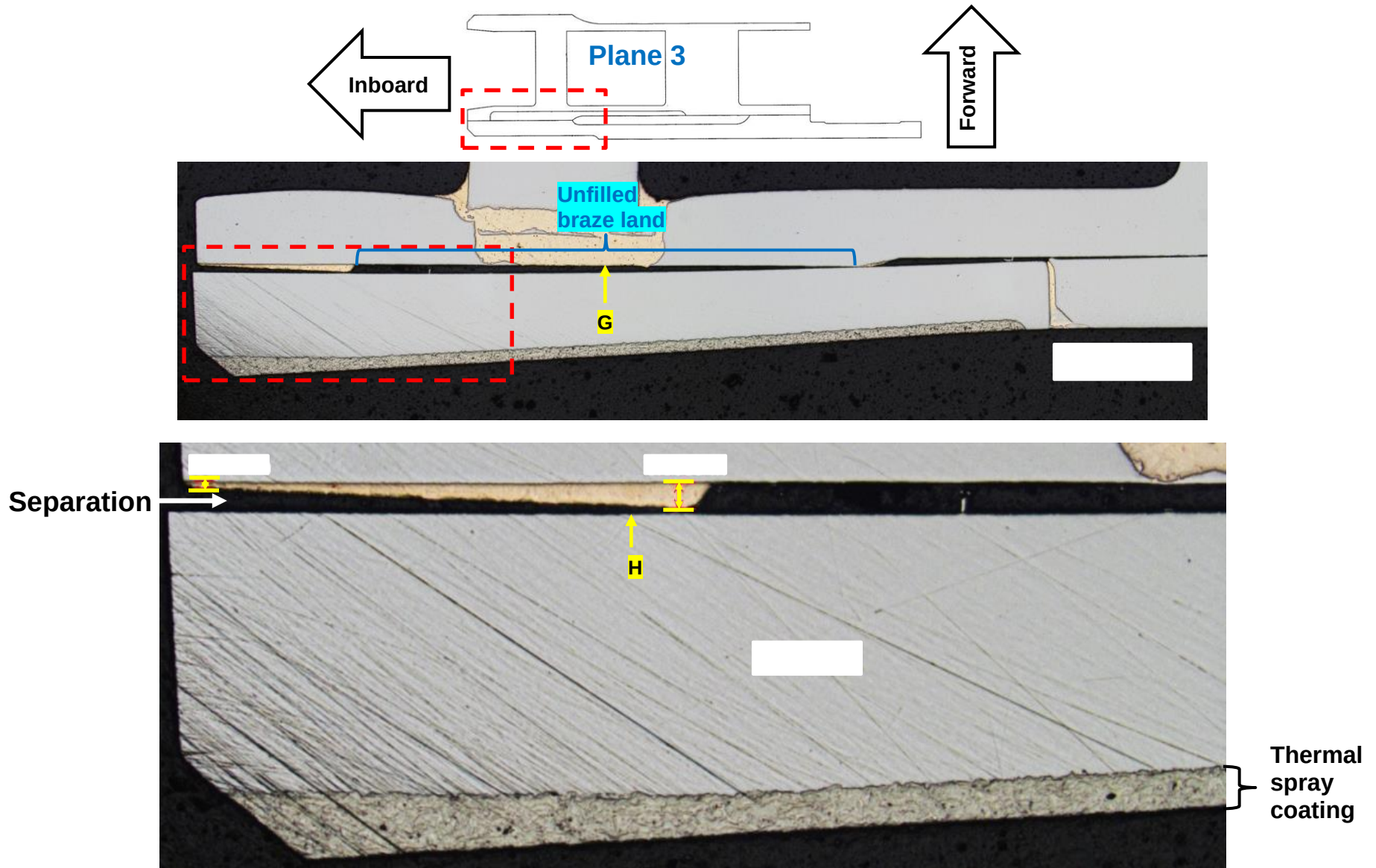


Figure 17. Photographs showing the metallographic cross-section through the inboard aft joint (see plane 3 in Figure 2). The braze alloy did not cover the entire braze land. The braze gap could not be measured since the aft ring plate was separated from the assembly, but the the thickness of braze alloy did not meet the component definition requirement. Locations G and H are shown in more detailed in Figure 18. Unetched

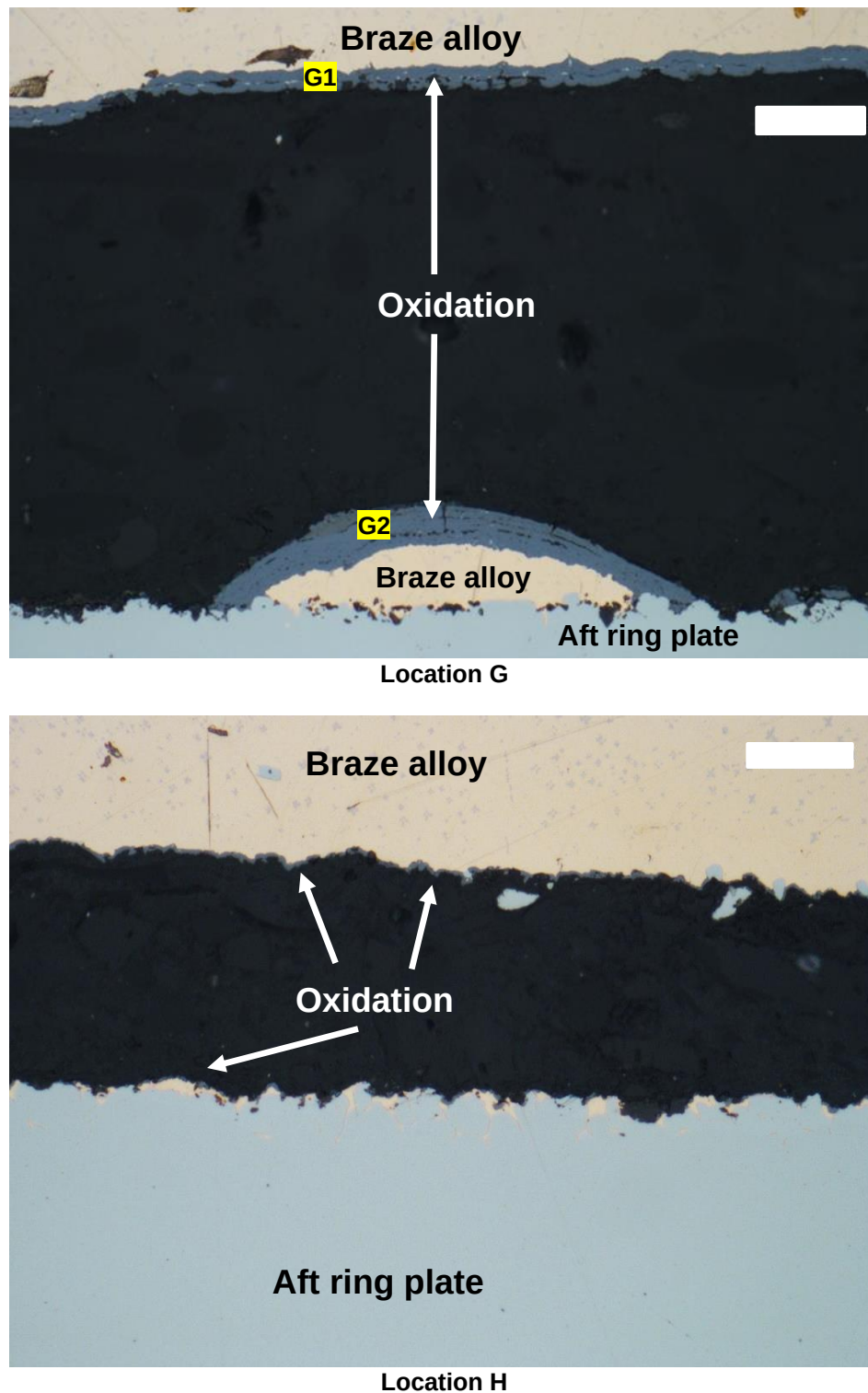


Figure 18. Detailed views of the metallographic cross-section through the inboard aft joint (see locations G and H in Figure 17). The top image shows braze alloy in the unfilled portion of the braze gap, which exhibited oxidation. The bottom image shows surfaces where the aft ring plate separated from the braze alloy, which also displayed light oxidation. Unetched

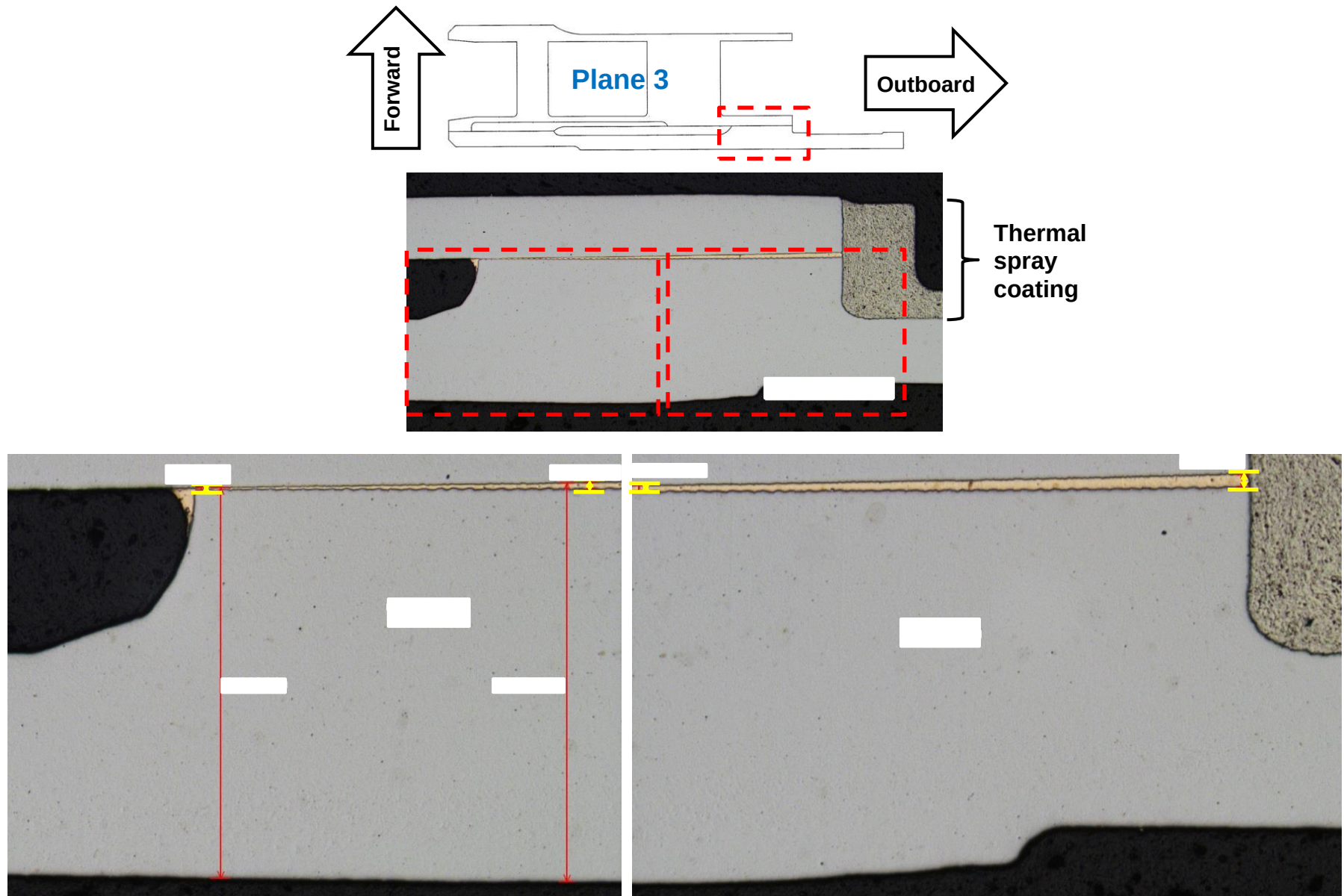


Figure 19. Photographs showing the metallographic cross-section through the outboard aft joint (see plane 3 in Figure 2). The braze gap was completely filled, but its thickness did not meet the component definition requirement. Unetched