

NATIONAL TRANSPORTATION SAFETY BOARD

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



December 19, 2018

MATERIALS LABORATORY FACTUAL REPORT

Report No. 18-100

A. ACCIDENT INFORMATION

Place : Murphy, Idaho
Date : November 3, 2017
Vehicle : Piper PA-18-150, N43632
NTSB No. : WPR18FA026
Investigator : Tealeye Cornejo, AS-WPR

B. COMPONENTS EXAMINED

Left and right wing aileron balance cables (inboard and outboard ends), left and right wing aileron control cables (inboard ends), left wing aileron control cable turnbuckle, and upper flap control cable pieces.

C. DETAILS OF THE EXAMINATION

An overall view of the submitted control cables is shown in figure 1. The left aileron control cable was found separated from the turnbuckle, and the separated end was photographed on-scene. However, the outboard end of the left aileron control cable was not included in the submitted components. The ends of the cable segments shown in figure 1 had been cut to facilitate disassembly and shipping. Before taking the photograph shown in figure 1, the inboard end of the control cable was disassembled from the bolted connection and cleaned, and the lock wire on the left aileron balance cable turnbuckle was cut to facilitate documentation of part numbers.

As installed on the airplane, the aileron control cable assembly for each wing connects the control stick at the inboard end of the cable to a control horn on the upper side of the aileron at the outboard end of the cable. Balance cable assemblies connect control horns on the lower sides of the left and right wing ailerons to each other. A turnbuckle is located at the outboard end of each aileron control cable and balance cable. Each turnbuckle has an eye end fitting that is attached to a cable eye and a clevis fitting that is bolted to an aileron control horn. At the inboard ends of the cables, cable eyes were bolted to linkage plates between the left and right wing control cable and balance cable assemblies. The upper portion of the flap control cable system includes a location in the wing where eye ends of three cable segments are bolted to a plate, which was the segment of the flap control system submitted for examination.

A closer view of the left aileron control cable turnbuckle is shown in figure 2. The turnbuckle had been recovered intact as shown in figure 2 with the clevis end bolted to

the aileron control horn and with the control cable separated from the eye end fitting. The lock wire for the turnbuckle was intact. The thimble associated with the eye at the outboard end of the left aileron control cable remained within the eye.

Closer views of the end fittings for the left aileron control cable turnbuckle are shown in figures 3 and 4. The clevis end fitting shown in figure 3 was colored brownish to reddish orange consistent with general oxidation. One face of the clevis was stamped with a "B" inside a bell shape, and the opposite face was stamped "SL-260 16RS". The eye end fitting shown in figure 4 was light gray and appeared free of oxidation or pitting. The flat face of the eye was also stamped with a "B" inside a bell shape, and the same face was also stamped "NAS647". The opposite side of the eye was stamped "16LS".

Multiple parallel grooves consistent with sliding contact with the left aileron control cable were observed on the external surface of the thimble on the left aileron control cable turnbuckle as indicated in figure 4. The thimble had a reflective light gray appearance and was relatively free of deposits and oxidation compared to cable eyes at the outboard ends of the left and right wing balance cables (see figure 5). The interior surface of the left aileron control cable thimble at the outboard location was marked "LOOS & CO", which is partially visible in figure 4.

A close view of the inboard end of the left aileron control cable is shown as-received in figure 6. The eye was bolted to the linkage plates, and the components were covered in tan and brown deposits. The sleeve had an irregular crimp pattern as shown in figure 5. Brackets in figure 5 indicate 4 approximately parallel faces at either side of the crimp split line. By comparison, the sleeve for the balance cable at the outboard location had 3 relatively evenly spaced and uniform crimp locations as indicated with unlabeled brackets in figure 5. Partially obscured stamped letters consistent with "NICOPRESS" were observed on the crimped face of the left aileron balance cable outboard end sleeve.

The eye at the inboard end of the left aileron control cable was unbolted from the linkage, and the end was cleaned with a solution of Alconox detergent and water using a soft-bristle brush. No markings were observed on the interior surface of the thimble.

According to Instruction 32 from the National Telephone Supply Company,¹ Nicopress sleeves for 1/8-inch diameter cable require 1, 2, or 3 crimps, depending on the combination of sleeve part number and crimping tool. Properly crimped sleeves should fit within a go/no go gauge. However, Instruction 32 recommends that proof testing should be completed whenever the possibility of personal injury or property damage exists. According to Instruction 32, all Nicopress sleeves with 3 crimps installed on 1/8-inch diameter cable should fit within the Oval M slot in a Nicopress go/no go gauge. Each of the crimp locations associated with the sleeve on the inboard end of the left aileron control cable was able to slide into the Oval M slot in a Nicopress go/no go gauge.

¹ Instruction 32 – *Splicing Flexible Steel Cables with Nicopress Sleeves and Tools*, The National Telephone Company, Cleveland, Ohio (05.12).

The inboard end of the right aileron control cable also had an irregular crimp pattern with at least 3 crimp locations. A view of the sleeve as it was tested with the Nicopress go/no go gauge is shown in figure 7. The outboard and middle crimp locations fit within the Oval M slot, but the crimp location at the inboard end of the sleeve did not fit in the slot.

Regular crimp patterns with 3 crimps similar to the end shown in figure 5 were observed on each end of the left and right wing balance cables and on the flap cable ends. The sleeves with a regular crimp pattern fit in the Oval M slot of the Nicopress go/no go gauge.

According to the Piper Parts Catalog² for the Piper PA-18-150, the turnbuckle assemblies used in the aileron control and balance cable assemblies are listed as part number 42722-02. The engineering drawing for part number 42722-02 was provided by a representative of Piper Aircraft, Inc. The eye end fitting for the part number 42722-02 turnbuckle assembly is specified as a NAS647-16LS eye fitting, and the clevis end is specified as an Associated Aircraft Ind. part number SL260-16RS end fitting per Federal Aviation Administration Technical Standard Order (TSO) TSO-C21. A note in the engineering drawing for the turnbuckle that was added in 1957 and revised in 1958 and 1967 indicated the eye and clevis end fittings for the part number 42722-02 shall be made of corrosion-resistant steel in accordance with a referenced military specification. The referenced military specification allows use of either AISI type 302 or type 316 stainless steel.

The drawing for the eye end fitting is provided in National Aerospace Standard (NAS) 647.³ The specified material listed in NAS 647 is cadmium-plated steel. No provision for a corrosion-resistant steel option is listed in the NAS 647 standard. A note in NAS 647 states the standard became inactive for design after October 15, 1964 and instructs the reader to “see drawing MS21255”.

Military Standard (MS) MS21255 was first approved on November 1, 1961, and version U, amendment 3 of MS21255⁴ is currently active. The active version of MS21255 has a drawing of the eye end fitting and specifies the material as either 17-4PH stainless steel or cadmium-plated carbon or alloy steel in accordance with Military Specification MIL-DTL-8878.⁵ Parts made of 17-4PH stainless steel have a “C” after “MS21255” in the part number while parts made of carbon or alloy steel have a dash after “MS21255”. In discussing replacement parts, active version MS21255 states in part “...alloy and carbon steel MS21255 parts cannot replace comparable 17-4PH stainless parts...”.

² Piper Parts Catalog, Piper Aircraft Corporation, Vero Beach, Florida (June 27, 1988).

³ NAS 647, *Eye, Turnbuckle (for Cable) Clip Locking*, Aerospace Industries Association of America, Inc., Washington, DC (1964).

⁴ MS21255U (Amendment 3), *Detail Specification Sheet: Eye End, Turnbuckle, Clip Locking (for Wire Rope)*, (February 9, 2011).

⁵ MIL-DTL-8878K, *Detail Specification: Turnbuckles, Positive Safetying, General Specification for*, (November 8, 2006).

The 17-4PH stainless steel material option for the MS21255 eye end fitting was included in version L of MS21255 dated August 15, 1997. No stainless steel option was included in version K of MS21255 dated November 3, 1982, where the material was specified as cadmium-plated carbon or alloy steel. MS21255 version K further states MS21255 items are interchangeable with the NAS 647 items of like thread size and material.

The markings on the end fittings of the turnbuckles for the left and right balance cable assemblies were examined. All four end fittings were stamped with a "B" inside a bell shape. The eye fittings were each stamped "MS21255 3LS" on the face opposite the bell-shaped mark. The clevis end fitting on the left balance cable was stamped "SL-260 16RS" on the face opposite the bell-shaped mark. The clevis end fitting on the right balance cable was also stamped "SL-260" on the face opposite the bell stamp, but "16RS" was stamped on the same face as the bell-shaped marking.

The composition of each of the end fittings on turnbuckles from the left and right aileron balance cable assemblies and left aileron control cable assembly was analyzed using a Thermo Scientific Niton XL3t-980 x-ray fluorescence (XRF) alloy analyzer. The composition of all three clevis end fittings had compositions where mostly cadmium and iron were detected consistent with cadmium-plated carbon or alloy steel. The composition of the eye end fittings on the turnbuckles from the two aileron balance cable assemblies also had compositions consistent with cadmium-plated carbon or alloy steel. The composition of the eye end fitting from the left aileron control cable assembly turnbuckle had 17.7 weight percent chromium, 9.89 weight percent nickel, and 0.154 weight percent selenium, consistent with AISI type 303Se stainless steel. The amount of sulfur and phosphorus were below the limits of detection (<0.344 weight percent sulfur and <0.481 weight percent phosphorus). The composition of AISI type 302 is similar to that of AISI type 303Se, but with lower maximum levels of sulfur and phosphorus. AISI type 302 does not include selenium in the composition requirements, but AISI type 303Se requires at least 0.15 weight percent selenium.

In discussion with a representative from Bell-Memphis, Inc., custom-ordered end fittings made with customer-specified material have been manufactured using dimensional requirements outlined in NAS or MS specifications. However, the representative also stated that according to procedures in place at Bell-Memphis at least since 1999, end fittings made with customer-specified materials are not stamped with the Bell-Memphis logo and standard part number.

Matthew R. Fox, Ph.D.
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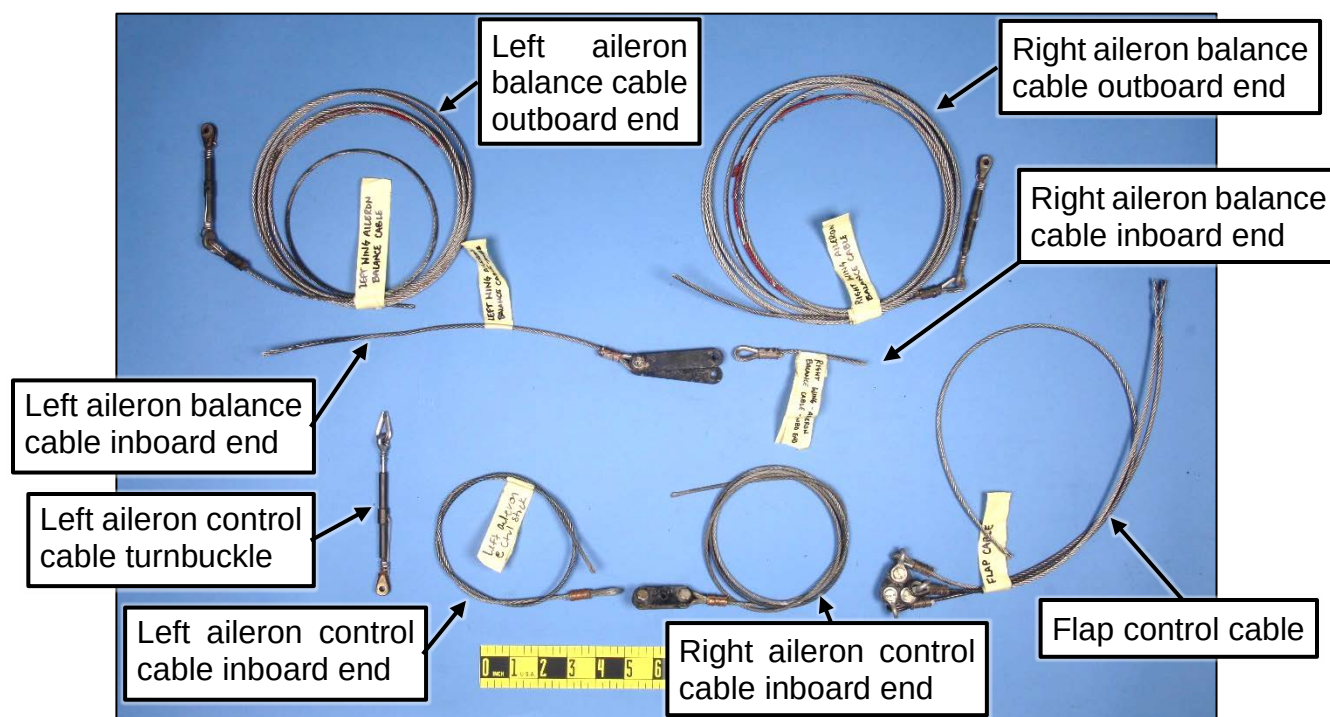


Figure 1. Overall view of the submitted control cable assemblies.

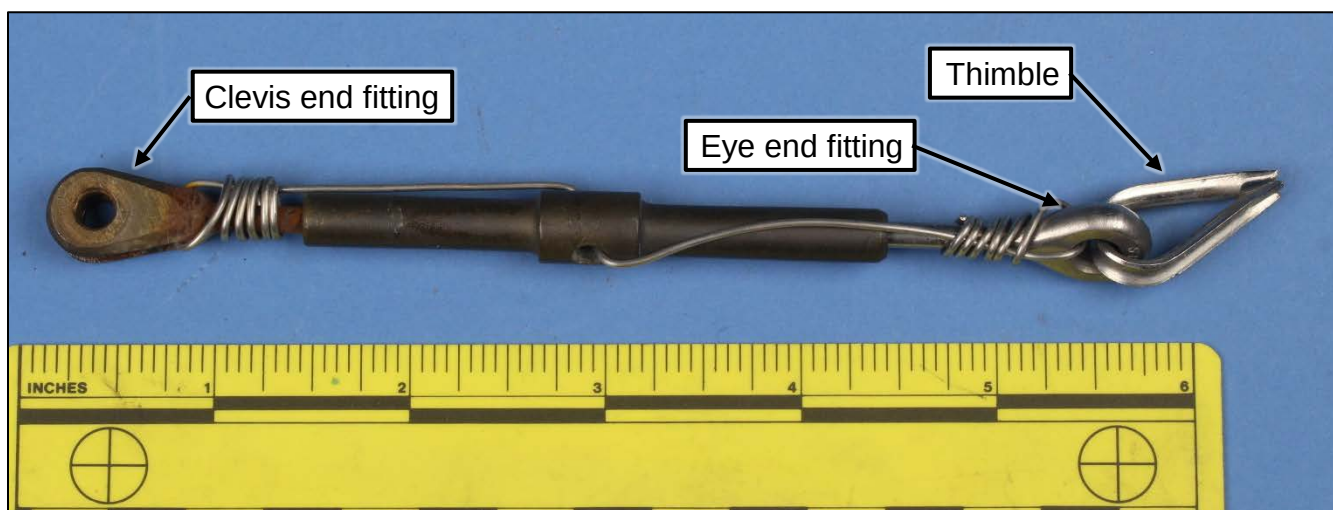


Figure 2. Closer view of the left aileron control cable turnbuckle. The control cable was separated from the eye end of the turnbuckle, but the thimble remained.



Figure 3. Closer view of the clevis end fitting on the left aileron control cable turnbuckle.

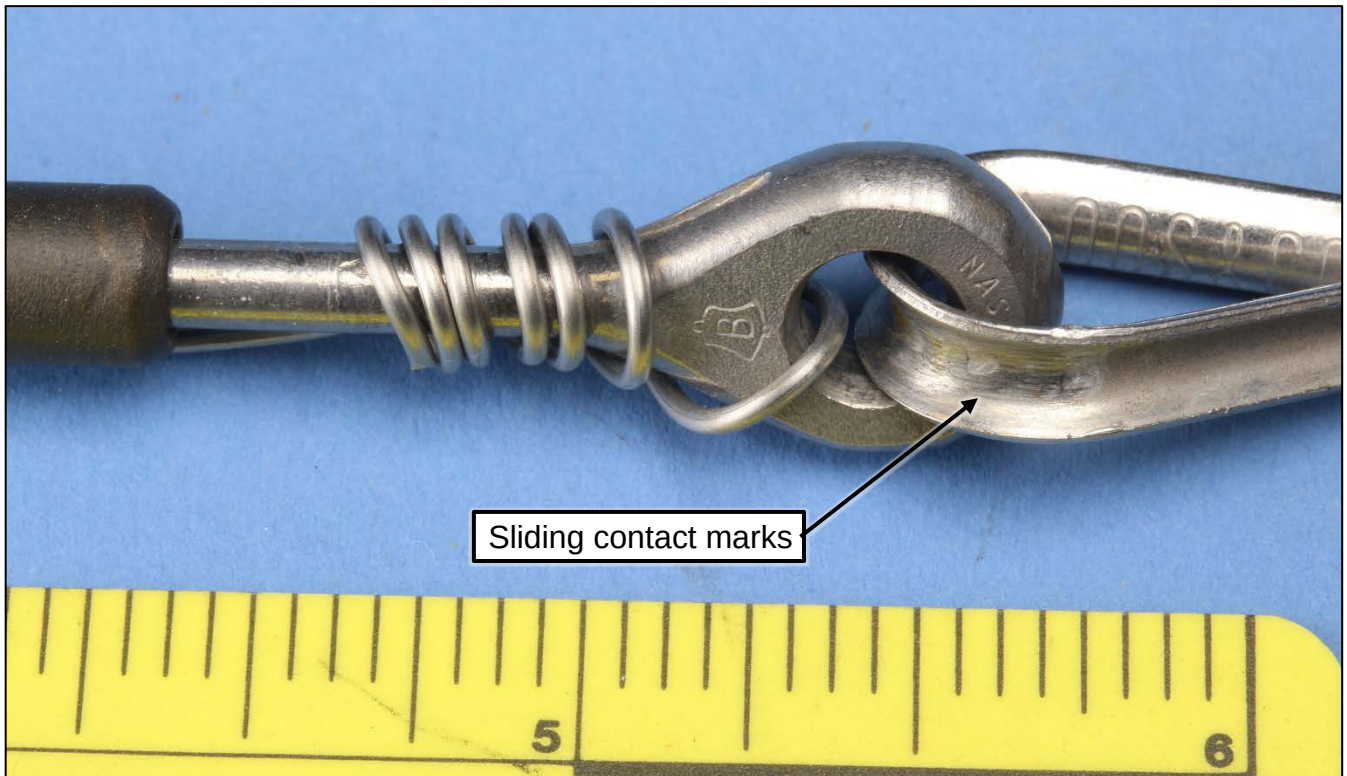


Figure 4. Closer view of the eye end fitting and thimble on the left aileron control cable turnbuckle.



Figure 5. Close view of the cable eye at the outboard end of the left aileron balance cable. Brackets indicated crimp locations.



Figure 6. Close view of the sleeve at the inboard end of the left aileron control cable. Brackets indicate likely crimp locations.

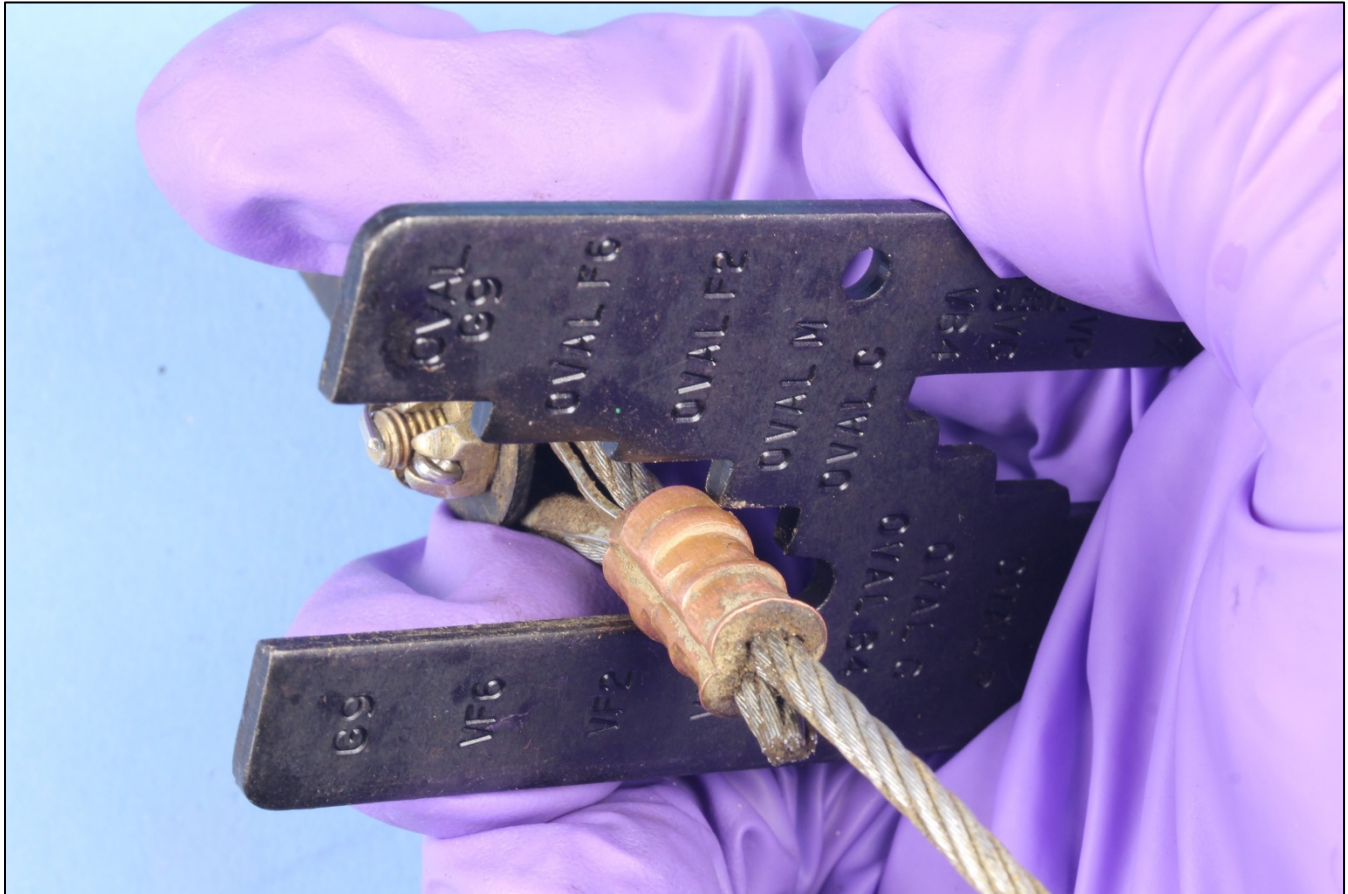


Figure 7. Sleeve at the inboard end of the right aileron control cable with a Nicopress go/no go gauge applied against the inboard crimp.