

NATIONAL TRANSPORTATION SAFETY BOARD

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



December 13, 2013

MATERIALS LABORATORY FACTUAL REPORT

Report No. 13-080

A. ACCIDENT INFORMATION

Place : Henderson, Nevada
Date : July 28, 2012
Vehicle : Piaggio P180, N146SL
NTSB No. : WPR12FA332
Investigator : Van McKenny, ASI-WPR

B. COMPONENTS EXAMINED

Accident parts:

- 1) Left elevator bellcrank with attached fractured torque tube;
- 2) MS27643-6 double row ball bearing;
- 3) MS16625-1143 retaining ring from left elevator;
- 4) 2 sets of right elevator attachment hardware consisting of the following:
 - a. NAS6404A10 cadmium-plated iron-nickel-chromium alloy (A286) ¼-28 bolt;
 - b. MS21043-4 silver-plated nut;
 - c. NAS1149D0463K gray-anodized washer;
 - d. NP320006-2C-4.5 bushing.

Exemplar parts:

- 1) 2 NAS6404A10 cadmium-plated iron-nickel-chromium alloy (A286) ¼-28 bolts;
- 2) 2 NAS6304U21 titanium ¼-28 bolts;
- 3) 4 MS21043-4 silver-plated self-locking nuts;
- 4) 2 NAS1149D0463K gray-anodized 2024 T3 aluminum washers.

C. DETAILS OF THE EXAMINATION

On July 28, 2012, at 0945 Pacific daylight time, a Piaggio P180, N146SL, arrived at Henderson Executive Airport, Henderson, Nevada, missing its left elevator. The accident parts listed above were sent to the NTSB Materials Laboratory for examination along with exemplar attachment hardware, also listed above. The accident parts are shown in figure 1, a schematic of the left elevator is shown in figure 2, and the exemplar hardware is shown in figure 3. For illustration purposes, in figure 1 the right elevator attachment hardware has been oriented in a similar manner as the left elevator counterparts (which were not recovered).

The elevator is controlled by a push/pull rod (not shown) that attaches to the end of the bellcrank. The displacement of the control rod causes rotation of the elevator

about the inboard bearing and about the two outboard attachment fittings. On the outboard attachment fittings, the elevator rotates about bushings that are held in place by ¼-28 bolts, washers, and self-locking nuts.

1. Accident Hardware Examination

The left elevator torque tube remained bolted to the left elevator attachment fitting just outboard of the bellcrank. The attachment fitting was observed to be fractured through a flange where it transitioned out of a cylindrical section. As shown in figure 4, the top part of the flange was bent in the outboard direction and the lower part of the flange was bent in the inboard direction. Using a stereomicroscope, the fracture surfaces were examined and were found to have a smeared appearance. The deformation and fracture features were consistent with an overstress failure caused by downward bending of the left elevator about the attachment fitting.

The running torque of the right attachment fitting self-locking nuts was measured using a calibrated torque wrench with 0.1 in-lbs precision.¹ A stack of washers was placed over each right attachment fitting bolt shank such that three bolt threads were exposed when the nut was turned onto the bolt and tightened to a wrenching torque of 115 in-lbs in accordance with the P180 maintenance manual (Piaggio, 1991) and MS21043 (NASC, 2003). The wrenching torque was measured using a calibrated torque wrench with 1 in-lbs precision. The running torque was measured while turning the nut onto the bolt (on-running torque) and while turning the nut off of the bolt (off-running torque). For the first bolt/nut combination, the on- and off-running torque was 1.2 in-lbs and 1.5 in-lbs, respectively. For the second bolt/nut combination, the on- and off-running torque was 8.5 in-lbs and 9.0 in-lbs, respectively. According to the P180 maintenance manual, self-locking nuts should be discarded when the running torque (called breakaway torque in the manual) falls below 3.5 in-lbs for ¼-28 nuts.

2. Exemplar Hardware Examination

The change in running torque and breakaway torque with sequential torque cycles was measured using exemplar hardware.² Two titanium bolts and two A286 bolts were used in conjunction with silver-plated self-locking nuts and gray-anodized aluminum washers. The A286 bolts, nuts, and washers were the same material types as the accident attachment hardware. The results for the A286 bolts are shown in tables 1 and 2. The results for the titanium bolts are shown in tables 3 and 4.

¹ In this report, the running torque is defined as the torque required to turn the self-locking nut once the locking mechanism has engaged the bolt threads but before any load is transferred to the bolt.

² In this report, the breakaway torque is defined as the torque required to turn the self-locking nut after it has been torqued to a wrenching torque of 115 in-lbs.

D. REFERENCES

NASC. (2003). *NASM21043 Rev. 2, Military Specification Sheet: Nut, Self-Locking, 800F, Reduced Hexagon, Reduced Height, Ring Base, Corrosion Resistant Steel*, National Aerospace Standards Committee, Washington, DC.

Piaggio. (1991). *I.A.M. Rinaldo Piaggio P-180 Avanti Maintenance Manual*, Piaggio Aero Industries, Genova, Italy.

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Table 1: Torque data for the first exemplar A286 bolt and silver-plated self-locking nut combination. The nut was torqued to a wrenching torque of 115 in-lbs.

Turn Number	On-running torque, in-lbs	Breakaway torque, in-lbs	Off-running torque, in-lbs
1	6.5	90	8.6
2	7.0	80	8.0
3	6.8	84	7.0
4	7.8	86	6.8
5	6.1	87	7.5

Table 2: Torque data for the second exemplar A286 bolt and silver-plated self-locking nut combination. The nut was torqued to a wrenching torque of 115 in-lbs.

Turn Number	On-running torque, in-lbs	Breakaway torque, in-lbs	Off-running torque, in-lbs
1	6.0	90	5.8
2	5.0	86	5.5
3	5.0	85	5.5
4	5.5	88	5.5
5	5.2	90	4.9
6	5.0	90	5.0
7	4.3	91	4.8
8	5.0	89	4.8
9	4.5	92	4.5
10	4.5	92	5.0

Table 3: Torque data for the first exemplar titanium bolt and silver-plated self-locking nut combination. The nut was torqued to a wrenching torque of 115 in-lbs.

Turn Number	On-running torque, in-lbs	Breakaway torque, in-lbs	Off-running torque, in-lbs
1	16.0	—	23.0
2	12.0	82	13.0
3	11.6	84	12.5
4	12.5	86	12.5
5	9.5	95	12.5

Table 4: Torque data for the second exemplar titanium bolt and silver-plated self-locking nut combination. The nut was torqued to a wrenching torque of 115 in-lbs.

Turn Number	On-running torque, in-lbs	Breakaway torque, in-lbs	Off-running torque, in-lbs
1	12.5	85	12.0
2	13.8	88	11.0
3	13.0	89	15.0
4	14.5	95	15.2
5	14.5	93	14.5

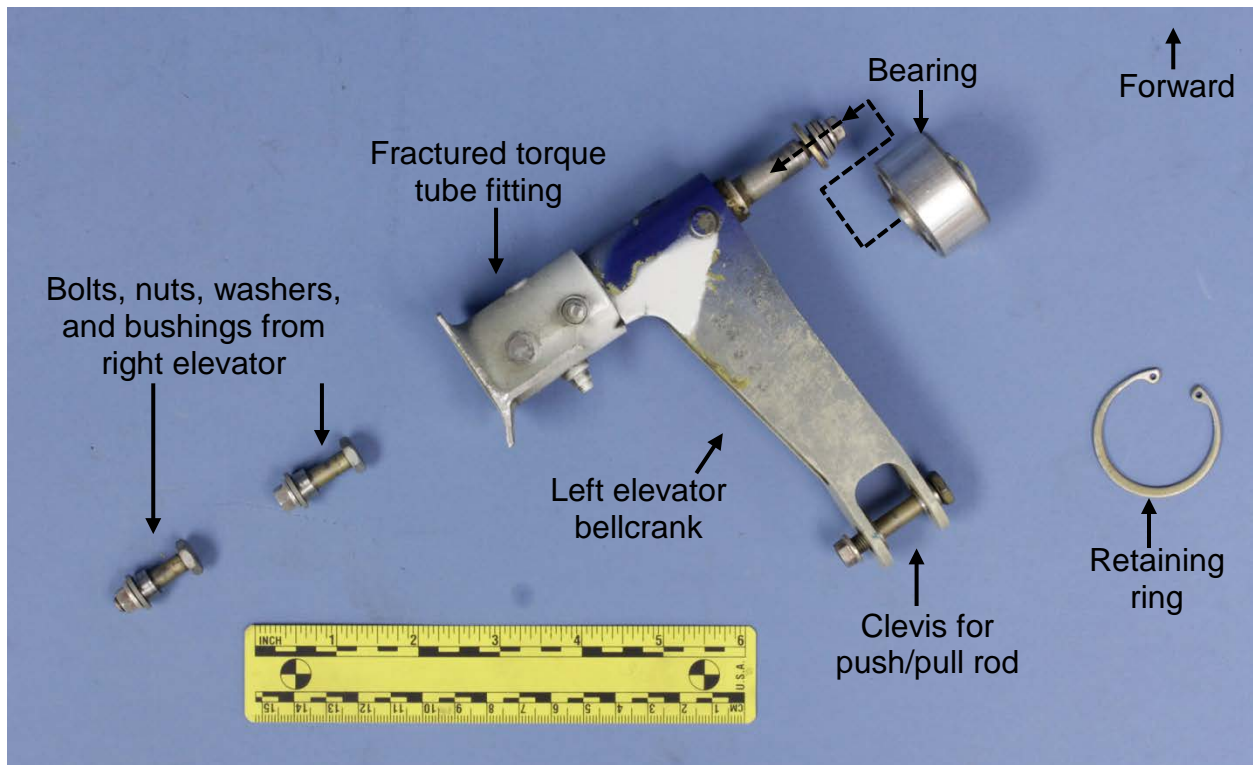
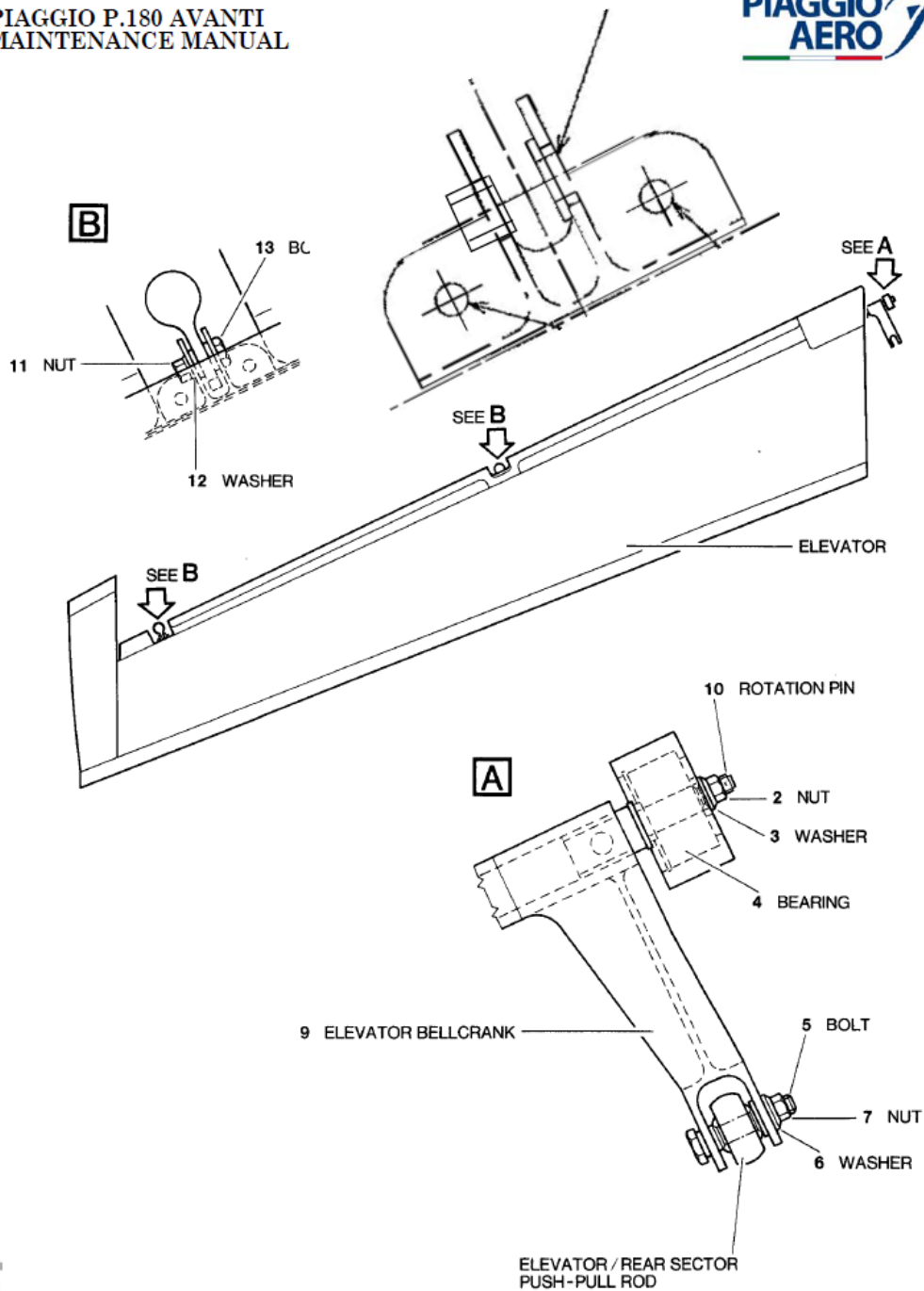


Figure 1: Image of the right and left elevator pieces as-received by the lab. The piece of the bellcrank, bearing, and retaining ring are from the left elevator. The bolts, nuts, washers, and bushings are from the right elevator. For illustration purposes, they have been oriented in a similar manner as their left elevator counterparts. Note: Hardware arrangement not to scale. See the illustration in figure 2.

PIAGGIO P.180 AVANTI
MAINTENANCE MANUAL



MM_273000-201_2

Fig. 201 - Elevator - Removal/Installation (Sheet 2 of 2)

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Figure 2: Illustration from the aircraft maintenance manual showing the arrangement of the elevator bellcrank and the two outboard attachment fittings.

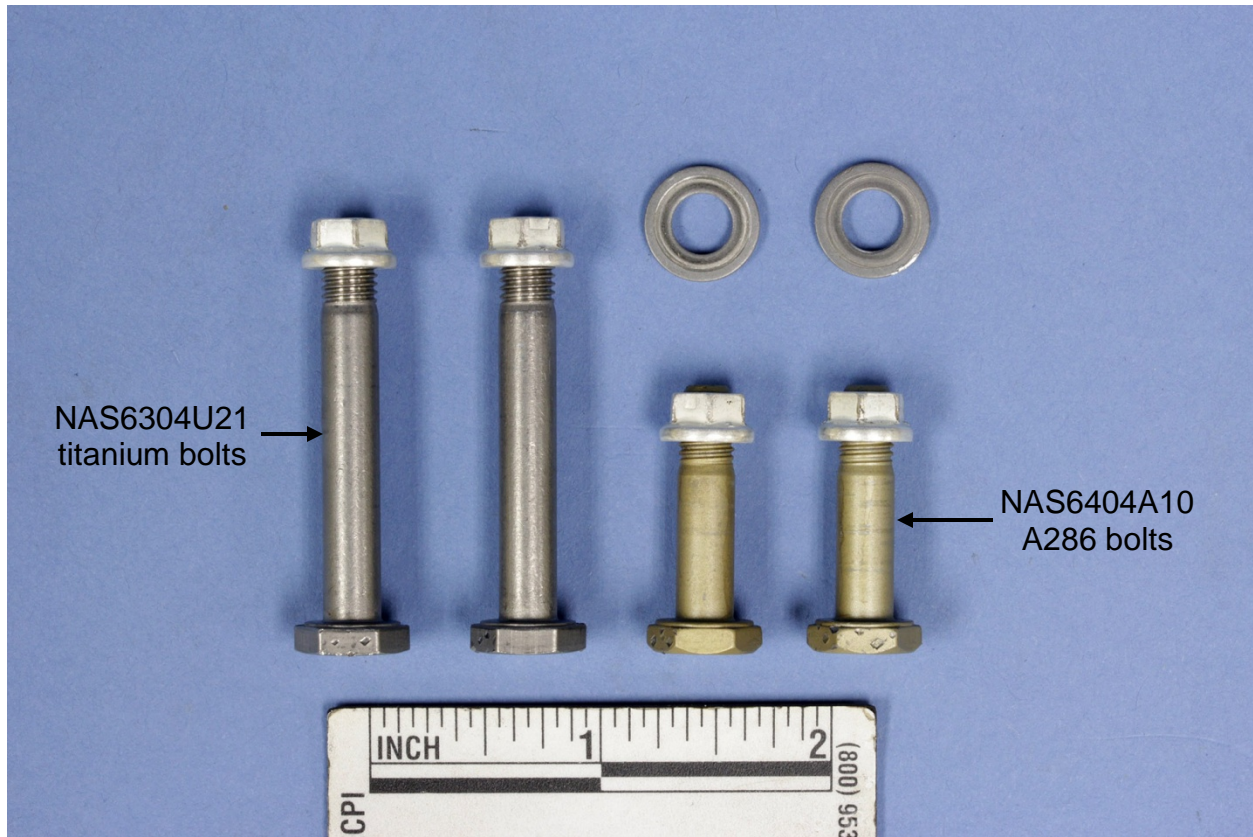


Figure 3: Exemplar hardware used for torque testing. The hardware included two titanium ¼-28 bolts (NAS6304U21), two A286 ¼-28 bolts (NAS6404A10), two gray-anodized 2024 T3 aluminum washers (NAS1149D0463K), and four silver-plated ¼-28 self-locking nuts (MS21043-4).

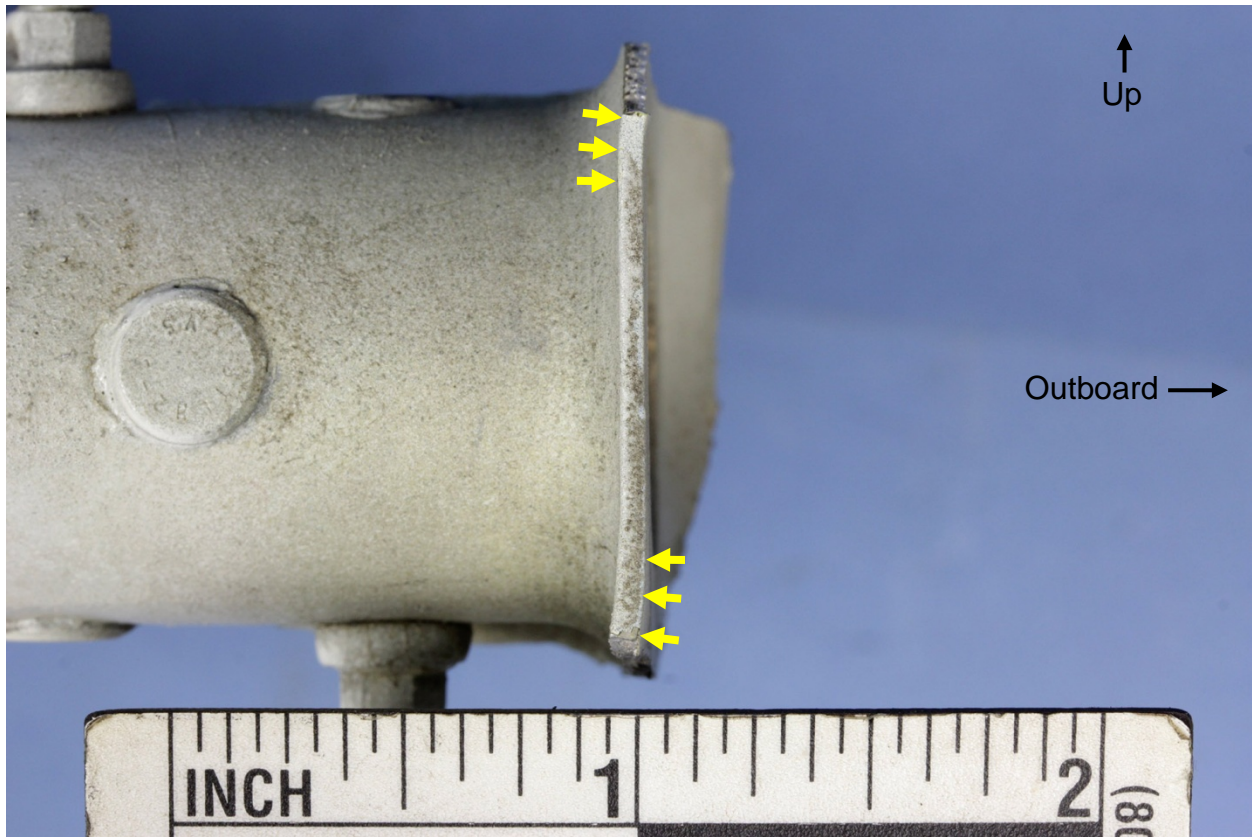


Figure 4: Image of the fractured left elevator torque tube fitting looking in the aft direction. Bending deformation of the fitting is indicated by yellow arrows in the image. The deformation of the fitting was consistent with downward bending of the elevator.