**NATIONAL TRANSPORTATION SAFETY BOARD**
Office of Aviation Safety
Washington, D.C. 20594

May 26, 2000

**Systems Group Chairman's Factual Report Addendum Regarding Teardown of Selected Longitudinal Control System Components**

DCA-00-MA-006

## A. ACCIDENT

| | |
|---|---|
| Operator: | EgyptAir |
| Location: | 60 Miles Southeast of Nantucket Island (N40.20, W69.45) |
| Date: | October 31, 1999 |
| Time: | 0148 EST |
| Airplane: | Boeing 767-366ER, SU-GAP |

## B. SYSTEMS GROUP

Chairman: Scott Warren
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Member: Hani S. Mahmoud
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Member: Rick Krantz
Boeing
Seattle, Washington

Member: Randy Fehlhaber
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Member: John (Wes) Kennedy
Boeing
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Member: William Richardson
Boeing
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Member: Michael Marx
Consultant for Egyptian Civil Aviation Authority
Springfield, Virginia

## C. SUMMARY

About 0150 eastern standard time (EST), on October 31, 1999, a Boeing 767-366ER, SU-GAP, operated by EgyptAir, as flight 990, crashed into the Atlantic Ocean about 60 miles south of Nantucket, MA. EgyptAir flight 990 was being operated under the provisions of Egyptian Civil Aviation Regulations Part 121 and United States Title 14 Code of Federal Regulations Part 129 as a scheduled, international flight from John F. Kennedy Airport (JFK), New York, New York to Cairo International Airport in Cairo, Egypt. The flight departed JFK about 0122 EST, with 4 flightcrew members, 10 flight attendants, and 203 passengers on board. There were no survivors. The airplane was destroyed by impact forces. Floating debris from the aircraft was recovered on the morning of October 31, 1999.

The systems group participated in the accident investigation by conducting tear down examinations of selected longitudinal control system components. The examinations took place on April 17-20, 2000, at the Boeing Engineering Quality Assessment Laboratory in Seattle, Washington.

## D. DETAILS OF THE INVESTIGATION

The Systems Group met on April 17-20, 2000, at the Engineering Quality Analysis (EQA) Laboratory at the Boeing facility in Seattle, Washington. The group performed external examinations and disassembled the recovered items of the longitudinal control system.

The items were numbered using an identification system that was designed to insure that each part had a unique identification number. The identification system was not designed to convey any information regarding the placement of the parts on the accident aircraft or on other recovered parts.

The results of the teardown activities were as follows:

**Elevator PCA #1**

See Appendix A, Figures 1, 2, and 3

Position of piston:
The position of the piston as received in the EQA laboratory was documented by measuring from the gland face to the runout of the chrome which equaled 3.65 inches. There was a pronounced mark and bend in piston at approximately 1.75 inches from the runout of the chrome. The mark is 1/8 inch wide.

Disassembly:
The actuator was removed from the reaction link and the forward gland was removed from the cylinder barrel to extract the piston. Lockwire was noted in place on all gland retaining nuts (gray seals). The piston was bent out-of-round on the forward, or non-rod end portion of the actuator. The piston had to be removed with force (hammered out).

Observations:
The identification plate was missing. The piston has a visible bend, and there was mud and debris around the piston and inside the bore. The debris appeared to be silt or mud. The manifold was not recovered with this PCA, so the ports in the actuator assembly were open.

**Elevator Power Control Actuator (PCA) #2**

See Appendix A, Figures 4 and 5

Position of piston:
The position of the piston as it was received in the EQA laboratory was documented by measuring the distance from the face of snubbing gland (IPC item 520) to the chrome runout area of the piston rod end which equaled 2.2 inches. After disassembly and cleaning, a more pronounced mark on the piston was noted 2.0 inches from the chrome runout area of the piston rod end.

Disassembly:
The actuator was removed from the reaction link and the forward gland was removed from the cylinder barrel in order to extract the piston. Lockwire was noted in place on all gland retaining nuts (the lockwire was sealed with gray seals). The piston was removed with little resistance. The piston was bent at the forward, or non-rod end portion of the actuator.

Observations:
The identification plate was missing. The piston has a visible bend, and there was mud and debris around the piston and inside the bore. The debris appeared to be silt or mud.

The manifold was not recovered with this PCA, so the ports in the actuator assembly were open.

**Elevator PCA #3**

See Appendix A, Figures 6-9

Part number: 282700-1007
Serial number: 638

Position of piston:
The position of the piston as received in the EQA laboratory was documented by measuring from the gland face to the runout of the chrome which equaled 0.28 inches. The forward, or non-rod end portion of the piston was not damaged.

Disassembly:
The actuator was removed from the reaction link, manifold assembly, and summing lever assembly. The forward gland was removed from the cylinder barrel to extract the piston. Lockwire was noted in place on all gland retaining nuts (green seals).

Observations:
Upon removal, the piston appeared straight.

**Manifold Housing for PCA #3**

See Appendix A, Figures 10 and 11

Observations:
The input arm moves freely.

Disassembly:
The input arm position on the spline was scribed for reference. The hi-lock was sheared off to remove the input arm. The input arm cover was removed. Oil samples were taken after the cover and spline arm were removed. The input crank and overtravel cam were removed.

The pin that attached the spring guide retaining cap to the slide had separated in two places at the point where the pin was adjacent to the retaining cap and the spring guide retaining cap was loose (i.e., not connected to the slide) with the spring having one coil over top of the retainer. All sections of the shear pin were retained in either the slide or the retainer. The slide and sleeve metering edges of the holes and lands were examined under an optical stereo microscope. The sleeve metering hole inside edges were examined from the outside. No significant marks were found on any of the edges.

**PCA #4**

See Appendix A, Figures 12, 13, and 14

Part number: 282700-1009
Serial number: 1778

The position of the piston was not measured due to an oversight during the teardown process. The dimension was taken during the initial sorting activities, and it is documented in the systems group factual report. The forward, or non-rod end portion of the piston was damaged. This unit was removed from the center position of the large piece of stabilizer. The manifold housing was still attached to the cylinder.

Disassembly:
The assembly was still pressurized, and the pressure was relieved by removing the manifold housing from the cylinder. The actuator was removed from the reaction link, manifold assembly, and summing lever assembly. The forward gland was removed from the cylinder barrel to extract the piston. Lockwire was noted in place on all gland retaining nuts (green seals).

Observations:
Upon removal, the piston appeared straight. There was no debris inside of the cylinder.

**Manifold Housing for PCA #4**

Observations:
This manifold housing was removed from PCA #4. The input arm moves freely. Both gray and green lockwire seals were noted.

Disassembly:
The input arm position on the spline was scribed for reference. The hi-lock was sheared off to remove the input arm. The input arm cover was removed. Oil samples were taken after the cover and spline arm were removed. The input crank and overtravel cam were removed.

The pin that attached the spring guide retaining cap to the slide was intact, and the spring guide retaining cap was in its proper position. The slide and sleeve metering edges of the holes and lands were examined under an optical stereo microscope. No significant marks were found on any of the edges. The sleeve metering hole inside edges were examined from the outside.

**Manifold Housing (MH) #1**

See Appendix A, Figures 15-19

Observations:
This manifold housing was recovered separately from any of the PCA's. Gray lockwire was noted on the unit. The shear pin and spring guide retaining cap were intact (the shear pin was not sheared) and in their proper positions.

Disassembly
The slide and sleeve assembly were difficult to remove. The manifold housing was milled in order to leverage the sleeve and slide out of the housing. The section of the housing adjacent to the servo-valve port was ground away to provide for access. The slide and sleeve contained significant debris and had some corrosion. The shear pin was removed from the guide to aid disassembly. The slide and sleeve metering edges of the holes and lands were examined under an optical stereo microscope. The sleeve metering hole inside edges were examined from the outside. No significant marks were found on any of the edges of the slide. The edges of two metering holes could not be examined due to excessive debris.

**MH #2**

See Appendix A, Figures 20, 21, and 22

This manifold housing was recovered separately from any of the PCA's. Upon removing the input crank gland, the inside collar was found to be have been deformed. During the process of removing the gland from the manifold housing for examination, a small piece broke away from the deformed area of the inside collar. A scrape mark was formed in the inside housing bore as a result of the removal process.

**MH #3**

See Appendix A, Figures 23-27

This piece of manifold housing was recovered separately from any of the PCA's. The input crank section of the MH3 housing was missing. There was a fracture surface on MH3 that matched a fracture surface on MH4. The input section of the slide and sleeve assembly was broken off. The shear pin was not sheared, and it was not removed during disassembly. The slide and sleeve assembly were heavily corroded. The slide and sleeve metering edges of the holes and lands were examined under an optical stereo microscope. The sleeve metering hole inside edges were examined from the outside. No significant marks were found on any of the edges of the slide.

**MH #4**

See Appendix A, Figures 26, 28, and 29

This piece of manifold housing was recovered separately from any of the PCA's. Only the input crank assembly portion of the housing was present. There was a fracture surface on MH3 that matched a fracture surface on MH4. The white teflon washer was missing beneath the input crank. A small (approximately 2 inch) segment of the slide was found with this piece. None of the slide lands were present on this piece.

**Bellcrank #1**

See Appendix A, Figures 30-35

As received in the EQA laboratory, the bellcrank arms rotated freely. Removed the bolt and separated the bell crank arms. The rivets were sheared in the direction of the bell crank arms moving to a higher relative angle.

**Bellcrank #2**

See Appendix A, Figures 36-41

As received in the EQA laboratory, the bellcrank was frozen at a relatively small angle of approximately 20 degrees. Removed the bolt and separated the bell crank arms. The rivets were sheared in the direction of the bell crank arms moving to a higher relative angle.

**Bellcrank #3**

See Appendix A, Figures 42-47

As received in the EQA laboratory, the bellcrank arms rotated freely. Removed the bolt and separated the bell crank arms. The rivets were sheared in the direction of the bell crank arms moving to a lower relative angle.

**Bellcrank #4**

See Appendix A, Figures 48-53

As received in the EQA laboratory, the bellcrank arms were frozen at an angle of approximately 120 degrees. Removed bolt and separated the bell crank arms. The rivets were sheared in the direction of the bell crank arms moving to a lower relative angle.

**Bellcrank #5**

See Appendix A, Figures 54-59

As received in the EQA laboratory, the bellcrank arms were frozen at an angle of approximately 120 degrees. Removed bolt and separated the bell crank arms. The rivets were sheared in the direction of the bell crank arms moving to a higher relative angle.

**Elevator Feel Computer #1**

See Appendix A, Figures 60, 61, and 62

The bolts holding the cover on the unit were all lockwired. When the lockwire was removed, the bolts were found to be very easy to loosen. The cover was removed, and photos were taken of the inside mechanisms.

**Elevator Feel Computer #2**

See Appendix A, Figures 60, 61, and 63

The bolts holding the cover on the unit were all lockwired. When the lockwire was removed, the bolts were found to be very easy to loosen. The cover was removed, and photos were taken of the inside mechanisms.

Scott Warren
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6/19/00