

NATIONAL TRANSPORTATION SAFETY BOARD
Office of Aviation Safety
Washington, DC

August 21, 2002

**ADDENDUM No. 3 TO SYSTEMS GROUP CHAIRMAN'S
FACTUAL REPORT OF INVESTIGATION**

Alaska Airlines "Zero-Endplay" Jackscrews

- A. **ACCIDENT:** NTSB Case No. DCA00MA023
- LOCATION: Near Anacapa Island (Pacific Ocean), California
- DATE: January 31, 2000
- TIME: 1621 Pacific Standard Time (PST)
- AIRCRAFT: McDonnell Douglas MD-83; N963AS

B. **GROUP MEMBERS**

Jeffrey B. Guzzetti Chairman
National Transportation Safety Board
Washington, D.C.

C. **SUMMARY**

On January 31, 2000, about 1621 Pacific Standard Time, N963AS, a McDonnell Douglas MD-83, operating as Alaska Airlines flight 261, crashed into the Pacific Ocean about 3 miles from Anacapa Island, California. All 83 passengers and 5 crewmembers were fatally injured. The flight, from Puerto Vallarta, Mexico, to Seattle, Washington, with an intermediate stop in San Francisco, California, was operating under Title 14 Code of Federal Regulations Part 121.

This addendum provides information related to two jackscrews that were recently removed from two Alaska Airlines MD-80 airplanes, reportedly due to a "zero endplay" reading during routine on-wing jackscrew endplay checks. The first jackscrew removal, from airplane N982AS, occurred in late March 2002, and was investigated by the NTSB. The second jackscrew removal, from airplane N943AS, occurred in late April 2002, and was investigated by the FAA with NTSB observation.

D. DETAILS OF THE INVESTIGATION

1.0 N982AS Jackscrew

1.1 Background

According to Alaska Airlines, airplane N982AS underwent a scheduled jackscrew endplay inspection in Oakland, California, as per AD 2000-15-15. During the inspection, the mechanics reportedly received a “zero endplay” during all iterations¹ of the check, which is below the minimum specified endplay of 0.003-inch. (Note: According to FAA inspectors, the endplay was actually reported to be about 0.001-inch). A decision was made to immediately remove the jackscrew.

The jackscrew was installed new onto N982AS on February 12, 2000, and had accumulated about 7,300 flight hours since that time. According to Alaska Airlines records, the following on-wing endplays were recorded for the jackscrew since its installation onto N982AS:

Feb. 2000	0.008-inch
June 2000	0.009-inch
August 2001	0.010-inch
January 2001	0.0055-inch
August 2001	0.012-inch

1.2 Testing and Disassembly at Integrated Aerospace

The jackscrew assembly was examined and disassembled at Integrated Aerospace (IA) on April 3, 2002, under the supervision of the NTSB.² External, gross examination of the assembly did not reveal any obvious abnormalities. The acme nut was manipulated up and down on the acme screw and endplay was observed with tactile sensing. The assembly was then placed on a bench (oriented horizontally) and endplay was measured with a dial indicator. The endplay measurements varied from 0.009 to 0.010 inch.

The assembly was then placed in the IA acceptance test fixture and operated. A slight wobble of the acme nut was noted as the acme screw rotated about it. The wobble was more noticeable as the acme nut was near the top portion of the assembly, and the wobble decreased as it lowered. After about two passes up and down the acme screw, the wobble was no longer noticeable. No squealing or unusual noise was noted during this operation.

About one half of the acme screw (about its longitudinal axis) appeared to have less black oxide on it than the other half.

¹ According to FAA inspectors, it was reported that the check was repeated approximately 8 times and verified by two separate mechanics and inspectors.

² Participants included Jeff Guzzetti (NTSB Systems Group Chairman), Gerardo Hueto (Alaska Airlines); Andy Leiper (Alaska Airlines), and technicians at Integrated Aerospace.

External examination of the grease fitting, both before and after it was extracted, revealed that the fitting was filled with red grease.³

The following markings on the acme nut indicated the following: Production date of August 9, 1999; serial number T-3391; part number 5914169-507L; production endplay of 0.004-inch.

An attempt was then made to measure the slewing force on the jackscrew assembly. The assembly was mounted upside down in the acceptance test fixture and a spring gauge was attached to the end of the jackscrew. The jackscrew required a force of about 40 lbs. at the spring gauge to begin to move the jackscrew. The spring gauge was attached about 2 feet from the spherical bearing about which the acme screw slews; therefore, the torque required to slew the assembly was about 80 ft-lbs.

The jackscrew assembly was then disassembled. The torque tube nut was marked with a line indicated its in-situ position relative to the acme screw, and then the torque tube nut was backed off and brought back to the index mark with a calibrated torque wrench. The measured torque required to return the nut to its previous in-situ position was about 30 ft-lbs.⁴ The nut was then removed and the assembly was dismantled.

Examination of the bore of the acme nut revealed the presence of green grease near the grease fitting entrance, and red grease all along the bore in all other locations. No evidence of foreign object debris was noted.⁵

After the acme screw and nut were thoroughly cleaned, they were mated again and placed on a granite table (vertically) adjacent to a dial indicator rig. The measured endplay readings were 0.011-inch at the top, middle, and bottom of the acme screw.⁶ The side-to-side movement of the acme nut to the acme screw was about 0.002-inch.

The torque tube was then examined. A wear band was noted near the top of the tube. The diameter at this wear band was 2.0878-inch. (Note: According to IA, a steel sleeve repair is typically required if the diameter is less than 2.1200-inch, and the tube must be scrapped if there is less than 2.0615 inch diameter remaining after the wear band is filed away for concentricity in preparation for the steel sleeve.) The wear band was not concentric and was about 0.0245 inches deep at its deepest area.

The acme screw surface finish was then measured and the readings were found to be within specification along the entire length of the acme screw. The screw was then placed in an optical comparator, and the acme screw thread flanks and tips were measured to be within specification (0.085 inches at thread tip and 0.2488 inches at thread root).

³ The NTSB did not obtain or test samples of this grease.

⁴ The final torque value that Integrated Aerospace uses for newly manufactured jackscrews is 55 ft-lbs.

⁵ The NTSB did not obtain or test samples of this grease.

⁶ Based on this endplay, the calculated average wear rate for this jackscrew is 0.00096 in. per 1,000 hours.

The bore of the acme nut was then examined under magnification with the use of a bore scope camera. The examination did not reveal any significant evidence of gouging, galling, or thread deformation. Striation marks consistent with acme screw contact were noted in some of the valleys of the acme nut threads (i.e. the major diameter of the nut).

Castings of the opposite ends of the acme nut threads were taken for detailed measurements to check for any anomalies or unusual wear. The castings were examined and measured with an optical comparator at the NTSB's Materials Laboratory. No anomalies or unusual wear marks were evident.

No additional examinations, tests, or actions were sought by the Safety Board for the subject jackscrew. Alaska Airlines elected to have the jackscrew assembly overhauled.

1.3 Testing of Restraining Fixture

On May 14, 2002, the horizontal stabilizer restraining fixture tool (s/n 7698) used for the N982AS endplay was examined and tested.⁷ According to FAA representatives, the examination and testing did not reveal any obvious anomalies. The tool appeared to be similar to the Boeing restraining fixture design. The exposed threads of the tool appeared in operable condition, were well lubricated with a light machine oil, and were easily rotated by hand. The tool was put into the nominal configuration (i.e. typical "span" length of 9.625 inches) and evaluated on an Enstron test machine at a Boeing laboratory facility in Huntington Beach, California. The tool produced 2,800 to 3,100 pounds at 250 in-lb. applied torque, and 3,700 to 3,900 pounds at 300 in-lb. applied torque.⁸ According to the FAA, it is not known if the fixture was in the same condition as tested when the "zero" endplay checks were accomplished.

1.4 Maintenance Questionnaire Information

The Systems Group developed an anonymous 2-page questionnaire (attached) that was submitted to Alaska Airlines by the NTSB investigator-in-charge so that all maintenance personnel associated with the subject endplay could provide additional information regarding the "zero endplay." According to Alaska Airlines, the mechanics declined to complete the surveys.

⁷ The examinations of the restraining fixtures were conducted in Huntington Beach, California, by Systems Group representatives of the FAA, Alaska Airlines, and Boeing. The NTSB was not present.

⁸ According to Boeing information and previous Systems Group activities, these values are sufficient to provide enough force for the endplay.

2.0 N943AS Jackscrew

2.1 Background

According to Alaska Airlines, airplane N943AS underwent a scheduled C-check in April 2002 at a contract maintenance facility, known as Goodrich Aviation Technical Services (GATS), in Everett, Washington. According to Alaska Airlines, GATS mechanics were utilizing Alaska Airlines maintenance task cards during the C-check, and one of these cards specified that a jackscrew endplay was to be performed. (Note: According to Alaska Airlines, this card should have been deleted from the C-check package because AD 2000-15-15 superseded the task). During the jackscrew inspection, the mechanics reportedly received a “zero endplay” during all iterations⁹ of the check, which is below the minimum specified endplay of 0.003-inch. (Note: According to FAA inspectors, the endplay was actually reported to be about 0.001-inch). A decision was made to immediately remove the jackscrew.

The jackscrew was installed new onto N943AS on May 6, 2000, and had accumulated about 5,761 flight hours since that time. According to Alaska Airlines records, the following on-wing endplays were recorded for the jackscrew since its installation onto N943AS:

August 2000	0.010-inch
January 2001	0.011-inch
July 2001	0.011-inch
March 2002	0.013-inch

2.2 Testing and Disassembly at Integrated Aerospace

The jackscrew assembly was examined and disassembled at Integrated Aerospace on May 14-15, 2002, under the supervision of the FAA.¹⁰ The following information was noted on the jackscrew: serial number TA-3481 DCA-1467, manufacture date April 27, 2000, production endplay of 0.006-inch.

The jackscrew assembly was found to be covered with grease on the acme screw and outside of the acme nut and gimbal assembly. A bench endplay in the "as received" condition was measured at 0.012-inch by using Boeing prototype endplay check tools.¹¹

⁹ According to FAA inspectors, the individuals interviewed at GATS reported to them that they repeated the check approximately 6 times before reporting it to their supervisors and ASA personnel. It was reported that the 0.001” readings were consistently repeated.

¹⁰ The following persons were present: Gerardo Hueto and Andy Leiper, ASA; Peter Kovacik and Chuck Heald, Boeing Long Beach; Richard Burger, Integrated Aerospace; Albert Lam and Mike O’Neil, FAA Los Angeles Aircraft Certification Office.

¹¹ These new tools included a jackscrew anti-rotation clamp, a dial indicator bracket installed on the upper part of the acme screw, and a large dial indicator.

The bench endplay of the cleaned jackscrew (without grease) was measured at 0.0125-inch.¹² This measurement was taken after the torque tube was removed.

No foreign object damage was noted inside the acme nut, except small thread burrs were seen at the acme nut thread crests. Signs of slight polish wear marks at the major diameter of the acme nut were noted as an indication of possible contact of the acme screw at the acme nut major diameter. The use of “Go/ No-Go” thread gauges in the acme nut indicated no anomalies of the nut thread.

Prior to tear down of the jackscrew assembly, the slewing force was examined. A lateral moment of 140 ft-lbs. was required to move the screw; a longitudinal moment of 124 ft-lbs. was required to move the screw.

The torque on the torque tube nut was evaluated by loosening and tightening the nut. This procedure indicated an as-received torque of 45 ft-lbs. A torque of 55 ft-lbs. was applied and resulted in the torque tube nut turning 5 to 10 degrees beyond the as-received position. Upon removing the torque tube from the jackscrew assembly, a wear band of 0.005-0.006-inch in depth around the circumference of the torque tube cup was noted.

Grease samples that were taken from various locations along the jackscrew thread, immediately above and below the acme nut, exhibited the appearance of a mixture of green grease and red grease. No evidence of hard or dried grease was found. cursory examination did not indicate the presence of particulate material in the recovered grease.

The jackscrew assembly was not tested for “wobble” before disassembly and cleaning.

After cleaning, a gray-white deposit was noted on the cadmium plating on the boss for the mechanical stop at the lower end of the acme nut.¹³ The deposit was found only on plated-plated surfaces, and no deposits were noted in the bore of the nut. With the concurrence of Alaska Airlines and the NTSB, the FAA transported the acme nut FAA’s National Resource Specialist for Metallurgy, located at the Los Angeles Aircraft Certification Office. Samples of the deposit were taken to a Navy laboratory for identification. The FAA then forwarded the acme nut, grease samples¹⁴, and Navy lab report to the NTSB.

2.3 Testing of Restraining Fixture

Examination and testing of the horizontal stabilizer restraining fixture tool (s/n 0100) used on the N943AS jackscrew during the “zero endplay” was performed at a Boeing laboratory at Huntington Beach. The tool appeared to be of the Boeing

¹² Based on this endplay, the calculated average wear rate for this jackscrew is 0.0011 in. per 1,000 hours.

¹³ Representatives at IA stated that they had not seen such a deposit before.

¹⁴ The grease samples did not undergo any testing by the NTSB or the FAA.

restraining fixture design. The exposed threads of the tool appeared in good condition, were well lubricated with a light machine oil, and could be easily rotated by hand. It was noted that the horizontal stabilizer mounting bracket on the fixture was attached to the left hand thread clevis which would require clockwise rotation (looking down on the installed fixture) to retract the clevis and pull the horizontal stabilizer down.¹⁵ “Normal” installation of the bracket is to the right-hand thread clevis requiring counter-clockwise rotation to retract the clevis. The tool was put into the “normal” configuration (i.e. proper orientation up/down and at a typical “span” length of 9.625 inches) and evaluated on an Enstron test machine. The fixture produced 3300-3700 pounds at 250 in-lb. applied torque and 4200-4500 pounds at 300 in-lb. applied torque.¹⁶ According to the FAA, it is not known if the fixture was in the same condition as tested when the “zero” endplay checks were accomplished.

3.0 Fleetwide Zero Endplay Data

At the request of the NTSB, Boeing provided information related to the number of zero endplays, and the number of endplays less than 0.004-inch, that have been reported as a result of AD 2000-15-15. According to Boeing, the information was obtained only from endplay readings that were submitted from airlines electronically, rather than hard copy; however, Boeing indicated that the majority of the airlines have been submitting the data in this form.¹⁷

According to the information provided, from December 2001 through May 2002, there were no reported zero endplays (other than the subject Alaska Airlines jackscrews), and six reported endplays less than 0.004-inches. The data also indicates that during the entire year of 2001, there were 26 reported endplay readings of less than 0.004-inch, including 5 that were reported as zero; during the entire year of 2000, there were 123 reported endplay readings of less than 0.004-inch, including 15 that were zero endplays.

4.0 FAA Inspection Results and Alaska Airlines Training/Notification for Jackscrew Concerns

On May 1, 2002, the FAA Alaska Airlines Certificate Management Office (CMO) was notified by the FAA’s Office of Accident Investigation (AAI-100) regarding the two “zero” endplay check readings on MD-80 jackscrews. The CMO responded by conducting interviews with the mechanics and inspectors who performed the checks that produced these readings. On May 1 and 2, 2002, CMO inspectors inspected the restraining fixtures, torque wrenches and dial indicators used to perform the checks at Alaska Airline’s Oakland, CA, maintenance facility (OAK) and at Goodrich Aviation Technical Services (GATS) in Everett, WA.

¹⁵ According to FAA inspectors who examined this tool prior to shipment for testing, the tool had the correct configuration.

¹⁶ According to Boeing information and previous Systems Group activities, these values are sufficient to provide enough force for the endplay.

¹⁷ Alaska Airlines has been submitting the data with hard copies.

According to the FAA CMO inspectors, all of the tools in both locations were found to be the correct tools and in calibration.

According to the FAA CMO inspectors, interviews with the mechanics and inspectors who performed the endplay checks at OAK and GATS revealed they understood the procedures for checking the jackscrew endplay. When asked by the FAA CMO inspectors what would happen if the restraining fixture was torqued in the wrong direction, the Alaska Airlines personnel at OAK knew it would produce a zero reading; the individuals at GATS stated that they were not sure. Jackscrew endplay checks were performed for the CMO inspectors at both locations. The individuals who performed the previous checks accomplished these checks. The observed checks were accomplished satisfactorily.

At both locations, endplay checks were performed in accordance with ASA task cards and MD-80 maintenance manual procedures in accordance with AD 2000-15-15.

According to the FAA CMO inspectors, four hours of training reviewing the task cards and maintenance manual procedures on the performance of jackscrew endplay checks were conducted by Alaska Airlines personnel at both locations prior to the low end play readings. The training included “hands-on” performance of the check by every trainee. All of the individuals involved in the low reading checks had received this training. According to the FAA CMO inspectors, a review of the training records of the individuals verified the training (7 persons received training at OAK and 12 persons received training at GATS).

According to the FAA CMO inspectors, only the group of trained mechanics and inspectors were performing endplay checks for Alaska Airlines.

According to the FAA CMO inspectors, Alaska Airlines reported that jackscrew endplay check results, along with any anomalies encountered during the checks, are forwarded through a report prepared by ASA’s Director of Technical Compliance. The report is sent to Boeing Technical Support Engineering in Long Beach, California, Alaska Airline’s Safety Department, and the Alaska Airlines Flight 261 Accident Coordinator. The Alaska Airlines Flight 261 Accident Coordinator is to subsequently forward the report information to the NTSB.

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