

NATIONAL TRANSPORTATION SAFETY BOARD

Office of Research and Engineering
Materials Laboratory Division
Washington, D.C. 20594



June 30, 2017

MATERIALS LABORATORY FACTUAL REPORT

Report No. 17-051

A. ACCIDENT INFORMATION

Place : Ingleside, Texas
Date : October 25, 2016
Vehicle : Boeing A75N1 (PT-17), N48182
NTSB No. : CEN17LA032
Investigator : Andrew Todd Fox, ASI-CEN

B. COMPONENTS EXAMINED

1. Right horizontal stabilizer bracing wire with fractured shackle fitting and a piece of a fractured attachment bolt;
2. Piece of fractured right horizontal stabilizer forward spar tube and piece of horizontal stabilizer with mating fracture face;
3. Piece of fractured right horizontal stabilizer aft spar tube and piece of horizontal stabilizer with mating fracture face;
4. Vertical stabilizer spar tube, fractured into two pieces.

C. DETAILS OF THE EXAMINATION

Pieces of a Boeing A75N1 (PT-17) involved in the accident referenced above were sent to the NTSB Materials Laboratory for examination. The pieces included a right horizontal stabilizer bracing wire with a fractured shackle fitting and fractured attachment bolt at the outboard end (figure 1a), fractured forward and aft spar tubes pieces from the right horizontal stabilizer (figure 1b), and fractured spar tube pieces from the vertical stabilizer (figure 1b).

The airplane had a braced tail structure with the bracing wire connecting the right horizontal stabilizer's forward spar tube to the vertical stabilizer's leading edge. The fractured shackle fitting and the fractured attachment bolt pieces from the bracing wire assembly were examined visually to determine their respective modes of failure. The bracing wire outboard shackle fitting consisted of a clevis (figures 2a and 2b) that was joined to a knuckle-type fitting on the horizontal stabilizer spar tube by means of a bolt (figures 3a and 3b) that was inserted through both clevis arms and the knuckle. The bolt was fractured through the grip toward its threaded (aft) end at the interface between the knuckle and the aft clevis arm and the shackle fitting was fractured through its forward arm.

The bolt shank exhibited transverse shear deformation adjacent to the fracture surface (figure 3a). The fracture surface was planar and perpendicular to the axial direction of the bolt (transverse plane). Shear rub marks were observed along its lower edge, as pictured in figure 3b, which was adjacent to the transverse shear deformation across the shank. The fracture surface was comparatively featureless elsewhere. Considered together, the features were consistent with a shear overstress fracture.

The hardness of the bolt was measured using a Rockwell hardness tester to compare with the strength requirement for the bolt. According to the aircraft illustrated parts catalog (IPC), the specified attachment bolt was of type AN3-20¹ (see Appendix A of this report for the relevant pages from the IPC). The AN specification does not directly list a required material strength or hardness for the bolt. However, the specification lists an ultimate breaking strength (load) at the thread root. For a 10-32 UNF-3A AN3 bolt like the fractured bolt, the listed ultimate tensile strength (load) at root diameter was 2,210 lbs. According to the specification for UNF-type threads,² the section at the minor diameter at $D - 2h_b$ is 0.0175 inch² and the tensile stress area is 0.0200 inch². Using the smaller of the two area values, the approximate minimum tensile strength requirement is 126 ksi, which correlates with a hardness of approximately 26 HRC in accordance with ASTM E140.³ The bolt head was sectioned from the shank and two opposing faces of the bolt head were ground flat using abrasive grinding paper. The hardness, measured on the bolt piece in accordance with ASTM E18,⁴ was 28.4 HRC, meeting the minimum strength requirement of the bolt.

The forward clevis arm was fractured starting at the fillet and progressing forward as indicated in figure 2b. The fracture surface exhibited a rough appearance with a darker thumbnail-shaped region near the fillet, 45° shear lips along the other three edges, and a comparatively specular appearance elsewhere. The observations were consistent with an overstress fracture starting in bending and transitioning to tensile overstress.

The vertical stabilizer spar tube was examined visually to determine its mode of failure. The lower and upper fractured vertical stabilizer spar tube pieces are shown in figures 4a and 4b, respectively. Along the right, forward, and aft sides of the tube, the fracture surfaces were inclined at 45° to the transverse plane of the tube, consistent with a ductile overstress fracture. Towards the left side of the tube, the fracture path deviated from the radial/circumferential plane and the tube exhibited out-of-plane bending deformation. The features were consistent with a ductile overstress fracture in bending from the right to left sides of the aircraft as viewed aft looking forward.

¹ Military Specification: Bolt – Machine, Aircraft: AN3 THRU AN20, 14 Jan 1991.

² ASME B1.1 – 2003: Unified Inch Screw Threads, (UN and UNR Thread Form), The American Society of Mechanical Engineers, New York, NY, 2003.

³ ASTM E140 – 12be1, Standard Hardness Conversion Tables for Metals Relationship Among Brinell Hardness, Vickers Hardness, Rockwell Hardness, Superficial Hardness, Knoop Hardness, Scleroscope Hardness, and Leeb Hardness, ASTM International, West Conshohocken, PA, 2012, www.astm.org.

⁴ ASTM E18-14a, Standard Test Methods for Rockwell Hardness of Metallic Materials, ASTM International, West Conshohocken, PA, 2014, www.astm.org.

The forward and aft right horizontal stabilizer spar tubes were examined visually to determine their mode of failure. The inboard and outboard fractured horizontal stabilizer forward spar tube pieces are shown in figures 5a and 5b, respectively, and the inboard and outboard fractured horizontal stabilizer aft spar tube pieces are shown in figures 6a and 6b, respectively. Along the top of the forward tube, the fracture followed the toe of a weld where the tube passed through an inboard rib and exhibited a specular appearance. Elsewhere, the top, forward, and aft sides of the two tubes exhibited fracture surfaces that were inclined at 45° to the radial/circumferential plane of each tube, consistent with ductile overstress fractures. Towards the bottom of the two tubes, each fracture path deviated from the transverse plane and each tube exhibited regions of double-sigmoidal bending deformation, each consistent with a bend buckle, as indicated in figures 5b and 6b. Taken together, the features were consistent with ductile overstress fractures in tip-downward bending.

Donald Kramer, Ph.D.
Sr. Materials Engineer

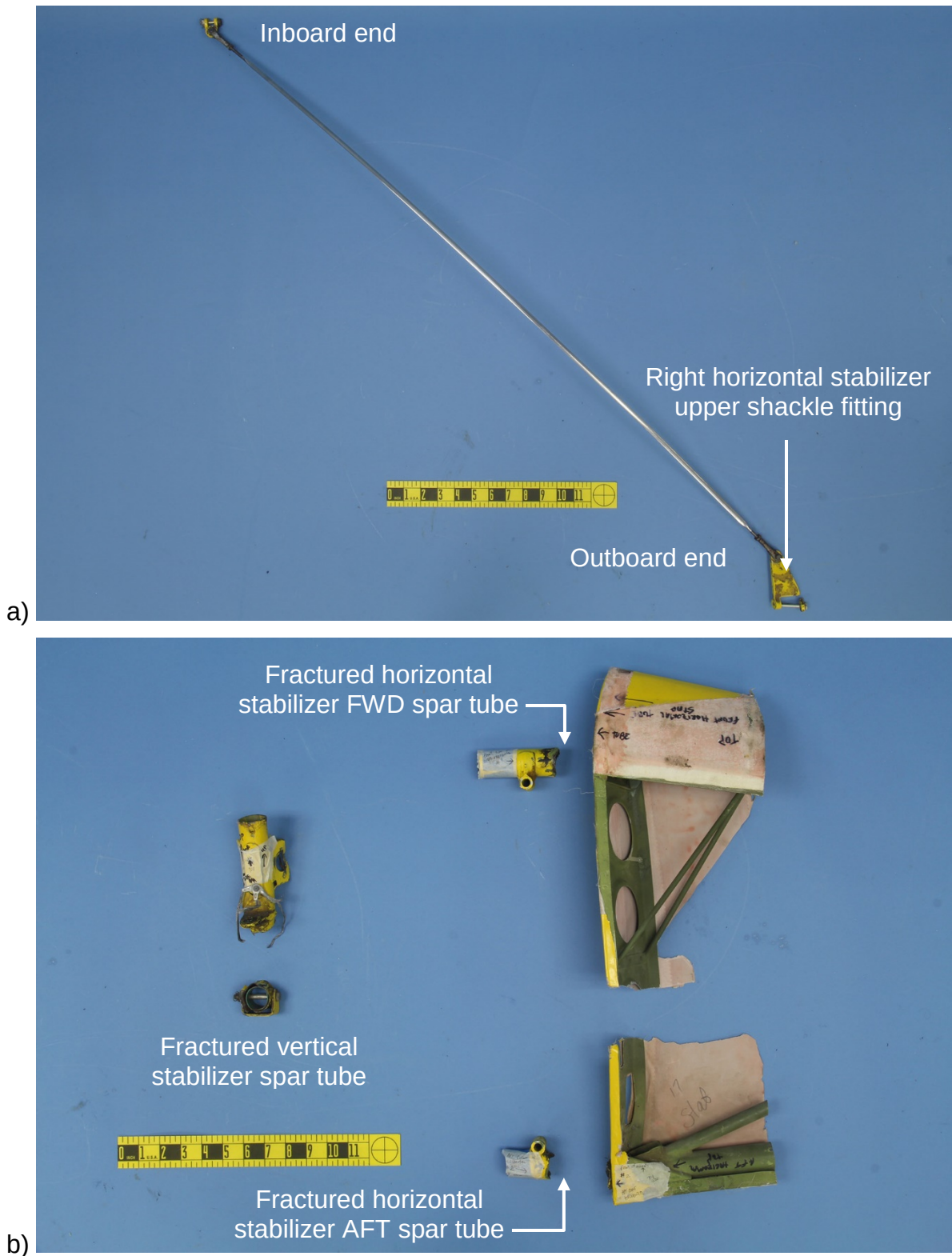


Figure 1: a) Image of the as-received right horizontal stabilizer upper bracing wire with the fractured shackle fitting and attachment bolt at the outboard end; b) image of the as-received fractured horizontal stabilizer forward spar tube, horizontal stabilizer aft spar tube, and vertical stabilizer spar tube.

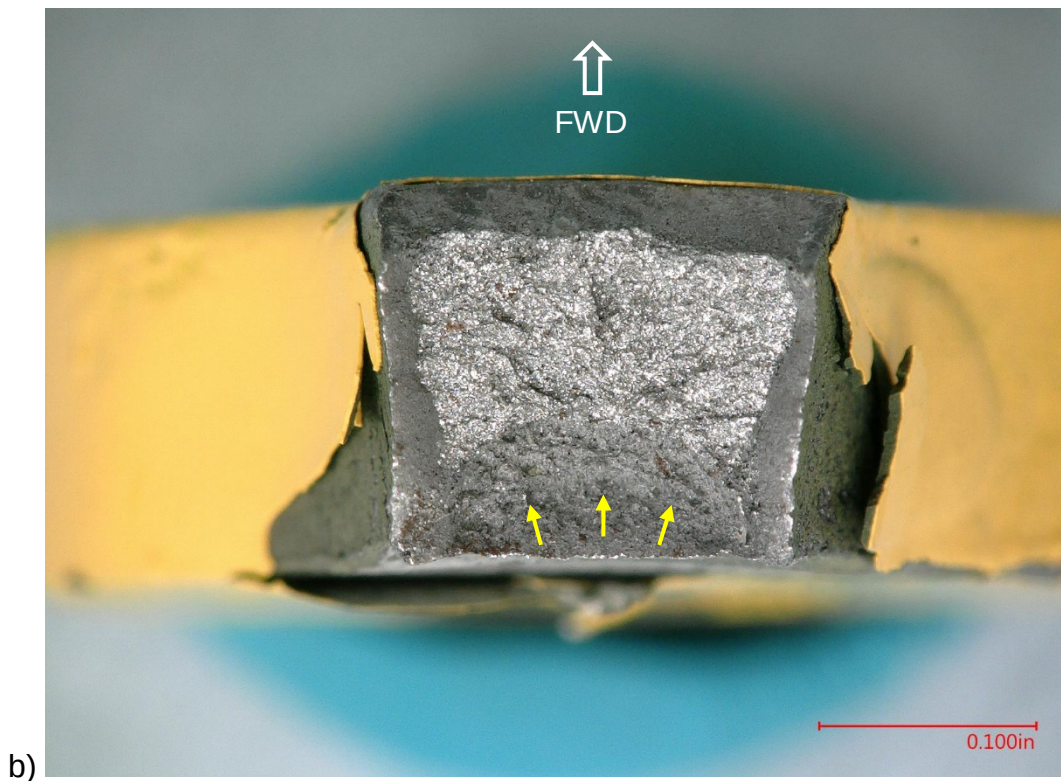
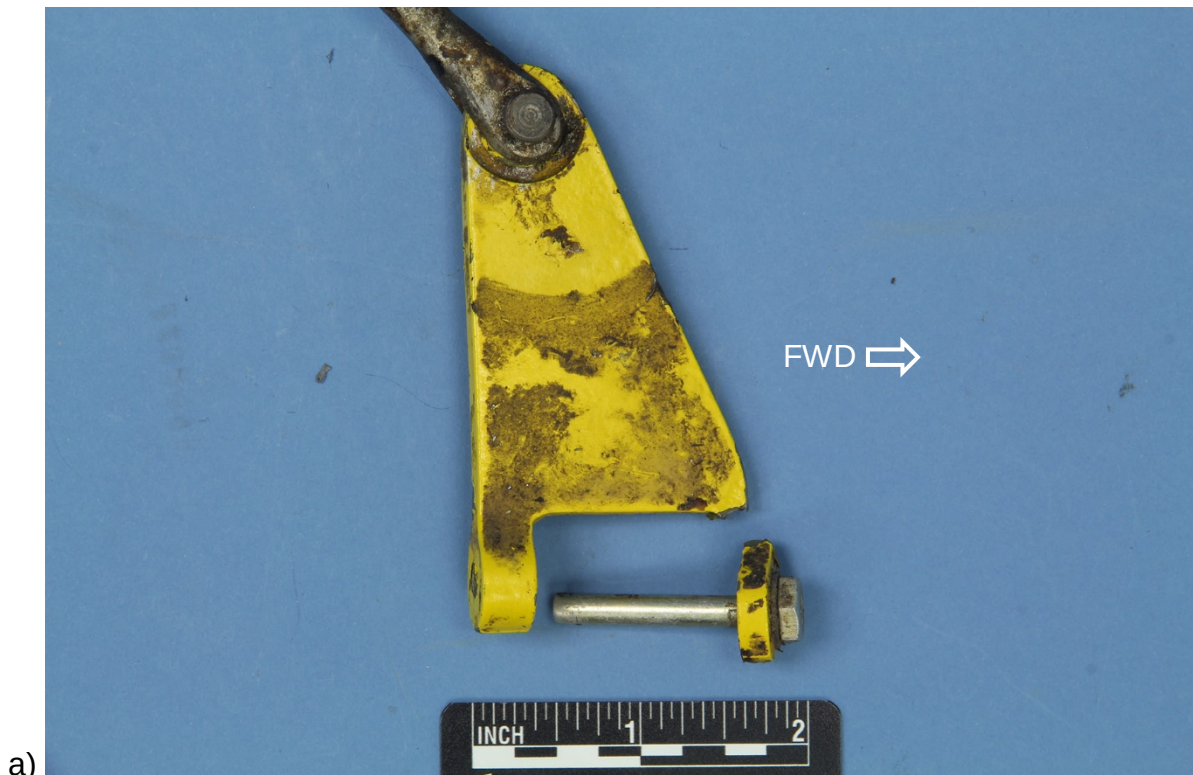


Figure 2: a) Image of the fractured upper right shackle fitting and b) image of the shackle fitting forward arm fracture surface. Yellow arrows indicate the direction of crack progression from the fillet.

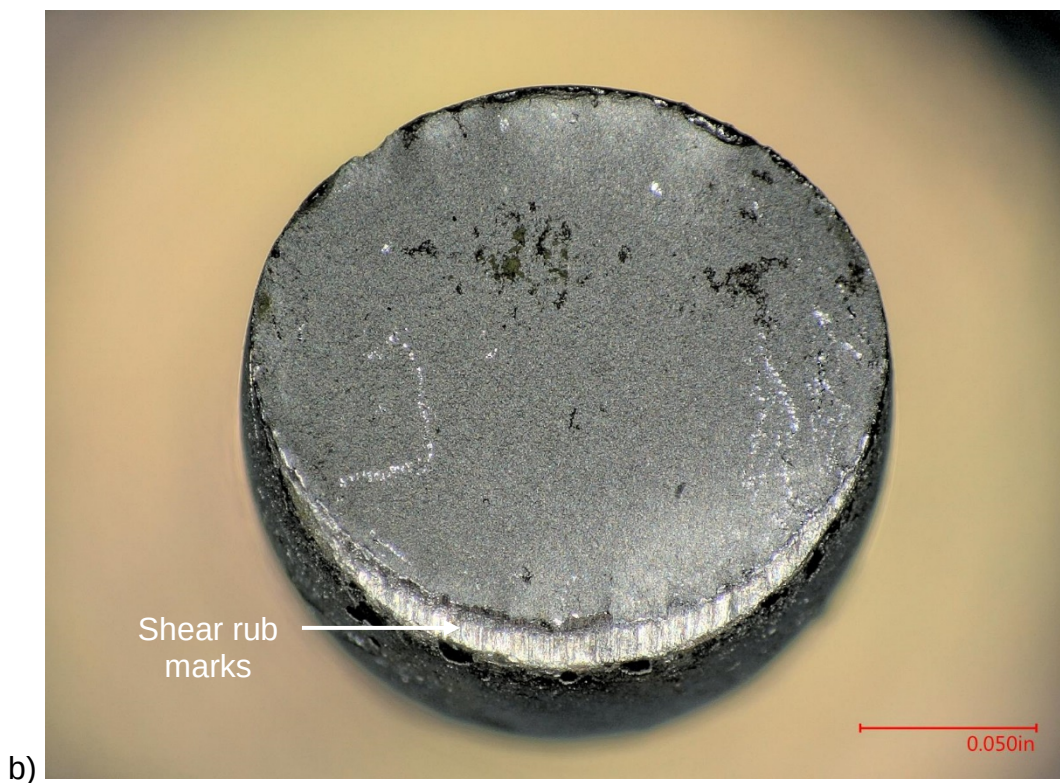
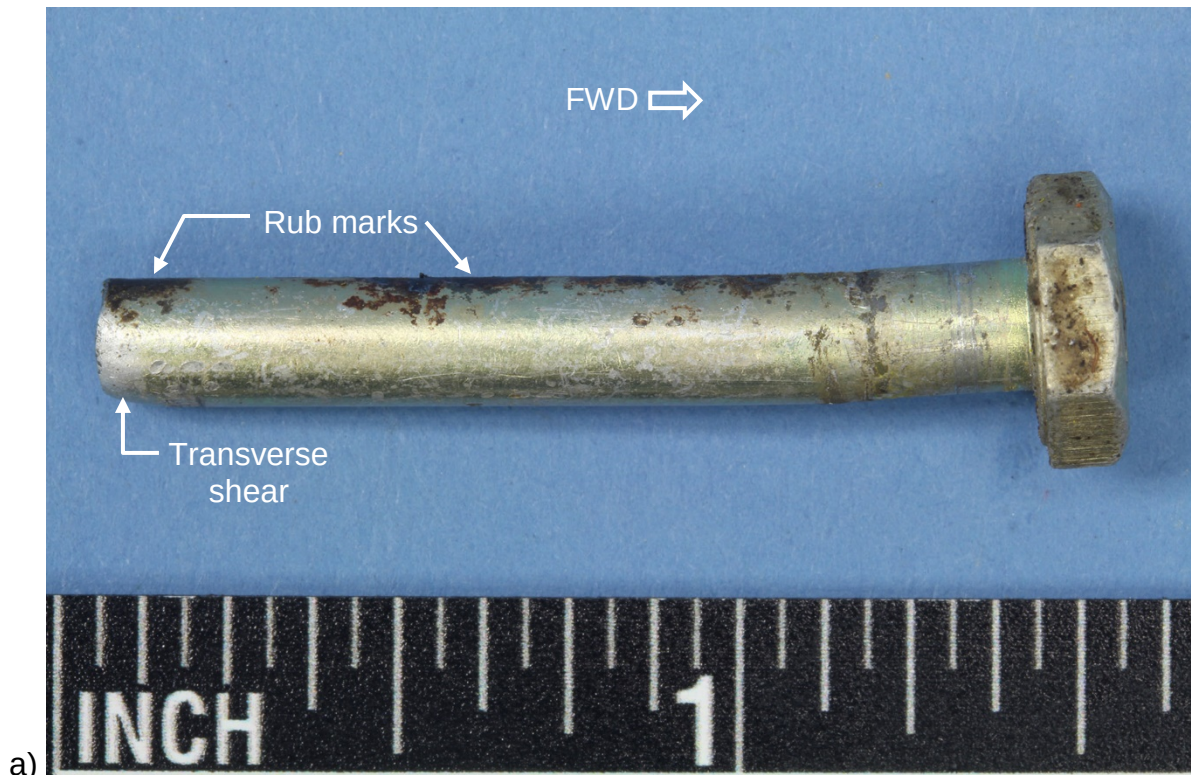


Figure 3: a) Image of the fractured shackle fitting attachment bolt showing transverse shear across the shank adjacent to the fracture and b) image of the bolt fracture surface showing rub marks on the lower part of the image and a flat featureless fracture elsewhere.

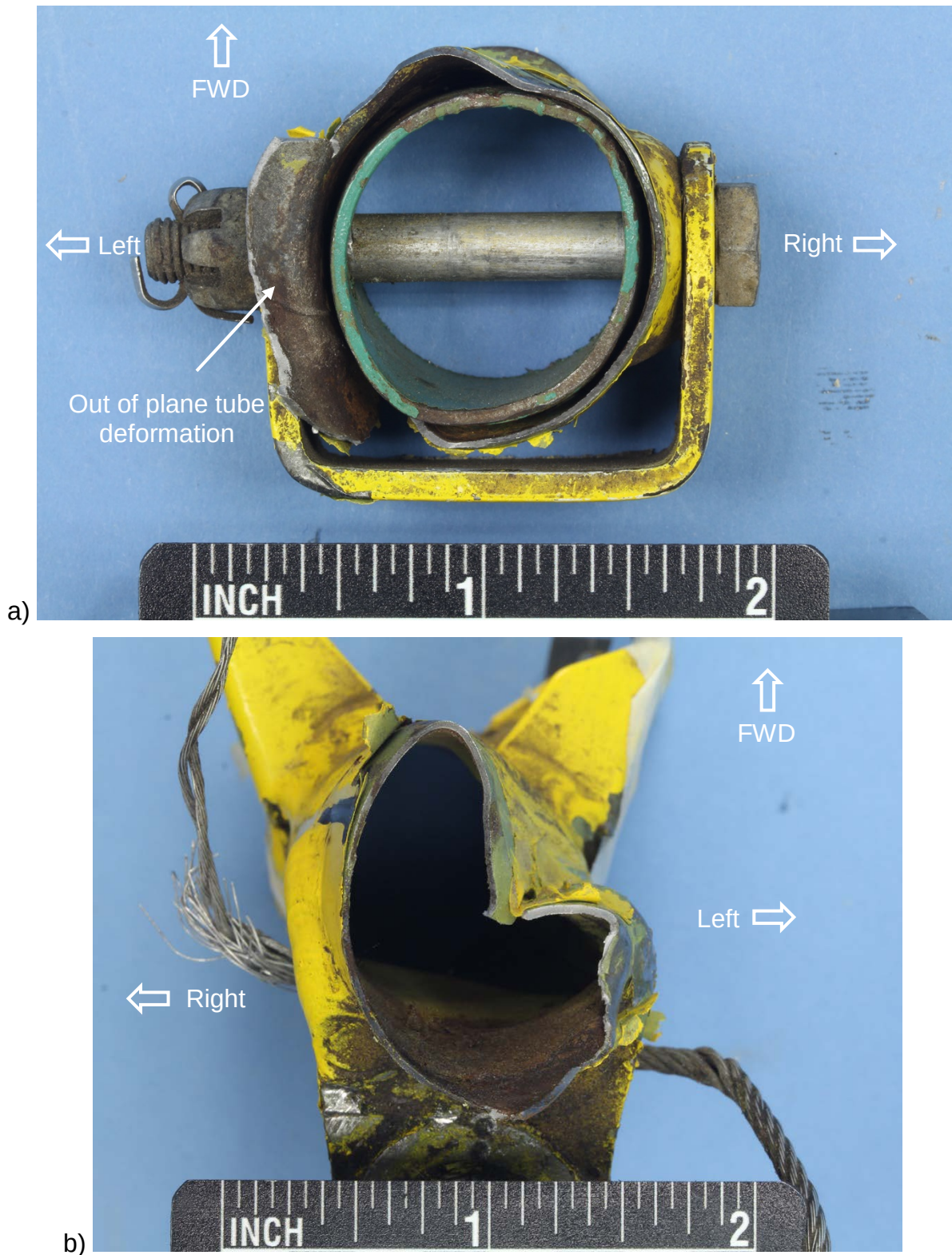


Figure 4: Images of fractured vertical stabilizer tube pieces. The appearance of the the tube pieces was consistent with a ductile overstress fracture in bending from right to left; a) lower fractured piece viewed from above looking down; and b) upper fractured piece viewed from below looking up.

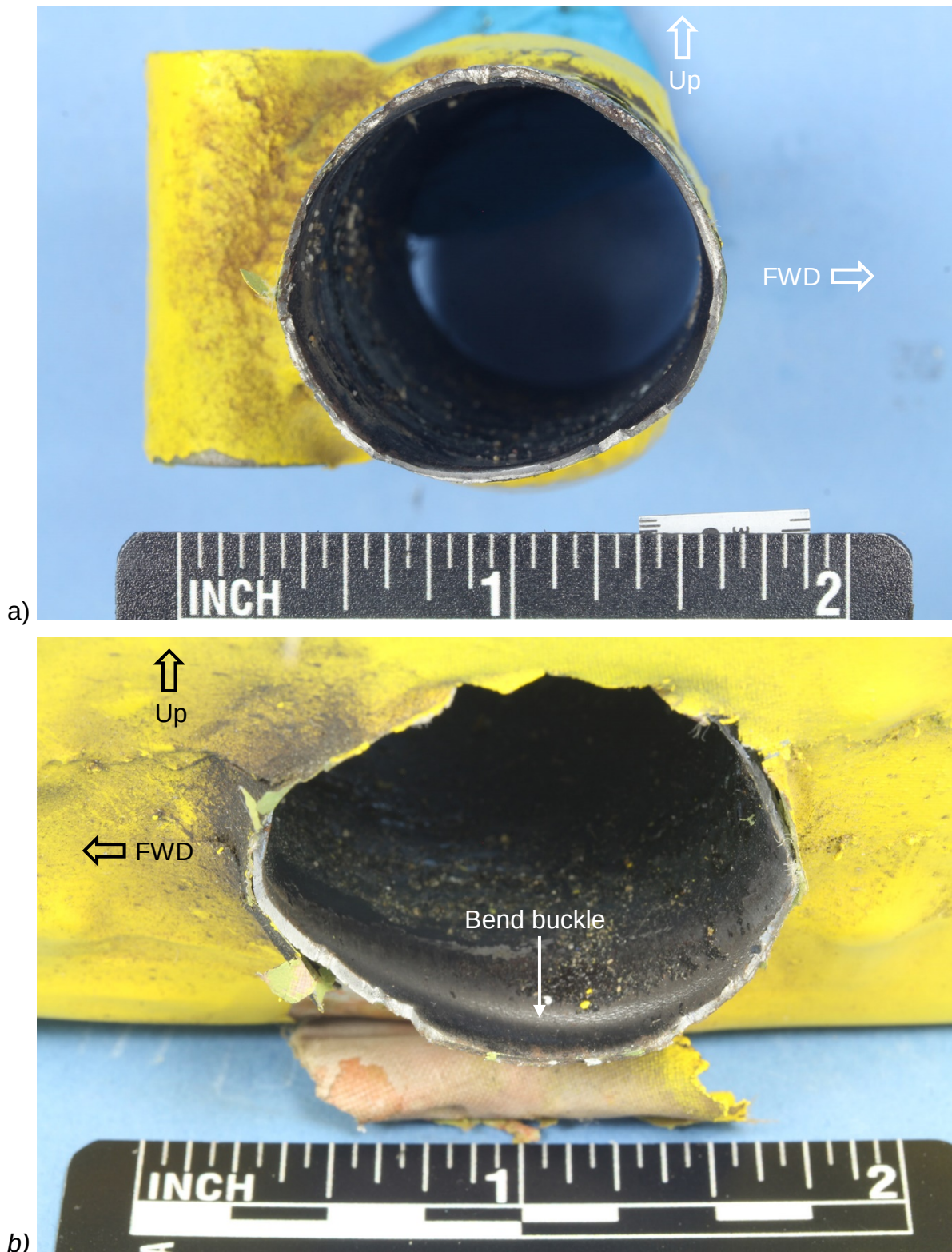


Figure 5: Images of fractured horizontal stabilizer forward spar tube pieces. The appearance of the the tube pieces was consistent with a ductile overstress fracture in tip-downward bending; a) inboard fractured piece viewed outboard looking inboard; and b) outboard fractured piece viewed inboard looking outboard.

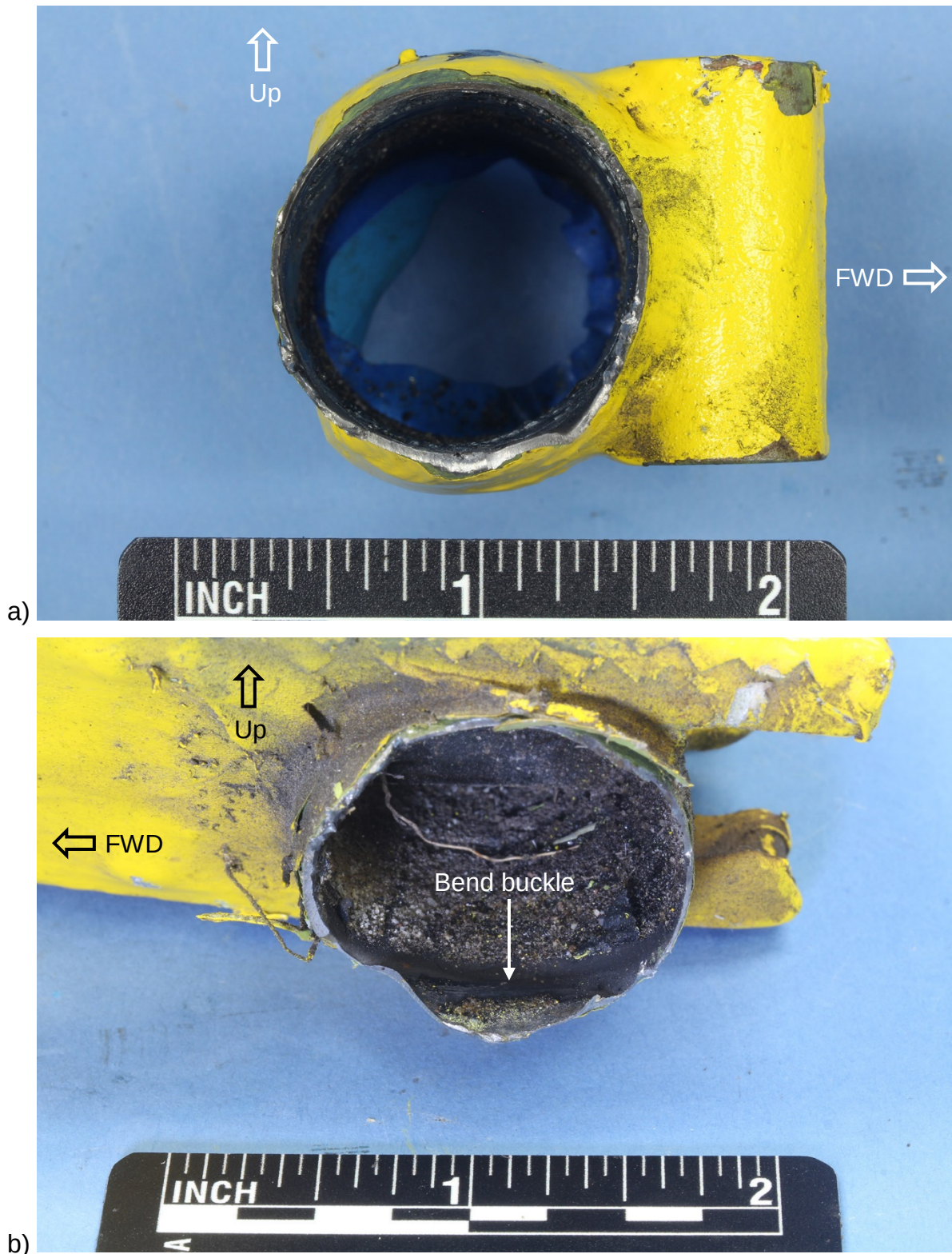


Figure 6: Images of fractured horizontal stabilizer aft spar tube pieces. The appearance of the the tube pieces was consistent with a ductile overstress fracture in tip-downward bending; a) inboard fractured piece viewed outboard looking inboard; and b) outboard fractured piece viewed inboard looking outboard.

**APPENDIX A: PAGES FROM THE BOEING-STEARMAN ILLUSTRATED PARTS
CATALOG**

HORIZONTAL STABILIZER & COMPONENT PARTS

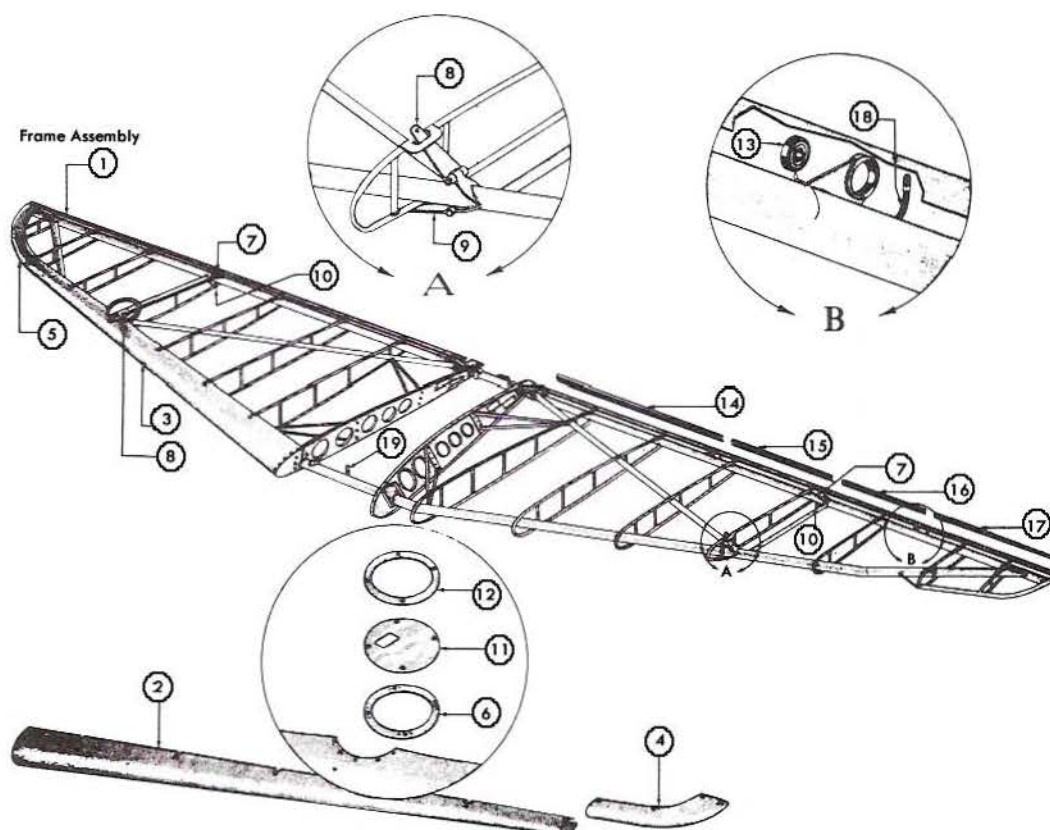


Figure 11 Stabilizer Assembly

Index No.	Part No.	Description	Cond.
1	75-1700	Stabilizer assy-covered grade "A" fabric	
1	75-1751	Stabilizer assy-uncovered	
	75-1704-4	Rib-stabilizer root lh	N-P
	75-1704-3	Rib-stabilizer root rh	N-P
	75-1704-2	Rib-stabilizer root nose, lh	N-P
	75-1704-1	Rib-stabilizer root nose, rh	N-P
2	75-1705-4	Cover-stabilizer leading edge lh	N-P
3	75-1705-5	Cover-stabilizer leading edge rh	N-P
4	75-1705-2	Cover-stabilizer leading edge left tip	N-P
5	75-1705-3	Cover-stabilizer leading edge right tip	N-P
	Attach hdw.	33 ea. AN530-4-3 & 3 ea. AN530-4-4	
6	AG75-1118	Frame assy-inspection opening	FAA-PMA
7	75-1607	Shackle-2100# brace-upper rear, 2 required	N-S
	Attach hdw.	2 ea. AN3-11, 2 ea. AN310-3, 2 ea. AN380-2-2	F/N
8	75-1737	Shackle-stabilizer, front upper, 2 required	N-S
	Attach hdw.	2 ea. AN3-20, 2 ea. AN310-3, 2 ea. AN380-2-2	F/N
9	75-1739	Shackle-stabilizer, front lower, 2 required	N-S
	Attach hdw.	2 ea. AN4-24, 2 ea. AN310-4, 2 ea. AN380-2-2	
10	75-1741	Shackle-stabilizer rear lower, 2 required	N-S
	Attach hdw.	2 ea. AN4-16, 2 ea. AN310-4, 2 ea. AN380-2-2	
11	75-1727	Window-brace wire inspection, 2 required	FAA-PMA
12	AG75-1117	Frame-inspection opening outer, 2 required	FAA-PMA
	Attach hdw.	8 ea. AN526-1032-7	F/N
13	K3L	Bearing-stabilizer hinge, 4 required	New
14	AG75-1707-1	Strip-stabilizer fabric, 2 required	FAA-PMA

HORIZONTAL STABILIZER & COMPONENT PARTS continued

Figure 11

Index

No.	Part No.	Description	Cond.
15	AG75-1707-2	Strip-stabilizer fabric, 2 required	FAA-PMA
16	AG75-1707-3	Strip-stabilizer fabric, 2 required	FAA-PMA
17	AG75-1707-4	Strip-stabilizer fabric, 2 required	FAA-PMA
	Attach hdw.	38 ea. AN530-6-6 sheet metal screw	
18	2AJ8-8	Jumper-bonding, 4 required	New
	AN231-2	Drain grommet, 38 required	F/N
19	3AJ8-8	Jumper-bonding, 1 required	F/N
	AN6-33	Bolt-front stabilizer attachment, 2 required	F/N
	AN6-40	Bolt-rear stabilizer attachment, 2 required	F/N
	AN960-616	Washer, 20 required	F/N
	AN310-6	Nut, 4 required	F/N
	AN380-3-3	Cotter pin, 4 required	R/N

ELEVATOR & COMPONENT PARTS

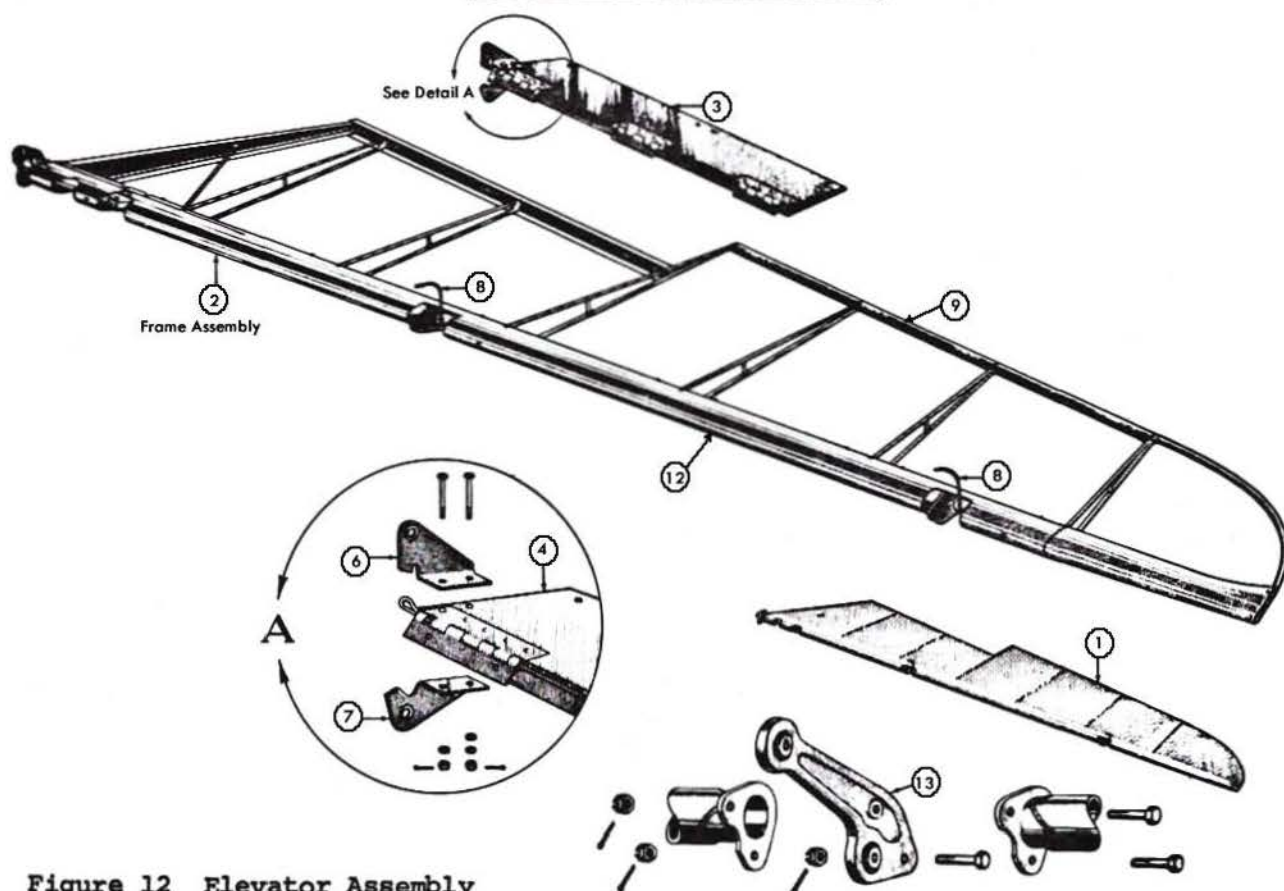


Figure 12 Elevator Assembly

Index

No.	Part No.	Description	Cond.
1	75-1800	Elevator assy, lh covered grade "A", less tabs	
1	75-1800-1	Elevator assy, rh covered grade "A", less tabs	
2	75-1801	Elevator assy, lh uncovered, less tabs	Recond.
2	75-1801-1	Elevator assy, rh uncovered, less tabs	Recond.