NATIONAL TRANSPORTATION SAFETY BOARD
Bureau of Technology
Washington, D. C.

November 25, 1986

Materials Laboratory
Report No. 87-15

METALLURGIST'S FACTUAL REPORT

A. ACCIDENT

Place : St. Croix, USVI
Date : October 28, 1986
Vehicle : Grumman Mallard G-73, N604SS
NTSB No. : MIA 87-F-A013
Investigator: Jeff Kennedy (MIA)

B. COMPONENTS EXAMINED

1. One turnbuckle from aileron balance cable in two pieces.
2. Left inboard aileron cable fairlead.
3. Two cable segments from each of six fractured control cables.
4. One section of electrical wiring bundle.

C. DETAILS OF EXAMINATION

1. Turnbuckle

The received turnbuckle, labeled "aileron balance cable," was in two pieces, as shown in figure 1. One piece contained the turnbuckle barrel, the left hand threaded cable fitting and a length of fractured safety wire. The second piece was the right hand (RH) threaded cable fitting and the mating half of the fractured safety wire. The RH fitting appeared to have been unscrewed from the barrel and neither the barrel nor the RH fitting were fractured. In the laboratory it was demonstrated that the RH fitting could be screwed into the barrel with minimal effort up to the last four threads on the fitting which were slightly damaged. The mating threads on the barrel appeared to be undamaged.

The safety wire between the barrel and the RH fitting was fractured near the hole in the RH fitting. Close examination of the break with an optical microscope revealed features typical of an overstress break.

2. Fairlead

The left inboard aileron cable fairlead, shown in figure 2, was in three pieces, two of which were received. The fairlead was reported to have been found intact in the aircraft and was subsequently fractured during its removal. Inspections showed that the cable hole in the fairlead had been deformed such that the originally round hole resembled

the shape of a "D" with its straight portion vertical and toward the forward side of the hole. Microscopic inspection of the cable hole in the phenolic composite fairlead revealed scrape marks and evidence of mechanical removal of material from the forward side of the hole. Further, the contour of the enlarged hole suggests that the material was removed by sliding contact with the aileron cable.

3. Control Cable Segments

Ten pieces of the received cable segments were identified as mating fracture pairs from 5 different control cables within the aircraft, labeled, down elevator, up elevator, right rudder, left rudder and forward aileron cable right wing. The fractured ends of these cables exhibited various amounts of unraveling of the individual wires and strands. Microscopic examinations of the wire fractures from each cable segment showed plastic deformation (yielding) of the wires adjacent to either a slant fracture or a necked-down, reduced section fracture, both characteristics are indicative of overstress separations in thin wire. No evidence of significant wear or progressive fractures was detected adjacent to these separations.

The two remaining cable segments were labeled forward aileron cable, right (inboard) and left (outboard) pieces. These two cable ends reportedly did not mate and approximately two inches of cable between the received ends was reported to have been missing. In contrast to the previously noted cables, the ends of the left wing aileron cable segments were not unraveled. The left wing aileron cable was a 3/8 inch cable constructed of 133, 0.01 inch diameter wires in a 7 by 19 right hand twist pattern.

The wires at the separated ends of the left wing aileron cable had been melted and partially fused together. Almost all the wires on the inboard segment end were fused into one ball. Several fused balls were present on the separated end of the outboard cable segment. The fused end of the outboard segment is depicted in figure 3. In addition, wires were found fused together at many localized areas on the outer surface of the outboard cable segment as shown in figure 4. Energy dispersive x-ray analysis of the fused areas and the base wire of the cable established that both were representative of a 300 series stainless steel. However, significant additional amounts of aluminum were detected in the fused zones. These fusion areas were present along approximately 6.0 inches of the cable outboard from the separated end and tended to be on one half of the cable circumference. Heavy wear and some broken and protruding wire filaments were found in this area of the cable. The fusion at the end of the cable segments and along the surface of the outboard segment are indicative of intense localized heating consistent with electrical arcing.

4. Electrical Wiring Bundle

The received section of electrical wiring bundle is shown in figure 5. The bundle was made up of one large, approximately 7/16 inch diameter,

insulated power cable, arrow "P" in figure 3, and 35 smaller (14, 16, 18 and 20 gage) insulated electrical wires held together by 4 plastic wire ties, and two mechanical clamps, arrows "T" and "M" respectively in figure 5. The power cable reportedly connected the battery and the "J" box. The smaller wires were unidentified.

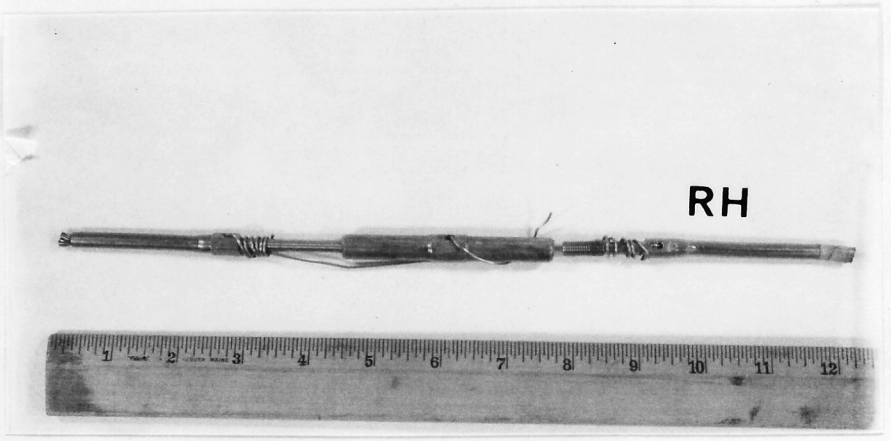
At the location of bracket "E" in figure 5, a 0.5 by 0.5 inch area of the power cable conductor was exposed and a 1.5 inch strand comprised of 13 wire filaments was protruding from the bundle. The exposed conductor and protruding wires were located on the side of the power cable facing the smaller electrical wires in the bundle. One of the mechanical clamps and one wire tie were removed from this area of the bundle to allow closer inspection the power cable.

This inspection showed that the protruding wires were fused to the exposed power cable conductor and that these wires did not appear to have been part of the original conductor (see fig. 6). The protruding wires were approximately 0.01 inches in diameter and were later determined to be a stainless steel alloy in contrast to the aluminum coated copper power cable conductor wires. The plastic insulation and woven fiberglass abrasion shield were blackened and burnt along the edges of the exposed conductor area. In addition, scrape marks were found on many of the individual conductor wires. These scrape marks resemble marks left when a wire rope, such as a typical aircraft control cable, is slid across a surface. Eleven of the smaller electrical wires and one of the mechanical clamps showed evidence of localized heating in the immediate area of the exposed power conductor and protruding wire strand. However, the insulation was breached on only one of these wires.

Joe Epperson

Joe Epperson
Metallurgist

Attachments



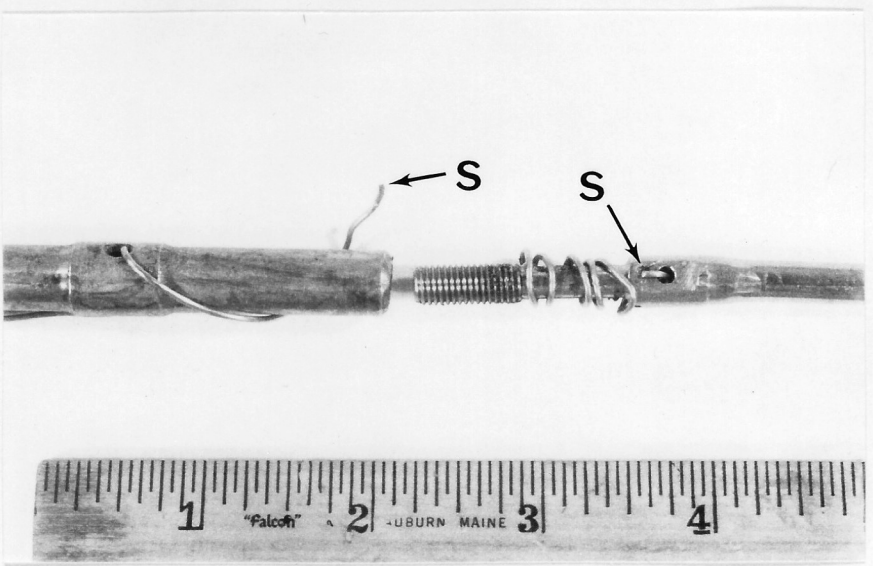


Figure 1. An overall view of aileron balance cable turnbuckle (upper view) with the disconnected RH fitting. Lower view shows the mating safety wire fractures at arrows "S".

Figure 2. View of the outboard surface of the left inboard aileron cable fairlead, fractured during removal. Black bracket indicates deformation of hole by aileron cable. Mag 4X.

Figure 3. An SEM macrograph (10X) of the fused end of the left aileron cable outboard segment.

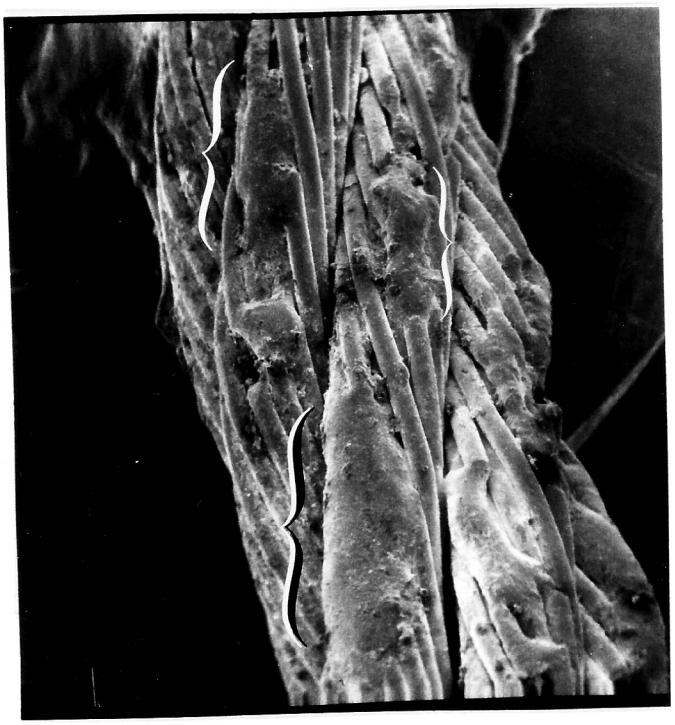


Figure 4. An SEM macrograph (10X) of fused wires (brackets) on the surface of the left aileron cable.

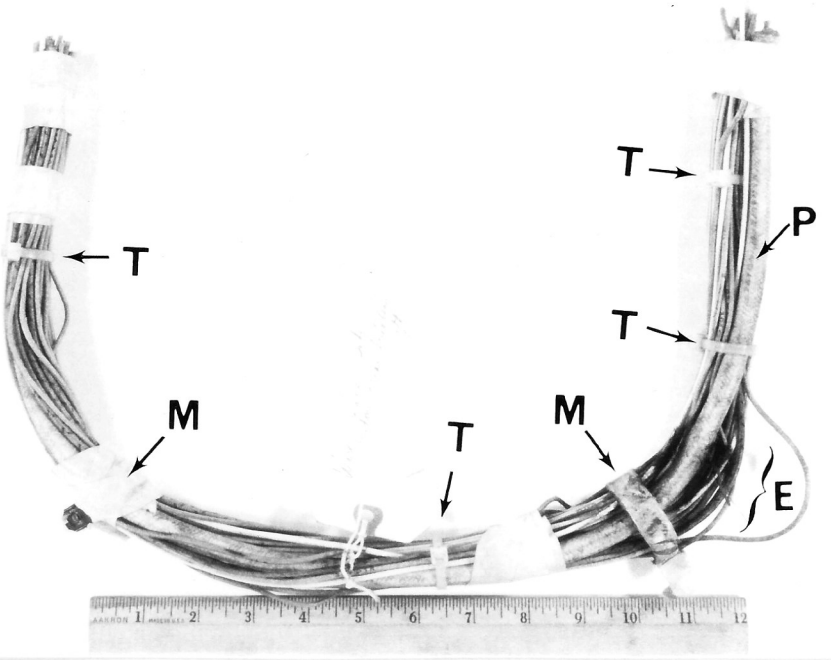


Figure 5. An overall view of the electrical wiring bundle, with wire ties at arrows "T", clamps at arrows "M" and power cable at arrow "P". Bracket "E" denotes area of exposed power cable conductor and protruding wires.

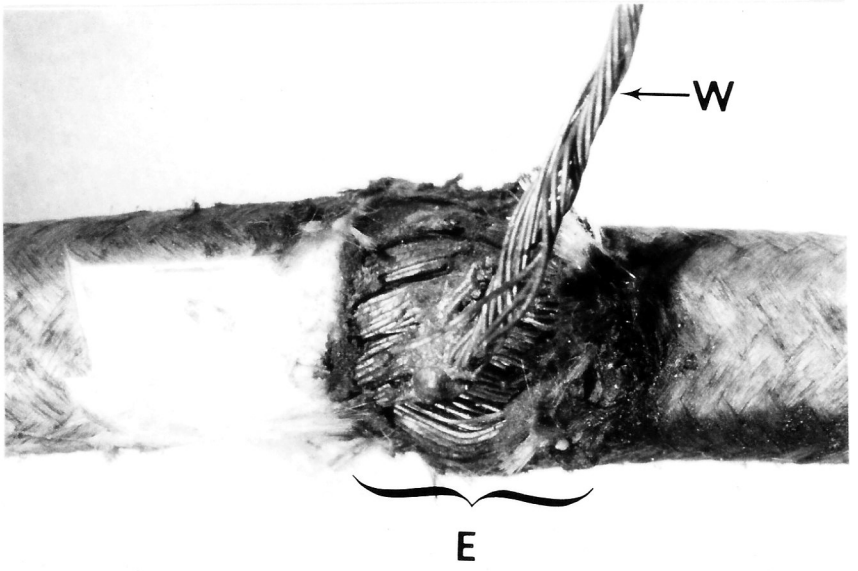


Figure 6. A 3X view of the exposed area, bracket "E" on the power cable and the fused-on protruding wires, arrows "W". Fiberglass sheath to left was cut away during examination.