National Transportation Safety Board

Office of Research and Engineering

Washington, DC 20594

DCA24MA063

MATERIALS LABORATORY

Factual Report 24-010

April 18, 2024

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A. ACCIDENT INFORMATION

Location:	Portland, Oregon
Date:	January 5, 2024
Vehicle:	Boeing 737-9, N704AL
Investigator:	Matthew Fox, RE-30

B. COMPONENTS EXAMINED

Forward and aft lower hinge fittings from the left mid exit door (MED) plug

C. EXAMINATION PARTICIPANTS

Specialist	Michael Meadows National Transportation Safety Board Washington, District of Columbia

D. DETAILS OF THE EXAMINATION

On January 5, 2024, about 1714 Pacific standard time, Alaska Airlines flight 1282, a Boeing 737-9, N704AL, returned to Portland International Airport (PDX), Portland, Oregon, after the left mid exit door (MED) plug departed the airplane leading to a rapid decompression. Seven passengers and one flight attendant received minor injuries. The flight was operated under Title 14 Code of Federal Regulations (CFR) Part 121 as a scheduled domestic passenger flight from PDX to Ontario, California (ONT).

The recovered left MED plug and associated components removed from the opening in the fuselage were examined by the NTSB Materials Laboratory (Washington, DC) as detailed in Materials Laboratory Factual Report 24-007, which this report supplements with a focus on the components identified in Section B.

The forward and aft lower hinge assemblies were disassembled to isolate the hinge fittings as shown in figure 1. A Keyence VL-500 Series Three-Dimensional (3D) Scanner Coordinate Measuring Machine (CMM) was used to scan the disassembled components to generate 3D models of the component surfaces. This technique used a non-contact optical pattern from a blue light emitting diode (LED) source and a camera to detect reflected pattern distortions and convert to a digital 3D model.

Multiple scans of each hinge fitting were performed at various orientations to acquire data across all part surfaces. Internal surfaces (i.e. hole features) were incomplete due to line-of-sight limitations, however sufficient data was acquired to create continuity with external surfaces and perform pertinent measurements. Each scan was manually aligned using common features to establish the complete models as shown in figures 2 and 3.[1] Feature dimensions measured on the models were compared with digital caliper measurements on the physical parts to validate the models.

Figure 4 shows a view of the aft hinge fitting model used to measure inboard/outboard bending deformation observed along the hinge shaft. Two methods were used to characterize the degree of bending in the inboard direction. Method 1 established two best-fit cylinder elements, one about the upper shaft region, and the other about the lower shaft region as shown in green. The angle between the axes of these two constructed cylinders was measured to be 3.2 degrees, with the upper shaft region bent inboard relative to the lower shaft region. Method 2 established two planes, one on the upper shaft surface, and the other on the shoulder at the base of the shaft (lower bearing surface of the lift assist spring washer). The angle between the normal vectors of these two constructed planes was measured to be 3.7 degrees, with the upper shaft plane normal angled inboard relative to the lower shaft plane normal. The cylinder axes established from method 1 were compared to the respective plane normal vectors established from method 2 and offsets of 0.3 degrees and 0.2 degrees were measured between the lower shaft region and upper shaft region, respectively. When added to the offset angle measured using method 1, the measurement agreed with the offset angle of 3.7 degrees measured using method 2.

Figure 5 shows a view of the aft hinge fitting model used to measure hinge shaft bending in the forward/aft direction. A best-fit cylinder element was established along the inner surface of the gooseneck region as shown in green. The angle between the axis of this cylinder and the normal vectors of the planes established as part of method 2, detailed above, was measured to be 90 degrees and 89.8 degrees relative to the lower and upper shaft planes, respectively. This was consistent with no appreciable forward/aft bending observed in the lower shaft region and 0.2 degree aft bending observed in the upper shaft region relative to the gooseneck feature axis. The same measurements were performed using the hinge bracket attachment hole axis as opposed to the gooseneck feature axis which produced similar results.

A similar measurement approach was employed on the forward hinge fitting to characterize shaft bending. Figure 6 shows a view of the forward hinge fitting model used to measure inboard/outboard bending deformation observed along the hinge shaft. Method 1, as detailed above, was not employed as distinct best-fit cylinder elements could not be established along the hinge shaft, so only method 2 was used. The angle between the normal vectors of the two constructed planes was measured to be 0.4 degree, with the upper shaft plane normal angled inboard relative to the lower shaft plane normal.

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[1] Coordinate system convention for 3D scan models: +X = forward, +Y = outboard, +Z = up relative to the installed configuration on the aircraft.

Figure 7 shows a view of the forward hinge fitting model used to measure any hinge shaft bending in the forward/aft direction, using the same approach as was used for the aft hinge fitting. The angle between the axis of the gooseneck cylinder element and the normal vectors of the planes established were measured to be 90 degrees. This was consistent with no appreciable forward/aft bending observed in the shaft region.

Figures 8 and 9 show section cut locations (left, red line) taken through the aft and forward hinge fittings, respectively. The corresponding image on the right of the 3D image shows the two-dimensional profile of the section cut. The dimensions of the hinge attachment holes were measured, and results are summarized in Table I. The nominal hole diameter was measured by constructing a best-fit circle element along the hole profile. This value ranged from 0.449 inch to 0.458 inch. Roundness was calculated as the maximum deviation of the dataset from the best-fit circle element and ranged from 0.001 inch to 0.006 inch. The actual hole diameter was measured in two orientations, between the upper and lower edge (horizontal measurement in the profile images) and between the inboard and outboard edge (vertical measurement in the profile images). These values ranged from 0.448 inch to 0.461 inch. More variation in the measurements was observed closer to the aft end of each hinge fitting. According to the engineering drawing, the specified hole diameter is 0.442 – 0.452 inch.

Submitted by:

Michael Meadows
Materials Engineer

Table I: Summarized Hinge Attachment Hole Measurements

Feature Dimension (in.)	Aft Hinge Fitting				FWD Hinge Fitting			
Section Location [1]	FWD	Inner 1	Inner 2	AFT	FWD	Inner 1	Inner 2	AFT
Diameter [2]	0.451	0.450	0.451	0.458	0.450	0.450	0.449	0.451
Roundness [3]	0.004	0.001	0.002	0.006	0.002	0.002	0.003	0.006
Up/Down [4]	0.453	0.451	0.450	0.452	0.450	0.450	0.448	0.454
Inboard/Outboard [5]	0.448	0.449	0.452	0.461	0.450	0.450	0.450	0.449

Notes:
[1] FWD and AFT section locations were taken as close as practical to the forward and aft ends of the attachment hole, respectively. Inner section locations are ordered progressing from forward to aft.
[2] The nominal diameter was established as a best-fit circle element along the hole profile of the section cut.
[3] Roundness is considered the maximum deviation of the dataset along the hole profile from the best-fit circle element described above.
[4] The hole diameter in the up/down direction relative to the installed hinge configuration.
[5] The hole diameter in the inboard/outboard direction relative to the installed hinge configuration.

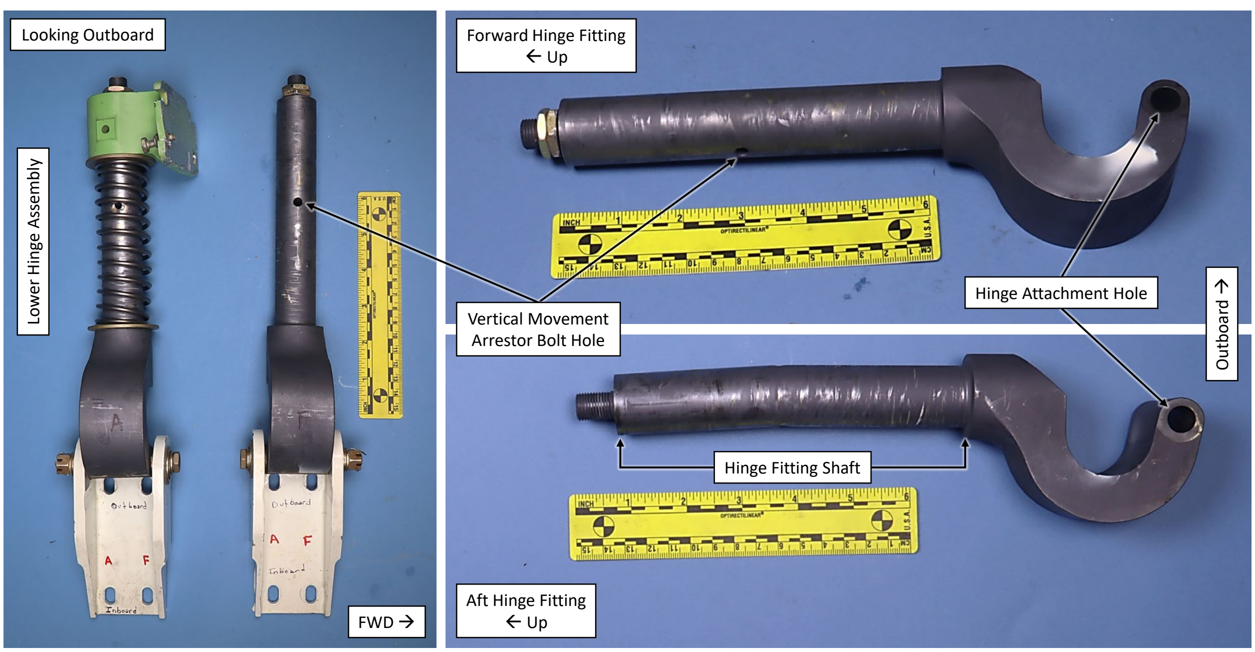

Figure 1. Photographs showing the MED plug hinge assemblies (left) and after disassembly to isolate the forward and aft hinge fittings (right).

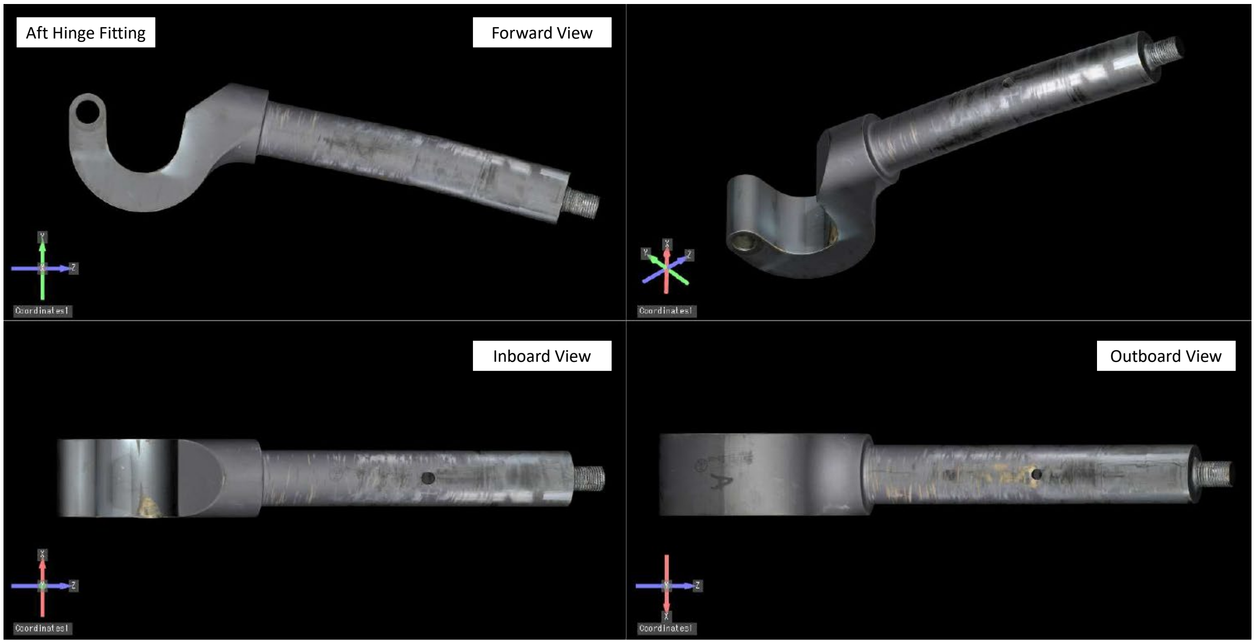

Figure 2. Modeled views of the aft hinge fitting from 3D scan data.

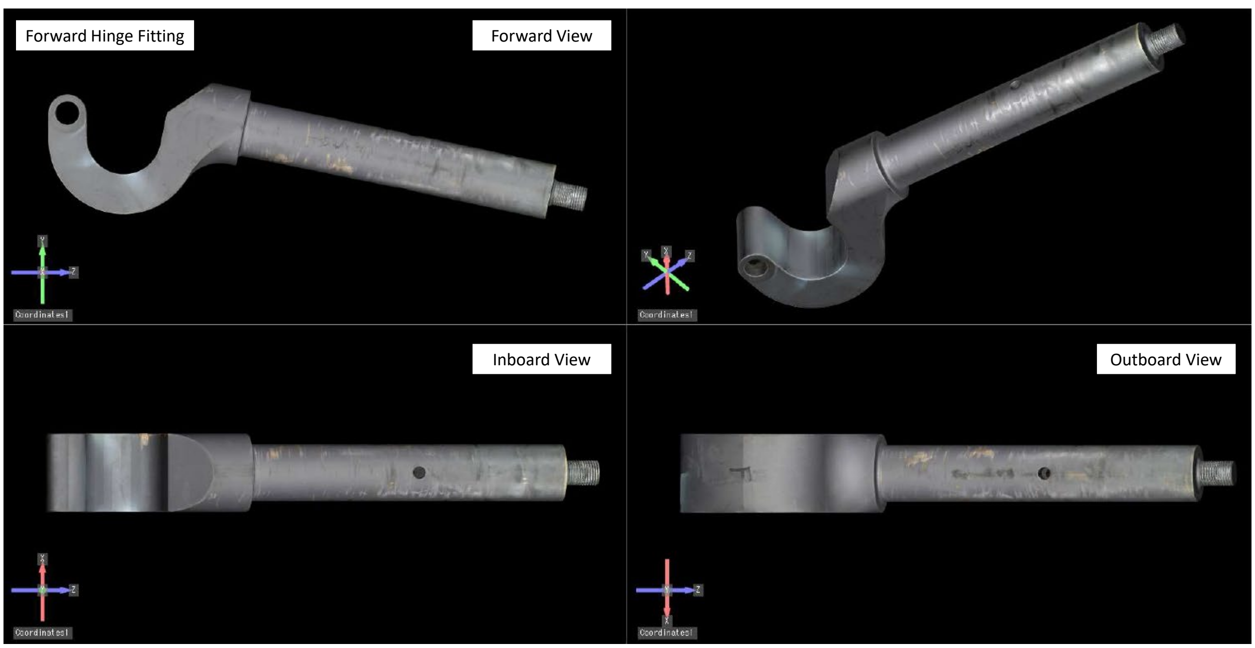

Figure 3. Modeled views of the forward hinge fitting from 3D scan data.

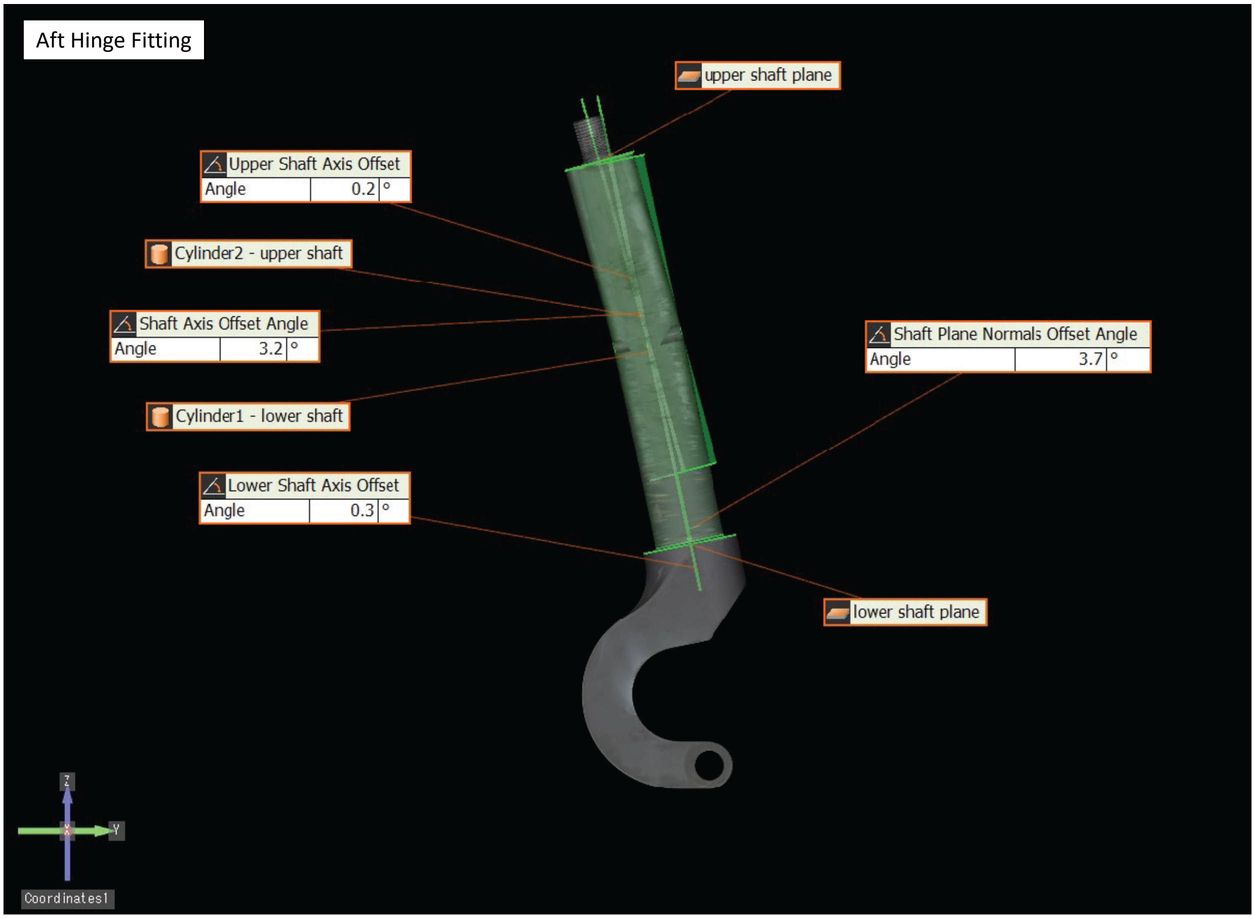

Figure 4. Modeled view of the aft hinge fitting showing cylinder elements constructed along the upper and lower shaft regions, planes constructed on the top surface and base of the shaft, and measured bend angles between the cylinder axes and plane normal vectors.

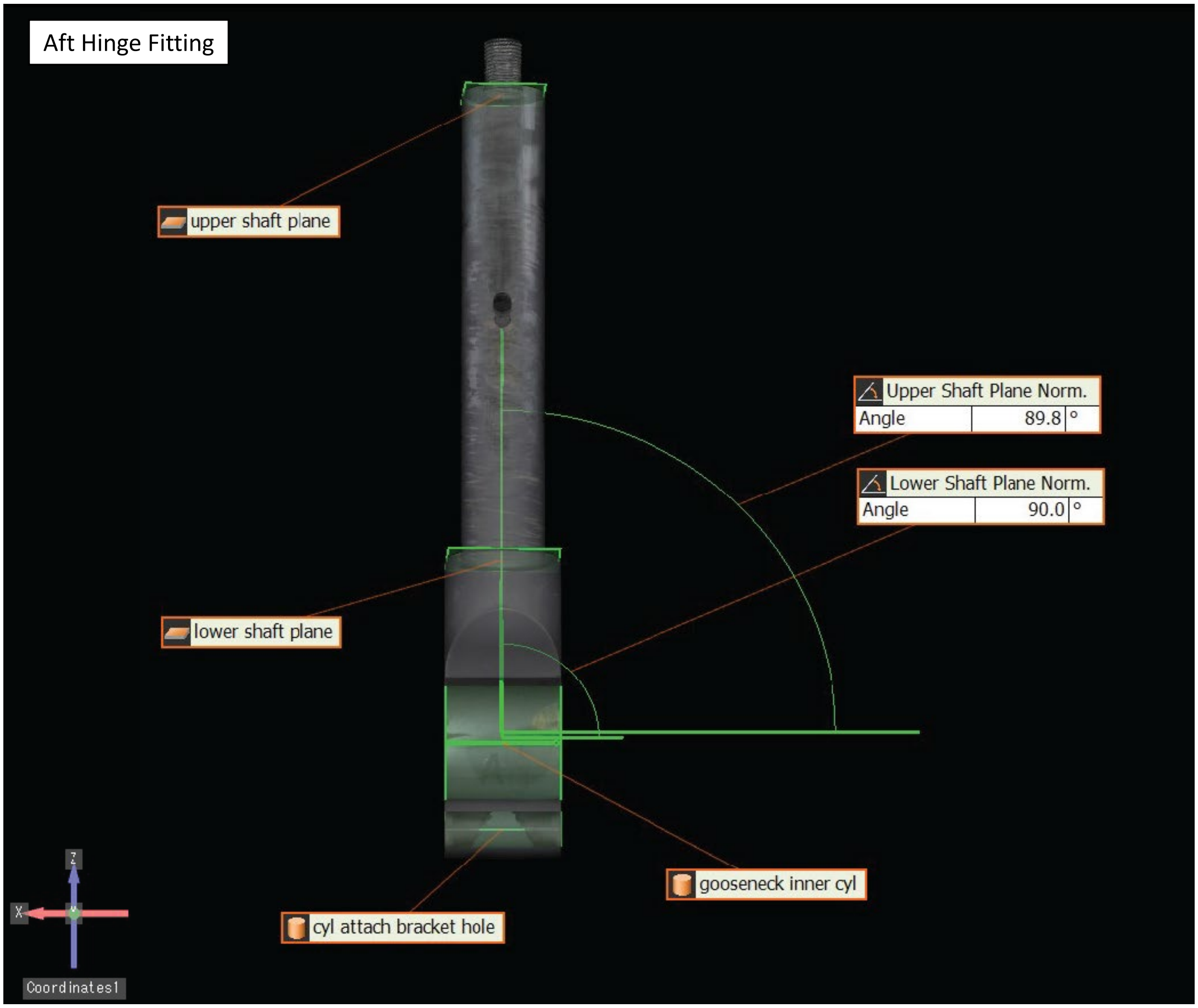

Figure 5. Modeled view of the aft hinge fitting showing cylinder elements constructed along the internal gooseneck and attachment hole regions, planes constructed on the top surface and base of the shaft, and measured bend angles between the cylinder axes and plane normal vectors.

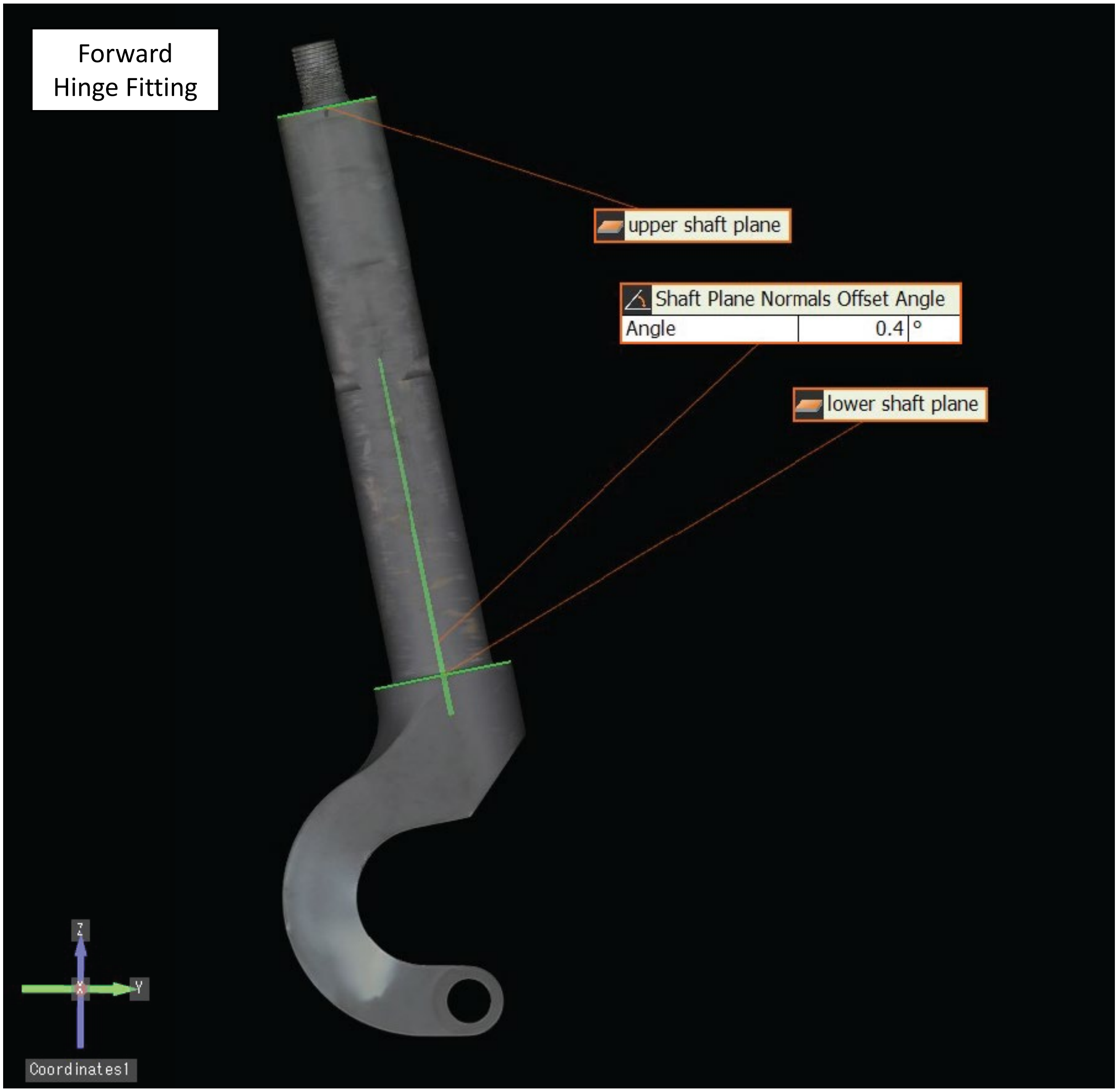

Figure 6. Modeled view of the forward hinge fitting showing planes constructed on the top surface and base of the shaft and measured bend angle between the plane normal vectors.

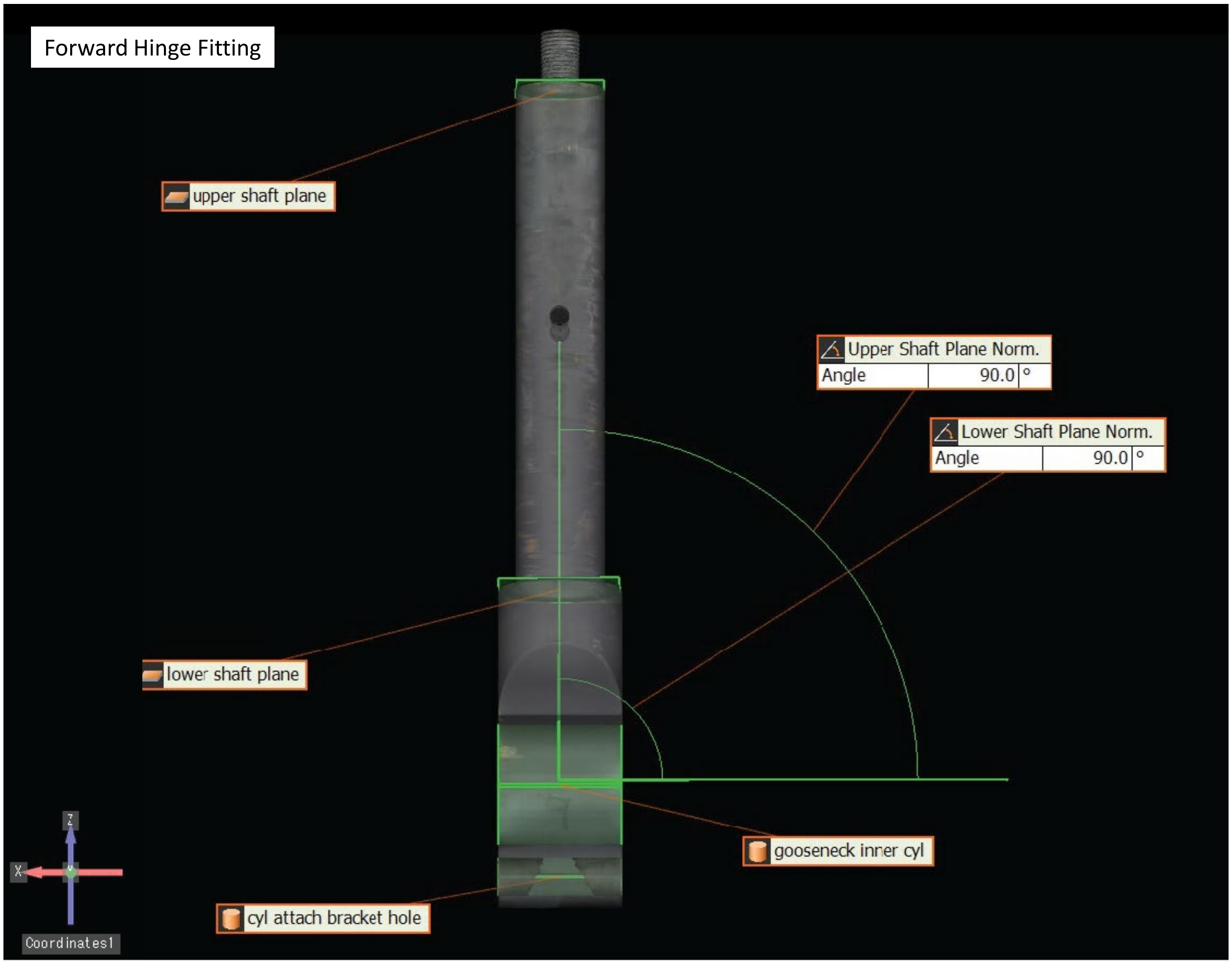

Figure 7. Modeled view of the forward hinge fitting showing cylinder elements constructed along the internal gooseneck and attachment hole regions, planes constructed on the top surface and base of the shaft, and measured bend angles between the cylinder axes and plane normal vectors.

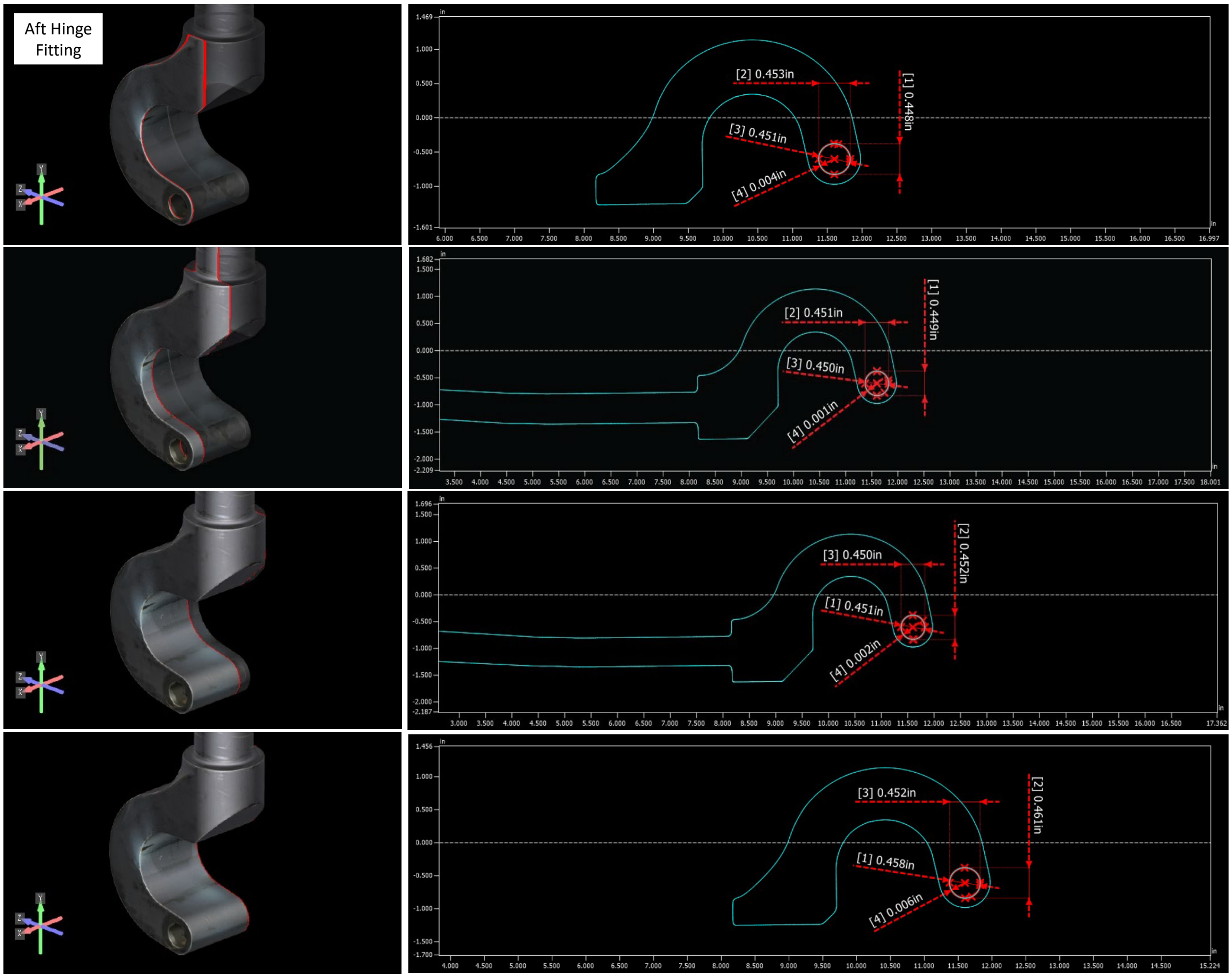

Figure 8. Section cut locations through the aft hinge fitting (left, red lines) and the associated 2D profile of the part at the section cut (right) progressing from forward to aft (top to bottom). Measured values of the attachment hole are indicated in the 2D profile views.

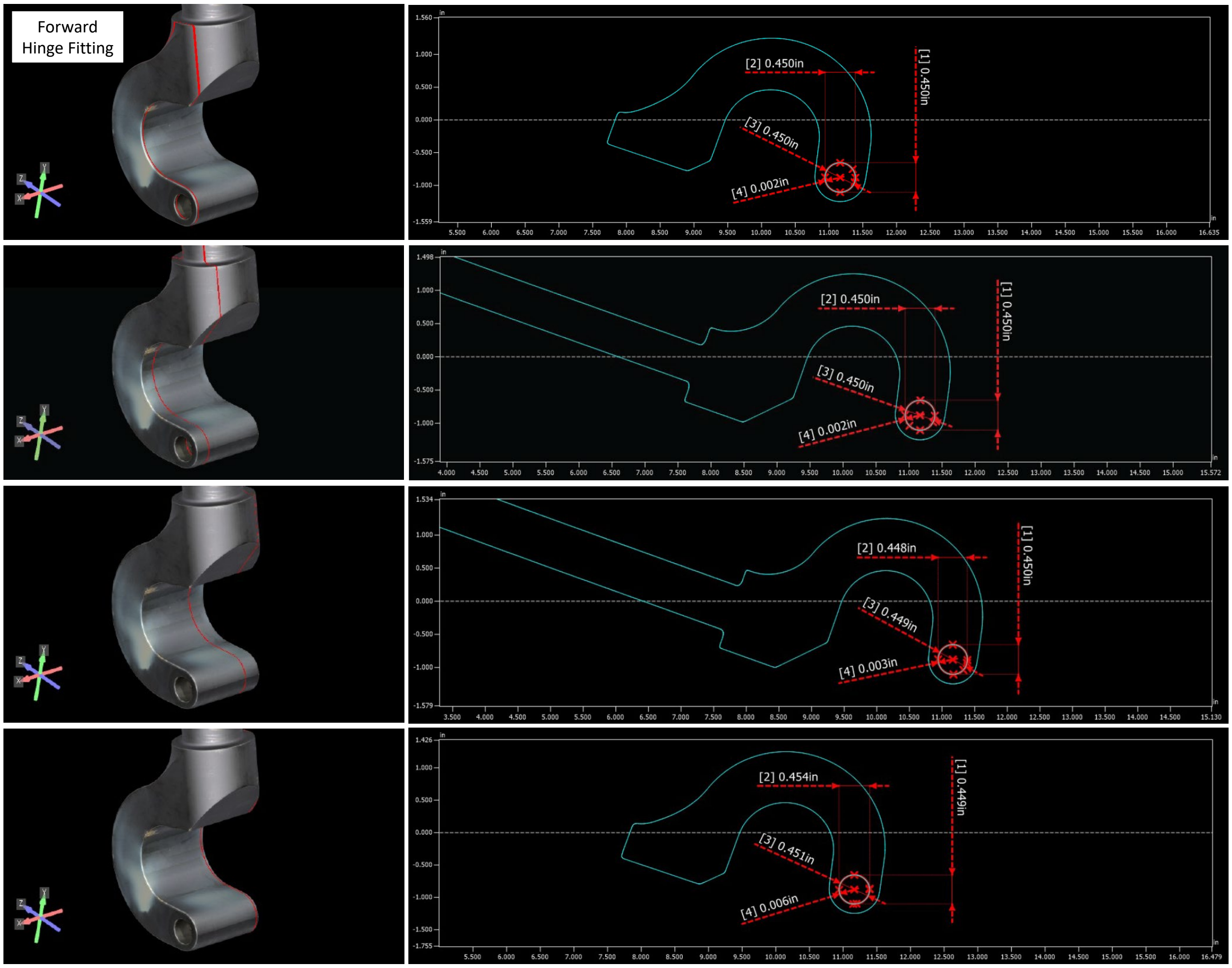

Figure 9. Section cut locations through the forward hinge fitting (left, red lines) and the associated 2D profile of the part at the section cut (right) progressing from forward to aft (top to bottom). Measured values of the attachment hole are indicated in the 2D profile views.