



CESSNA AIRCRAFT COMPANY

WICHITA, KANSAS 67277

MATERIAL AND PROCESS ENGINEERING

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Examination of a Damaged Elevator Trim Tab Assembly from a Crashed
M310Q Aircraft, N7648Q

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1.0 SUMMARY

Cessna Air Safety submitted a portion of a M310Q (N7648Q) elevator trim tab assembly to M&P for examination. The trim tab assembly was heavily damaged, and had been involved in a fatal crash of aircraft N7648Q on 11-07-01 in Winston Salem, NC. Prior to the crash, the pilot had radioed that he was experiencing oscillations in the airplane's controls. He then radioed that the problem was under control, and he continued on. Shortly after that he radioed that he was experiencing a lot of down pressure on the yoke. The aircraft crashed shortly after this transmission. The trim tab assembly and part of the elevator was cut from the aircraft at the crash site and brought back to Cessna for examination. Along with the trim tab assembly, the elevator push-pull tube was also submitted for examination. The forward clevis of the elevator push-pull tube had separated from the tube.

The purpose of this examination was to determine if the trim tab mechanism could have malfunctioned during flight, and to determine if the elevator push-pull tube clevis had separated as a result of the crash.

Based on the observations made during the examination of the trim tab assembly and the elevator push-pull tube, the following conclusions were reached:

1. The dry, oxidized condition of the forward trim tab push-pull rod clevis indicates that the attaching bolt was likely missing for some time prior to the crash.
2. The geometry of the trim tab push-pull rod in its current state would allow it to pass behind the forward elevator spar.
3. Damage to the trim tab push-pull rod indicated that it was in the full up position at the time of the crash.
4. The separation of the forward elevator push-pull tube clevis from the tube likely occurred as a result of the crash.

2.0 DISCUSSION OF RESULTS

The elevator and trim tab assembly were heavily damaged in the crash, making it difficult to differentiate between pre and post crash damage. However, there were a few observations which give an indication of the position of the trim tab during the crash, and how it may have gotten into that position, as follows.

The trim tab push-pull rod was bent upward, with indentations present on the aft clevis and the tab horn. This type of damage

is consistent with the trim tab being in the full up position (elevator full down) at the time of the crash. The force of the crash would have been the most likely cause of this damage.

There was very little damage, other than normal wear and tear present on the trim tab actuator.

The forward clevis of the trim tab push-pull rod was not connected to the actuator, and the attaching bolt was missing, however the aft bolt was in place. The bore of the attaching bolt holes of the forward clevis were dry and lightly oxidized, however the bore of the aft clevis attaching bolt holes were coated in a dark oily substance. The lack of lubricant on the forward clevis could have been due to the loss of the forward attach bolt some time prior to the crash. The forward clevis legs were spread open by approximately 0.3 inches, however it could not be determined what would have caused this. Indentation markings on the inner surface of the leading edge of the elevator were made after the clevis was spread open.

Rub marks on the opening of the forward elevator spar correspond to rub marks found on the underside of the trim tab push-pull rod. The geometry of the assembly in its current condition would allow the forward clevis to fall behind the forward elevator spar.

The forward elevator push-pull tube clevis was separated from the tube. The attaching rivets fractured due to shearing, with the shearing direction indicative of relative twisting between the tube and the clevis. It was not possible to determine with certainty whether or not this occurred before or during the crash. However there were markings in the vicinity of the rivet fracture surfaces which are indicative of various relative positions of the tube with the clevis.

3.0 EXAMINATION OF THE ELEVATOR TRIM TAB ASSEMBLY

3.1 Background

A portion of the elevator trim tab assembly along with the elevator push-pull tube had been removed from the aircraft and were brought to the M&P laboratory in a sealed carton by Cessna Air Safety. The sealed carton was opened in the M&P lab by a representative of the FAA. The FAA representative surrendered the elevator trim tab assembly and the elevator push-pull tube to Cessna M&P for the course of this examination.

3.2 Visual Examination

3.2.1 Examination of The As-Received Elevator Trim Tab Assembly

The elevator trim tab assembly is located on the RHS elevator as shown in Figure 1. The sample which was submitted to M&P consisted of a portion of the elevator and trim tab approximately 8 inches wide, along with the push-pull rod and the trim tab actuator outer housing, as shown in Figure 2. The 8 inch wide sample was heavily damaged, exhibiting torn and bent metal components and an overall soiled appearance with light corrosion of the internal areas.

3.2.2 Examination of the Trim Tab Actuator

The trim tab actuator, shown in Figure 3, was in a moderately worn condition, and was not attached to the trim tab push-pull rod. It was reported that the push-pull rod and the actuator were found to be disconnected at the crash site. The forward clevis of the push-pull rod attaches to the actuator by a bolt, which was not found at the crash site. The bolt would have been held in place by a castellated nut and cotter pin, similar to the attachment at the aft trim tab clevis, as shown in Figure 4.

3.2.3 Examination of the Trim Tab Push-Pull Rod

The trim tab push pull rod consisted of a steel tube, 0.38 inches OD by approximately 11 inches long, with steel clevises silver brazed to each end of the tube. The clevis on the push-pull rod was spread open approximately 0.3 inches, as shown in Figure 5. There were some wear marks on the end of the clevis fork, as shown in Figure 6. There was also some slight wear on the underside of the rod near the clevis, as shown in Figure 7. Examination of a similar M310 aircraft showed that the rod passes through the elevator spar through an opening; the worn area would have corresponded with the opening, as shown in Figure 8. It was also noted that on the representative M310 aircraft, there was nothing in contact with the ends of the clevis fork. Light wear marks were also found on the inner surface of the clevis, as shown in Figure 9. The marks on the inner surface of the clevis corresponded in shape and configuration with the screw assembly of the actuator, as shown in Figure 10.

The push-pull rod was slightly bent upward, as shown in Figure 11. Close examination of the clevis at the aft end showed that it was lightly corroded in a similar manner as the remainder of the rod. Indentation marks were found on the upper side of the clevis, which corresponded with indentations found on the tab horn, as shown in Figures 12a, 12b, and 12c. The indentations on the tab horn were also not corroded. The retaining bolt in the trim tab horn did not appear to be bent, and the cotter pin was intact. The horn bearing was corroded, but not seized.

3.2.4 Examination of the Elevator and Trim Tab Structure

The structure of the trim tab and the elevator was heavily damaged upon receipt in M&P. Movement of the sheet metal components was generally toward the rear of the aircraft. Attention was focused on the area where the trim tab push-pull rod attaches to the actuator. A rub mark was found on the lower side of the opening in the elevator spar, as shown in Figure 13, which corresponds to the rub mark found on the push-pull rod (Figure 7).

Indentations were found on the leading edge of the elevator, as shown in Figure 14. The indentations on the elevator leading edge were slightly inboard of the opening for the trim tab actuator, and corresponded to the spread-open clevis of the push-pull rod, as shown in Figure 15. It was noted that the indentations did not correspond to the non-deformed aft clevis.

3.2.5 Examination of the Elevator Push-Pull Tube

The elevator push-pull tube had been cut into two pieces to facilitate shipping. The push pull tube consisted of a steel tube, 0.625 inch OD by approximately 23.5 inches long with aluminum clevises at each end. The aluminum clevises were held in place by 2 aluminum rivets each, as shown in Figure 16. At the forward end, the clevis had become separated from the tube, with both rivets sheared off, as shown in Figure 17.

3.3 Microscopic Examination

3.3.1 Examination of the Trim Tab Push-Pull Rod Clevises

The forward clevis of the trim tab push pull rod was examined under light microscopy. Attention was focused on the bore of the attaching bolt hole. No scratches or markings were found on the bore of the forward clevis. The bore was lightly oxidized, and exhibited some dry powdery substance resembling dust or iron oxide, as shown in Figure 18. The aft clevis was also examined, and the bore of the attaching bolt hole was found to be coated with a dark greasy substance, with no dust or iron oxide present. This is also shown in Figure 18.

3.3.2 Examination of the Forward Elevator Push-Pull Rod Clevis

The sheared attaching rivets of the forward clevis were examined using the scanning electron microscope (SEM). The appearance of the fracture surfaces of the rivets indicates that they had broken in one shearing motion. The shear direction of the rivets indicates that the push-pull tube had twisted in relation to the clevis, causing the rivets to shear off. Slight angular displacement of the tube in relation to the clevis was evident by the presence of witness marks on the rivet fracture surfaces, as shown in Figure 19.

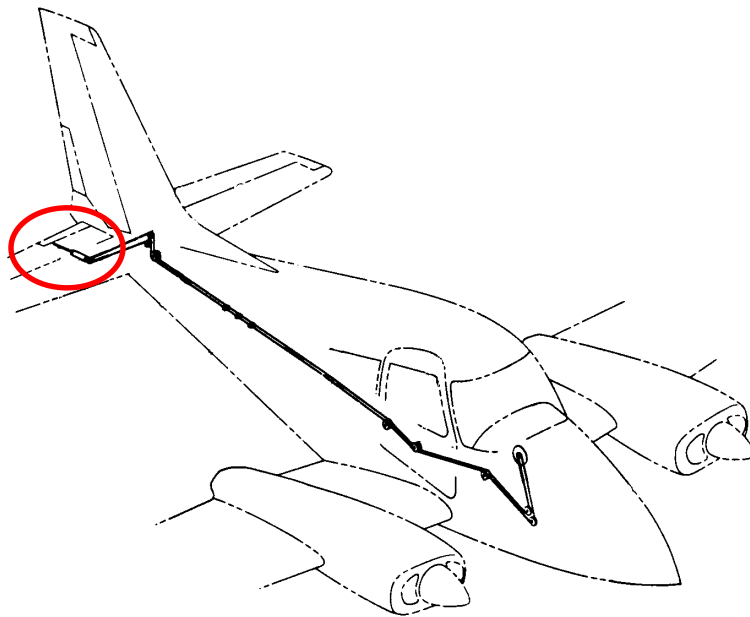


Figure 1. Diagram showing the elevator trim tab control mechanism in a M310 aircraft. The location of the actuator and push-pull rod are circled.

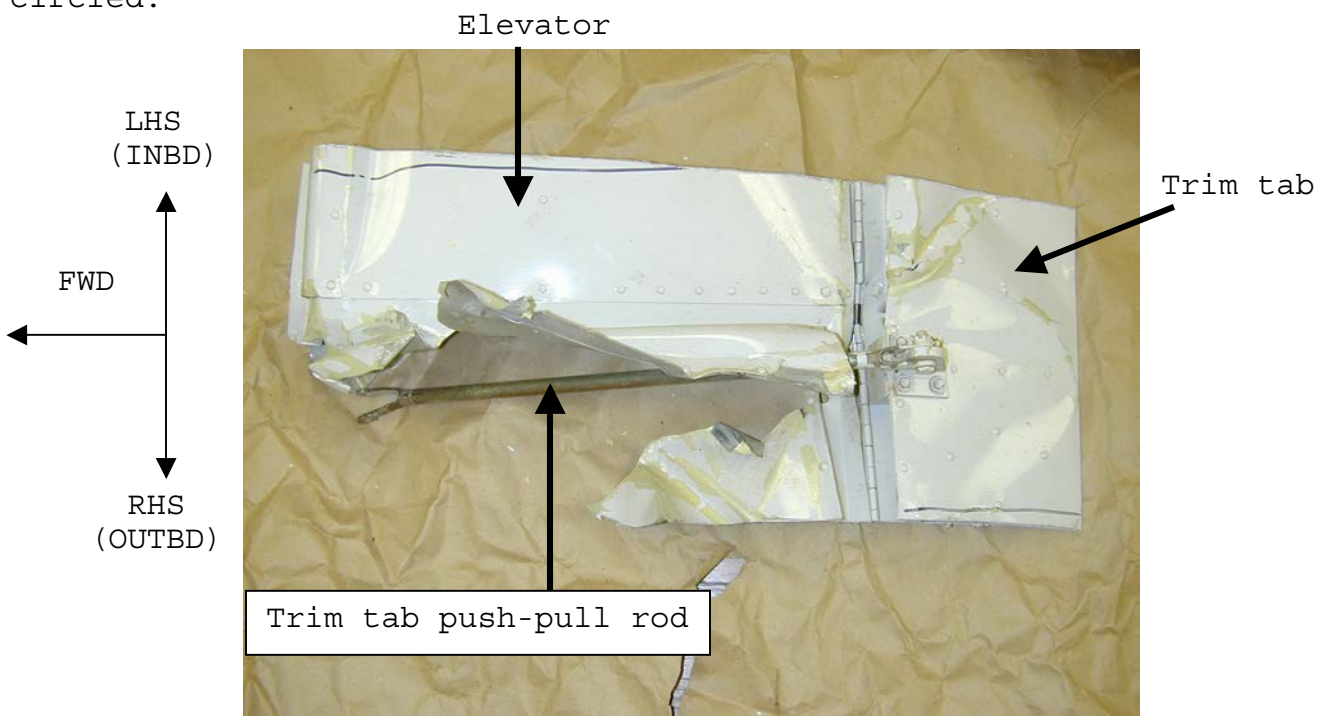


Figure 2. View of the underside of the elevator trim tab sample.

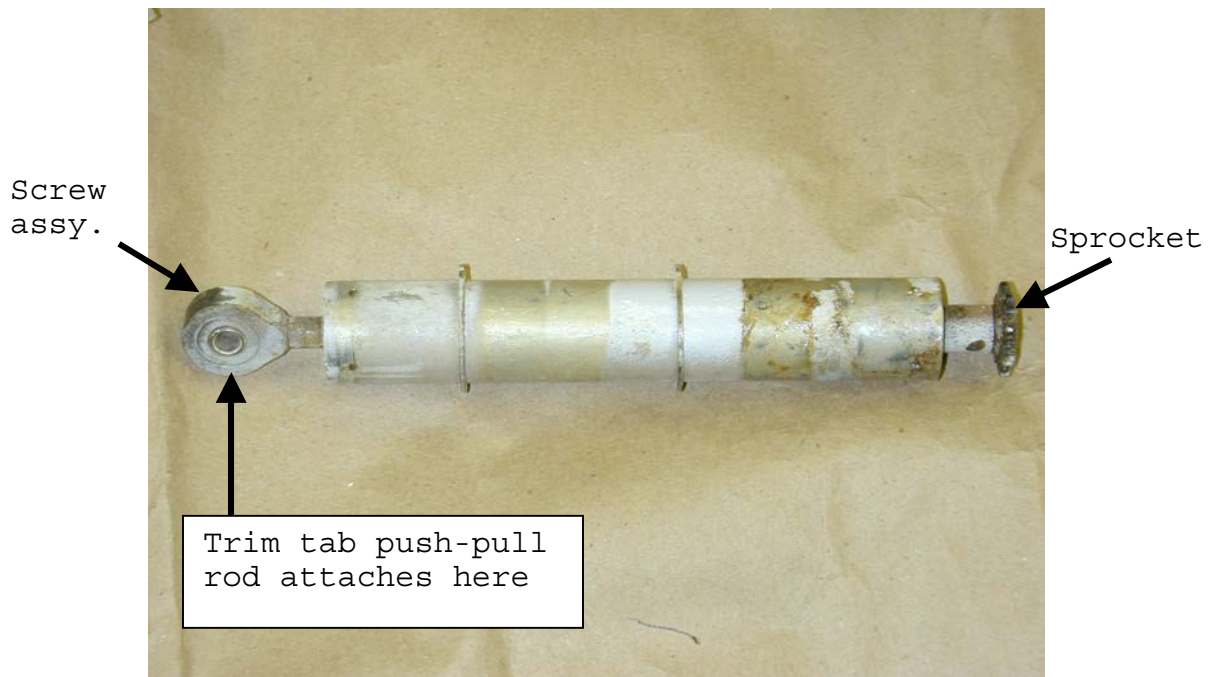


Figure 3. View of the trim tab actuator, with the various components labelled.

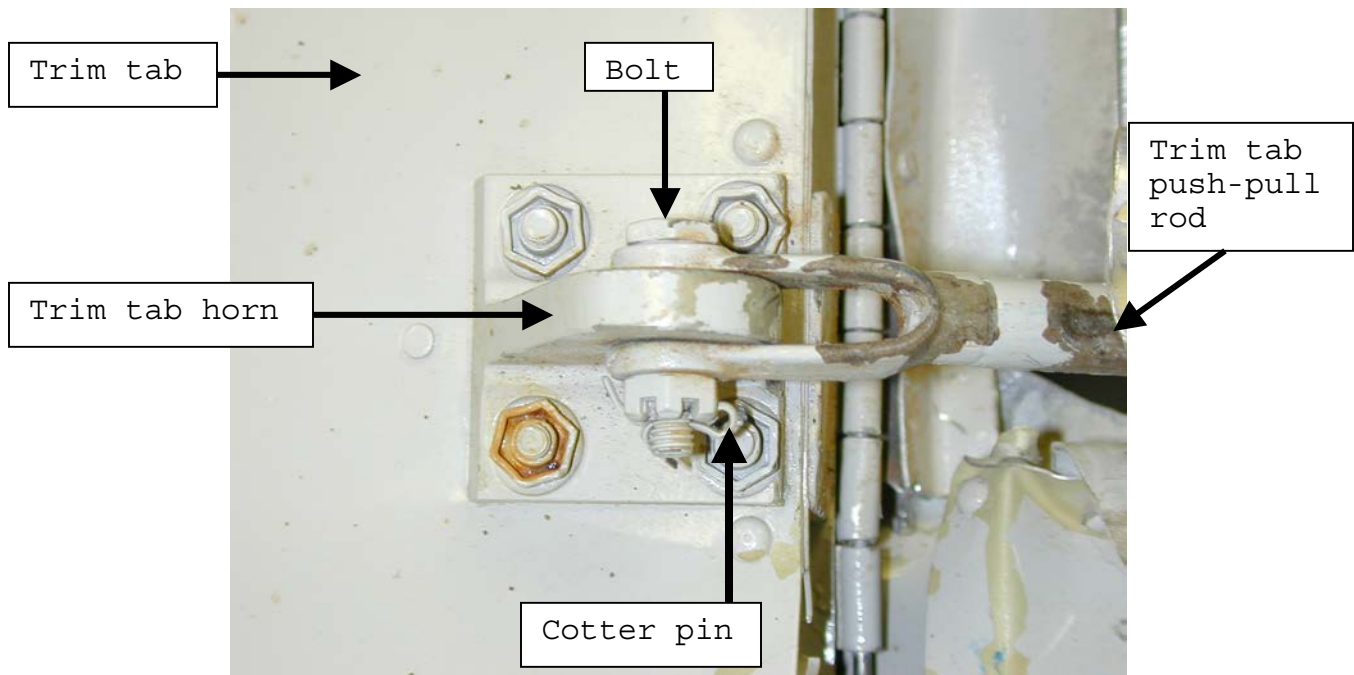


Figure 4. View of the attachment of the trim tab push-pull rod to the horn on the trim tab, in the condition in which the part was received.



Figure 5. View of the forward clevis of the trim tab push-pull rod, which was spread open approximately 0.3 inches. Magnification: x1.4.



Figure 6. Close-up view of the ends of the forward clevis forks, showing some non-corroded worn areas (arrows). Magnification: x2.45.



Figure 7. View of the underside of the trim tab push-pull rod showing light wear (circled). Magnification: x2.8.

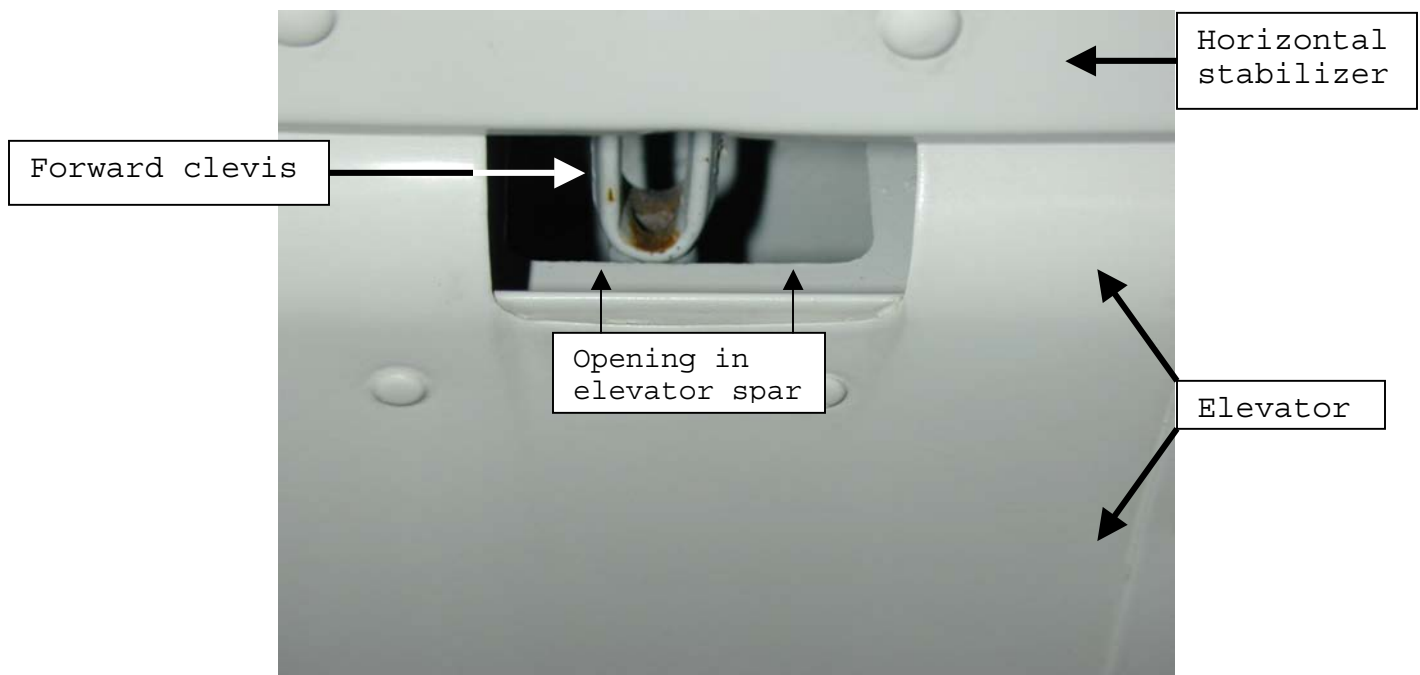


Figure 8. View of a trim tab actuator rod clevis on a representative M310 aircraft. Note the proximity of the clevis to the opening in the elevator spar.



Figure 9. Close up view showing light wear marks on the inner surface of one of the forward clevis (arrow). Magnification: x2.9.

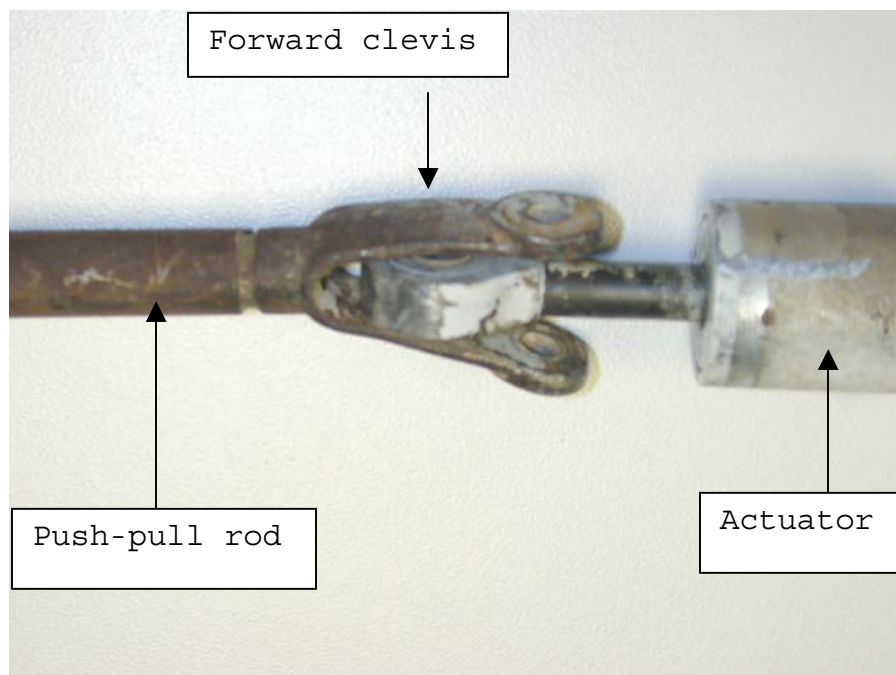


Figure 10. View showing how the screw assembly corresponds with the location of the wear marks on the inner surface of the forward clevis. Magnification: x1.16.



Figure 11. View of a trim tab actuator rod. Note that the rod has been bent upward near the trim tab.

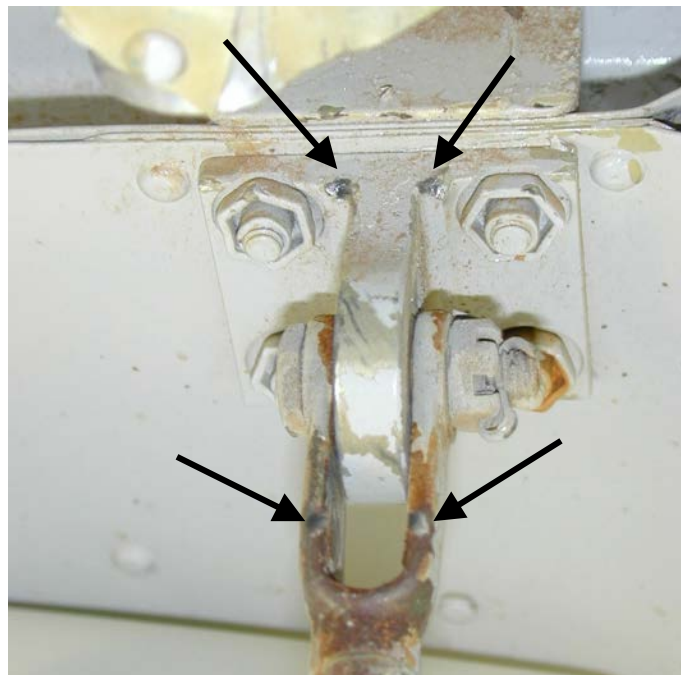


Figure 12a. View of the aft clevis, showing indentation markings on the clevis forks and on the tab horn (arrows). The trim tab rod has been moved downward approximately 90° from its actual orientation for this photo. Magnification: x1.48.

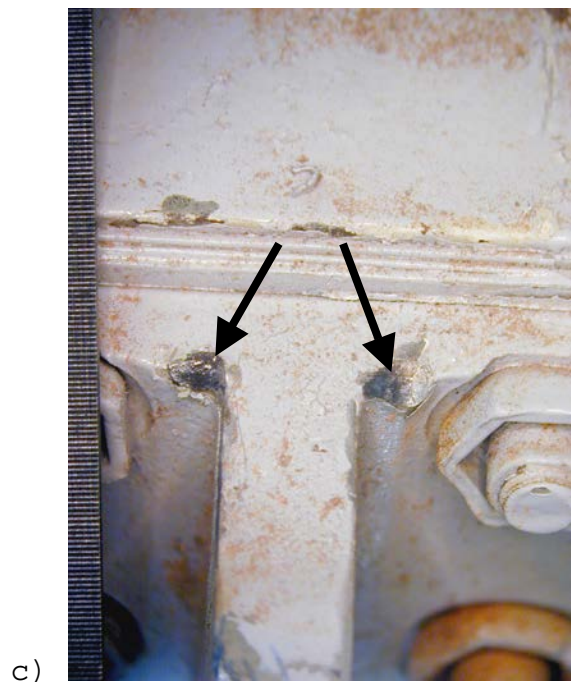
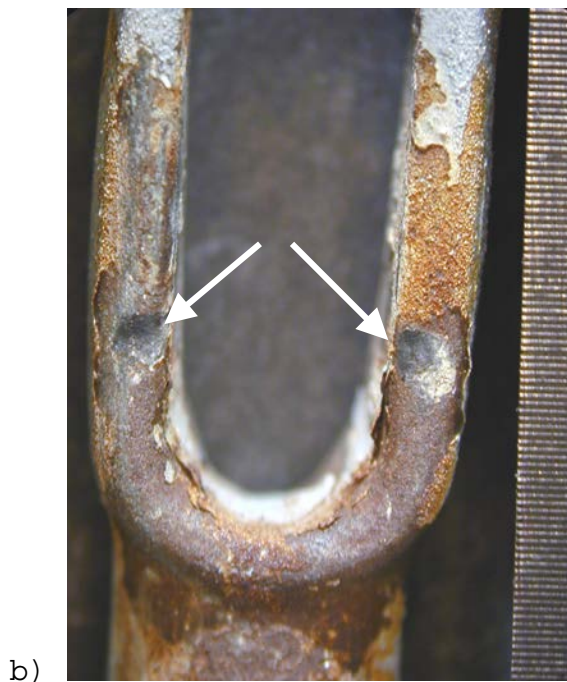


Figure 12b and 12c. Close-up views of the aft clevis (b) and the trim tab horn (c), showing the un-corroded indentation markings (arrows). Magnifications: x4 (b) and x2.8 (c).

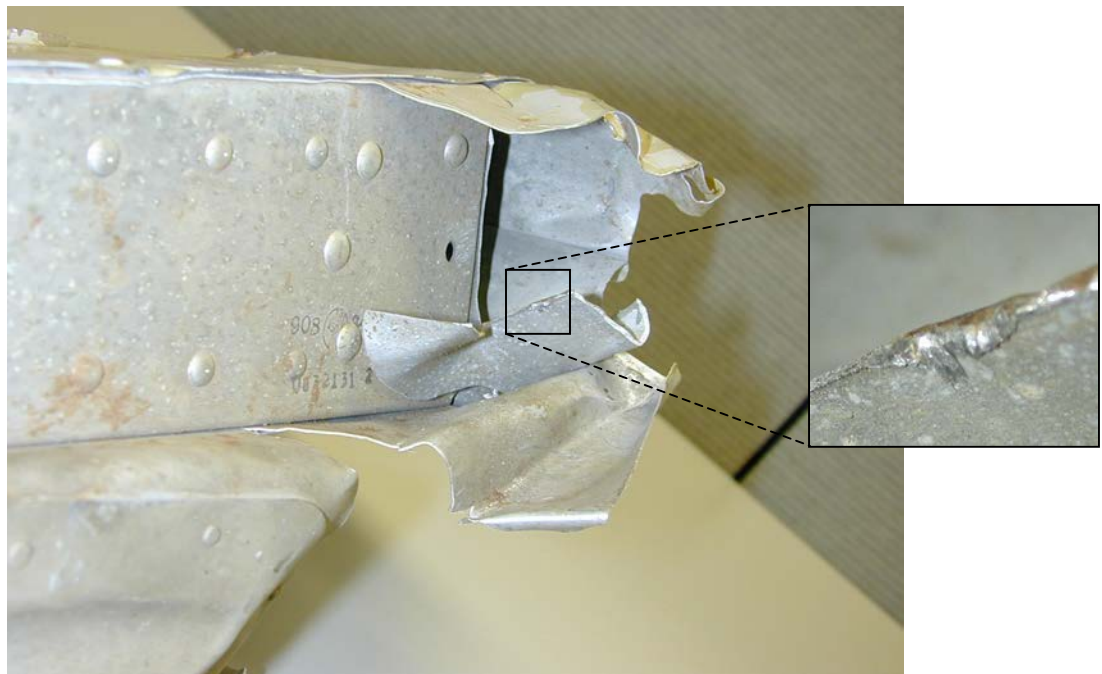


Figure 13. View of the opening in the elevator spar, showing rubbing wear on the lower edge (inset). Magnification: x2.6 (inset).

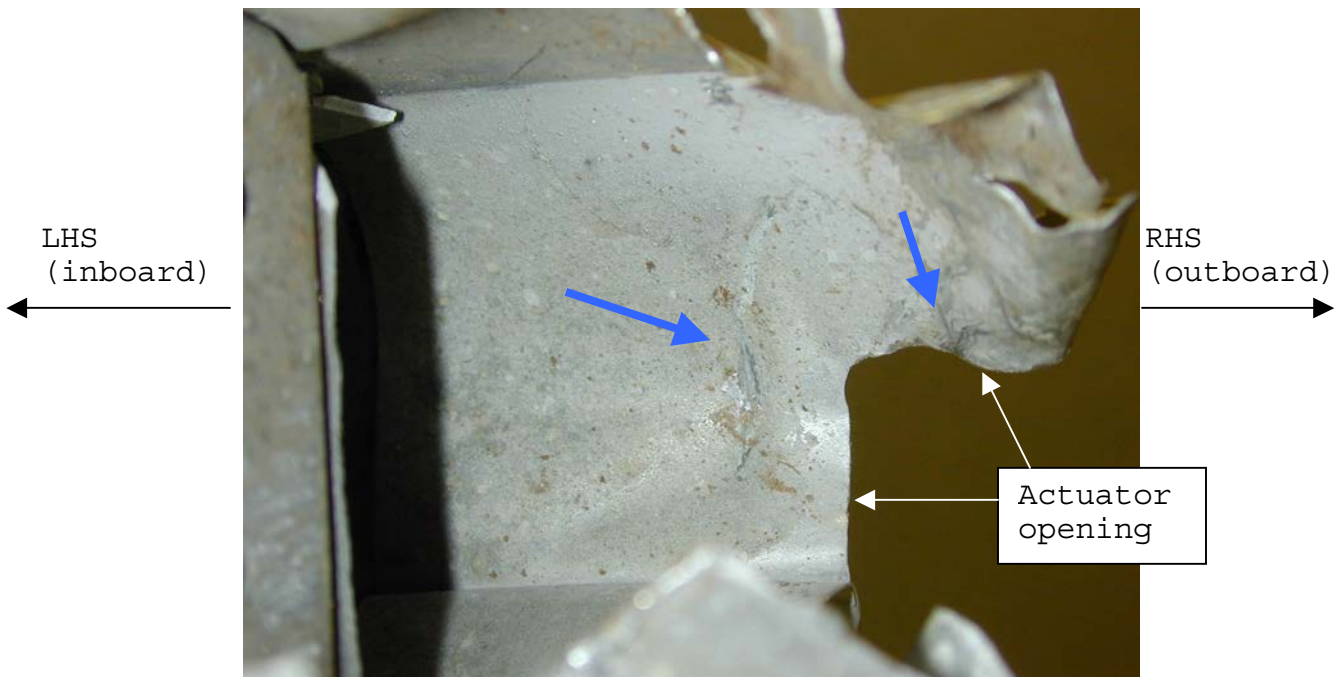


Figure 14. View from within the elevator structure, looking forward at the inner surface of the leading edge. The blue arrows denote indentations on the leading edge. Magnification: x1.3.



Figure 15. View of the lead edge of the elevator, looking aft, showing the indentations and the corresponding positions of the legs of the forward trim tab actuator clevis.

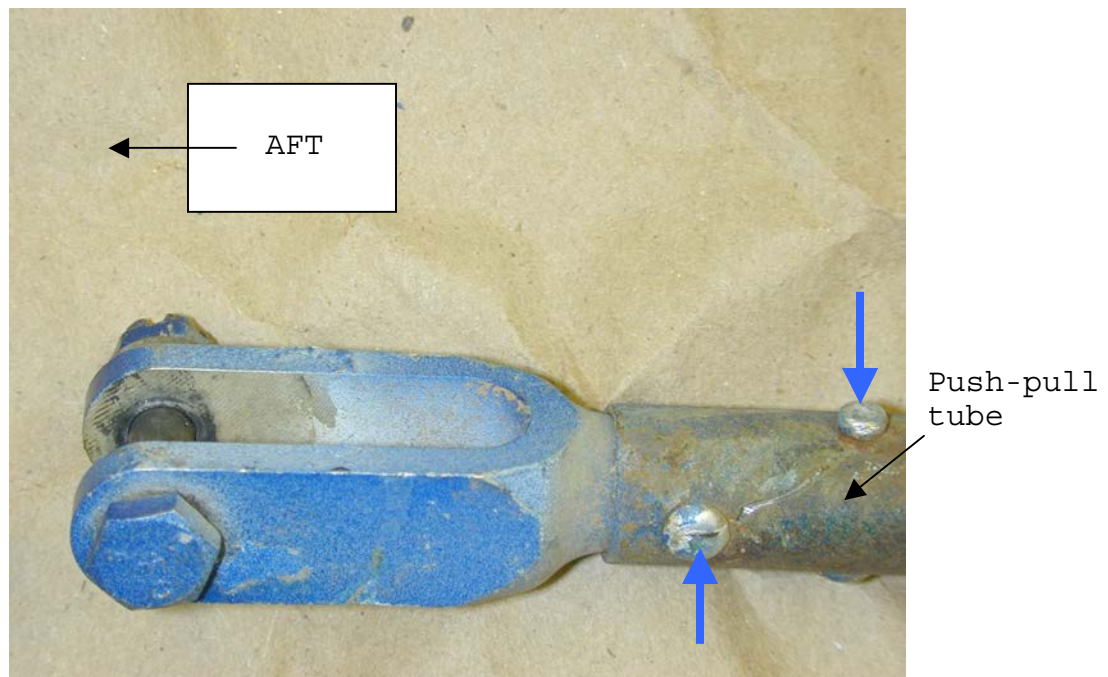


Figure 16. View of the aft clevis of the elevator push-pull tube. The aluminum clevises were fastened to the elevator push-pull tube with two rivets each (arrows). Magnification: x1.3.

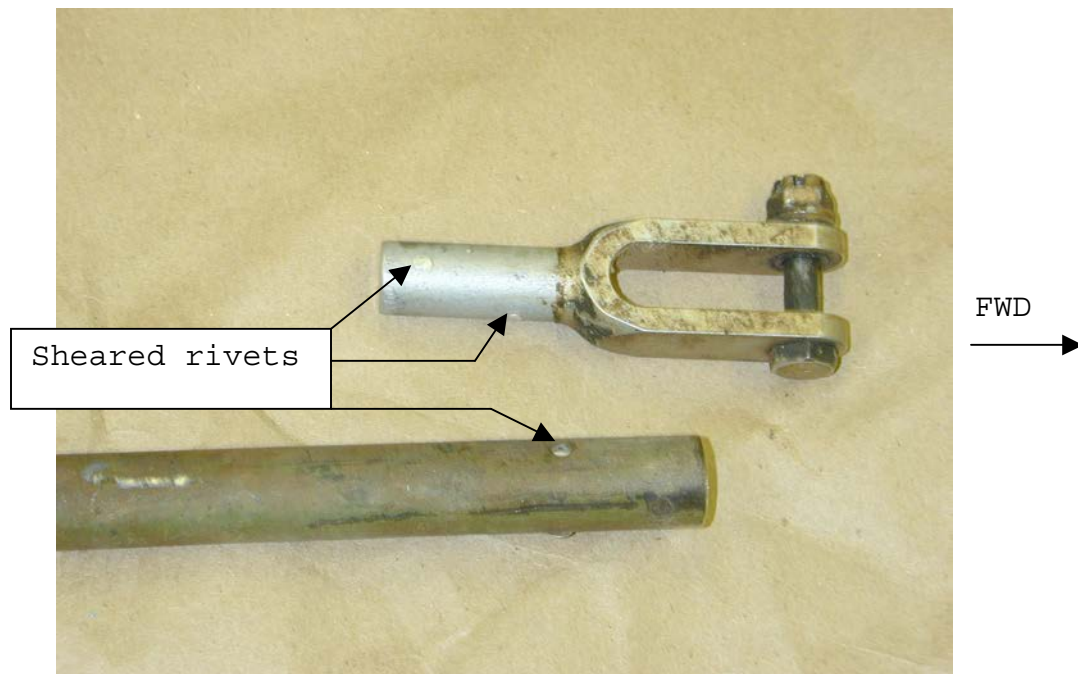


Figure 17. The forward clevis was separated from the elevator push-pull tube, with both rivets sheared away.

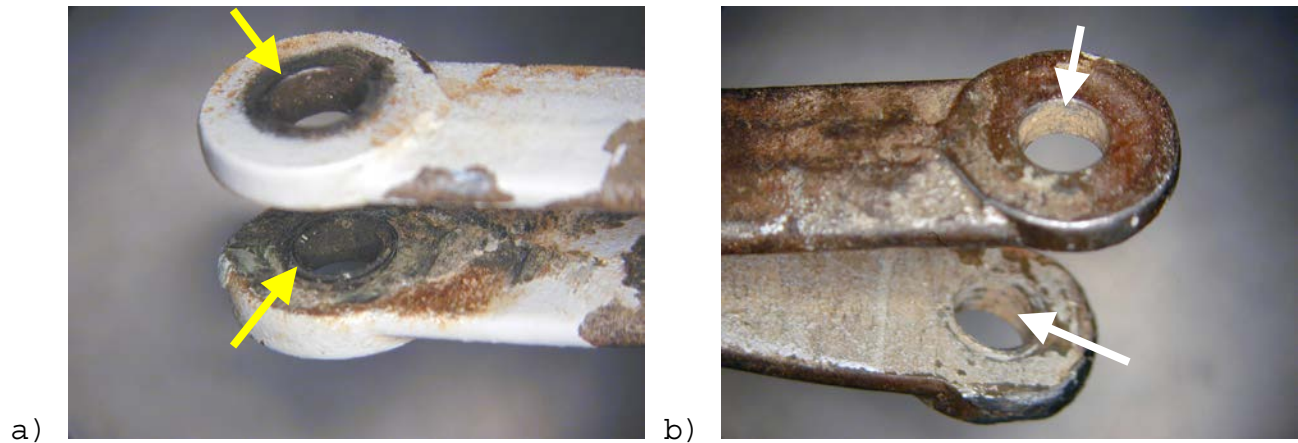


Figure 18. Views of the trim tab clevises, a) aft and b) forward. Note the presence of dark oily deposits on the bore of the attaching bolt hole at the aft clevis (yellow arrows) however at the forward clevis there was a dry, dusty iron oxide present (white arrows). Magnification: x2.5.

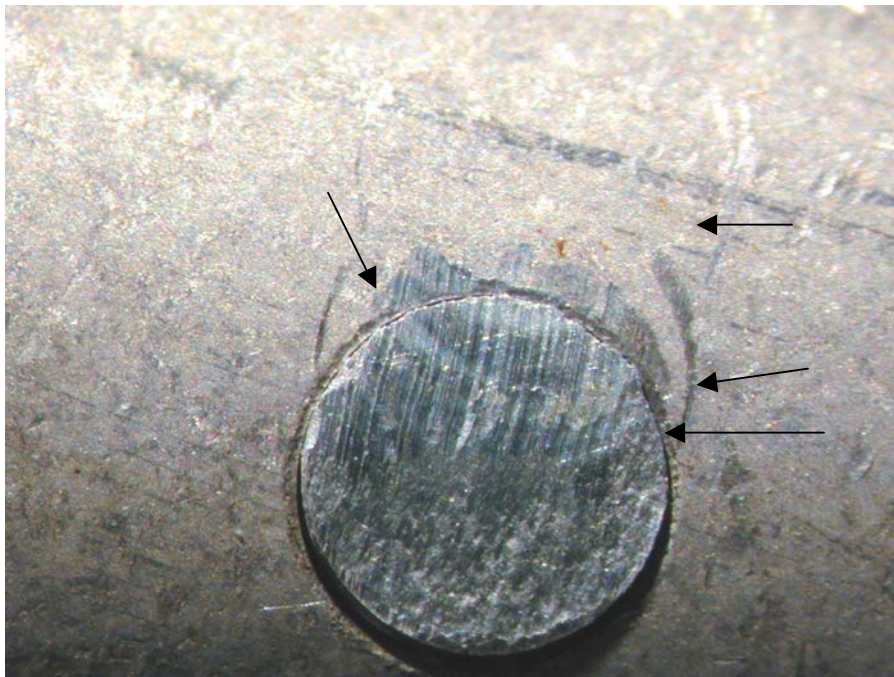


Figure 19. Magnified view of one of the sheared attaching rivets in the forward elevator push-pull tube clevis. The arrows point to witness marks made by the mating portion of the rivet denoting various positions of the tube relative to the clevis. Magnification: x15.