



Equipment Quality Analysis Report

Boeing Commercial Airplanes



TO: Air Safety Investigations (ASI)

EQA NUMBER: AS13825
DATE: October 30, 2024
MODEL NUMBER: 767-300ERSF
AIRPLANE NUMBER: VN967

SUBJECT: *Auxiliary Power Unit (APU) Access Doors Departed During Flight*

IDENTIFICATION:

Part name:	Left hand (LH) APU door assembly
Boeing part number:	[REDACTED]
Supplier:	Bombardier Inc
Part name:	Right hand (RH) APU door assembly
Boeing part number:	[REDACTED]
Supplier:	Bombardier Inc
Part name:	LH elevator assembly
Boeing part number:	[REDACTED]
Serial number:	000639
Supplier:	Alenia Aeronautica Spa
Part name:	RH elevator assembly
Boeing part number:	[REDACTED]
Serial number:	000639
Supplier:	Alenia Aeronautica Spa
Part name:	Rod assembly
Boeing part number:	[REDACTED]
Supplier:	Lefiell Manufacturing Company
Part name:	Hold open strut
Boeing part number:	[REDACTED]
Supplier part number:	[REDACTED]
Supplier:	Avibank Manufacturing Inc
Part name:	Seal



Boeing part number:	[REDACTED]
Part name:	Flexible drive shaft
Boeing part number:	Unknown
Supplier:	Unknown

BACKGROUND:

The flight crew of airplane VN967, a 767-300ERSF, reported a fire/overheat message on the engine indication crew alerting system (EICAS) shortly after departure from Cincinnati, Ohio (CVG). The flight crew noted an audible loud bang at 13,000 feet and increased airframe vibrations while climbing to flight level 25,000 feet (FL250). Severe airframe vibration was noted after level off at FL250. The flight crew performed an air turn back to CVG. No emergency was declared during approach and the aircraft was able to return to CVG without any further issues reported.

During the post flight ground inspection, the LH and RH APU access doors were discovered to have departed from the aircraft and damage was observed on the lower inboard surfaces of the LH and RH elevators.

Departed sections of the LH APU door were recovered. The departed section of the RH APU door was not recovered.

The damaged sections of the LH and RH elevators were removed from the aircraft along with the remaining portions of the LH and RH APU doors. Other damaged components were removed from the aircraft including an elevator control rod assembly, an APU door hold open strut, a horizontal stabilizer panel seal, and a flexible drive shaft.

The sections of the LH APU door, a section of the RH APU door, an elevator control rod assembly, an APU door hold open strut, a horizontal stabilizer panel seal, a flexible drive shaft, the LH elevator assembly, and the RH elevator assembly were sent to the Boeing Equipment Quality Analysis (EQA) facility in Seattle, Washington for examination and analysis.



SUMMARY:

On October 7, 2024, an examination for the departed APU doors and related components was held at the Boeing EQA facility in Seattle, Washington. Boeing Air Safety Investigation (ASI), Boeing Research & Technology (BR&T) Metallurgical Fracture Analysis, and Boeing Mechanical & Structural Engineering were in attendance.

The following components were analyzed at the EQA facility including the recovered sections of the LH APU door, removed sections of the remaining LH and RH APU doors, the damaged LH and RH elevator sections, an elevator control rod assembly, an APU door hold open strut, a horizontal stabilizer panel seal and a flexible drive shaft.

Each received component was visually examined, documented and photographed.

The BR&T Metallurgical Fracture Analysis team determined that further fracture analysis of the received damaged components was not necessary and would not provide any benefit to this examination.

EXAMINATION:

EQA received two wooden crates on August 2, 2024. Images of the crates were captured upon arrival; see Figure 1 and Figure 2.



Figure 1: First wooden crate



Figure 2: Second wooden crate

Due to their size, the crates were stored in the Boeing Test and Evaluation (BT&E) building high bay instead of the EQA lab.



EQA received a third crate on August 23, 2024, which was stored within the EQA facility. Images of the crate were captured upon arrival; see Figure 3 and Figure 4.

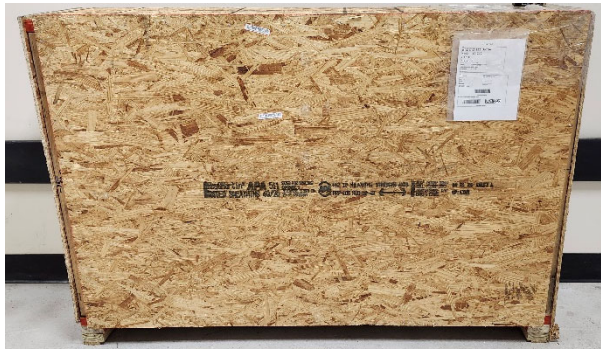


Figure 3: Front of third crate



Figure 4: Side of third crate

On October 7, 2024, an examination was held at the EQA facility with Boeing ASI, BR&T Metallurgical Fracture Analysis, and Boeing Mechanical & Structural Engineering in attendance.

The examination began with the third crate that was sent to EQA; see Figure 5. The cover of the third crate was removed revealing parts that were sufficiently covered with protective bubble wrap; see Figure 6.



Figure 5: Third crate



Figure 6: Cover of third crate removed



The first part removed was wrapped in multiple layers of bubble wrap. The part was removed from the bubble wrap and was identified as the aft section of the [REDACTED] LH APU door assembly. This section of the LH APU door measured approximately 21 inches along the latch edge and 27 inches along the torn forward edge; see Figure 7 through Figure 10.

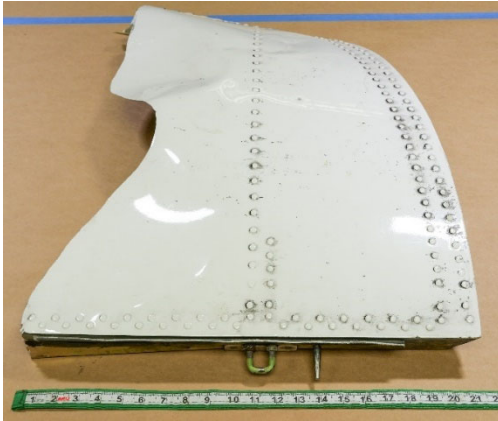


Figure 7: Aft section of LH APU door, outboard surface



Figure 8: Aft section of LH APU door, inboard surface

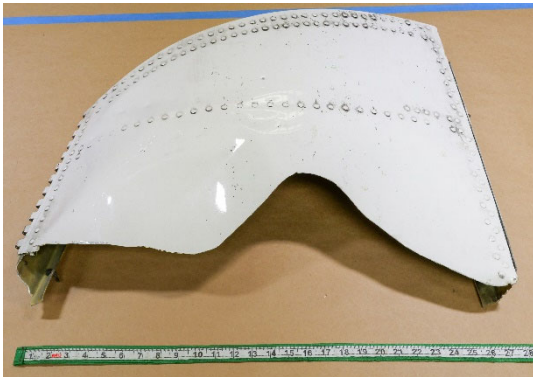


Figure 9: Aft section of LH APU door, outboard surface



Figure 10: Aft section of LH APU door, inboard surface

Two attachment tabs were fractured with material that remained riveted to the middle support rib; see Figure 11.

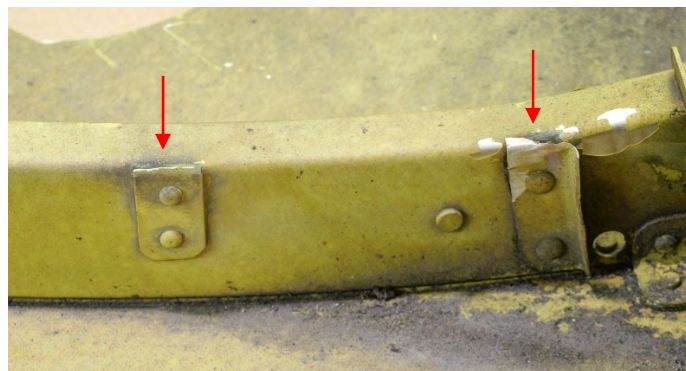


Figure 11: Fractured attachment tabs



Three rivets were noted to be missing from the door structure on the inboard surface of the aft LH APU door section; see Figure 12 and Figure 13.

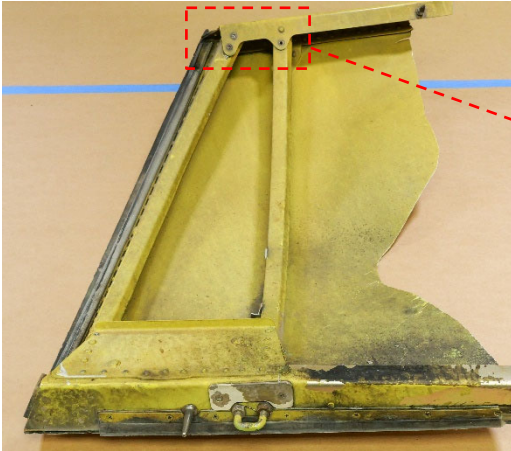


Figure 12: Aft LH APU door section, inboard surface.

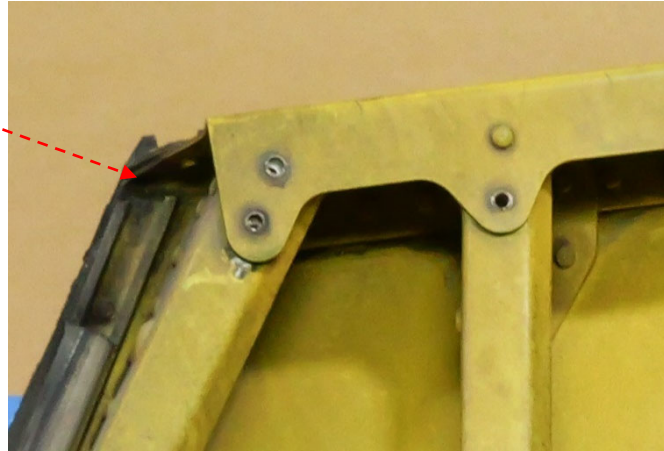


Figure 13: Missing rivets

A broken electrical bonding strap was observed with the attachment fastener still in place; see Figure 14.



Figure 14: Broken bonding strap



The hinge pin was sheared in multiple locations and missing from multiple locations of the hinge barrels on the aft LH APU door section. Five hinge pin pieces were observed within 12 of the hinge barrels. Figure 15 and Figure 16 show images of the hinge pin pieces lodged within the hinge barrels.



Figure 15: Hinge pin pieces within hinge barrels of the aft LH APU door section

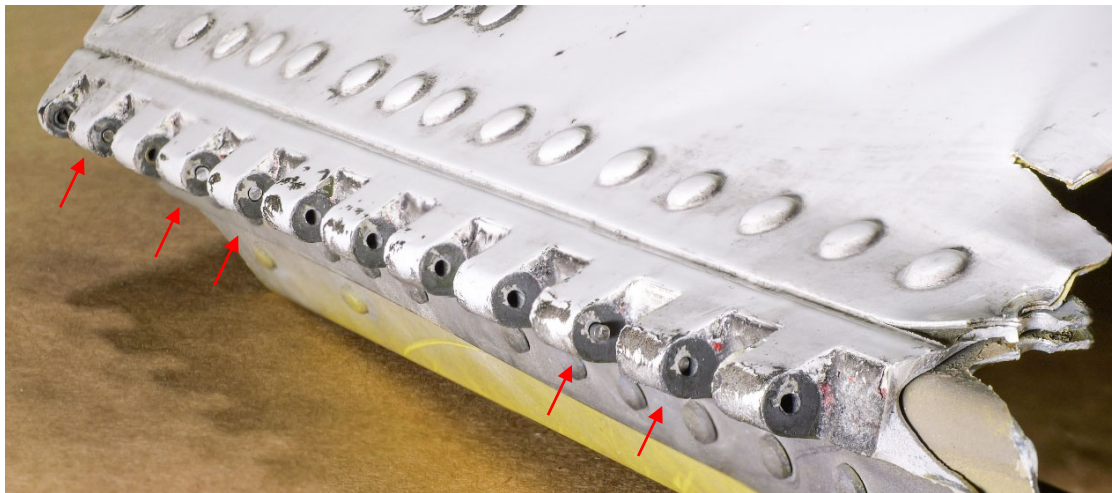


Figure 16: Hinge of the aft LH APU door section with hinge pin pieces within hinge barrels



Some of the hinge barrel holes were damaged and ovalized. Figure 17 and Figure 18 show examples of the damaged and ovalized hinge barrel holes.



Figure 17: Example of ovalized hinge barrel hole



Figure 18: Example of ovalized hinge barrel hole

The U-bolt, part of the latching mechanism, on the aft LH APU door section was visually examined. The U-bolt lock wire was intact. The appearance of the U-bolt was unremarkable and typical of an in-service aircraft. An image of the U-bolt from the aft LH APU door section is shown in Figure 19.



Figure 19: U-bolt on the aft LH APU door section



The second part removed from the crate was wrapped in multiple layers of bubble wrap. The part was removed from the bubble wrap and identified as the larger, forward section of the [REDACTED] LH APU door assembly; see Figure 20 and Figure 21. This door section measured approximately 38 inches along the forward edge, and 70 inches along the latch edge.



Figure 20: Latch edge of the forward LH APU door section, outboard side

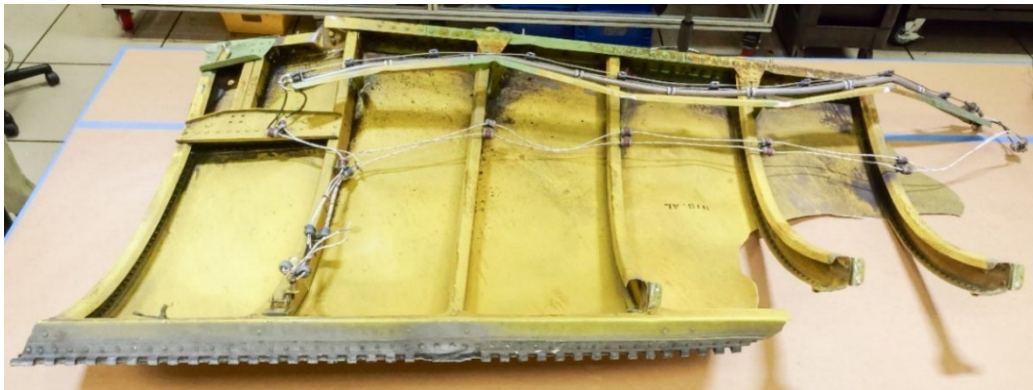


Figure 21: Hinge edge of the forward LH APU door section, inboard side

A section of skin along and support ribs were noted to be missing from the aft end of the LH APU door section; see Figure 22.



Figure 22: Missing section of skin and support ribs



The door was misshapen, bent and the skin was wrinkled in multiple areas; see Figure 23 through Figure 26.

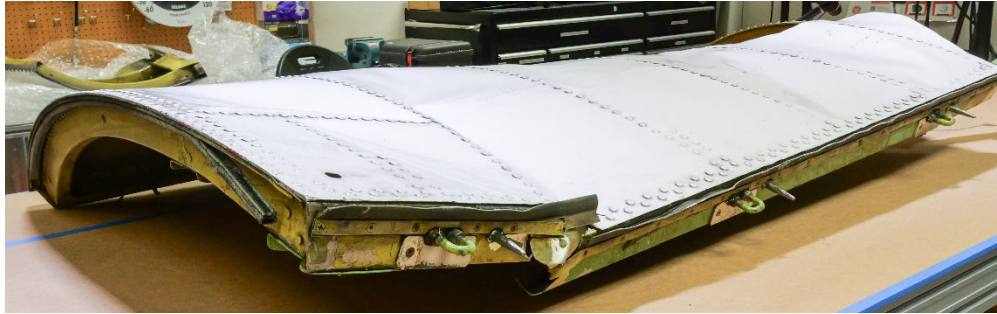


Figure 23: Forward LH APU door section, forward-inboard corner



Figure 24: Forward LH APU door section, aft-inboard corner

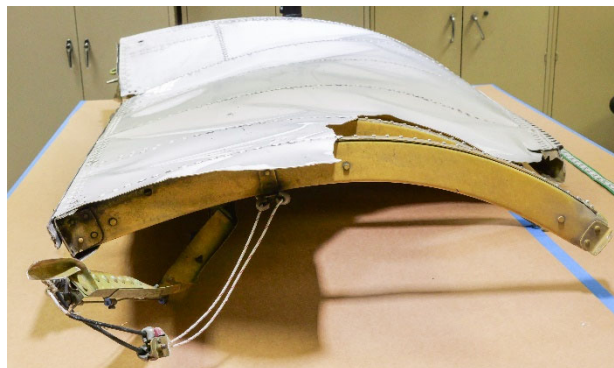


Figure 25: Forward LH APU door section, aft end



Figure 26: Forward LH APU door section, aft-outboard corner



The fourth support rib was separated from the hinge edge and the skin panel. Two rivets were broken that attached the support rib to the hinge structural member. Seven rivets were broken that attached the support rib to the skin; see Figure 27 and Figure 28.

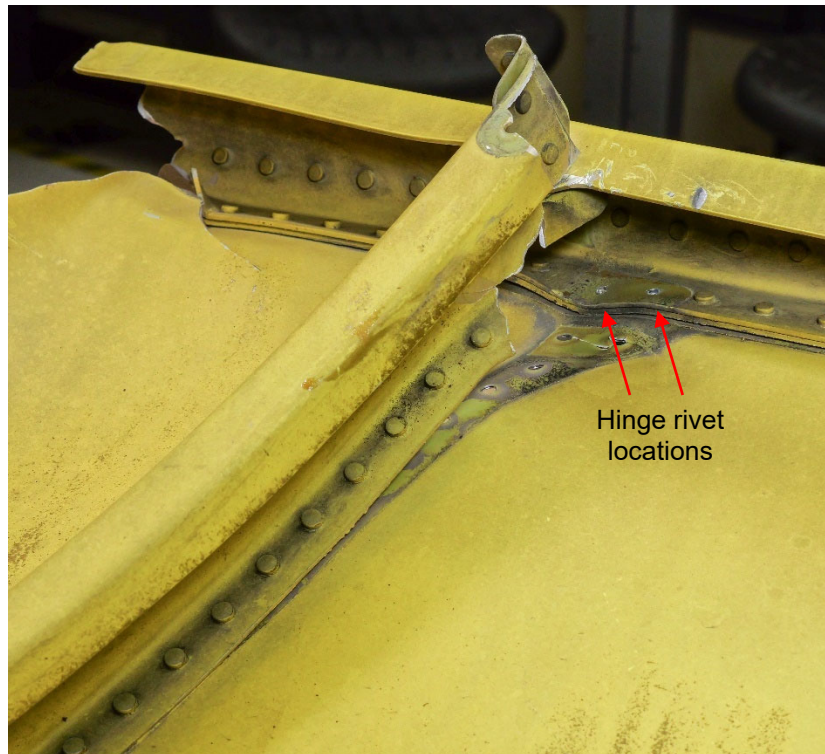


Figure 27: Fourth support rib separated from skin and hinge



Figure 28: Fourth support rib separated from skin and hinge



The skin was fractured and bent in the outboard direction at the second support rib from the forward edge of the door; see Figure 29 and Figure 30.

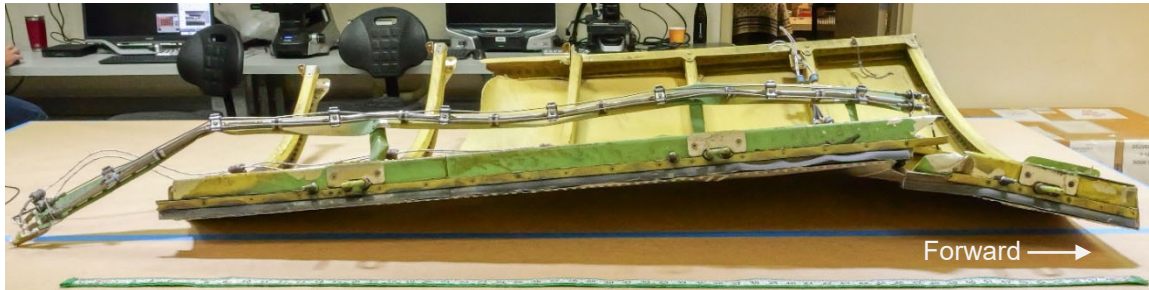


Figure 29: Inboard latch edge of the forward LH APU door section



Figure 30: Forward-inboard corner of the forward LH APU door section

The skin was separated from the second support rib with portions of the rivet remaining in the second support rib; see Figure 31.

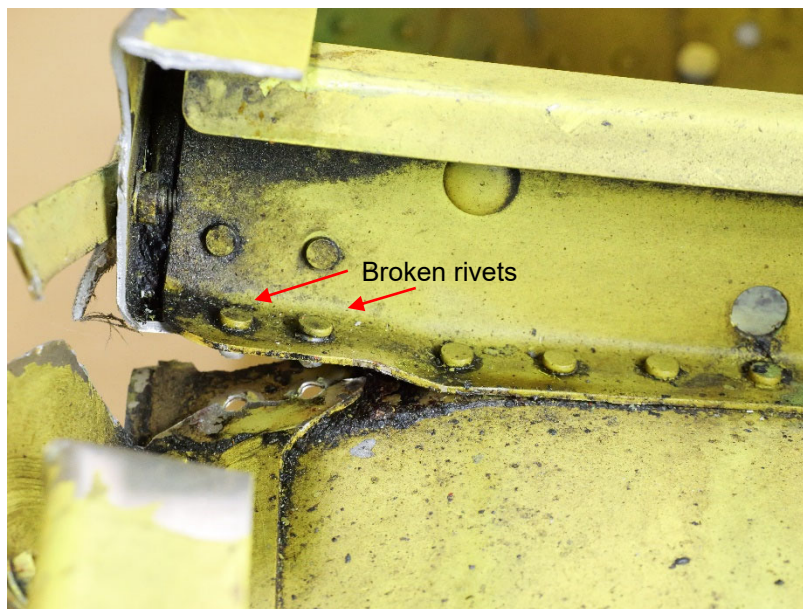


Figure 31: Broken rivets on second support rib



The forward and aft LH APU door sections were placed alongside each other in their approximate originating positions. These two sections did not complete the entire LH APU door assembly. These two sections of the LH APU door were aligned along the latch edge; see Figure 32.



Figure 32: Forward and aft LH APU door sections placed alongside each other

The hinges on the LH APU door sections were visually examined. The forward hinge section appeared straight. The middle hinge section appeared bent and broken with the aft section of the hinge noted to be missing. The aft hinge section was broken with the forward section of the hinge noted to be missing. An overview image from the hinge edge of the LH APU door sections is shown in Figure 33.

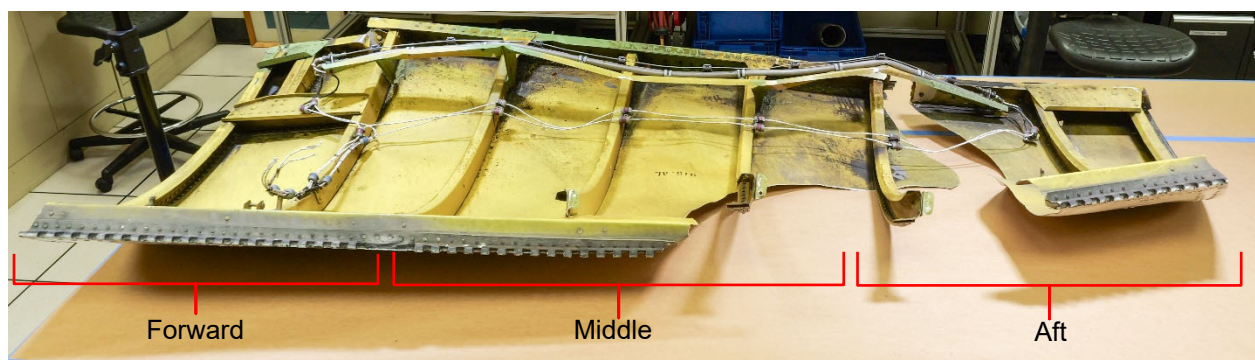


Figure 33: Hinge edge of the LH APU door sections



Approximately seven inches of honeycomb material was trapped between the door seal and the door frame between the second and third support ribs on the latch edge of the forward LH APU door section; see Figure 34 and Figure 35.

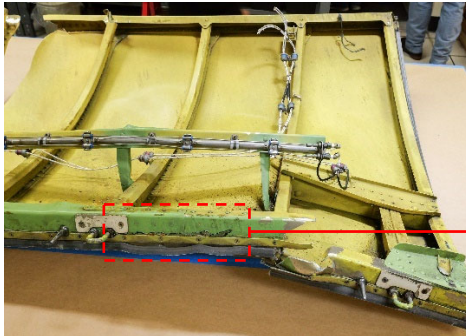


Figure 34: Forward LH APU door section, latch side

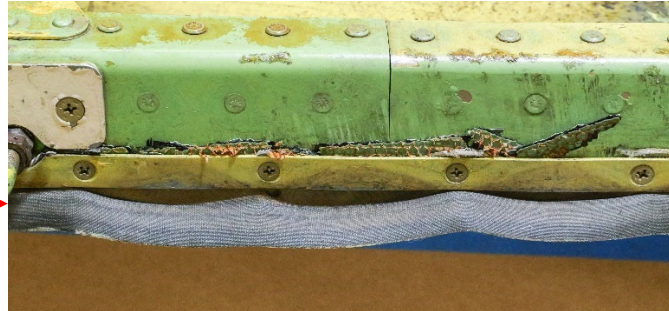


Figure 35: Trapped honeycomb material

The three U-bolts on the forward LH APU door section were visually examined with nothing remarkable to note.

The three alignment pins on the forward LH APU door section were visually examined. There were no remarkable observations on the forward and aft alignment pins. The middle alignment pin displayed circumferential witness marks in a spiral pattern between approximately 1.0 to 1.2 inch section away from the base of the pin; see Figure 36 through Figure 38.

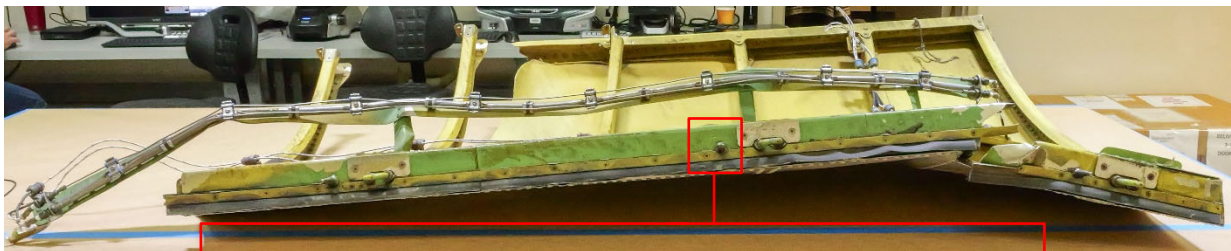


Figure 36: Middle alignment pin on the forward LH APU door section



Figure 37: Middle alignment pin, aft looking forward

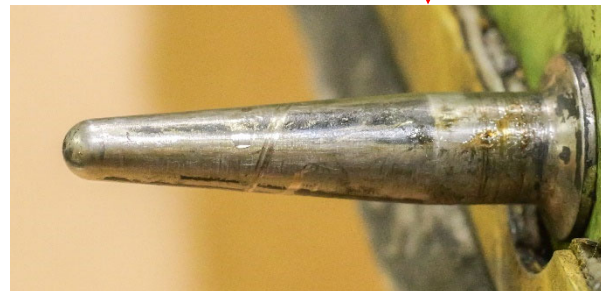


Figure 38: Middle alignment pin, forward looking aft



The examination team transferred to the BT&E high bay area containing the first and second wooden crates.

The lid was removed from the first wooden crate revealing that the components were well protected by multiple layers of bubble wrap; see Figure 39.



Figure 39: Lid removed from first wooden crate

The multiple layers of bubble wrap were removed revealing the [REDACTED] RH elevator assembly and seven additional parts protected with bubble wrap; see Figure 40.



Figure 40: RH elevator assembly and seven additional parts



The seven additional parts were removed and placed on a metal cart to be examined later in the EQA facility. An image of the parts on the metal cart is shown in Figure 41.



Figure 41: Seven additional parts from first crate on metal cart

An overview image of the damaged RH elevator assembly was captured; see Figure 42.



Figure 42: Overview image of damaged RH elevator assembly



The damaged RH elevator assembly was removed and rested on top of the first crate.

An image of the identification (ID) plates was captured; see Figure 43.

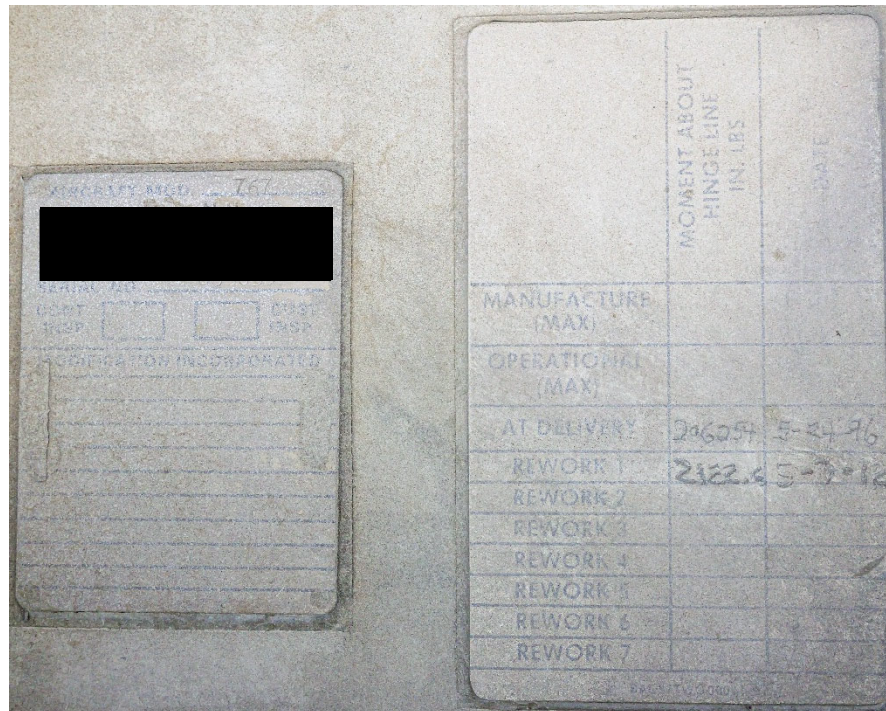


Figure 43: RH elevator assembly ID plates



The damage observed on the lower forward inboard surface of the RH elevator assembly was photographed; see Figure 44 and Figure 45. The damage in this area of the RH elevator measured approximately 17 inches wide by 29 inches long.



Figure 44: Damage on lower forward inboard surface of RH elevator



Figure 45: Damage on lower forward inboard surface of RH elevator



Damage was observed on the lower forward surface of the RH elevator assembly. The damaged area was located approximately five inches inboard of the center hinge fitting opening. Images of the damage were captured; see Figure 46 and Figure 47. The damaged area measured approximately five inches wide by seven inches long.

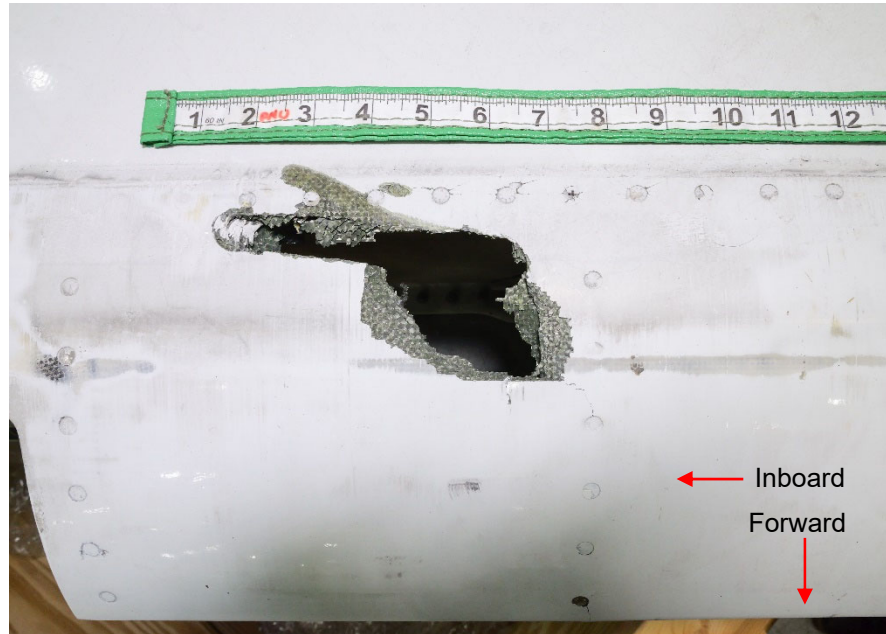


Figure 46: Damage on outer lower forward surface of RH elevator



Figure 47: Inner surface of the RH elevator damage



Cracking was observed toward the corner of a support rib and the outer surface of the RH elevator assembly. The location of the cracking is identified by a red square in Figure 48. An image of the crack in the support rib is shown in Figure 49 and an image of the crack on the outer surface of the RH elevator is shown in Figure 50.

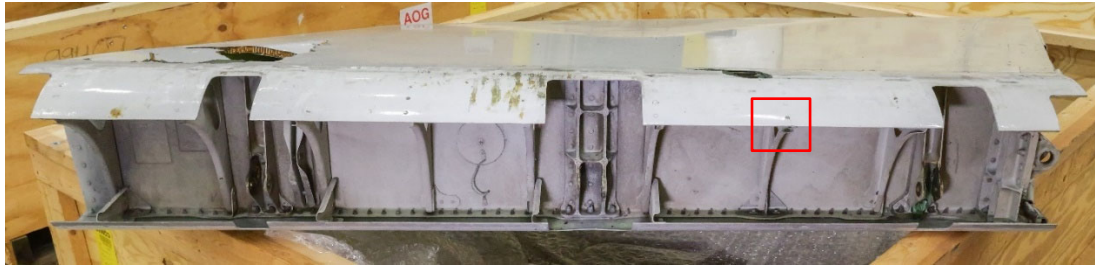


Figure 48: RH elevator assembly, forward looking aft

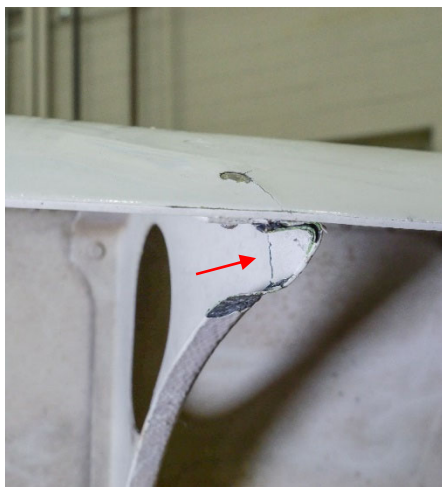


Figure 49: Crack on support rib



Figure 50: Crack on lower surface of RH elevator

Each hinge fitting on the RH elevator assembly was visually examined and photographed; see Figure 51 and Figure 52. All the hinge fittings were unremarkable.

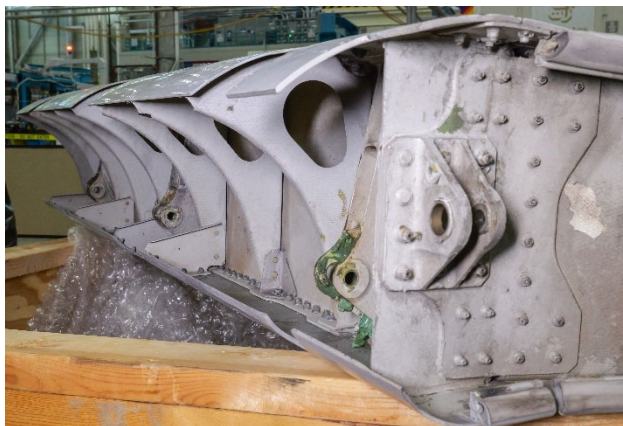


Figure 51: Forward side hinge fittings

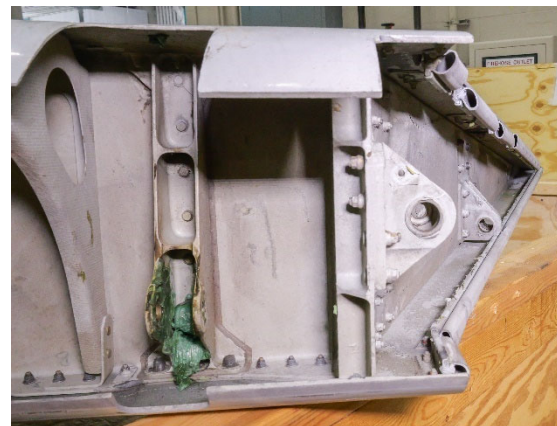


Figure 52: Outboard side hinge fittings

The damaged RH elevator assembly was placed back into the first crate and the lid was closed.



The lid was removed from the second wooden crate revealing a [REDACTED] LH elevator assembly, well protected with multiple layers of bubble wrap. The multiple layers of bubble wrap were removed revealing the damaged LH elevator assembly; see Figure 53.

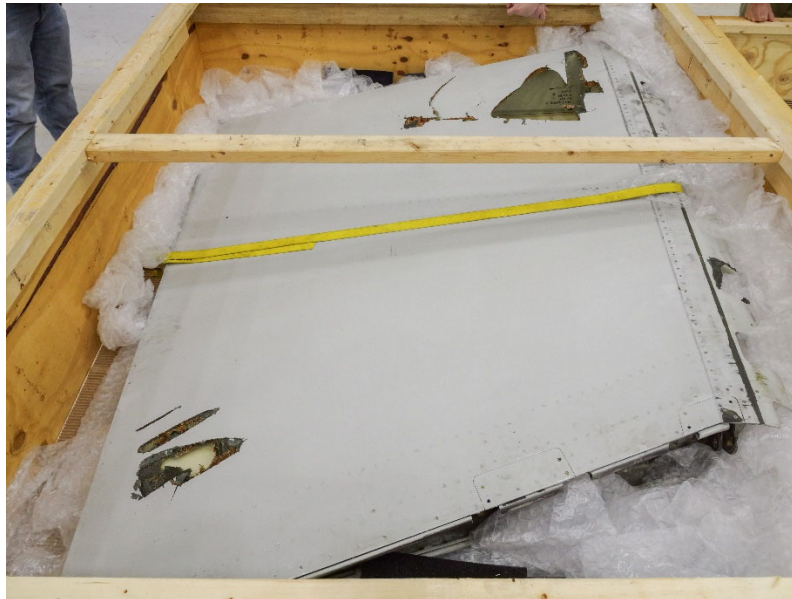


Figure 53: Damaged LH elevator assembly

The damaged LH elevator assembly was removed and rested on top of the second crate.

An image of the ID plates was captured; see Figure 54.



Figure 54: LH elevator assembly ID plates



The damage observed on the lower forward inboard surface of the LH elevator assembly was photographed; see Figure 55 and Figure 56. The damage in this area of the LH elevator measured approximately 25 inches wide by 33 inches long.

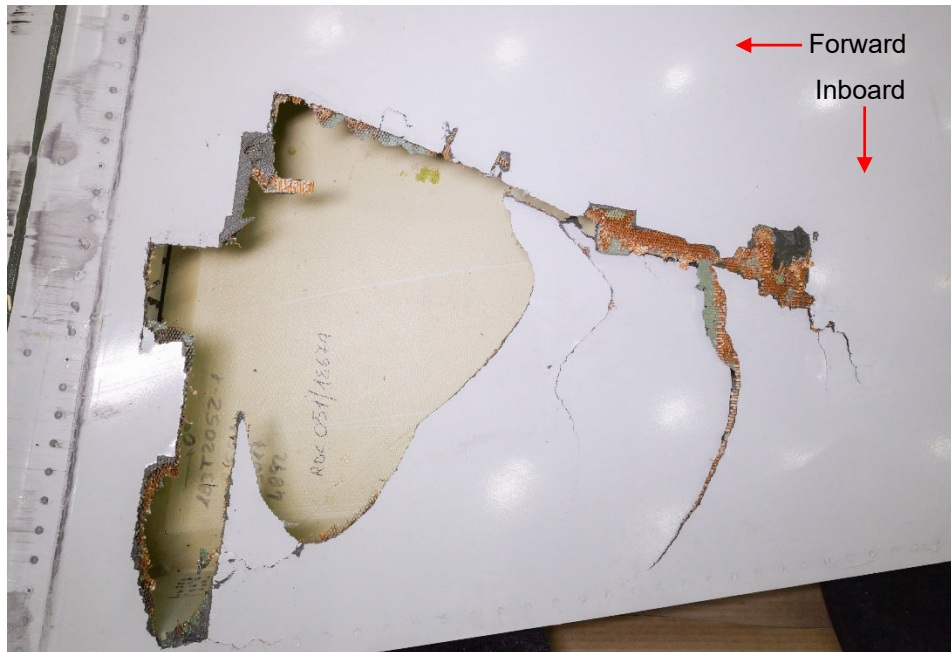


Figure 55: Damage on lower forward inboard surface of LH elevator

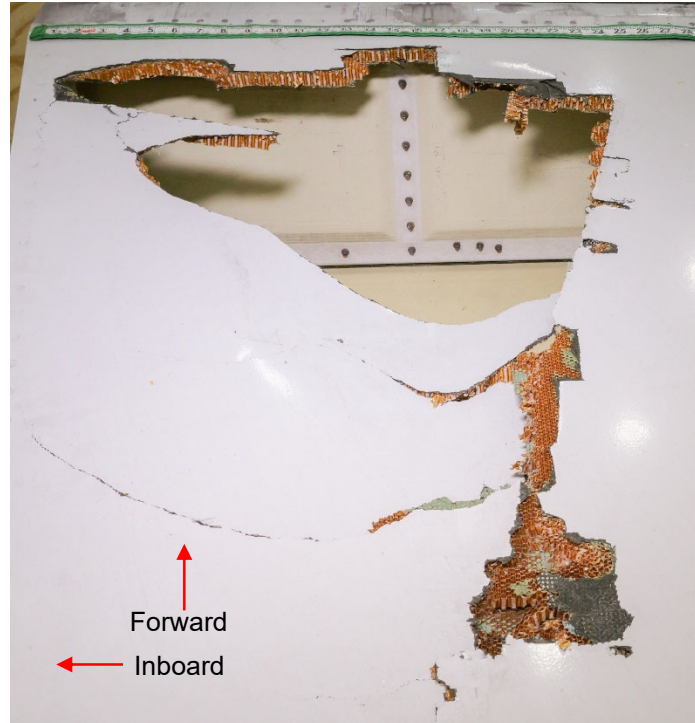


Figure 56: Damage on lower forward inboard surface of LH elevator



An approximate six inch wide by seven inch long section of material was missing from the forward lower edge of the LH elevator assembly. The location of the missing section of material on the LH elevator assembly is identified by a red square in Figure 57.



Figure 57: Section of material missing from LH elevator assembly, forward looking aft

Images of the area with the missing section of material on the LH elevator assembly were captured; see Figure 58 and Figure 59.



Figure 58: Missing section of material on LH elevator



Figure 59: Missing section of material on LH elevator

The damage observed on the lower aft outboard surface of the LH elevator assembly was photographed; see Figure 60. The damage was contained within an approximately 10 inch wide by 12 inch long area of the LH elevator.



Figure 60: Damage on lower aft outboard surface of LH elevator



Each hinge fitting on the LH elevator assembly was visually examined and photographed; see Figure 61 and Figure 62. All the hinge fittings were unremarkable.

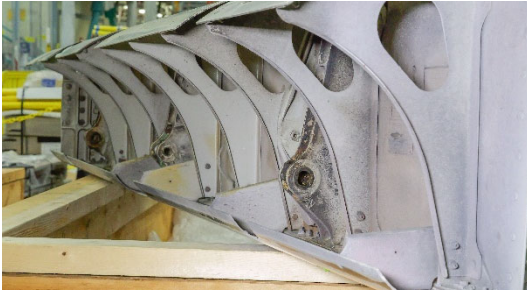


Figure 61: Forward side hinge fitting

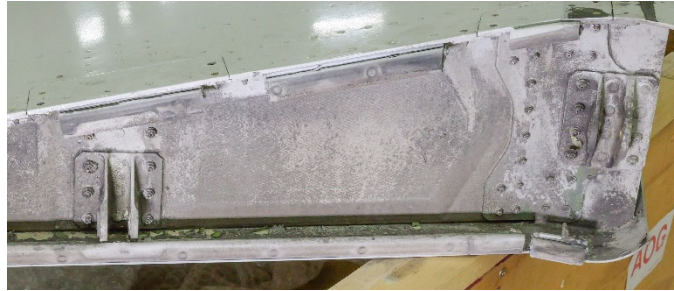


Figure 62: Outboard side hinge fittings

The damaged LH elevator assembly was placed back into the second crate and the lid was closed.

The seven additional parts discovered in the first crate were transferred to the EQA facility for examination.

The first part was removed from its protective bubble wrap and confirmed to be a section of the [REDACTED] LH APU door assembly. This LH APU door section remained attached to the aircraft after landing and was removed while the aircraft was on ground. The skin panel was deformed and set with a curvature in the outward direction. The rivets that attached the skin panel to the support ribs were no longer present. Overview images of the LH APU door section were captured; see Figure 63 and Figure 64.



Figure 63: Remaining LH APU door section, outboard side



Figure 64: Remaining LH APU door section, inboard side



The LH APU door section was placed in its approximate originating location alongside the forward and aft sections of the LH APU door. An image of the LH APU door sections was captured; see Figure 65. Figure 66 shows an end view image of the remaining LH APU door section with the curvature in the outward direction.

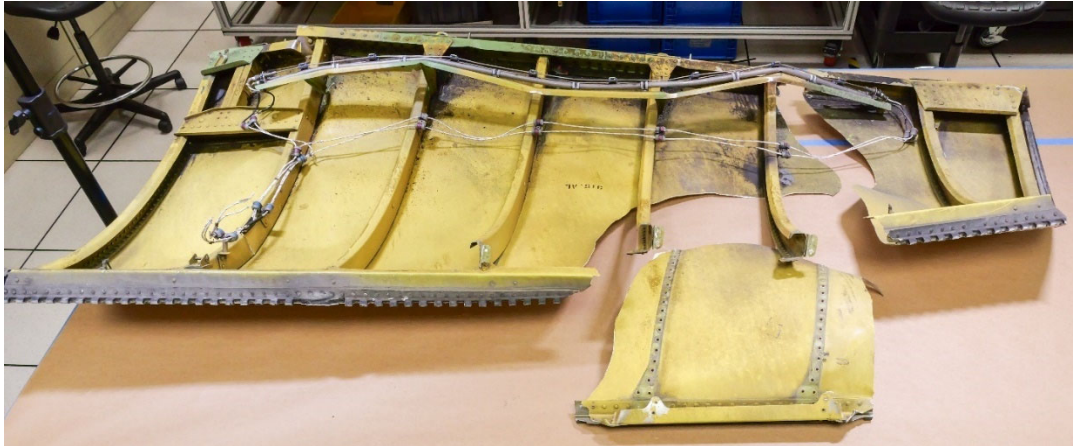


Figure 65: LH APU door sections placed in their approximate originating locations



Figure 66: End view of LH APU door section



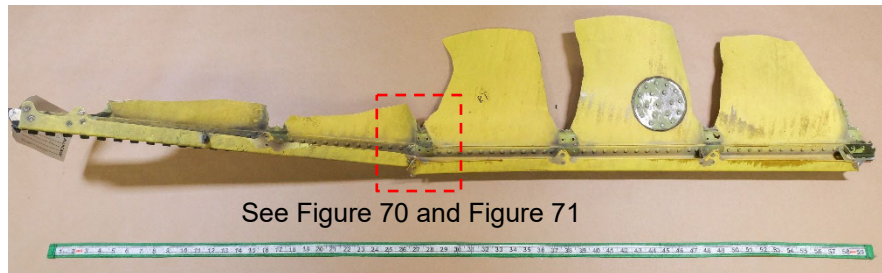
The second part was removed from its protective bubble wrap and confirmed to be a hinged section of the [REDACTED] RH APU door assembly. This RH APU door section remained attached to the aircraft after landing and was removed while the aircraft was on ground. The RH APU door section measured approximately 60 inches in length. Support ribs were not received with this part. The rivets that attached the skin panel to the support ribs were no longer present. Overview images of the RH APU door section were captured; see Figure 67 through Figure 69.



Figure 67: RH APU door section, outboard side



Figure 68: RH APU door section, placed on hinged edge



See Figure 70 and Figure 71

Figure 69: RH APU door section, inboard side

A bend and fracture existed common to the hinge and door frame structure towards the middle of the RH APU door section; see Figure 70 and Figure 71.



Figure 70: Bend and fracture common to RH APU door section



Figure 71: Bend and fracture common to RH APU door section



The third part was removed from its protective bubble wrap and confirmed to be a [REDACTED] elevator control rod assembly. An overview image of the rod assembly and the manufacturer information is shown in Figure 72.

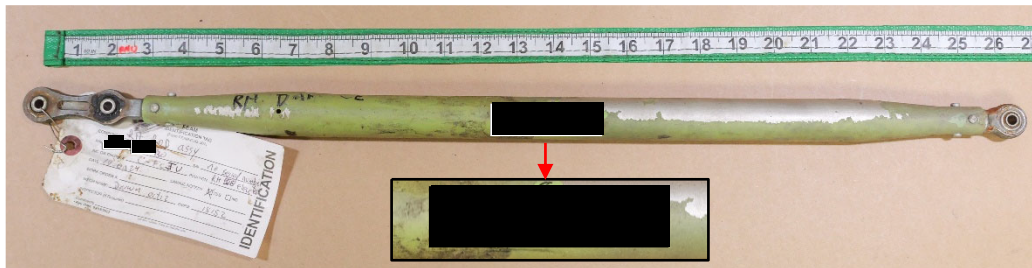


Figure 72: Overview of control rod assembly and manufacturer information

A dent was observed approximately eight inches away from the dual rod end of the rod assembly; see Figure 73 and Figure 74.



Figure 73: Dent in rod assembly



Figure 74: Dent in rod assembly, rotated approximately 90 degrees

The fourth part was removed from its protective bubble wrap and confirmed to be a [REDACTED] hold open strut. An overview image of the hold open strut and manufacturer information is shown in Figure 75.

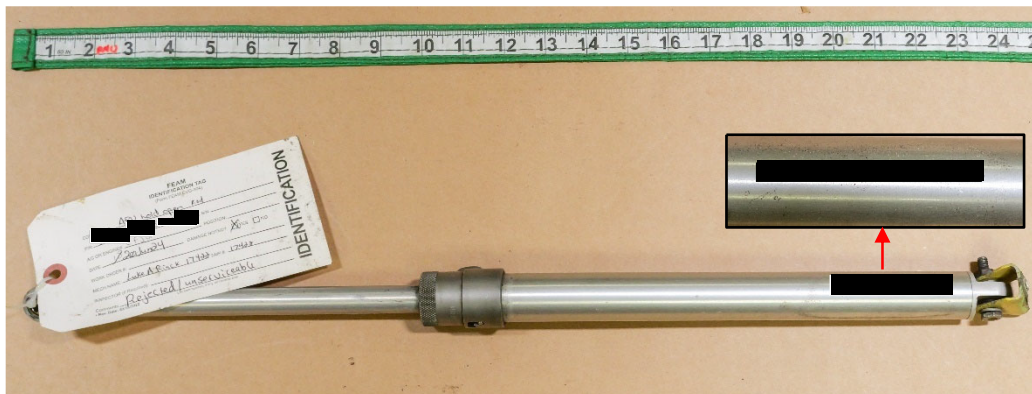


Figure 75: Overview of hold open strut and manufacturer information



The body of the hold open strut was visibly bent near the locking mechanism when rotated approximately 90 degrees from the manufacturer information; see Figure 76.



Figure 76: Bend in body of hold open strut

A fractured section of an attachment bracket was still attached to the hold open strut. A longitudinal crack existed that extended the entire length of the mounting surface on the fractured attachment bracket section; see Figure 77 and Figure 78.

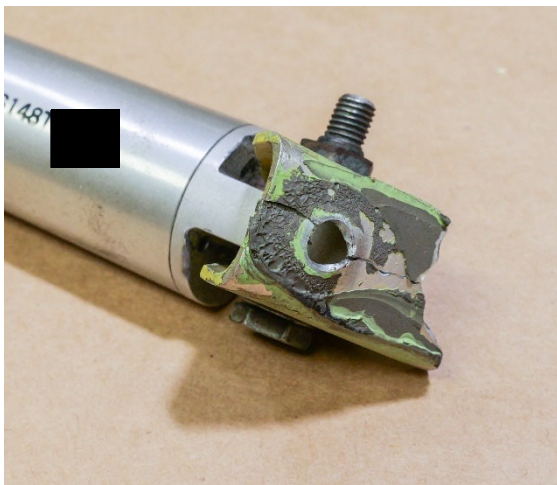


Figure 77: Fractured attachment bracket, underside

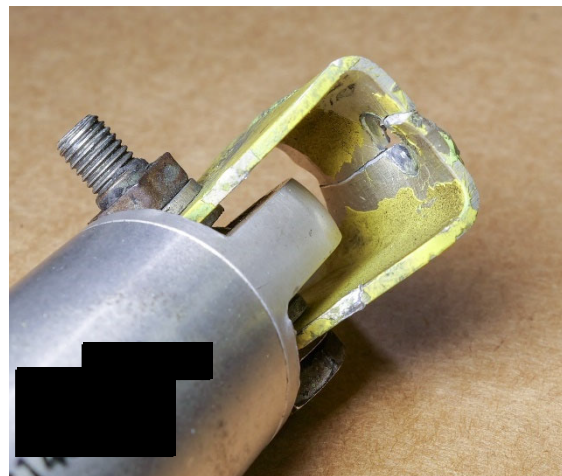


Figure 78: Fractured attachment bracket, top side

The profile of the fractured attachment bracket matched the profile of a fractured attachment bracket on the forward LH APU door section; see Figure 79 and Figure 80.



Figure 79: Fractured attachment bracket on the hold open strut

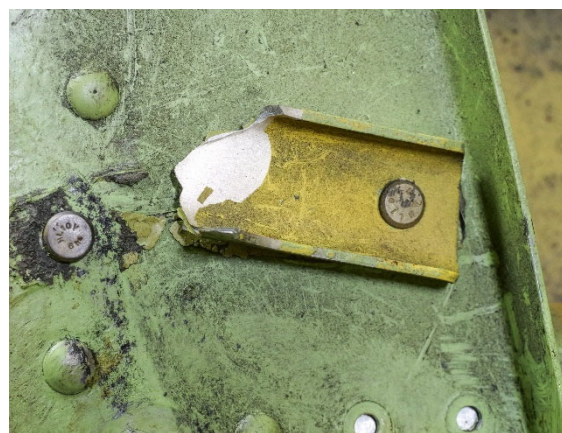


Figure 80: Fractured attachment bracket on the forward LH APU door section



The fifth part was removed from its protective bubble wrapping revealing an unidentified flexible shaft with a square drive on one end and a spline drive on the other end. A part number was not visible and its relationship to the APU doors and elevators was not understood. An overview image of the part is shown in Figure 81.



Figure 81: Overview of flexible shaft

Each end of the flexible shaft was photographed; see Figure 82 and Figure 83.



Figure 82: Square end



Figure 83: Spline end

The sixth part was removed from its protective bubble wrapping revealing a horizontal stabilizer panel seal. This panel seal resides on the lower surface of the horizontal stabilizer and contacts the leading edge of the elevator. The part marking on the inner surface was illegible and faint. Boeing Engineering determined that the part number for this panel seal was either a [REDACTED] or [REDACTED], depending on which side of the aircraft the part was removed from. The original position of the subject panel seal was not identified during this examination. Overview images of the panel seal are shown in Figure 84 and Figure 85.



Figure 84: Outer surface of panel seal



Figure 85: Inner surface of panel seal



The part number was illegible and faint. The remaining part marking was photographed; see Figure 86.



Figure 86: Remaining part marking on panel seal

Damage was observed on the inner and outer surfaces of the panel seal measuring approximately six inches in length on both surfaces; see Figure 87 and Figure 88.



Figure 87: Damage on inner surface of panel seal

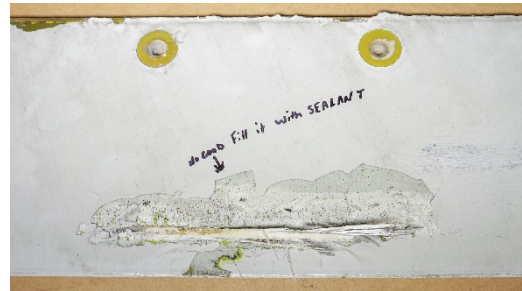


Figure 88: Damage on outer surface of panel seal

The seventh part was removed from a plastic bag revealing three hinge pins from the RH APU door section. The position that each hinge pin was removed from on the RH APU door section was not identified. An overview image of the three pins is shown in Figure 89.

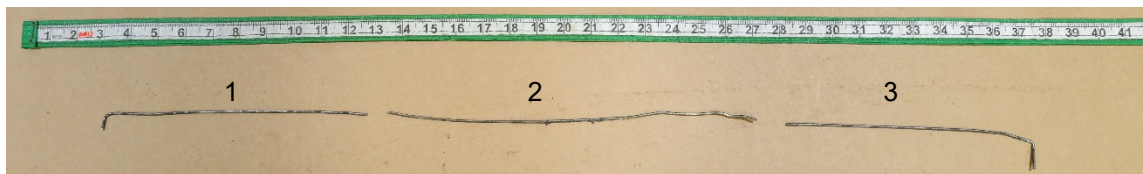


Figure 89: Overview of the three RH APU door hinge pins



An overview image of each hinge pin is shown in Figure 90 through Figure 92.



Figure 90: Hinge pin 1



Figure 91: Hinge pin 2

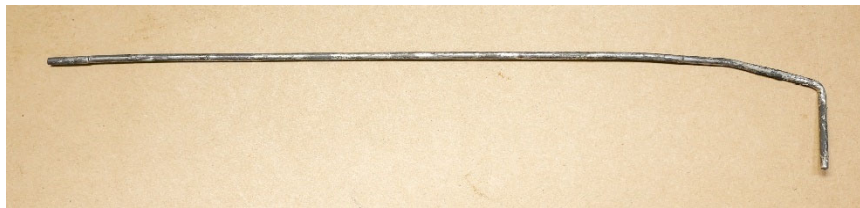


Figure 92: Hinge pin 3

Each hinge pin was visually examined, and deformation was observed in each hinge pin. Images were captured of the deformation observed in each pin; see Figure 93 through Figure 95.



Figure 93: Deformation of hinge pin 1



Figure 94: Deformation of hinge pin 2



Figure 95: Deformation of hinge pin 3