NATIONAL TRANSPORTATION SAFETY BOARD
Office of Aviation Safety
Washington, DC

February 28, 2002

ADDENDUM TO SYSTEMS GROUP CHAIRMAN'S FACTUAL REPORT OF INVESTIGATION

A. **ACCIDENT:** NTSB Case No. DCA00MA023

LOCATION: Near Port Hueneme, 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.
Albert Lam	Member Federal Aviation Administration Los Angeles Aircraft Certification Office
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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 near Port Hueneme, 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.

[1] Mr. Epperson participated in the Hawaiian Airlines trim system examination in Hawaii, the grease fitting examination of the wreckage in Oxnard, California, and torque tube examinations at Integrated Aerospace in Santa Ana, California.
[2] Mr. Cline participated in the overhaul shop visits and the Tulsa endplay tests.
[3] Mr. O'Neil participated in the Hawaiian Airlines trim system examination in Hawaii.
[4] Mr. Dilibrio participated in the jackscrew examinations conducted at Integrated Aerospace.
[5] Mr. Borodayko participated in the Hawaiian Airlines trim system examination in Hawaii.
[6] Mr. Ingham participated in the restraining fixture tool load cell tests in Huntington Beach, Oakland, Tulsa, and Hawaii.
[7] Mr. Bracken participated in the Georgia overhaul shop visit, in lieu of Mr. Acosta.

This addendum provides details related to all Systems Group activities and research[8] that were conducted since the December 13 – 16, 2000, Alaska Airlines flight 261 Public Hearing held in Washington, DC. These activities and research topics include the following:

- Research and tests related to electric load meter responses to trim system operation.
- Examination of grease fittings attached to the wreckage.
- Demonstrations of translucent acme nut lubrications.
- Tests and examinations of Boeing and Alaska Airlines horizontal stabilizer restraining fixture tools
- Tests involving the MD-80 jackscrew on-wing endplay procedure.
- Testing, research, and examinations related to "wobbling" jackscrews.
- Examinations of pertinent in-service jackscrews.
- Survey results addressing pre-accident jackscrew maintenance procedures conducted by U.S. airlines.
- Jackscrew wear rate data of Alaska Airlines' entire fleet of MD-80 airplanes.
- Jackscrew overhaul manual discrepancies.
- Factual observations from visits to four jackscrew overhaul shops.
- Additional research into the certification of the jackscrew and initial grease specification.
- Research into the design of horizontal stabilizer ballscrew actuators, including discrepancies noted on two McDonnell Douglas C-17 military transport airplanes.

D. DETAILS OF THE INVESTIGATION

1.0 Electric Load Meter Responses to Trim System Activation

The Group investigated the effects of stabilizer trim system operation on the cockpit load meter in an attempt to compare these effects with verbal observations recorded by the accident flightcrew via the cockpit voice recorder.

According to technical information provided by Boeing, each engine and the Auxiliary Power Unit (APU) provide an independent source of alternating current (AC) electrical power generation in the DC-9, MD-80, MD-90, and 717 airplanes. These are controlled and monitored by switches and gages located in the overhead switch panel. Load meters located on this panel indicate the current load on each of these systems; these meters are electromechanical devices that, via a current transformer, monitor and react to current load across the 'A' phase of each system. Each load meter is scaled as such to read percentage of rated generator output. For example, a reading of ".5" on the meter corresponds to an electrical current load on that generator (left, right or APU) equating to 50 percent of the generator's rated capacity.

[8] Some of the research was conducted by the Systems Group Chairman only.

The primary stabilizer trim system is powered by a three-phase AC motor that normally draws current from the left engine generator. All three phases of the primary motor are protected by individual 50-amp (rated) circuit breakers. Likewise, the alternate system is powered by a three-phase motor that draws current from the right engine generator; these phases are each protected by individual 5-amp (rated) circuit breakers.

According to Boeing, under normal operation, activation of the left half of the thumb switch on each control column completes the circuit to all three phases of the primary motor; the right half of the thumb switch supplies power to, and releases, the motor brake. As the primary motor is a major draw of electrical current, it is expected to cause a rapid rise in load across the left generator circuit during motor spin up. This will result in a significant movement in the left generator load meter. However, once the motor reaches full speed, the amount of current required to sustain the motor at this speed drops significantly. This will result in an indicated drop on the load meter. Thus, during normal operation, activation of the primary motor will cause the load meter indicator to suddenly rise, then drop back down. Activation of the primary motor, while its brake remains engaged, will result in a sudden rise of indicated load on the left generator that holds steady as the motor attempts to turn against the brake. The meter will not drop back down until power is removed (de-activation of the thumb switch, tripping of the circuit breaker, or activation of the motor's thermal protection switch) to the motor.

Boeing also stated that the same principles of activation apply to the alternate motor as well; however, this motor is much smaller and does not draw a large current input in order to spin up as does the primary motor. Thus, indicated load current during alternate motor activation (with or without alternate motor brake activation) will result in a very small change (if any) in the right generator indicator.

The Systems Group representative from the Air Line Pilots Association verified Boeing's information by conducting a demonstration in the cockpit of an Alaska Airlines MD-83, registration N969AS. The following observations were made by the representative during the demonstration:

- While taxiing on the ground, there is no load indication from the alternate trim, with or without the brakes engaged. The alternate trim moves (with the brake off), but there is no discernible load meter indication. When activating the alternate trim with the brake engaged, the trim does not move and there is no discernible load meter needle indication.

- Activation of primary trim generates a momentary spike to about 1.0 units on the left AC load meter. The load meter quickly returns to its original indication (near zero) while the primary trim continues to operate. If the primary trim brake is left on, activating the primary trim sends the load up to 1.0 units; the load remains steady at about 1.0 units until the trim is released.[9]

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[9] The primary trim was operated for less than 3 seconds during this demonstration as per the flight crew operating manual.

- In-flight[10] observations of the load meter during trim activation were identical to ground observations.

2.0 Documentation of Grease Fittings

2.1 Background.

The Group reconvened in Oxnard, California, on October 16, 2001, to extract and examine a sampling of grease fittings from the aircraft wreckage.[11] This activity is a follow-on examination from a cursory, external examination of stabilizer, elevator, and aileron components that occurred on March 12, 2000, and was previously documented.[12] In this recent re-examination, an attempt was made to examine all fittings on the elevator, horizontal stabilizer, and rudder. Other fittings from other flight controls that were easily accessible in the wreckage were also sampled for comparison purposes. An NTSB metallurgist was involved in this activity to provide expertise and standardization of observations. Diagrams of the components examined, including the specific locations of each grease fitting on the components, are attached.

2.2 Descriptor Definitions

2.2.1 Condition

The Group defined the following standards[13] for observations of the conditions of the grease:

- **Fresh** -- Oily sheen visible; Smooth consistency
- **Semi-Fresh** -- No oily sheen visible; Smooth consistency
- **Semi-Dry** -- No oily sheen is visible; Consistency is not completely smooth and some clumps are present
- **Dry** -- No oily sheen is visible; Consistency is mostly solid with clumps
- **No Grease** -- The fitting is void of grease

2.2.2. Color

The Group defined the following standards for observations of grease color:

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[10] According to the ALPA representative, the in-flight observations were conducted during climb above 10,000 feet as the airplane was accelerating. The trim system was operated in identical fashion with that on the ground, except that the brake was not activated.

[11] The Group noted that the grease fittings examined were attached to components that had already undergone an impact with the ocean, a salvage operation that included two fresh-water rinsings, storage in a building for 20 months (including two summer seasons), and a high-pressure washing in December 2000 to remove bird droppings from the wreckage.

[12] This document can be found as an attachment to the initial Systems Group Chairman's Factual Report. It is also found in Exhibit 9-G of the Alaska Airlines Public Hearing materials.

[13] These standards were not derived from any existing standard, rather they were generated by the Group on the day of this activity

The first color listed is the predominant color observed. The subsequent color listed describes any additional tints that were visible. For example, "Yellow-Red" indicates that the predominate color observed is yellow, along with a less predominate tint of red. In some cases, there was no tint, in which case only one color is listed. Colors that were observed were as follows: Red, Green, Yellow, Black, Brown, Grey, Blue, and Pink.

2.2.3 Fitting Type

Two types of grease fittings were extracted and examined:

- **Needle --** smaller, low profile fittings that are flush with, and pressed into, the associated component
- **Zerk** -- larger fittings that screw into the associated component

2.3 Specific Observations

2.3.1 Left Elevator / Horizontal Stabilizer

(Last lubrication occurred on September 24, 1999; Lubrication interval for this component was 245 days)

Sample No.	**Location/Comments**	**Type**	**Color**	**Freshness**
1	L/H Elevator Control Tab Input Arm	Needle	Yellow-Red	Semi-fresh
	(Another fitting on same part)	Needle	Yellow-Red	Semi-fresh
2	L/H Stabilizer Control Tab (Stab)	Needle	Red-Yellow	Semi-fresh
	(Another fitting on same part)	Needle	Red-Yellow	Semi-fresh
	(Another fitting on same part)	Needle	Red-Yellow	Semi-fresh
3	L/H Elevator Stop Hinge	Zerk	Yellow-Red	Semi-dry
4	L/H Elevator Control Tab Hinge (3rd from Inb'd)	Needle	Yellow	Dry
5	L/H Elevator Control Tab Hinge (4th from Inb'd)	Needle	Yellow-Red	Dry
6	L/H Elevator Control TabHinge (5th from Inb'd)	Needle	Yellow-Red	Dry
7	L/H Elevator Control Arm to Geared Tab	Needle	Black	Fresh
8	L.H Elevator Inb'd end of Antifloat Tab	Needle	Red	Semi-dry
9	L/H Elevator Hinge (2nd from inboard)	Needle	Red-Yellow	Semi-fresh
10	L/H Elevator Hinge (2nd from Inboard hinge in EPAS area)	Needle	Red	Semi-dry

11	L/H Elevator Outboard Hinge	Needle	Red-Yellow	Semi-dry
12[14]	L/H Elevator Hinge Outboard of EPAS	Needle	Black	Semi-fresh
	(Another fitting on same part)	Needle	Black	Semi-fresh
	(Another fitting on same part)	Needle	Black	Semi-fresh
	(Another fitting on same part)	Needle	Black	Semi-fresh

2.3.2 Right Elevator / Horizontal Stabilizer

(Last lubrication occurred on September 24, 1999; Lubrication interval for this component was 245 days)

101[15]	R/H Elevator Control Tab Pushrod Rod End Bearing (Protected by Fairing)	Needle	Red-Yellow	Fresh
	(Another fitting on same part)	Needle	Red-Yellow	Fresh
102	R/H Elevator Control Tab Pushrod "Fixed" Rod End Bearing (Protected by Fairing)	Needle	Red	Fresh
	(Another fitting on same part)	Needle	(Dark) Red	Semi-fresh
103	R/H Elevator Stop	Zerk	Red	Semi-fresh
104	R/H Elevator Control Tab Hinge (3rd from Inb'd.)	Needle	Red-Yellow	Dry
105	R/H Elevator Control Tab Hinge	Needle	Red-Yellow	Dry
106	R/H Elevator	Needle	Red-Yellow	Dry
107	R/H Elevator Gear Tab (Elevator side)	Needle	Red-Yellow	Semi-fresh
	(Elevator side)	Needle	Red-Yellow	Semi-fresh
	(Tab side)	Needle	Red-Yellow	Semi-fresh
	(Tab side)	Needle	Red	Semi-fresh
108	R/H Elevator Input Rod to Geared Tab (Elevator Side)	Needle	Red-Yellow	Dry
	(Elevator Side)	Needle	Yellow	Dry
	(Tab Side)	Needle	Black	Semi-fresh
	(Tab Side)	Needle	Black-Red	Semi-fresh
109	R/H Elevator Antifloat Tab – Inb'd	Needle	Black	Semi-dry
	(Another fitting on same part)	Needle	Red-Yellow	Semi-fresh
110	R/H Elevator Geared Tab Control Rod (Elevator side) (Protected by fairing)	Needle	Red-Yellow	Dry
	(Tab Side)	Needle	Black	Dry
	(Tab Side)	Needle	Black	Dry
111	R/H Elevator Inb'd Hinge (EPAS area)	Needle	Red	Semi-fresh
112	Horizontal Stabilizer Left Hinge	Zerk (partial)	Red	Fresh

[14] Grease found on this component was extracted with the intention of further analysis and identification, if needed, by the Grease Group.
[15] Grease found on this component, and component no. 102, was extracted with the intention of further analysis and identification, if needed, by the Grease Group.

113	Horizontal Stabilizer Right Hinge	Zerk (partial)	Red	Fresh

2.3.3 Rudder

(Last lubrication occurred in January 1999 during the last C6 check; Lubrication interval was every C-check, or 15 months.)

201	Rudder–LowerHinge	Needle	Yellow	Fresh
202	Rudder-Center Hinge	Needle	Red-Yellow	Fresh
203	Rudder-Top Hinge	Needle	Yellow	Dry
204	Rudder PCU (Piston side)	Zerk	Yellow	Fresh
205	Rudder PCU (Cylinder side)	Zerk	Yellow-Red	Fresh
206	Rudder PCU (limit cont.arm)	Zerk	Red-Yellow	Fresh
	(Another fitting on same part)	Zerk	Red-Yellow	Fresh
207	Rudder Trim Link	Zerk	Yellow-Red	Fresh
	(Another fitting on same part)	Zerk	Yellow-Red	Fresh
208	Rudder-Lower Bearing	Zerk	Yellow	Semi-fresh
209	Rudder Tab Control Arm (Stab side)	Needle	Red-Yellow	Semi-fresh
210	Rudder Tab Hinge	Needle	Black	Semi-dry

2.3.4 Right Aileron

(Last lubrication occurred on September 10, 1999, in Los Angeles; Lubrication interval was 245 days.)

301	R/H Aileron Hinge (Inboard)	Needle	Yellow-Red	Semi-fresh
302	R/H Aileron Hinge (2nd from inboard)	Needle	Yellow-Red	Fresh
303	R/H Aileron Control Tab Hinge (Inboard)	Needle	Yellow-White	Dry
304	R/H Aileron	Needle	Red-Yellow	Semi-dry

2.3.5 Left Aileron

(Last lubrication occurred on September 9, 1999, in Los Angeles; Lubrication interval was 245 days.)

401	L/H Aileron Inboard No. 1 Hinge	Needle	Yellow-Red	Fresh
402	L/H Aileron No. 2 Hinge	Needle	Red	Fresh
403	L/H Aileron Control Tab Hinge (Inboard)	Needle	Yellow-Red	Dry
	L/H Aileron Control Tab Hinge(Outboard)	Needle	Yellow	Semi-dry
404	L/H Aileron Bus Trim	Needle	Red-Yellow	No Grease
405	L/H Aileron Control Tab Input Rod	Needle	Red-Yellow	Fresh
	(Another fitting on same part)	Needle	Red-Yellow	Semi-fresh
406	L/H Aileron Outboard Hinge	Needle	Yellow	Dry
407	L/H Aileron Trim Tab Actuator	Zerk	Black-Red	Fresh
408	Trim Tab Hinge	Needle	Yellow	Semi-dry

2.3.6 Flaps (found separated from wing)

(Last lubrication occurred on September 9-10, 1999, in Los Angeles; Lubrication interval was 245 days.)

1001	Flap Actuator	Zerk	Yellow-Brown	Fresh
1002	Flap Actuator	Zerk	Green	Fresh
1003	Flap Actuator	Zerk	Red-Yellow	Fresh
1004	Flap Actuator Opposite 1001	Zerk	Yellow	Fresh
1005	Flap Actuator Rod End	Zerk	Black-Yellow	Semi-fresh

2.3.7 Spoiler Actuator (found separated from wing)

(Last lubrication occurred on September 9-10, 1999, in Los Angeles; Lubrication interval was 245 days.)

1006	Spoiler Actuator	Zerk	Green	Semi-fresh
1007	Spoiler Actuator (same)	Zerk	Green-grey	Fresh
1008	Spoiler Actuator (same)	Zerk	Yellow-brown	Semi-fresh
1009	Spoiler Actuator (same)	Zerk	Red	Fresh
1010	Spoiler Actuator (same)	Zerk	Red-Yellow	Semi-fresh

2.3.8 Main Landing Gear Wheel Doors

(Last lubrication occurred on January 15, 2000, in Seattle; Lubrication interval was 600 hours.)

1011	Main Landing Gear Wheel Door Actuator	Zerk	Blue-Green	Semi-fresh
1012	Main Landing Gear Wheel Door Actuator	Zerk	Grey-Green	Fresh
1013	Main Landing Gear Wheel Door Actuator	Zerk	Yellow-Brown	Semi-dry
1014	Main Landing Gear Wheel Door Actuator (opposite 1012/1013)	Zerk	Yellow-Brown	Semi-fresh
(1015)	None Assigned			
1016	Main Landing Gear Wheel Door Actuator	Zerk	Green	Fresh
	(Another fitting on same part)	Zerk	Green	Fresh
(1017)	None Assigned			

2.3.9 Slat Bull Wheel

(Last lubrication occurred on September 9-10, in Los Angeles; Lubrication interval was 245 days.)

1018	Slat Bull Wheel Assembly-Dog Bone Link	Zerk	Red-Yellow	Fresh
1019	Slat Bull Wheel Assembly-Dog Bone Link	Zerk	Red-Yellow	Semi-fresh
1020	Slat Bull Wheel-Top	Zerk	Red	Fresh
1021	Slat Bull Wheel Actuator – R/H – Piston End	Zerk	Red-Yellow	Fresh

2.3.10 Nose Landing Gear

(Last lubrication occurred on January 15, 2000, in Seattle; Lubrication interval was 600 hours.)

1022	Nose Landing Gear – Scissors Link – Mid	Zerk	Green	Semi-fresh
	(Another fitting on same part)	Zerk	Green-Yellow	Semi-dry
	(Another fitting on same part)	Zerk	Green	Semi-dry
1023	Nose Landing Gear – Scissors Link – Upper	Zerk	Green-Yellow	Semi-fresh
	(Another fitting on same part)	Zerk	Green-Yellow	Semi-fresh
	(Another fitting on same part)	Zerk	Green	Semi-fresh
	(Another fitting on same part)	Zerk	Green	Semi-fresh
1024	Nose Landing Gear Steering Actuators	Zerk	Yellow-Brown	Semi-dry
	(Another fitting on same part)	Zerk	Green	Semi-dry
	(Another fitting on same part)	Zerk	Green	Semi-dry
	(Another fitting on same part)	Zerk	Green	Semi-dry
	(Another fitting on same part)	Zerk	Green	Semi-dry

2.3.11 Slats

(Last lubrication occurred on September 9-10, in Los Angeles; Lubrication interval was 245 days.)

1025	Slats-R/H side-No.10	Zerk	Yellow-Brown	Semi-dry
	(Another fitting on same part)	Zerk	Grey-Green	Semi-fresh
	(Another fitting on same part)	Zerk	Grey-Green	Fresh
1026	Slat-L/H side-No.4	Zerk	Green	Semi-fresh
	(Another fitting on same part)	Zerk	Green	Semi-fresh
	(Another fitting on same part)	Zerk	Yellow-Brown	Semi-fresh

2.3.12 Main Landing Gear

(Last lubrication occurred on January 15, 2000, in Seattle; Lubrication interval was 600 hours.)

1027	Not assigned			
1028	Not assigned			
1029	Not assigned			
1030	Main Landing Gear-Left Hand – Mid&Upper Scissor	Zerk	Green	Semi-fresh
	(Another fitting on same part)	Zerk	Green	Semi-fresh
	(Another fitting on same part)	Zerk	Green	Semi-fresh
	(Another fitting on same part)	Zerk	Green	Semi-fresh
1031	Main Landing Gear-Right Hand – Trunion	Zerk	Blue-Green	Fresh
	(Another fitting on same part)	Zerk	Blue-Green	Fresh
	(Another fitting on same part)	Zerk	Blue-Green	Fresh
	(Another fitting on same part)	Zerk	Green	Semi-fresh
	(Another fitting on same part)	Zerk	Grey-Blue	Fresh

2.3.13 Flaps and Spoilers (Attached to wing)

(Last lubrication occurred on September 9-10, in Los Angeles; Lubrication interval was 245 days.)

1032	Flap Actuator – R/H Outboard	Zerk	No Grease	No Grease
	(Another fitting on same part)	Zerk	Red-Yellow	Semi-dry
1033	Flap Actuator – R/H – Mid-Inboard from 1032	Zerk	No Grease	No Grease
	(Another fitting on same part)	Zerk	Yellow-Brown	Semi-dry
1034	Flap Actuator – R/H – Inboard	Zerk	Pink	Semi-fresh
	(Another fitting on same part)	Zerk	Yellow-Brown	Semi-dry
1035	Flap Actuator – L/H – Inboard	Zerk	Red-Brown	Semi-fresh
	(Another fitting on same part)	Zerk	Red	Semi-fresh
1036	Flap Actuator – L/H – Mid	Zerk	Red	Semi-fresh
	(Another fitting on same part)	Zerk	Yellow-Red	Semi-fresh
1037	Flap Actuator – L/H – Outboard	Zerk	Yellow-Red	Semi-fresh
	(Another fitting on same part)	Zerk	Red-Yellow	Semi-fresh
1038	Spoiler Actuator – R/H Wing	Zerk	Green	Semi-fresh
	(Another fitting on same part)	Zerk	Yellow-Brown	Fresh
	(Another fitting on same part)	Zerk	Yellow-Brown	Semi-fresh

3.0 Translucent Acme Nut Lubrication Observations

3.1 Background

The Group met at Integrated Aerospace[16] on June 11, 2001, to observe a lubrication demonstration of a translucent plastic acme nut. The demonstration involved operating a jackscrew through the nut on Integrated Aerospace's Acceptance Test Procedure (ATP) fixture. The fixture places a static load of about 1,350 lbs on the jackscrew assembly during the test.[17] With the knowledge of the NTSB, Boeing initially prepared the test plan with no input from the Systems Group; however, some additional modifications to the Boeing Test Plan were discussed by the Group and incorporated into it.

Prior to the test, the acme screw and clear plastic acme nut were clean. The thread form and clearances of the acme nut met new production standards. The acme nut was manufactured from a HIDEX 301 polyurethane base plastic. According to Boeing, the acme nut underwent the same processing and production configuration as the aluminum-bronze acme nuts used in MD-80 aircraft. The lubricants that were used in the tests were virgin. Three different tests were conducted:

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[16] The current supplier of the acme screw and nut assembly is now Integrated Aerospace, Inc. (formerly known as Trig Aerospace, Inc.), and is located in Santa Ana, California. The assembly on the accident aircraft was supplied to McDonnell Douglas by the Peacock Company of Norwalk, California on June 28, 1990. In late 1994, Peacock was purchased by the Derlan Company, which in turn was purchased by Trig Aerospace in July 1999, which then became Integrated Aerospace, Inc., in October 2000.

[17] Actual static load of the MD-80 stabilizer is about 1,600 lbs. Additionally, normal flight loads acting on the jackscrew in flight are significantly higher (about 5,000 – 6,000 lbs.)

3.2 Lubrication of Grease Fitting Only

The first test involved injecting lubrication into the acme nut grease fitting only. Seven pumps of the grease gun were required until grease (Mobile 28) began to extrude out of the top of the acme nut. The grease entered the top 6 or 7 threads of the nut (from a total of 32 threads) until it extruded out the top of the nut. Lubricating the grease fitting only[18] did not initially provide enough grease to lubricate all of the pressure flanks of the acme nut and screw threads. This method of greasing filled about 3 inches (about 1.5 inches above and below the grease fitting) of the acme screw valley.[19] This length corresponds to the depth/length of original grease insertion into the acme nut. With the aid of a black light, visual examination revealed that no grease had transferred to the remainder of the acme nut, even when the jackscrew was operated once or twice. Eventually, a very thin layer transferred to all of the threads of the acme nut and screw after three additional cycles of the jackscrew.[20] This was confirmed by a subsequent visual inspection of the interior of the acme nut.

3.3 Lubrication of the Acme Screw Only

This test was initiated with a clean acme nut and screw. The acme screw was lubricated with Mobile 28 by using a brush. The grease was brushed onto the entire length of the exposed portion of the acme screw, including the portion of the screw below the acme nut. The lubrication was performed through a mock-up of the aircraft access doors normally used for the on-wing lubrication tasks.[21] This "butter lube" of the screw appeared to provide significantly more application of the grease on the acme nut after the screw was cycled a few times. This method resulted in a very definite thin film of grease being applied to the pressure flanks on the entire length of the screw. All of the exposed portions of the acme screw thread valleys were filled by this method of applying grease. The only portion of the screw threads not filled were the ones that were originally covered by the acme nut during the initial lubrication at the beginning of the test run. The thread valleys that were covered by the acme nut were not filled with grease even after cycling of the jackscrew. The presence of grease was clearly seen on both flanks of each thread in the acme nut. This was confirmed by a visual inspection of the interior of the acme nut and the exterior of the screw.

It was noted by the Group that the actual method of grease application on the acme screw is not clearly stipulated in the Boeing maintenance procedure. The Boeing procedure states to “apply light coat of grease to threads, then operate mechanism through full range of travel to distribute lubricant over length of jackscrew.” There were different interpretations of the grease application discussed by the Group, such as using a

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[18] The actual airplane maintenance procedure specifies applying lubrication to not only the acme nut fitting, but also onto the jackscrew.

[19] According to Boeing, the acme screw valley of each jackscrew thread acts as a grease “reservoir”.

[20] The maintenance procedure stipulates, “cycling” the jackscrew, but does not specify number of cycles or length of travel of each cycle.

[21] Due to the physical constraints of the ATP fixture, the mock-up of the access panel was about 10 inches further away from the jackscrew than on an actual airplane.

brush, the nozzle of a grease gun, a glove, a bare hand, and a rag. Also, the procedure does not make specific reference to lubricating the portion of the screw below the acme nut, which is accessed by another access panel.

3.4 Combination of Grease Fitting and Acme Screw Lubrication

This test was run with a clean nut and screw. Combining the "butter lube" of the acme screw with the grease fitting lubrication appeared to provide the most lubrication.[22] During this test, Mobile 28 (red) was used in the fitting and Aeroshell 33 (green) was applied to the screw. About 50 pumps of the grease gun were required to provide about 4-7/8 inches (as measured from the top of the nut) of the 8-inch length of the nut.[23] Copious amounts of grease continued to extrude out the top of the nut during the 50 pumps, and no grease appeared to extrude out of the bottom of the nut. The greases appeared to mix quickly after two cycles of the acme screw. It appeared that the green grease on the screw did not immediately or readily enter the nut during these cycles. The grease mixture caused the screw threads and nut threads to appear more "wet" than with only the Mobile 28. The majority of the entire length of the screw valleys were filled with grease.

More grease was then inserted into the fitting of the already-lubricated nut and screw. Three more grease gun pumps were required until grease was seen to begin to extrude out of the top of the acme nut in one location along the circumference, and an additional 4 pumps until the grease extruded out the top of the nut along the entire circumference. No grease extruded out of the bottom of the nut.

4.0 Endplay Check Restraining Fixture Investigation

The Group conducted several tests related to the horizontal stabilizer restraining fixture used for the on-wing MD-80 jackscrew endplay check. The endplay check involves pulling down on the horizontal stabilizer by applying a specified amount of torque to the restraining fixture to change the load on the acme screw from tension to compression. The change in load causes movement between the acme nut and the acme screw threads that can be measured with a dial indicator. A specified amount of torque is applied to the midsection of the restraining fixture through the use of a torque wrench to cause the change in load on the acme screw.

4.1 Output Force Requirements

According to Boeing, the load required to measure the gap between the threads of the acme screw and the threads of the acme nut (end play) is dependent upon several factors:

[22] This method is the one that is specified in the Boeing maintenance procedure.

[23] The purpose of this was to maximize the length of grease application into the 8-inch acme nut. An airline mechanic would typically apply significantly less than 50 pumps from the grease gun into the acme nut fitting.

- Mass of the actual horizontal stabilizer
- Hinge moment of the stabilizer from the mass
- Distance from the hinge to the centerline of the jackscrew
- Stabilizer hinge friction
- Amount and condition of the grease in the gimbal nut
- Ambient environment (temperature and air movement)

Based upon the weights calculated for the basic design, the MD-83 has the heaviest stabilizer of the MD-80 series airplanes. Its mass is calculated to be 2,227 lbs. This translates into a hinge moment at the pivot point of 74,970 in-lb. The hinge moment for all MD-80 series airplanes (including the MD-80, -82, -83, -88) is reacted by the forward attach point which is the jackscrew. This reaction is calculated to be about a 1,600 lb. tension force. The amount and condition of the grease as well as the ambient environment are variable parameters; it is estimated that several hundred pounds of force may be necessary to offset the effects of these various parameters and completely close the gap. Therefore, according to Boeing, the minimum load required to produce an accurate measurement of the endplay is in the range of 2,000 – 2,100 lbs. for MD-80 series airplanes.

4.2 Huntington Beach Load Cell Tests

The Group reconvened at a Boeing laboratory in Huntington Beach, California, on April 4, 2001, to perform tests on several horizontal stabilizer restraining fixture tools manufactured by Boeing and Alaska Airlines. The purpose of the tests was to characterize and compare the load output of various horizontal stabilizer restraining fixture tools with the use of a load cell.

Each tool was photographed, measured and labeled prior to the test. Observations were also noted regarding the "feel" of the tools as they were manipulated (rotated) by hand prior to, and after, the installation on the load cell.

Tests were conducted with no lubricant and with the use of two types of lubricant[24]: (1) **DPM 37-7 Antiseize Lubricant** – Specified in Boeing Temporary Revision no. 27-445; dated April 13, 2000; the brand used in the test was Locktite C5-A; and (2) **VV-L-800 Spray Lubricant** – Specified in Boeing Temporary Revision no. 27-456; dated Nov. 20, 2000. Additional details and specifications related to these two lubricants are attached.

During each measurement, the torque was brought back to zero between test runs (i.e. torque up to 250 in-lbs, then back to zero, then to 275 in-lbs, etc). Additionally, only one technician would apply the torque throughout all of the tests for consistency.

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[24] Two types of lubricant were chosen because these two types were specified in two versions of the end play check procedure.

A calibrated torque wrench, with a plus/minus 4 percent error, was used for the test. The load cell was also calibrated to be within an ASTM-specified accuracy of plus/minus 1 percent. The following tool lengths and labeling data are as follows:

TOOL	Serial no.	Extended (in.)	Retracted (in.)
Boeing Tool No. 1	CE9122	10.5	7.50
Boeing Tool No. 2	CE9150	10.5	7.50
Boeing Tool No. 3	"RAMS"	10.5	7.53
ASA Tool No. 1	CE0826	13.0	8.20
ASA Tool No. 2	CE070811	13.0	8.125

All three Boeing tools provided a "smooth" action with no binding or significant friction noted before the tests. The left-hand thread on Boeing Tool No. 2 exhibited slightly rougher movement when compared with the others. The right hand threads of the Alaska-fabricated tools provided "smooth" action, and the left hand threads appeared to have noticeable and different friction when rotated in certain areas of the threads.

Test results were recorded and can be found in Appendix C. The following is a summary of the pertinent observations:

- Generally, the Alaska Airlines fabricated tools provided about one-third to one-half of the load as the Boeing tools, for the same applied torque input.

- After the ASA Tool No. 1 was run about 7 times, there appeared to be more friction when rotated by hand in the "nominal" range of travel, and "smoother" when rotated in areas outside of the nominal range of travel, near the "2X" range [25] used for the "2X" tests.

- After the first test with ASA Tool No. 1, the tool was cleaned (in an ultrasonic bath), and its action was much "smoother" upon hand manipulation than before.

- On both the Boeing and Alaska tools, lubricating the tool with the specified spray lube (as per the revised maintenance manual) resulted in a lower force output as compared with a dry tool. The dry tools consistently produced higher outputs. However, the use of the C-5 lubricant provided higher outputs than both the unlubed tools and those utilizing the spray lube.

- During one of the tests (dry, no lube) involving Boeing Tool no. 1, the tool's force output was suddenly reduced by about half. The Group could not visually detect any anomalies with the tool. The load returned to higher values when the tool

[25] The "2X" range refers to the additional extension of the Alaska-fabricated tools, which all had non-constant threaded length of turnbuckle thread engagement. The Systems Group explored the potential effects of this additional thread engagement. The Boeing tools had a constant threaded length of turnbuckle thread engagement.

was re-lubricated. This tool was examined in detail by the NTSB Materials Lab and no pertinent discrepancies were noted.

- For an undetermined reason, all of the Boeing tools (except Boeing Tool no. 1 mentioned above) gave increasing load outputs with the same torque inputs when the tests were repeated. For example, at 300 in-lbs: 1st run = 2,592 lbs.; 2nd run= 2,894 lbs.; 3rd run=3,400 lbs.

- Regarding the Alaska Airlines tool output, the sensitivity of force output versus varying clevis thread engagement was not able to be quantified.

- Lubrication with the C-5 antiseize lubricant gave the highest force output per given torque input. Also, this lubricant resulted in less variation in force output between test runs.

- The Boeing tools that were heated in an oven consistently provided slightly higher load outputs than at room temperature. When the tool was refrigerated, it consistently provided slightly lower load output values.

- The Group was unable to cause a "hydraulic lock" with the Alaska fabricated tool, despite efforts to expose the tool to copious amounts of the spray lubricant.

4.3 Oakland On-wing Restraining FixtureTests

The Group reconvened at an Alaska Airlines maintenance facility in Oakland, California, to conduct additional restraining fixture force tests on an MD-83 airplane.[26] The Group utilized three modified restraining fixture tools that incorporated load cells and strain gauges in order to measure the force required to pull down the stabilizer for on-wing endplay measurements. Additionally, the Group utilized restraining fixture tools that were not modified for head-to-head comparisons of endplay readings between Boeing fixtures and Alaska-fabricated fixtures. Test results are attached. The following are some pertinent, general comments regarding the tests:

- The on-wing load cell test results were similar to the Huntington Beach Lab tests in that the force output for the Alaska-fabricated tools was less than the Boeing tools. In side-by-side comparison check of endplay using unmodified restraining fixture tools, there was about 0.001-inch difference between the Boeing and Alaska tools when the jackscrew was restrained from rotating.

- The force required to tip the horizontal stabilizer leading edge down (zero hinge moment) was measured to be about 1,475 to 1,500 lbs., measured axially along the restraining fixture. In order to achieve the full endplay measure, the force needed to be increased to around 1,975 to 2,000 lbs. Applying less than 1,475 lbs. resulted in zero endplay. The measured endplay continued to increase as the force applied increased.

[26] The airplane utilized for the test was N976AS.

- The measured end-play varied from 0.0125 to 0.0210 inch, depending on the variables introduced. Some of these variables were extreme, and most resulted in higher, “conservative” end-play values.

- The "nominal" end-play, with a "nominal" procedure (no variables introduced), was 0.016 inch.[27]

- An Alaska fabricated tool (no. 0826) was damaged during the test. The damage appeared to be associated with the threads of the tool.[28] This was first evident when the measured end-play was less than the “nominal” end-play of 0.016-inch that was known to the Group. It was also evident by the zero endplay reading with 300 in-lbs of applied torque. This was the third known failure of an Alaska-fabricated restraining fixture tool since the accident.[29]

- The highest endplay value (0.021 inch) was recorded with a skewed dial indicator plunger and a rotating jackscrew. The smallest endplay value (0.0125 inch) was achieved with a rotating jackscrew and with the indicator plunger on the acme stop lug.

- Overall, the endplay was .016 inch +.005 / -.0035 with all the variables included.

- With no variables introduced, and under “nominal” conditions, the measured endplay was 0.016-inch plus/minus about 0.0015 inch. This includes both Boeing and Alaska-fabricated tools.

- The following variables were observed to affect the endplay readings during this activity in Oakland:

    - Force produced by the restraining fixture.
    - Torquing the restraining fixture in the wrong direction, resulting in zero endplay readings.
    - Contact between the dial indicator clamp/brackets and aircraft structure.
    - Incorrect nulling and improper indicator number subtraction.
    - Rotation of the jackscrew can cause higher endplay readings, by about 0.003 to 0.004" (vertical plunger).
    - Moving the indicator plunger further away from the jackscrew caused slightly higher endplay readings, by about 0.0005 to 0.001 inch.

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[27] The end-play was later checked on the bench at IA, and found to be 0.016 inch.

[28] The NTSB Materials Laboratory documented this tool and noted damage to the threads. The laboratory report is provided under separate cover as part of the NTSB docket for this investigation.

[29] According to Alaska Airlines, one tool was damaged when more than 300 in-lbs was applied to the tool during an endplay demonstration, and another tool was damaged when the horizontal stabilizer was operated while the tool was installed.

- Placing the dial indicator plunger on the acme nut stop lug resulted in lower endplay readings by 0.003 inch when the jackscrew was unrestrained and rotated. When the jackscrew was restrained, no appreciable difference was noted.
- Skewed dial indicator plunger resulted in 0.0005 inch increase in endplay with jackscrew restrained; 0.005 inch unrestrained.
- Skewed dial indicator plunger on acme stop lug resulted in 0.001 inch decrease in endplay unrestrained, and 0.003 to 0.0035 inch increase with jackscrew restrained.
- Heavy greasing between endplay checks accentuated jackscrew rotation, but with jackscrew restrained, the endplay decreased by 0.0005 inch to 0.0015 inch.

- The dial indicator installation (i.e. indicator mounted below the acme nut) requires reading the endplay measurement "backwards"[30]. For example, if the needle shows 0.085 inch on the indicator, the endplay is actually 0.015 inch.

- At least two mechanics were required to perform each endplay check. One is to observe and/or secure an acme screw from rotating and another is to apply torque to the restraining fixture.

- The dial indicator face is directed downwards, requiring an inspection mirror to read.

4.4 Tulsa On-wing Restraining Fixture Tests

The Systems Group reconvened in Tulsa, Oklahoma on July 10 – 12, 2001, to perform additional on-wing endplay tests. The tests repeated those conducted by the Group in Oakland[31] on four additional MD-82 series airplanes.[32] The tests also incorporated additional restraining fixture force output experiments. Additionally, the tests incorporated the assessment of experimental methods of affixing the dial indicator to the acme nut.

Test data for each test "run" were collected and tabulated. Test results are attached. The following are pertinent observations regarding the test results:

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[30] This installation results in the dial indicator needle moving counterclockwise during the endplay test. Consequently, the endplay indicated by the dial is not the actual endplay. Typical dial indicators that were used read 0.1 inch per full needle rotation. Per the Boeing Maintenance Manual, the needle is to be nulled to zero at the beginning of the endplay test. When the jackscrew load is reversed, the needle will move counterclockwise toward 0.090 inch. The true endplay is the absolute value difference between the starting and finishing points for the needle.

[31] As previously mentioned in this report, the Oakland tests were intended to characterize and compare force output and endplays on various restraining fixtures manufactured by Boeing and fabricated by Alaska Airlines, and to perform endplay checks with varying tools, dial indicator set-ups, greasings, rotating jackscrew, etc.

[32] All four airplanes had accumulated between 31,000 and 46,000 total flight hours, and all of them had their original jackscrew's installed.

- As was demonstrated in the Oakland on-wing tests, the force required to tip the horizontal stabilizer leading edge down (zero hinge moment) is around 1,475 lbs. to 1,500 lbs. measured axially along the restraining fixture. In order to achieve the full endplay measure, the force needed to be increased to around 1,975 to 2,000 pounds.

- As was demonstrated in the Huntington Beach lab tests and Oakland on-wing tests, the force output for the Alaska-fabricated tools was about 1/3 to 1/2 less than the Boeing tools.

- In several of the on-wing endplay test runs conducted on three of the four Tulsa airplanes, the Alaska-fabricated load cell tools provided endplay values between 0.003 to 0.005 inch lower than the Boeing load cell tools.[33]

- In almost all cases involving the "nominal" procedure, lubricated Alaska-fabricated tools provided readings between 0.001 to 0.003 inches lower than readings from lubricated Boeing tools.

- During similar tests conducted on two of the four Tulsa airplanes, a lubricated Alaska-fabricated tool provided an endplay reading of 0.001 inch lower than a lubricated Boeing tool

- When the dial indicator was mounted above the acme nut instead of below it (as is called for in the current end play check procedure), the dial indicator was easier to install in this position, its face could be seen more easily (without the need for an inspection mirror, as was the case when it was installed below the acme nut), and the end play reading could be read directly from the indicator because of the resulting clockwise movement of the needle.[34]

- When the dial indicator was mounted above the acme nut instead of below it (as is called for in the current end play check procedure), the majority of the readings were consistently 0.001 to 0.002 inches higher than the readings obtained from the indicators mounted below the acme nut in a nominal configuration.

- When the dial indicator was mounted such that the plunger contacted the canted surface of the acme nut stop lug at a skewed angle to the plunger axis, the end play reading was lower than it was when the plunger contacted a level surface on the acme nut at a right angle to the plunger axis. When the dial indicator was

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[33] Due to the specified limits of the Alaska Airlines load cell, the full torque value of 300 in-lbs could not be applied, and no data exists for torque values that produced a force in excess of 2,000 lbs.

[34] When the dial indicator was mounted below the acme nut, as called for in the current procedure, the dial indicator plunger end moved upward (extended) as the acme screw moved down, causing the needle to move counterclockwise, or opposite the normally anticipated, increasing dial reading direction. This counterclockwise movement required maintenance personnel to read the indicator backwards and interpret the total needle movement in order to obtain the end play.

mounted such that the plunger contacted a level surface on the acme nut at a right angle to the plunger axis, readings closer to the nominal value were obtained.

- Differences in endplay measurements conducted immediately before and after lubrications of the jackscrew were not significant.

- The amount of observed jackscrew rotation appeared to increase after successive test runs.

- Rotation of the jackscrew yielded endplay measurements no greater than +/- 0.005-inch from the presumed "nominal" readings.

- Endplays obtained by the Group under the "nominal" conditions were similar to the endplays recorded by the airlines that operated the Tulsa airplanes, except for one of the four. For airplane no. 487, the following endplays were recorded: Alaska-fabricated tool measure was 0.013-inch; Boeing tool measure was 016-inch; Tulsa airline measure was 0.018-inch.

- Because of the non-standard length of Alaska-fabricated tools that were modified with strain gages, the position of the horizontal stabilizer needed to be moved off of the nominal position specified in the endplay check procedure. It is unknown what effect this may have had on the results.

4.5 Metallurgical Examinations of Restraining Fixtures

The restraining fixtures that were used in the Huntington Beach and Oakland tests were submitted to the NTSB's Materials Laboratory for detailed examination. NTSB Materials Laboratory Factual Report No. 01-118, dated October 10, 2001, was completed.[35] The report documents several discrepancies with both Boeing and Alaska-fabricated tools.

4.6 FAA Guidance Regarding Tool Equivalency

On December 4, 2000, the FAA issued a Flight Standards Handbook Bulletin for Airworthiness (HBAW), no. 00-20A (attached), entitled "Equivalency of Special Equipment or Test Apparatus as provided by Parts 43 and 145." The bulletin provides guidance for the Principal Maintenance Inspectors (PMIs) when making a determination of acceptability for equivalency of special equipment and/or test apparatus used in maintaining aircraft and their associated components as provided under Title 14 Code of Federal Regulations part 43 and 145.

[35] This report can be found under separate cover in the NTSB's public docket for this investigation.

According to the FAA, the bulletin was issued in response to emergency Airworthiness Directive (AD) 2000-03-51[36], which mandated a check for excessive wear of the acme screw and nut assembly on DC-9-80 series aircraft. The AD incorporated Boeing's Alert Service Bulletin (SB) DC9-27A362, which outlines the methods for accomplishment, including a horizontal stabilizer restraining fixture tool necessary to accomplish the required check. The Alert SB advised that this tool was unavailable from Boeing at that time; however, Boeing would supply the drawing necessary for the operators to produce the tool. Thus, if the operator chose to manufacture the tool, it became the operator's responsibility to determine if the tool was equivalent to that of the manufacturer.

The bulletin states: "In instances involving the use of equivalent equipment and/or apparatus, the determination of equivalency for such equipment is the primary responsibility of the repair station or the air carrier, not the FAA." Additionally, the bulletin provided 8 items of guidance for PMI's to ensure that repair stations and air carrier comply with equivalency.

4.7 FAA Survey of Horizontal Stabilizer Restraining Fixtures

In August 2000, immediately following the temporary, self-imposed grounding of some Alaska Airline MD-80 airplanes after the airline disclosed that they were utilizing restraining fixtures that did not conform to manufacturer's specification, the FAA conducted a survey of all U.S. airlines. The survey revealed that the majority of the airlines utilized tools were either fabricated in-house as per the Boeing-provided restraining fixture drawing, or fabricated by a vendor under the same drawing specifications. One U.S. airline (not Alaska Airlines) fabricated the tool by "reverse engineering". According to Boeing, this tool was evaluated and found acceptable by Boeing. Also, a cargo-carrying airline had one tool that did not meet the Boeing specification.

5.0 "Wobbling" Jackscrew Investigation

5.1 Background

On November 26, 2000, Alaska Airlines maintenance personnel, while operating the horizontal stabilizer trim system on airplane N965AS, observed the jackscrew "wobble". The wobble appeared as a slight rocking motion of the acme nut as the jackscrew was rotated within it. The airline removed the jackscrew and alerted the Systems Group. On February 21, 2001, the Group examined the jackscrew at Integrated Aerospace. The Group observed the wobble as the assembly was operated on Integrated Aerospace's ATP fixture.

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[36] AD 2000-03-51 required all U.S. operators of DC-9, MD-80/90, and 717 series airplanes to perform the end play check every 2,000 flight hours and to report all end play measurements to the FAA.

Upon disassembly, the technician who removed the lower torque tube nut indicated that the nut was looser than what he had considered to be typical.[37] A groove, or “wear band”, was noted near the top portion of the torque tube. The band measured 0.035-inch at its deepest point. The depth of the wear band was not constant around the periphery of the groove. According to Boeing, this wear band frequently occurs in this area because the torque tube contacts the inside wall of the acme screw. The overhaul manual requires a steel-sleeve repair of the wear band during overhaul if the wear band exceeds 0.025-inch.

In a letter dated March 27, 2000, Alaska Airlines urged the NTSB to investigate the wobble. The letter cited the fact that the torque tubes from the accident airplane and airplane N981AS had a similar wear band.[38] The letter also expressed a concern that the wobble could produce erroneous endplay readings and/or excessive acme nut wear. As a result, the Group conducted tests and research to address these concerns.

5.2 Endplay Investigation

Representatives of Alaska Airlines expressed concern that the wobble motion of the jackscrew could affect the endplay as a result of the configuration of the measurement device locations. The endplay of the Alaska Airlines wobbling jackscrew was checked while installed on Integrated Aerospace’s ATP fixture prior to disassembly. Several checks were performed. The jackscrew was rotated each time before each endplay check in an attempt to discern any variance in endplay due to a variance in acme nut and acme screw position changes resulting from the wobble. No differences were noted. The endplay was consistently 0.018 inches.

Representatives of Alaska Airlines also expressed a concern that the wear band may cause the torque tube to move vertically, thus relieving some or all of the torque on the torque tube nut located at the bottom of the jackscrew. Should this occur, the clearances between the threads of the acme nut and the acme screw could be altered, thus providing an erroneous endplay reading. While no evidence of vertical movement was found[39], the Group performed an experiment at Integrated Aerospace on June 11, 2001, that involved endplay versus torque of the torque tube nut. A jackscrew assembly[40] was placed on a bench fixture,[41] and the torque nut was adjusted while end-play measurements were recorded. When the torque was tightened to 150 ft-lbs, the end play was measured at 0.008 inch. When the torque was relieved to 55 ft-lbs[42], the end-play increased to 0.012 inch. (The end play was not recorded at a zero torque value.) This

[37] The technician used a wrench to remove the torque nut. No measuring device was used to measure the torque required to loosen the nut. The technician’s comments were based on his personal tactile experience.
[38] According to a NTSB Materials Laboratory Report, the wear band on the torque tube of N981AS was 0.0065-inch in depth, and the wear band on the torque tube of the accident jackscrew was 0.028-inch in depth.
[39] Additional research into this area was addressed by the Structures Group.
[40] This test was performed once on an assembly of scrap parts; a matched nut/screw set was not used.
[41] This fixture rested on a table and was used solely to hold the assembly stable.
[42] This value is the final torque value that Integrated Aerospace uses for newly manufactured assemblies.

experiment demonstrated that the endplay can decrease (i.e. the gap between the threads of the nut and screw is smaller) if the torque on the torque tube nut is increased, and the end-play can increase (in the "conservative" direction that may cause an operator to prematurely remove a jackscrew) if the torque is relieved.

A related issue that was investigated by the Group involved vertical movement of the torque tube resulting from wear that was suspected to occur on the bottom face of the torque tube upper flange. This face contacts the upper portion of the acme screw in compression. On October 17, 2001, the Group reconvened at Integrated Aerospace to examine all torque tubes that had been deemed as scrapped during overhaul. All 17 torque tubes present at Integrated Aerospace were examined by the Group and an NTSB metallurgist. The examination did not reveal any evidence of wear of the bottom face of any torque tube's upper flange.

5.3 Acme Nut Wear Investigation (Torque Tube Wear Band)

Representatives of Alaska Airlines expressed a concern that the orbiting action of the acme screw around the torque tube resulting from wobbling motion could alter the engagement of the acme nut threads and acme screw threads, thus accelerating acme nut wear. (This was not seen on the wobbling jackscrew pulled by Alaska Airlines; the computed acme nut wear rate was 0.00038 inch per thousand flight hours, which is lower than the Boeing predicted value of 0.001 inch per thousand flight hours.) According to Boeing, the wobbling motion is accommodated by the ability of the acme nut to move freely in two axes about its gimbal supports and by the centralizing acme thread design itself. However, the Group attempted to determine if a relationship existed between acme nut wear rate and torque tube wear band depth. These data were submitted to an NTSB research specialist who analyzed the data by utilizing several specific methods. According to the analyses (attached), *no statistical significance* was found in comparing the differences of presumed acme nut wear rates between the following two groups: (1) torque tubes with no (or slight) wear band, representing jackscrews that do not have a perceptible wobble; and (2) torque tubes with deeper wear bands, representing jackscrews that have a perceptible wobble.

5.4 Douglas Service Bulletins and AOL Regarding Torque Tube Wear Band

In 1971, several airlines noted that the torque of the lower torque tube nut did not meet specification when checked during overhaul. The loose nut was considered to have contributed to the torque tube wear band. At the time, the specified torque for the nut was 30-35 ft-lb. In order to ensure that adequate torque be held on units, Douglas developed a procedure for the fleet that re-torqued the nut while installed in the airplane to the current 55 ft-lb specification. Douglas issued an All Operator Letter (AOL) and a service bulletin to provide such procedures to the operators. The AOL (9-613) and the Service Bulletin (27-144) are attached.

6.0 Pertinent Acme Screw & Nut Examinations

6.1 Hawaiian Airlines Jackscrews

6.1.1 Jackscrew No. 1: S/n DCA-110 (a)

As previously reported in the November 22, 2000, Systems Group Chairman's Factual Report of Investigation, an acme screw and nut, s/n DCA-110, was removed from a Hawaiian Airlines DC-9 (designated as Airline "F" by the Group) after 2,581 hours and 6,377 cycles since a 1997 overhaul by Derlan.[43] A bench check of the endplay, after the assembly was removed and cleaned, yielded a measurement of 0.048 inches. Using this figure, the acme nut and screw wear rate is 0.0159 in. per 1,000 flight hours, which is the highest overall jackscrew wear rate known to the Group. This wear rate also includes the contribution of acme screw thread wear.

A Group review of manufacturer records, airline maintenance records and overhaul records (attached) indicated that this assembly was manufactured in 1967. It is unknown how many times it had been overhauled since that time. In September 1997, the assembly was installed in N601AP, a Hawaiian Airlines DC-9, after overhaul. It was subsequently removed due to an on-wing endplay reading of 0.043-inch on February 17, 2001.

According to personnel from Integrated Aerospace, they received an acme screw and acme nut marked with "DCA110" from Hawaiian Airlines in February 2000 without any other components such as the gearbox support assembly or torque tube nut. However, records from the 1997 overhaul indicate that the DCA-110 screw and nut were overhauled, and the support assembly and associated hardware were present.[44]

The assembly was sent to the NTSB Materials Laboratory for detailed examination by the Materials Group. NTSB Materials Laboratory Factual Report No. 01-082, dated September 24, 2001, was completed.[45] According to the report, evidence of pink-colored grit material was found inside the acme nut grease fitting.

The Group Chairman visited the Hawaiian Airlines maintenance facility on January 22, 2001, to review maintenance records (attached), inspect N601AP, and collect grease samples. The following observations were noted:

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[43] Derlan was the acme screw and nut manufacturer at that time. The company is now known as Integrated Aerospace.

[44] According to Integrated Aerospace personnel, if they cannot read the serial number from a screw and nut that is received for overhaul, they etch on a serial number that they pull from their serialized log. However, if they were to receive a screw and nut for overhaul with "DCA110" stamped on it already, they would keep the same serial number on the new acme nut for tracking purposes. Therefore, at some point in the acme screw and nut's life, the "DCA110" stamp on the screw and nut may have been placed on them by another overhaul shop.

[45] This report can be found under separate cover in the NTSB's public docket for this investigation.

- An examination of all non-routine Hawaiian Airlines maintenance work cards for N601AP revealed numerous write-ups for "surface corrosion" of fasteners, access panels, and leading edge skin of the horizontal and vertical stabilizer. The corrective action in all cases stated: **"**cleaned, treated, and primed per [Structural Repair Manual] 57-10-3."

- One work card, dated December 4, 1999, (about 3 months prior to the jackscrew's removal for an end-play of 0.043 inch) indicated the following: **"**Grit blast accumulated in vertical stab as seen thru access panel 6401 and panel 3703 (left lower banana fairing). Area to be inspected after cleaning." The corrective action was: "Cleaned area. Inspected area. No discrepancies noted." According to Hawaiian Airlines personnel, the area noted in the work card was located inside the vertical stabilizer where the jackscrew is installed. Additionally, the "grit" that was used was most probably glass beads. Samples of the glass beads were taken from airline supplies for further examination.

- The airplane, N601AP, received a D-check in September 1996; a C-check in July 1998, and its most recent C-check in Feb 2000.

- The jackscrew was scheduled to be checked during the February 2000 C-check, whether or not the post-accident AD 2000 15-15 would have been issued.

- Because of the AD 2000-15-15, a visual inspection was immediately performed on the jackscrew, and no metal shavings were noted. The assembly was "properly lubricated" according to the AD reporting form.

- Before the accident, the airline lubrication interval for the acme screw and nut assembly was every 1,000 flight hours. The end-play check interval was every 3,000 flight hours.

- Jackscrew DCA110 was overhauled by Derlan (formerly known as Trig, and now Integrated Aerospace) in September 1997 with an outgoing endplay of 0.010 inches. It was sent to the airline at that time, where it sat in a non-climate controlled Quonset hut at the airline's supply depot. The assembly was then installed on N601AP in June 22, 1998, because the previous jackscrew had a zero endplay.

- According to airline records, the "DCA110" assembly was installed in N674MC, a DC-9 acquired by the airline on July 29, 1988. It remained on this airplane until 1997, when it was pulled and sent to Derlan. N674MC was manufactured on December 3, 1977.

- Records indicate that on Jan. 16, 1996, while N674MC was in a C-check, the endplay on DCA110 read 0.035 inch. The corrective action stated "reinspect jackscrew endplay at intervals which do not exceed 1000 flight hours."[46] On July 9, 1997, another record indicates that DCA110 was removed and replaced because "end play out of limits," with no indication of the endplay reading.

- The subject jackscrew (DCA110) remained in N674MC until the newly overhauled jackscrew was installed in June 1998.

6.1.2 Jackscrew No. 2: S/n DCA-110 (b)

On June 18, 2001, another jackscrew, serial number DCA-110 was removed from aircraft N601AP and sent to Integrated Aerospace for overhaul due to excessive wear rate. The airline obtained an endplay reading of 0.036 inch after the acme screw and nut assembly accumulated only 2,514 flight hours and 6,071 cycles. The assembly included the acme screw and nut, support assembly, torque tube, and stops.

While the number "DCA110" is stamped on the gear box support assembly, the serial numbers on the screw and nut are D-3351[47], indicating that the nut and screw from the first DCA-110 assembly were replaced by a new nut and screw assembly. Hawaiian Airlines personnel stated that they kept the DCA-110 gear box support assembly, torque tube, and stop nut with the airplane when they installed the D-3351 nut and screw in February 2000.

Because the wear rate of this second jackscrew, designated by the Group as DCA-110 (b), appeared excessive, the Group investigated the circumstances surrounding the assembly. The computed wear rate of this jackscrew (0.0084 per 1,000 flight hours) was the second highest known to the Group.

The DCA-110 (b) assembly was sent to the NTSB Materials Laboratory for detailed examination by the Materials Group Chairman. NTSB Materials Laboratory Factual Report No. 01-082, dated September 24, 2001, was completed. Following this examination, the assembly was shipped to Integrated Aerospace and underwent another examination by the Systems Group. The following observations were noted:

Examination of marks on the lower stop and acme nut stop indicated that the lower stop had once been mis-intstalled on the acme screw. Reconstruction indicated that the "clocking" of the lower stop was offset and not in the proper position.

The upper stop did not have any numbers stamped on it, and appeared to be an older "dash 1" stop. After reviewing engineering drawings of the upper stop, it was apparent that the spline/indexing cockpit pin on this stop was moved to another re-drilled

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[46] According to Hawaiian Airlines representatives, the 1,000-hour interval checks were never accomplished.

[47] The serial number on the nut is very difficult to read. An NTSB metallurgist could discern a "D-33", while Integrated Aerospace personnel could discern a "D-8". The screw serial number is clearly distinguishable as D-3351. The manufacturing paperwork also indicates D-3351 for both the screw and nut.

hole in order to have it be modified to fit a “dash 505” configuration. According to company personnel, this is something that Integrated Aerospace personnel would not have performed.

The “joystick” or slewing force, which is the force required to move the upper bearing by side-to-side manipulation of the jackscrew was qualitatively evaluated. The jackscrew could be easily moved by hand.

The assembly was placed on a bench and a manual end-play was performed. Only a “hand tightening” of the torque tube nut was performed. The following readings were recorded:

Acme nut on Bottom of Screw	0.0220 inch
Acme nut on Middle of Screw	0.0215 inch
Acme nut on Top of Screw	0.0220 inch

The assembly was then placed on the ATP fixture under the static test load, and a forklift was used to control the direction of the applied load. The torque on the torque tube nut was set at 55 ft-lbs. The following readings were recorded with the acme nut at the “nominal” position on the screw (to simulate on-wing endplay procedure):

With Load Applied Upward	0.027 inch (not restrained)
With Opposite Load Applied	0.029 inch (w/rotation of jackscrew)
With Load Applied Upward	0.030 inch (w/ rotation of jackscrew)
Load in Both Directions	0.027 inch each time (jackscrew restrained)

The assembly was cycled up and down on the ATP fixture and no “wobbling” was observed.

The torque on the torque tube nut was then increased to 110 ft-lbs. The end play (restrained) was measured (under load) to be 0.026 inch. The torque was then reduced to zero, and the endplay remained the same.

The assembly was then removed from the ATP fixture and disassembled. The gear box support assembly was disassembled, freeing the spherical bearing and shims.

Grease samples were extracted from seven locations on the jackscrew and sent to the NTSB Materials Laboratory for additional examination.

The torque tube was press fit out of the support assembly. A polish mark (wear band) was noted on the top portion of the torque tube. There was no discernable depth to the wear band when a fingernail was passed over it. No anomalies or cracks or marks were noted on the torque tube, other than the polish mark. The torque tube had a manufacturing date stamp of 1997 on it.[48]

[48] According to Integrated Aerospace personnel, the torque tube was installed new during the Sept. 1997 overhaul of DCA110.

All of the components of the entire assembly were then cleaned. The acme nut was placed back on the screw and another manual bench end-play was performed. The following readings were obtained:

Acme nut on Bottom of Screw	0.022 inch
Acme nut on Middle of Screw	0.023 inch
Acme nut on Top of Screw	0.022 inch

The following surface finish readings were taken:

	Bottom of Screw Flanks (Non-wearing)	Top of Screw Flanks (Wearing)
Top	28	25
Middle	31	26
Bottom	37	28

A maximum of 32 Ra is surface finish is specified at manufacturer.

The screw was then placed in the Optical Comparator for examination of thread profile. The screw threads all appeared to be newly manufactured. There were no obvious anomalies, steps, burrs or wear marks noted.

The screw pitch diameter was then checked with a Johnson Gage. The following readings were recorded (specified range is 1.5591 inch min to 1.5629 inch max):

Position 1 (upper portion)	1.5609
Position 2	1.5609
Position 3 (middle portion)	1.5610
Position 4	1.5618
Position 5 (lower)	1.5610

All pitch diameter readings were within specification.

The screw concentricity was checked. The following readings were obtained (specification calls for 0.004 inch max):

Position 1 (upper portion)	0.001
Position 2	0.001
Position 3 (middle portion)	0.001
Position 4	0.001
Position 5 (lower)	0.001

The concentricity varied no more than 0.0005 inch when the torque tube was rotated while the concentricity gage was placed on the flange.

A visual (naked eye) and finger feel examination of the acme nut threads revealed the presence of "chatter marks" or "serrations" on the non-pressure edges of the thread crests of one set of acme nut threads (every other thread spiral, indicating only one of the two sets of threads).

Four castings of the acme nut threads were produced and examined under the Optical Comparator. The following observations were made:

Casting 1 – Upper Portion of Nut – Opposite Grease Fitting
No step or burrs or anomalies noted
Crest length 0.0820 inch

Casting 2 – Upper Portion of Nut – On Grease Fitting Side
No step or burrs or anomalies noted
Crest length 0.0803 inch

Casting 3 – Lower Portion of Nut – Opposite Grease Fitting Side
About 3 threads show small burrs at thread crest.
(Highest measured at 0.0116 inch)
No step
Crest length 0.0830 inch

Casting 4 – Lower Portion of Nut – On Grease Fitting Side
Numerous burrs on all thread crests
Crest length 0.0826 inch

A bore scope was then placed inside the acme nut. A live, magnified video image was projected for the Group to see. The following observations were made:

- Every other thread crest, non-pressure side, had small "dimples" along its entire circumference. These dimples appeared to be very uniform in size and pattern.
- A uniformly-thick "ridge" was noted an all thread crests, pressure side.
- A "wood grain" appearance was noted on most thread flanks, pressure side, and was circumferential. Some threads appeared to have deeper grain marks than others.
- Very few brass-colored "splinters" were noted.

A Rockwell Hardness test was then performed on the nut. The following results were recorded (specification calls for 93-100 B): 98.5 B and 98.6 B.

6.1.3 Hawaiian Airlines Investigation

On August 20, 2001, the Group Chairman revisited Hawaiian Airlines along with specialists from Boeing and the FAA. The purpose of the visit was to conduct further examinations of N601AP. The structure associated with the vertical and horizontal stabilizer of N601AP was examined for any discrepancies. Additionally, the horizontal stabilizer was tested with a Boeing restraining fixture load cell. Grease samples were extracted from N601AP and other airplanes, and maintenance records were examined. The following observations were noted:

- No discrepancies were noted with the structure of the empennage, including alignments, installations, clearances, and riggings.
- The force measurements recorded with the use of a horizontal stabilizer restraining fixture load cell while performing endplay checks yielded nominal values.
- The left side roller bearing plate (mounted to the vertical stabilizer) exhibited some scoring. The bearing itself was free to rotate.
- Very small amounts of pink-colored grit material was found inside the tail area.

Hawaiian Airlines personnel indicated that the pink-colored grit material was probably used as another medium for grit blasting. An examination of the storage room where their grit blast was stored revealed bags of a grit medium called "Australian Garnet." The material is a natural almandite garnet of 30–60 mesh manufactured by the Barton Mines Company in Lake George, New York. This garnet was stored next to bags of glass beads. A sample of the garnet was taken for analysis by the NTSB Materials Laboratory.

According to the DC-9 Structural Repair Manual (SRM), which is used by Hawaiian Airlines (excerpts attached), "abrasive blasting" is allowed for "large areas"; however, there are specific location prohibitions cited. Also, there is a note in the SRM (excerpts attached) that states: "The abrasive materials should be aluminum oxide or glass beads - never silicon carbide."

At the suggestion of the Group Chairman, Hawaiian Airlines initiated a fleet campaign to inspect for the presence of the Australian garnet in proximity to the jackscrew. A total of three aircraft, including N601AP, had positive findings.

6.2 Spirit Airlines Jackscrew: S/n DCA-302

The Group examined a jackscrew from a Spirit Airlines DC-9 airplane at Integrated Aerospace on June 12, 2001. According to Integrated Aerospace records, the endplay of the screw and nut, after it was cleaned and reassembled, was measured to be 0.062-inch. Maintenance records indicate that the jackscrew was pulled during the post-accident AD check upon discovery that its on-wing endplay was 0.057 inch (maintenance records attached).

An examination of the acme screw revealed that it had a slight "step" on its pressure flanks. Plastic castings of the nut threads were taken, and these casting were examined on an "optical comparator". Measurements taken from the optical comparator image indicated that the amount of nut thread wear was 0.037 inch. Therefore, the estimated as-received end-play from the optical comparator measurements is about 0.044 inch (0.037 inch + 0.007 inch presumed[49] initial endplay = 0.044 inch). The acme nut threads did not have any burrs, and the threads were not deflected or deformed in any way.

The acme screw was then examined under the optical comparator. A wear "step" was observed on both flanks of the screw threads. Threads in the middle portion of the screw had a step in the pressure flank that measured 0.0075 inch, and a step in the non-pressure flank of 0.0026 inch. Threads in the bottom portion of the screw had a step in the pressure flank that measured 0.002 inch, and no step in the non-pressure flank. Presuming that the screw wear contributes to the end-play, then the additional wear shown on the middle of screw thread would contribute about 0.010 inch (0.0075 + 0.0026 inch) to the nut wear (0.044 inch as mentioned above) for a total end-play of 0.054 inch.

The screw and nut underwent another bench end-play check. The end-play was measured to be 0.058 inch.

The assembly was sent to the NTSB Materials Laboratory for detailed examination by the Materials Group. NTSB Materials Laboratory Factual Report No. 01-082, dated September 24, 2001, was completed.[50]

6.3 China Northern Jackscrew: S/n DGA-2204

On June 12, 2001, at Integrated Aerospace, the Group examined the acme screw and nut assembly from a China Northern MD-90 airplane that had a reported end-play of 0.100 inch. The assembly had not yet been disassembled. The nut had an end-play stamp of 0.004 on it, indicating the production end-play at the time of manufacture. The unit was placed on the ATP fixture and was subjected to the static tensile test load and a reversing, compressive load. End-plays of 0.032 and 0.033 inch were recorded.[51] The assembly was then operated and no "wobble" (fore-to-aft or side-to-side rocking of the acme nut) was discerned.

The unit was then disassembled. No damage was noted on the lower stop. The upper portion of the torque tube had a polished band on it; the polishing was not worn enough to produce a discernable groove when dragging a fingernail across it.

The acme nut and screw were disassembled, steam cleaned, and reassembled. A bench check of the endplay yielded 0.022 inch at the middle and lower positions on the screw. The unit was re-lubricated, and the endplay was repeated on the bench; a reading of 0.022 inch was obtained. The screw and the nut were subsequently cleaned.

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[49] The initial endplay has a specified range of 0.003 to 0.010.
[50] This report can be found under separate cover in the NTSB's public docket for this investigation.

[51] The end-play was taken by using a forklift to lift the static load off the assembly, and subsequently applying a compressive load.

The unit was then reassembled and placed on the ATP fixture, without lubrication. The endplay reading, under the compressive load, was 0.0305 inch. The unit was then taken out of the fixture and underwent another bench endplay. The bench endplay was 0.028 inch. The unit was then placed back on the ATP fixture, lubricated, and operated through two cycles. The endplay was then measured under the compressive load of the ATP fixture to be 0.030 inch.

Plastic castings of the nut threads were then taken, and these castings were examined on the optical comparator. Measurements taken from the optical comparator image indicated that there was a step that measured 0.0272 inch in length on the pressure flank side of the nut thread. The nut thread crest measured 0.078 inch. Additionally, the end-play stamped on the nut indicated that it left the manufacturer with an end-play of 0.004 inch. Therefore, the estimated as-received end-play from the optical comparator measurements is about 0.0312 inch. (0.0272+0.004 starting endplay = 0.0312 inch). The nut threads were not deflected; however, the thread crest had a slight lip on the pressure flank side.

The acme screw was then examined under the optical comparator. Threads in the middle portion of the screw had a step in the pressure flank that measured 0.0015 inch, and no step in the non-pressure flank. Presuming screw wear contributes to endplay, then the total end-play would be 0.0312 + 0.0015 = 0.0327 inch.

With an end-play reading of 0.033 inch, after the airplane accumulated about 11,000 flight hours, and with a starting endplay of 0.004 inch, the wear rate of this acme nut and screw assembly is estimated to be 0.0026 inch per 1,000 flight hours.

An examination of the acme nut revealed that the nut threads had numerous burrs along the length of the threads. Some of the burrs could be separated from the base material as splinters that measured about 0.002 inch in thickness.

A magnified bore scope device was used to probe the nut threads. It appeared that the crests of the threads had numerous “feather burrs” on their edges, and there was evidence of darker areas, or “staining” on the threads.

The assembly was also examined at the NTSB Materials Laboratory. NTSB Materials Laboratory Factual Report No. 01-082, dated September 24, 2001, was completed.[52]

6.4 U.S. Navy Jackscrew

On June 12, 2001, at Integrated Aerospace, the Group examined jackscrew components that were shipped to Integrated Aerospace from a Navy contract maintenance facility by direction of the NTSB. The jackscrew had already been disassembled prior to shipment. The assembly had reportedly been removed by the Navy

[52] This report can be found under separate cover in the NTSB’s public docket for this investigation.

from a C-9 aircraft as a result of “shavings” being found when it was inspected as a result of the AD.

The Group determined that the acme nut could not be screwed onto its mating screw. It appeared that the nut has received externally induced damage. There were several tool marks (half-moon impressions) on the side of the nut, which appeared to have pushed in the nut threads, causing binding between the nut and the screw.

Plastic castings of the nut threads were taken, and these castings were examined on an "optical comparator". Measurements taken from the optical comparator image indicated that the nut thread crest measured 0.083 inch. This nut did not appear to have excessive end play. No evidence of thread deflection, deformities, or burring were present in the nut threads.

6.5 AeroCalifornia Jackscrew: S/n AZ004

The Group was informed of records that indicated that an acme screw and nut assembly was removed from an AeroCalifornia DC-9 due to a reported 0.071 on-wing end-play and was awaiting overhaul at a repair station located near Los Angeles. The Group visited the repair station and examined the jackscrew. The examination revealed the following:

The acme screw had no steps on the thread flanks. The screw had areas where black oxide had worn off. The nut threads had small burrs on the crests. Endplay measurements of about 0.040 inch were obtained with the nut in both the improper (as received by the overhaul shop from a parts broker) and then in the proper configuration.

6.6 Overhauled Jackscrew Data from 1996-1999

Boeing provided bench endplay data of all jackscrews that had been shipped to Integrated Aerospace for overhaul from 1996 through 1999.

A review of the data revealed the following:

- 211 jackscrews were reported to be overhauled by Trig during 1996-1999
- 13 jackscrews had a recorded bench endplay of 0.045 inch or greater
- 5 jackscrews had a recorded bench endplay of 0.055 inch or greater
- 1 jackscrew had a bench endplay of 0.075 inch.

6.7 Overhauled Jackscrew from Airline D: Endplay of 0.075 inch

The jackscrew that had a recorded bench endplay reading of 0.075 inch was the highest reported endplay reading known to the Systems Group. According to Integrated Aerospace records, the jackscrew was received from Airline D and overhauled in 1999. According to representatives from Airline D, this jackscrew, s/n DCA-2239, was originally installed in an MD-88 airplane that was delivered new to Airline D from

McDonnell Douglas on March 17, 1993. On July 18, 1999, Airline D performed an on-wing endplay check and the check revealed an endplay of 0.075-inch. The airplane had accumulated 18,416.5 flight hours and 14,520 cycles at that time, and the jackscrew had never been changed. The excessive endplay prompted Airline D to remove the jackscrew and send it to Trig Aerospace for overhaul. Trig received the jackscrew on Oct. 29, 1999, measured the endplay on the bench as 0.075-inch, and mated a new acme nut to the overhauled screw. The assembly was returned to Airline D on December 17, 1999. No further information related to the maintenance history of this jackscrew was found. According to representatives at Integrated Aerospace, the acme nut was scrapped after the jackscrew was overhauled, as per routine procedure. If the endplay and flight hour figures were reported accurately for this jackscrew, the wear rate would be about 0.0037 per 1,000 flight hours. Airline D reported that their lubrication interval in 1999 was 1,750 flight hours, and their endplay check interval was 10,500 flight hours.

7.0 Jackscrew Data for Entire Alaska Airlines Fleet

The following data was obtained from Alaska Airlines and Boeing in an effort to produce a complete inventory of all jackscrews used by Alaska Airlines:

Alaska Airlines Airplane Tail No.	Original Airline Airplane?	Airplane Delivery Date	J-screw Flight Hours	ENDPLAY[53]	YEAR R/R'd[54]	WEAR RATE[55]	J-screw serial no.
N931AS	Y	d 2/85	46834	0.029	2000	**0.00047**	DCA 1315
932	Y	d 6/85	45521	0.032	2000	**0.00055**	DCA 1364
933	Y	d 6/85	46499	0.031	2000	**0.00052**	DCA 1365
934	Y	d 11/85	45170	0.031	2000	**0.00053**	DCA 1400
935	Y	d 12/85	45860	0.04	2000	**0.00072**	"AC935"
937	Y	d 5/86	42918	0.024 (ow)	ORIG	**0.00039**	UNK
943	Y	d 11/90	30853	0.02	2000	**0.00042**	DCA 1934
944	Y	d 11/90	30213	0.019 (ow)	ORIG	**0.00039**	UNK
947	Y	d 12/90	27860	.029	1999	**0.00079**	DCA 1935
948	Y	d 12/90	30181	0.022 (ow)	ORIG	**0.00049**	UNK
949	Y	d 12/90	29599	0.018	2000	**0.00037**	DCA 1974
950	Y	d 2/91	30257	0.024 (ow)	ORIG	**0.00056**	UNK
951	N	d 12/83	52894	.045	2000	**0.00074**	"AC951"
951 (#2)		N/a	1387	.010	2000	**0.004**[56]	DCA 1645
953	N	d 12/86	43670	0.02	2000	**0.0003**	DCA 1475
954	N	d 12/86	42192	0.033	2000	**0.00062**	DCA 1467
955	N	d 11/81	61769	0.010	2000	**0.00005**[57]	"AC955"

[53] Most endplay readings in this column were taken during a bench endplay measurement after the jackscrew was removed. If no bench reading could be obtained, than the reading from the most recent on-wing endplay check was used, and these are denoted by a "(ow)" after the reading.
[54] R'R'd is an abbreviation for "removed and replaced" of the jackscrew.
[55] The wear rates shown for the original jackscrews in this column assume an initial endplay at delivery of 0.007-inch, which is the mean between the 0.003 to 0.010-inch specification for manufacture.
[56] The wear rate reflected in this jackscrew represents the initial wear-in period of a newly-manufactured jackscrew.

Alaska Airlines Airplane Tail No.	Original Airline Airplane?	Airplane Delivery Date	J-screw Flight Hours	ENDPLAY	YEAR R/R'd	WEAR RATE	J-screw serial no.
958	Y	d 3/91	29999	0.022 (ow)	ORIG	**0.0005**	UNK
960	Y	d 3/92	27502	0.032	2000	**0.00091**	DCA 2163
961	Y	d 3/92	27392	0.029	2000	**0.0008**	DCA 2184
962	Y	d 4/92	26750	0.019 (ow)	ORIG	**0.00045**	UNK
963	Y	d 5/92		*See below*	N/A	***See below***	DCA 2064
964	Y	d 6/92	26348	.023	2000	**0.00061**	DCA 2192
965	Y	d 6/92	28710	0.018	2000	**0.00038**	DCA 2120
967	N	d 12/82	53181	0.03 (ow)	2000	**0.00043**	DCA 1630
968	Y	d 9/91	27551	0.025	2000	**0.00065**	DCA 1876
969	Y	d 9/91	28227	0.01 (ow)	2000	**0.00011**	DCA 1840
972	Y	d 3/94	23123	0.028	2000	**0.0009**	DCA 2251
973	Y	d 3/94	20640	.036	2000	**0.0014**	DCA 2264
973 (#2)		N/a	30354[58]	0.022	2000	**0.0005**	DCA 1840
974	Y	d 3/94	22307	0.044 (ow)	2000	**0.0017**	DCA 2267
975	Y	d 5/94	19960	0.030	1999	**0.0012**	DCA 2272
975 (#2)		N/a	1387	.031	2000	**0.0022**[59]	DCA 1171
976	Y	d 4/95	22722	0.016	2001	**0.00041**	DCA 2186
977	Y	d 5/95	17463	0.014 (ow)	ORIG	**0.0004**	UNK
979	Y	d 5/96	13646	0.021 (ow)	ORIG	**0.00103**	UNK
981	Y	d 4/97	10201	0.053	2000	***0.0045***	DCA 3008
982	Y	d 5/97	9980	0.048	2000	***0.0041***	DCA 3000

Because of the 1997 endplay check of N963AS, the accident damage, and the unique characteristics of the acme nut thread remnant, it is not possible to clearly define the pertinent wear rate for the accident airplane. Therefore, the following tables are presented to offer possible wear rate scenarios:

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[57] Given the relatively high number of flight hours, and relatively low bench endplay, this jackscrew may not have been the original jackscrew installed on the airplane. N955AS was purchased by Alaska Airlines with 24,177 flight hours. If the previous owner removed and replaced the jackscrew at the time the airplane was sold to Alaska Airlines, the resulting calculated wear rate is 0.00008-inch per 1,000 flight hours. If the jackscrew was removed and replaced prior to the sale to Alaska Airlines, the calculated wear rate would be between 0.0005 and 0.0008 inch per 1,000 flight hours. According to Alaska Airlines, they have never replaced a jackscrew on this airplane.

[58] The flight hours reflected here are for the jackscrew. This jackscrew was previously taken from N969AS with 28,227 hours, then accumulated an additional 2,127 hours before being pulled from N973AS.

[59] The wear rate measurement is based on a recorded bench starting endplay of 0.028-inch from an overhaul shop when it was placed onto N975AS. After installation onto N975AS, the airplane accumulated only 1,387 flight hours until the airline removed and replaced it as a precaution. This wear rate would change significantly if either the starting or ending bench endplay is not accurate within +/- 0.001.

Computed Wear Rates for N963AS: <u>Delivery to 1997 Endplay</u>

TIMEFRAME & ENDPLAY	**WEAR RATE**[60] (inches / 1,000 flight Hours)
From zero hours to Sept. 1997 endplay check (26,600 hours), and assuming a **0.033-in**. endplay at that time.	0.0015
From zero hours to Sept. 1997 endplay check (26,600 hours), and assuming **0.040-in**. endplay at that time.	0.0019

Computed Wear Rate for N963AS: <u>1997 Endplay to Accident</u>

TIMEFRAME & ENDPLAY	**WEAR RATE** (inches / 1,000 flight Hours)
From Sept. 1997 endplay check to accident (8,900 hours), assuming **0.033-in**. endplay in Sept. 1997, and **0.070-in**. total acme nut actual wear at accident.	0.0049
From Sept. 1997 endplay check to accident (8,900 hours), assuming **0.033-in**. endplay in Sept. 1997, and **0.080-in**. total acme nut actual wear at accident.	0.0061
From Sept. 1997 endplay check to accident (8,900 hours), assuming **0.033-in**. endplay in Sept. 1997, and **0.090-in**. total acme nut actual wear at accident.	0.0072
From Sept. 1997 endplay check to accident (8,900 hours), assuming **0.033-in**. endplay in Sept. 1997, and **0.100-in**. total acme nut actual wear at accident.	0.0083
From Sept. 1997 endplay check to accident (8,900 hours), assuming **0.033-in**. endplay in Sept. 1997, and **0.120-in**. total acme nut actual wear at accident.	0.0110
From Sept. 1997 endplay check to accident (8,900 hours), assuming **0.033-in**. endplay in Sept. 1997,and **0.140-in**.total acme nut actual wear at accident.	0.0128
From Sept. 1997 endplay check to accident (8,900 hours), assuming **0.040-in**. endplay in Sept. 1997, and **0.070-in**. total acme nut actual wear at accident.	0.0042
From Sept. 1997 endplay check to accident (8,900 hours), assuming **0.040-in**. endplay in Sept. 1997, and **0.080-in**. total acme nut actual wear at accident.	0.0053
From Sept. 1997 endplay check to accident (8,900 hours), assuming **0.040-in**. endplay in Sept. 1997, and **0.090-in**. total acme nut actual wear at accident.	0.0064
From Sept. 1997 endplay check to accident (8,900 hours), assuming **0.040-in**. endplay in Sept. 1997, and **0.100-in**. total acme nut actual wear at accident.	0.0075
From Sept. 1997 endplay check to accident (8,900 hours), assuming **0.040-in**. endplay in Sept. 1997, and **0.120-in**. total acme nut actual wear at accident.	0.0098
From Sept. 1997 endplay check to accident (8,900 hours), assuming **0.040-in**. endplay in Sept. 1997, and **0.140-in**. total acme nut actual wear at accident.	0.0120

[60] The wear rates shown in the wear rate columns of all of these tables assume an initial endplay at delivery of 0.007-inch, which is the mean between the 0.003 to 0.010-inch specification for manufacture.

Computed Wear Rate for N963AS: Delivery to Accident

TIME FRAME & ENDPLAY	WEAR RATE (inches / 1,000 flight Hours)
From zero hours to time of accident (26,600 hrs), assuming total acme nut actual wear at accident was **0.070-in.**	0.0026
From zero hours to time of accident (26,600 hrs), assuming total acme nut actual wear at accident was **0.080-in.**	0.0030
From zero hours to time of accident (26,600 hrs), assuming total acme nut actual wear at accident was **0.090-in.**	0.0034
From zero hours to time of accident (26,600 hrs), assuming total acme nut wear actual at accident was **0.100-in.**	0.0038
From zero hours to time of accident (26,600 hrs), assuming total acme nut actual wear at accident was **0.120-in.**	0.0045
From zero hours to time of accident (26,600 hrs), assuming total acme nut actual wear at accident was **0.140-in.**	0.0053

These data reveal that three airplanes, N981AS, N982AS, and the accident airplane (N963AS), all had mature jackscrews and experienced acme nut wear rates in excess of 0.004 inch per thousand flight hours. A chronology of the most recent lubrication dates and locations for these three airplanes is as follows:

Date of Lubrication	Aircraft Tail No.	Location of Lubrication
2-27-97	963	San Francisco (On the line)
10-2-97	963	Oakland (C-check)
1-1-98	981	Seattle (On the line)
6-26-98	963	San Francisco (On the line)
8-2-98	981	Oakland (C-check)
9-5-98	982	Oakland (C-check)
1-13-99	963	Oakland (C-check)
4-26-99	981	San Francisco (On the line)
5-5-99	982	San Francisco (On the line)
9-24-99	963	San Francisco (On the line)
12-9-99	981	Oakland (C-check)
12-17-99	982	Oakland (C-check)
1-30-00	963	(Accident)

8.0 Airline Survey Results of Jackscrew Maintenance

The Systems Group Chairman sent a survey form (attached) to all operators of DC-9 / MD-80/90/ B717 airplanes who have at least 10 subject airplanes in their fleet. The survey asked the airlines to report what their acme screw and nut lubrication and endplay intervals were prior to the Alaska Airlines flight 261 accident. Additionally, the airlines were asked for the type of grease used, number of units removed in 1998-99, and their internally-imposed maximum allowed endplay limit prior to the accident. The following survey results were obtained ("wcf" represents the phrase "whichever comes first"):

Airline	Aircraft Type	Endplay interval	Lubrication Interval	Grease Type	Units Rem'd 1998-99	Max allowed endplay
A	DC-9	3,300 hrs. 15 mo.- wcf[61]	550 hrs.	A-22	3	0.040 in.
	B-717	7,200 hrs. r 30 mo.- wcf	3,600 hrs. 15 mo. –wcf	A-22	0	0.040 in.
B	DC-9 -10	6,900 hrs. 36 mo.- wcf	1,815 hrs.	M-28	18 (total for all)	0.031 in.
	DC-9 - 30/40/50	7,720 hr. 36 mo.- wcf	1,815 hrs.	M-28	Included above	0.031 in.
C	MD-80	8,000 hrs. 24 mo.-wcf	1,100 hrs	A-7	4	0.040 in.
D	MD-88	10,500 hrs. 42 mo. - wcf	1,750 hrs. 7 mo.- wcf	MIL 23827	2	0.040 in.
	MD-90	7,200 hrs 15 mo .- wcf	3,600 hrs. 15 mo.- wcf	MIL 23827	0	0.040 in.
E	DC-9	2,000 hrs. 24 mo.- wcf	2,000 hrs. 24 mo.- wcf	M-28	0	0.034 in.
F	DC-9	3,000 hrs. 18 mo. –wcf	1,000 hrs & C-ck (3K/15m)	A-22	2	0.040 in.
G	MD-80	8,400 hrs. (no calendar)	940 hrs.	M –28 A-7,-22	0	0.040 in.
H	DC-9	None (hard time at 15.5k)	675 hrs.	A-7	8	0.040 in.
	MD-80	3,500 hrs. 12 mo. –wcf	1,400 hrs.	A-7 M-28	6	0.035 in.
I	DC-9	5,060 hrs (even C-chk)	2,530 hrs. (every C-chk)	M-28	50 (since 1983)	0.038 in.
J	DC-9	20 mos. (C-chk)	10 mos (C&midC-ck)	M-28	9	0.040 in.
K	DC-9	1,750 hrs	600 hrs.	MIL-G 23827	0	0.040 in.
	MD-80	3,600 hrs. 15 mo. - wcf	600 hrs.	MIL-G 2382	0	0.040 in.
L	DC-9	2,928 hrs.	1,264 hrs.	M-28	5	0.040 in.
	MD-80	7,000 hrs.	1,750 hrs.	M-28	0	0.040 in.
Alaska	**MD-80**	**2C - chk At 30 mos. (9,950hr)**	**8 months (approx. 2,550 hrs.)**	**A-33**	**3**	**0.040in.**

The survey also included a request by the operators to provide the endplay check procedures that were in effect immediately prior to the accident. The review revealed the following:

[61] "wcf" is an abbreviation for "whichever comes first."

Airline I: The routine work card for the jackscrew endplay contains instructions to install the restraining fixture, apply torque to the lower torque tube retaining nut, lower the torque until the washer is free to rotate, then raise the torque to 55 ft-lbs (+/- 5 ft-lbs). After this is performed, the instructions call for mounting the dial indicator and obtaining the endplay reading.

Airline L: This airline also had a procedure (for DC-9 only) to re-torque the lower torque tube nut prior to the endplay check. The procedure states: Apply 200 in-lbs to restraining fixture. Re-torque "nut assembly at bottom of torque tube" to 55 $\pm$ 5 ft-lbs. Remove torque to restraining fixture. Perform nominal endplay check. Also, a "worksheet" is provided to record five free play and endplay readings. This same airline did not use this procedure for the MD-80/81/82; for these airplanes, the procedure was as per the nominal manufacturer procedures, (i.e. no torque tube nut re-torqueing); however, there is a reference at the very end of the procedure that states: "Double safety nut with .041 steel lockwire. CAUTION: Threads on the nut are left hand. Make sure safety nut is installed correctly" Also, there is no worksheet provided to record endplay like the DC-9 procedure.

Airline K: The dial Indicator call out is for "Starcraft", not Starrett as per the Boeing procedure. The work card provides four blank spaces to write in endplay and free play numbers.

Airline J: Nominal procedure as per manufacturer.

Airline H: Nominal procedure as per manufacturer.

Airline G: The endplay work card states to restrain jackscrew; however, this was not found in the airline maintenance manual procedure.

Airline F: Nominal procedure as per manufacturer.

Airline D: Did not provide endplay check procedure documentation.

Airline B: The endplay procedure stated: "verify jackscrew does not rotate and exaggerate the free play values while torqueing the restraining fixture." The work card that was submitted provided a procedure to measure the end play, but did not address the free play. (It is unknown if there was a separate work card for free play). The endplay work card has a blank space to record end play reading

Airline A: The work card has four blanks to fill in endplays. There is also a blank for "Final Results"

9.0 End-Play Data Analysis

The Group requested that endplay data being reported by U.S. airlines as a result of AD 2000 15-15[62] be analyzed by Safety Board research analysts in an attempt to correlate pre-accident airline lubrication intervals with acme screw and nut wear. Initial analyses of the data indicated that the requested correlation could not be performed; however, additional analyses were performed to investigate the adequacy of the endplay check procedure. A report of these analyses was prepared by the NTSB's Office of Research and Engineering.[63]

The first section of the report focuses on the AD-mandated on-wing end play measurements that were collected between February 2000 and June 2001. It describes the techniques that were used to screen and prepare the data for statistical analysis as well as providing an overview of the methods that were employed to assess the reliability of the end play measure. The second section of the report is devoted to an examination and analysis of the small subset of cases where both on-wing and bench-check end play measurement data are available. At the end of each section, results and interpretations of our statistical analyses are provided.

10.0 Jackscrew Overhaul Investigations

10.1. Background

According to Boeing and FAA, the jackscrew is classified as an aircraft accessory component and can be overhauled by airlines and/or repair stations that have appropriate FAA-approved repair station ratings. The procedures that are set forth to overhaul jackscrews are specified in the Douglas Aircraft Company DC-9 Overhaul Maintenance Manual, Horizontal Stabilizer Actuator Control Installation chapter. This overhaul manual, which is normally accepted by the FAA, delineates the acme screw as "screw"-- item no. 52; the acme nut as "nut"-- item no. 51; and the assembly of the acme screw, acme nut, and gimbal ring support assembly pieces as the "nut assembly"-- no. 40.

The overhaul manual specifies that if axial end play exceeds 0.040 inch, the nut assembly (40) must be replaced. This allows the overhaul facility to continue to refurbish all components of the jackscrew assembly (i.e. fasteners, torque tube, torque tube nut, lower stop, gear box components, upper bearing, etc.), except for the acme screw, acme nut and associated gimbal ring support components. If the facility must install another nut assembly, the replacement nut assembly can either be a newly manufactured assembly purchased from Douglas/Boeing, which would have an end play of 0.003 to 0.010 inch, or a used assembly which would have an endplay no greater than 0.040 inch.

[62] AD 2000 15-15 requires all U.S. operators of DC-9, MD-80/90, and 717 series airplanes to perform the endplay check every 2,000 flight hours and report the end play measurements to the manufacturer after every check. Before the Alaska Airlines flight 261 accident, operators performed the check at various intervals that exceeded 2,000 flight hours, depending upon the approval of each airline's maintenance program by the airline's FAA principal maintenance inspector (PMI).
[63] This report can be found under separate cover in the NTSB's public docket for this investigation.

The overhaul manual does not provide instructions to mate another acme nut to the subject nut assembly. The overhaul shop also has the option of sending nut assemblies that exceed 0.040 inch end play to Boeing to perform an overhaul of that assembly. If this occurs, Boeing would receive the used nut assembly and forward it to a contracted repair facility (e.g. Integrated Aerospace) for overhaul.

According to Boeing, Integrated Aerospace (IA) is Boeing's only contracted overhaul facility to perform overhauls of the nut assembly. Integrated Aerospace receives the used nut assemblies, disassembles them, scraps the acme nut and gimbal ring supports in all cases, and conducts a detailed dimension check of the screws. Screws that meet internal IA minimum specifications are refurbished and mated to a new acme nut. . The IA minimum specifications for overhaul are generally more stringent than the requirements specified in the DC-9 Overhaul Maintenance Manual. Each nut and screw pair is re-serialized and new gimbal ring supports are installed. According to Integrated Aerospace, the maximum limit of axial end play that they will allow for the overhaul of a jackscrew (without an acme nut replacement) is 0.015 inch. (This is 0.005 inch higher than the maximum end play stipulated by the jackscrew production drawing. Used acme nut with endplays in excess of 0.015 inch are to be replaced by Integrated Aerospace)

According to Boeing, the installation of the gimbal ring supports involves precision machining at tolerances as small as five ten-thousandths of an inch so that the alignment of fastener bores within the gimbal ring supports, the gimbal rings, and the acme nut are adequate to maintain the integrity of the dual load path design. Following the build-up of the nut assembly, Boeing requires (as per drawing) that the nut assembly be functionally testing in a weighted fixture after the nut assembly is temporarily outfitted to additional support hardware and electric motors. This requirement is not found in the overhaul manual; however, Integrated Aerospace also performs this operational test for both new and overhauled units.

The instructions and specifications that Boeing imposes upon its contracted overhaul facility for the overhaul of a nut assembly are contained in a Boeing Service Rework Drawing (SRD).[64] Integrated Aerospace, as Boeing's sole contractor to perform "zero time" overhauls of nut assemblies, is the only overhaul facility to possess this drawing. The SRD is considered proprietary by the Boeing Company and ensures that Boeing maintains confidence and control over the precise machining tolerances of the gimbal ring supports and the criticality of the axial endplay of the acme nut and acme screw.

Jackscrew assemblies may require an overhaul for reasons other than excessive end play. For example, the free play tolerances may have been exceeded, or the lower stop may have been damaged due to a electric shut-off failure or misrigging. This type of overhaul may conceivably allow the airline or overhaul facility to satisfactorily complete

[64] Prior to the Alaska Airlines accident, information collected from numerous production drawings and proprietary documents served as the basis for the rework instructions. Following the accident, the FAA required Boeing to more formally organize the rework procedures. This requirement gave rise to the service rework drawing.

the overhaul with a screw assembly endplay of 0.040 inch. There is no requirement in the overhaul manual to record the outgoing endplay reading, nor alert the customer that its newly overhauled jackscrew that the endplay is at the maximum limit of 0.040 inch.

According to the FAA, inspectors from local FAA Flight Standards District Offices, are assigned to conduct surveillance at airline and overhaul facilities to ensure that they are complying with federal regulations. Airlines and overhaul shops may be granted authority to conduct overhauls if they comply with FAR section 145.31(f)(1) Class 1 Accessory Ratings. The FAA Airworthiness Inspection Handbook 8300-10, Chapter 161, provides guidance and procedures to the FAA Inspectors to certify a repair station; however, this guidance does not cite specific critical aircraft components such as a jackscrew which is currently classified as a Class 1 Accessory Ratings. The current Order does not stipulate a process to ensure that an overhaul facility is capable of performing overhauls of specific parts, nor does the Order require that the sub-vendors hold current revisions of the overhaul manual and retain updated airworthiness directives.

10.2 Integrated Aerospace Repair Station

The Group visited the Part 145 Repair Station section of Integrated Aerospace. Integrated Aerospace (formerly Trig Aerospace) is the Original Equipment Manufacturer (OEM) of the Acme screw and nut. The following factual observations were noted:

- Integrated Aerospace uses a set of detailed work cards that documents the overhaul procedure. These cards detail each step of the overhaul process, and are in addition to the Douglas DC-9 Overhaul Maintenance Manual for the jackscrew.

- Integrated Aerospace uses a Boeing Service Rework Drawing (SRD) to supplement the DC-9 Overhaul Maintenance Manual after the accident. This SRD allows IA to replace a worn acme screw and match a new acme nut to an in-service acme screw.

- Integrated Aerospace's self-imposed end-play limit is 0.015 inch after overhaul. If the endplay exceeds this figure, they will inform the customer that they will replace the screw and nut with a newly-manufactured set. They stated that they rarely send overhauled assemblies out with endplays between 0.010 inch and 0.015 inch (i.e. most overhauls require new acme nuts to be installed)

- Integrated Aerospace performs about 100 jackscrew overhauls per year. The following is a listing of the number of overhauls performed annually since 1994:

Year	Number of Units Overhauled
1994	23
1995	40
1996	47
1997	60
1998	75
1999	80
2000	157

10.3 Southern California Repair Station.

The Group visited another FAR Part 145 overhaul shop located in Southern California that overhauls jackscrews. The company is a manufacturing and overhaul facility founded in 1973. The company specializes in precision machining of high-strength steels. Its primary products are landing gear, actuators, accessories, and structural components. The Part 145 authorization allows the facility to overhaul hundreds of different types of aircraft components. The following are factual observations noted by the Group:

- Prior to the accident, the assigned PMI was not aware of DC-9 jackscrews being overhauled at this facility until he was informed by the company that they had received a suspect assembly from Aerocalifornia Airlines after the accident.[65] The PMI stated that he had surveyed numerous overhaul shops that overhaul hundreds of types of components, and that there was no updated comprehensive listing available for use by PMIs to make them aware of every component type overhauled by the repair stations that they survey.

- The repair station utilized a unique fixture to obtain endplay readings on acme screw and nut assemblies. The self-contained fixture provides a force on the acme nut by screwing onto the acme screw. The end-play reading is then taken by direct dial indicator reading. Rotation of the acme screw is eliminated by this design. This fixture is not referenced in the DC-9 overhaul manual.

- Representatives of the repair station stated that their internal policy is to limit acme screw and nut assemblies to a maximum endplay limit of 0.025 inch. If an assembly is received for overhaul that is beyond this limit, then the overhaul shop will scrap the acme nut.

[65] Coincidentally, the PMI also served on the Structures Group for the Alaska Airlines accident investigation.

- Representatives of the repair station stated that they overhaul about six acme screw and nut assemblies per year, and that their customers include numerous aircraft parts brokers and several Mexican airlines.

- The repair station did not have any written overhaul procedures or documentation other than the DC-9 jackscrew overhaul manual. By using this DC-9 overhaul manual, the Group could not determine which sections in the DC-9 overhaul manual were performed on a particular jackscrew. Additionally, ,the Group was unable to determine if each step of the overhaul was satisfactorily inspected after reviewing the paperwork that documented completed jackscrew overhauls.

- The repair station routinely contracts out specific jackscrew overhaul tasks to sub-vendors, which may not be required to be an FAA-approved repair station under FAR Part 145, thus eliminating FAA surveillance. These tasks include plating, black oxide finishing, and non-destructive testing.

- The Group did not observe any documents that provided procedures for an inspection process after a part is overhauled or repaired from a sub-vendor, or for parts sent in from the outside. Exemplar paperwork reviewed by the Group revealed that an overhauled jackscrew released for service to a domestic airline had an endplay of 0.025 inch; however, the overhaul shop could not provide any data to indicate that the endplay of the jackscrew measurement was taken prior to the overhaul process, so a determination could not be made as to whether this assembly should have been overhauled or scrapped as per the self-imposed limit of 0.025 inch.

- Representatives of the repair station agreed that the acme screw surface finish is critical. They stated that they could verify the screw surface finish by feeling it and comparing it with a surface finish scratch pad template.

- Representatives of the repair station stated that they remove the original nameplate and replace it with one of their own (with data transposed from the original nameplate) whenever they overhaul a jackscrew. This nameplate removal procedure is not specified in the overhaul manual and this repair station is not associated with Integrated Aerospace, the original equipment manufacturer.

- Representatives of the overhaul shop stated that they do not typically lubricate the acme screw and nut assembly following overhaul.[66]

- The Group reviewed an overhauled jackscrew which revealed that the part number, serial number, manufacturing data, and manufacturer name were not on the jackscrew assembly. The only visible number stenciled on the gimbal nut bracket was a job number.

[66] This is contrary to the overhaul manual requirements.

10.4 Georgia Repair Station

The Group reconvened in Georgia on June 2, 2001, to review a third Part 145 repair station that performs jackscrew overhauls. The repair station was founded in 1968 and overhauls between 1,500 and 2,000 different types of parts. The facility overhauled six acme screw and nut assemblies in the year 2000. The following observations were made by the Group:

- Records of overhauls are retained by the facility for a total of 2 years, as per FAA regulations (The Group did not review any jackscrew overhaul document during this visit.)

- No in-service jackscrews were not available at the time of the Group's visit; therefore, the Group was unable to observe how this repair station overhauls a jackscrew.

- There were no engineers on staff. [67]

- The shop underwent a rigorous FAA inspection immediately after the Alaska Airlines accident. No significant findings were noted by the local FAA FSDO.

- Facility representatives stated that they use a magnet to hold the dial indicator in place on the screw, and that the nut is "held on a table" for the manual end-play check. They do not use a fixture for this check. They perform several endplay readings and use the "worst" (highest) measurement.

- Facility representatives stated that if a jackscrew had a high endplay upon overhaul, they would probably alert the customer. However, prior to the accident, they would not have. They stated that there is no requirement to alert the customer.

- Facility representatives stated that they have no internal endplay limit. They will overhaul a jackscrew and ship it to the customer no matter how high the endplay value, as long as it is no greater than 0.040 inch, as per the overhaul manual.

- Facility representatives stated that they would rely on the vendor who performs the black oxide coating to ensure the surface finish is correct. They do not check the surface finish themselves.

- Facility representatives stated that many of their employees are not licensed airframe and powerplant mechanics, nor are they required to be licensed.

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[67] There is no requirement for overhaul shops to employ engineers.

- Facility representatives stated that they found numerous discrepancies in the DC-9 overhaul manual.[68]

- They indicated that the black oxide process is performed only if a "judgment" is made to do it, upon examination of the screw.

- Before the accident, the facility only used the overhaul manual for guidance. Since the accident, they now employ "tip sheets" that provide clarification and a more readable checklist for technicians to use while overhauling the screw. The "tip sheet" is a work card, and each step requires 3 initials for completion.

10.5 Northern California Overhaul Shop Visit

The Group Chairman visited a fourth Part 145 repair facility in Northern California on June 15, 2001. The following observations were noted:

- The shop overhauls jackscrews only. Additionally, their only clients are the U.S. Navy and Air Force. They have been performing these overhauls since 1994, except for a period of time that spanned from February 1999 through September 2000.[69]

- The shop utilized a wooden cradle to hold the acme screw and nut assembly in a horizontal position in order to perform the end play check. The endplay check was performed by moving the acme nut by hand while reading a dial indicator that was attached to the acme screw via a magnetic fixture. The dial indicator was not a Starret indicator.[70]

- The chief inspector stated that they will not overhaul the acme nut if the end play is greater than 0.030 inch. In those cases, he will obtain a new acme screw and nut from Boeing.

- The chief inspector stated that he does not inform the customer of the final end play reading after overhaul.

- The shop utilizes Aeroshell 22 to lubricate the acme screw and nut. The overhaul manual specifies MIL-G-81322, and Aeroshell 22 is qualified under this specification.

- The shop utilizes the most recent overhaul manual.

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[68] Many of these discrepancies are addressed later in this report under section 10.7.

[69] During that time, the military had contracted the overhauls to a facility in Alabama.

[70] A Starret indicator is specified in the MD-80 airplane maintenance procedure for the endplay check. The overhaul manual does not specify how, and with what specific tools, an endplay check should be accomplished.

- The chief inspector stated that he believes he could interchange acme screw and nuts during the overhaul process if he desired, and that the manual does not clearly prohibit this; however, he stated that he would never attempt this. He stated that the acme nut is not defined as a "life limited" or "critical" part.

- The shop utilizes a surface finish scratch pad template to ensure the surface finish meets specifications. No demonstration was performed to the Group.

10.6 Parts Broker Visit

The Group Chairman visited an Aircraft Parts Broker located in Southern California on February 24, 2001. The broker was listed on an "ILS" subscription listing of organizations that can sell jackscrews and other aircraft components[71]. The office was located in an industrial park and consisted of a storage room filled with various aircraft components that were received from overhaul shops and awaiting sale to airlines that wished to purchase them. The sales manager of the office stated that he had a recently-overhauled jackscrew in stock; it was inspected by the Group Chairman. The inspection revealed that it was stored in an opened cardboard box and was wrapped loosely in plastic. Documents that accompanied the assembly indicated it was overhauled by a repair station located in the Los Angeles area in November 2000 due to a broken upper stop. The documents did not contain any endplay readings or detailed information related to the overhaul process. The assembly had red grease on it.

10.7 Overhaul Manual

The NTSB review of the Douglas Aircraft Company DC-9 Overhaul Maintenance Manual, Horizontal Stabilizer Actuator Control Installation, dated April 15, 1998, (excerpts attached) noted the following.

[71] The ILS is a subscription listing for overhaul shops and brokers to advertise the fact that they carry certain parts that have been overhauled, so that airlines can purchase the parts when needed.

Item no.	Page no.	CURRENT INSTRUCTION	NOTES
1	6A	Check bearing (95) for…excessive wear	No definition of excessive wear and no procedure to accomplish check.
2	6B	Check radial clearance of nut (51) and screw (52)	Does not specify equipment or procedure to accomplish check. No requirement to record radial clearance.
3	6B	Check axial end play of screw assembly (50) as follows: (a) Install nut (51) on screw (52). (b) With screw assembly (50) in vertical position, manually slip nut (51) up and down without imparting any rotation. (c) Measure axial end play. (d) Repeat measurement…	No specification of a measuring device to measure end play. No detailed instructions to install measuring device and obtain accurate end play measurements. No requirement to record axial end play.
5	14A	L1. Repair Screw (52) If necessary, repair corrosion on threaded area of screw (52)…Blend threaded surface to 32 microfinish, and break all sharp edges.	No detailed instructions or equipment specifications to check surface finish. No verbiage to stress importance of surface finish.
6	18 & 18A	Apply grease to…torque tube…plate…splines…screw (52) under stop assembly…taking care not to get grease on threads of screw	No clear specification of grease type to be applied to each component. Only mention is MIL-G-81322 in "Assembly Materials" list on page 22.
7	20A	Check axial end play as follows…Install measuring device...Push nut (51) downward by hand with a force of approximately 30 pounds…Lift nut (51) vertically until actuator assembly is off the bench, and check axial end play…	No specification of "measuring device". No specification to determine "30 pounds." No detailed instructions to install measuring device and obtain accurate end play measurements. No verbiage about rotation as in page 6B. No requirement to record axial end play.
8	20A	Apply light coat of grease to threads of screw (52), then run nut (51) through full range of travel to distribute lubricant over length of screw (52).	No specific grease is specified in this paragraph. Only mention of grease in figure 7, "Assembly Materials", which cites MIL-G-81322. No details are provided for grease application method.
9	22	Figure 7. Assembly Materials. Lubricant, grease….MIL-G-81322	No other lubricants specified, but other lubricants are appropriate for torque tube components, gear box, etc.
10	22A	Screw assemblies with measured end play between 0.0340 and 0.0390 inch may be reinstalled in aircraft if wear check is made every 1000 flight hours maximum.	This instruction is not found in the aircraft maintenance manual and is not useful as cited in this manual. Also the word between" can be misinterpreted.
11	24	Storage Procedures…Wrap actuator assembly in barrier material and heat seal….Evacuate 80 percent of air from package.	No procedures specified for packing the assembly for immediate shipping after overhaul; only for "storage".
12	24	Mark part number on two tags. Attach one tag to unit and one tag to exterior of container.	No requirement to document or attach information related to axial end play of overhauled assembly.

11.0 Pertinent FAA Certification Regulations

According to the FAA, the MD-83 is certificated as a derivative model of the Douglas DC-9. The DC-9 certification basis is Civil Aeronautics Rule (CAR) 4b, Amendment 16, without any exceptions. The MD-81 (DC-9-81) certification basis is Federal Air Regulations (FAR) Part 25, Amendment 40 with exceptions, in 1980. The MD-83 (DC-9-83) certification basis is FAR Part 25, Amendment 40, with exceptions in 1985.

In 1965, CAR 4b, Amendment 16, was recodified to become FAR Part 25. During the codification, the certification rules essentially remained the same. The FAA deemed that the systems design philosophy for the MD-81 and MD–83 trim system was essentially the same as the DC-9 trim system.[72]

According to the FAA, the following table cites the pertinent structural certification requirements, as they related to the horizontal stabilizer, for the DC-9 under CAR 4b versus the MD-83 under FAR part 25.

DC-9 (CAR 4b)	**DESCRIPTION**	**MD-83** (FAR 25)
4b.200	General Structure	25.301/25.303
4b.201	Strength & Deformation	25.305
4b.202	Proof of Structure	25.307
4b.270	Fatigue Evaluation of Flight Structure	25.571
4b.305	Inspection Provisions	25.611

The general structural rules cite the use of maximum loads, static equilibrium, and a 1.5 factor of safety. The strength and deformation rules address that the structure should support limit load with no "detrimental permanent deformation," and support ultimate load for 3 seconds without failure. The proof structure rule addresses "reliable forms of analysis."

Under CAR 4b, the fatigue evaluation addresses that fatigue critical structure must be considered fail safe or safe life. Under FAR 25, the fatigue evaluation addresses

[72] According to FAA Order 8110.4A, entitled "Type Certification": "Components of the same design as the original which have exhibited a satisfactory service history need not demonstrate further compliance to later regulations." This order prescribes the responsibilities and procedures for Federal Aviation Administration (FAA) aircraft certification personnel responsible for the certification process required by Title 14 of the Code of Federal Regulations for civil aircraft, aircraft engines, and propellers.

damage tolerance, failure due to fatigue, corrosion, manufacturing, or accidental damage will be avoided. The inspection provisions address structural access for replacement, adjustment, and lubrication to be provided "…as necessary for continued airworthiness."

According to the FAA, the following tables cites the pertinent systems certification requirements for pitch trim system of the DC-9 under CAR 4b and the MD-83 under FAR part 25 for any new systems or equipments.

DC-9 (CAR 4b)	**DESCRIPTION**	**MD-83 (FAR 25)**
4b.320	Control Systems: General	25.671
4b.322	Trim controls and systems	25.677
4b.606	Equipment, systems and installations	25.1309

The general systems rules state that the system must work as intended, safe flight and landing must be accomplished with a single failure, and combinations of failures are shown to be extremely improbable. The trim controls rules stated that there shall be no inadvertent or abrupt motion, indication, and creeping. The equipment, systems, and installations rules stated that the system must perform its intended function under foreseeable conditions, with no hazard to the airplane if the system fails. During the certification of the DC-9 under CAR 4b, a "Fault Analysis" was prepared by Boeing and submitted to the FAA as part of a qualitative safety analysis for showing compliance with CAR 4b.606 which states "All equipment, systems, and installations shall be designed to safeguard against hazards to the airplane in the event of their malfunctioning of failure. . For new system certification under FAR 25.1309, qualitative and quantitative analyses such as Failure Mode and Effects Analyses (FMEA) and Fault Tree Analysis (FTA), respectively, are normally prepared by the applicants for showing compliance with FAR 25.1309 requirements.

According to the FAA, FAR Parts 21.50, 25.1529, and Appendix H of FAR Part 25 (attached) require a type certificate holder to provide a recommended maintenance program to enable aircraft to be maintained in an airworthy condition.

12.0 Original DC-9 Lubrication Specifications and Test Reports

According to Douglas Process Standard No. DPS 3.17-49, dated August 1, 1964, entitled "Lubrication of DC-9 Aircraft", the originally specified lubrication interval for the jackscrew was cited as "300 – 350 Hours." The standard also specified that the jackscrew receive "General Purpose" grease, with a "Douglas recommended product" of Aeroshell 17, applied by a brush (acme screw) and grease gun (acme nut fitting). The specification also noted that the "lubrication frequency intervals expressed are based on an average of 300 flight hours per month." (When the DC-9 On-Airplane Maintenance Program was issued subsequent to this specification, the jackscrew lubrication interval was cited as 600-900 flight hours.)

In 1967, as a result of reports by operators that six jackscrews were prematurely worn[73], Douglas performed testing to "determine the right material of the jackscrew end nut, and/or lubrication, which would generate a minimum of wear to provide a service life of 30,000 flight hours." According to Douglas Engineering Test Report DCA33748, dated May 18, 1967, entitled "Horizontal Stabilizer Jackscrew and Nut Wear Test: Model DC-9":

> During test #1, severe squealing occurred [during jackscrew operation], especially on the unloading side of the cycle at approximately every 100 cycles. Because of this squealing, more frequent greasing of the jackscrew and nut was done. This condition indicates that the jackscrews and nuts in service should be greased at more frequent intervals than 400 flight hours (approx. every 100 flight hours.)[74]

13.0 Ballscrew Actuators

13.1 General Description

According to Boeing, models of "classic" Boeing commercial aircraft (707, 727, 737, 747, 757, 767, and 777), utilize a single ballscrew actuator to move the horizontal stabilizer, instead of a single acme screw. Both the Acme screw design employed on the McDonnell Douglas Twinjet (DC-9, MD-80, MD-90, 717) series airplanes and the ballscrew design employed on the classic Boeing models utilize the concept of generating and transmitting rotational power into the linear movement required to position the horizontal stabilizer through the use of a single screw and nut. In both designs, the screw is rotated (either electrically or hydraulically); this rotation is converted into linear motion as the screw threads engage and are rotated against the nut threads.

According to Boeing, the basic operating principle defining the difference between the Acme and ballscrew design is the way the nut and screw threads interface with each other. By design, acme threads have continuous sliding contact between the nut and screw threads (similar to a nut and bolt). Typical Acme designs employ hardened screw threads and softer nut threads thus forcing any wear that might occur into the nut threads. By contrast, the ballscrew design employs one or more circuits of continuous rolling elements (balls) that are inserted between the nut and screw threads. These elements provide a rolling contact between the threads of the nut and screw (similar to a rolling element bearing). All three elements of this design (nut threads, balls, and screw threads) are hardened and are not intended to wear significantly under normal operation.

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[73] Additional details regarding these six jackscrews are provided in Section 8.4 of the initial NTSB Systems Group Chairman's Factual Report of Investigation, dated November 22, 2000.

[74] The test article used in this test was not nitrided, as later test articles and production jackscrews would become. Additionally, the condition of the screw (i.e. damage, surface roughness, etc.) was not documented in this report and is unknown. According to Boeing, there were no in-service reports of squealing at the 400 flight hour interval.

Both the Acme and ballscrew designs require periodic and proper lubrication procedures to ensure proper operation throughout their service life.

Both Acme and ballscrew designs employ features of redundancy against back driving and against the loss of structural integrity between the threads of the nut and screw. To prevent the horizontal stabilizer loads from back driving the trim system, the Acme thread design is irreversible whereas the ballscrew system employs mechanical brakes. To protect against loss of structural integrity, the Acme screw and nut utilize a dual start thread and periodic inspections of the nut thread wear whereas the ballscrew utilizes multiple ball circuits and separate load path elements. For the ballscrew system, two different types of designs are utilized for the separate load path. In the first type, each circuit of balls uses a hardened steel ball deflector located within the thread groove. Normally, this deflector simply directs the balls into the return tube. In the event of loss of all of the ball circuits, this deflector will act as the load path between the nut and the screw. The other type of separate load path utilizes special male threads either machined into one end of the nut, or as part of a separate component. These threads are cut smaller than the groove and do not normally transfer any load. However, in the event of a loss of all the balls at once, the load is then transferred to and carried by these male threads.

13.2 The Boeing C-17 Military Transport Ballscrew Anomalies

The U.S. Air Force C-17 military transport aircraft, manufactured by Boeing, is equipped with a single ballscrew assembly for horizontal stabilizer trim. The ballscrew assembly was essentially modeled after the Boeing 767 horizontal stabilizer trim actuator and is nearly identical to it.

According to Boeing, the U.S. Air Force alerted its C-17 maintenance crews immediately following the Alaska Airlines accident to report any discrepancies associated with the horizontal stabilizer pitch trim actuator during routine inspections known as Home Station Checks (HSC). The HSC inspections revealed several units exhibited a dry screw with light discoloration on the surface. Two units (from airplanes designated as "P4" and "P9") showed a significant amount of surface damage and corrosion to the screw and interfacing balls; these units were removed and replaced. The Air Force immediately formed a Crisis Management Team (CMT) to address potential problems related to ballscrew actuator failure.

According to Boeing proprietary documents, the root cause of the damage to the two C-17 units was "insufficient lubrication." As a result, Boeing and the Air Force initiated the following corrective actions:

- Initiate a one-time fleet inspection of the ballscrew assembly
- Initiate a requirement to perform a fleet-wide endplay inspection of the ballscrew assembly.
- Evaluate a decrease in the ballscrew lubrication interval from 240 days to 120 days.
- Review and clarify the lubrication job cards.
- Evaluate requirements to perform endplay checks while the airplane is in service.
- Review run-away pitch trim procedures and update the Flight Manual as required.

According to Boeing proprietary documents, the C-17 ballscrew assembly has 4 separate ball circuits containing a total of 568 balls. Backup threads are provided as a part of an "ice breaker" located at each end of the assembly, and also as part of 6 deflectors located internally to the ballnut. The Ice Breakers and Ball Extractors together provide a secondary load path. The ballnut has two grease fittings. Both fittings are either located on the forward or aft side of the nut depending on the aircraft installation. Lubrication of either fitting will fill the ballnut with grease.

According to Boeing failure analyses conducted as a result of the C-17 CMT, excessive corrosion or abrasion could cause several threads of both ballscrew thread sets to slip past bearing races and bottom out onto the backup thread sets. The analyses indicated that for the worst case weight and center of gravity condition, this would allow uncommanded change in the stabilizer beyond the capability of the elevator authority due to excessive play of the assembly. This condition was cited as "extremely improbable ("Hazard Level 4, Probability Level 2, RHI=8"), and that "better lubrication practice will further lower the probability." Additionally, the analyses stated that the "Probability level remains 2 which is the lowest probability level assigned for any conceivable event." No analyzes was cited for a condition involving the total loss of the backup threads.

[redacted] 2/28/02

Jeffrey B. Guzzetti
Aerospace Engineer

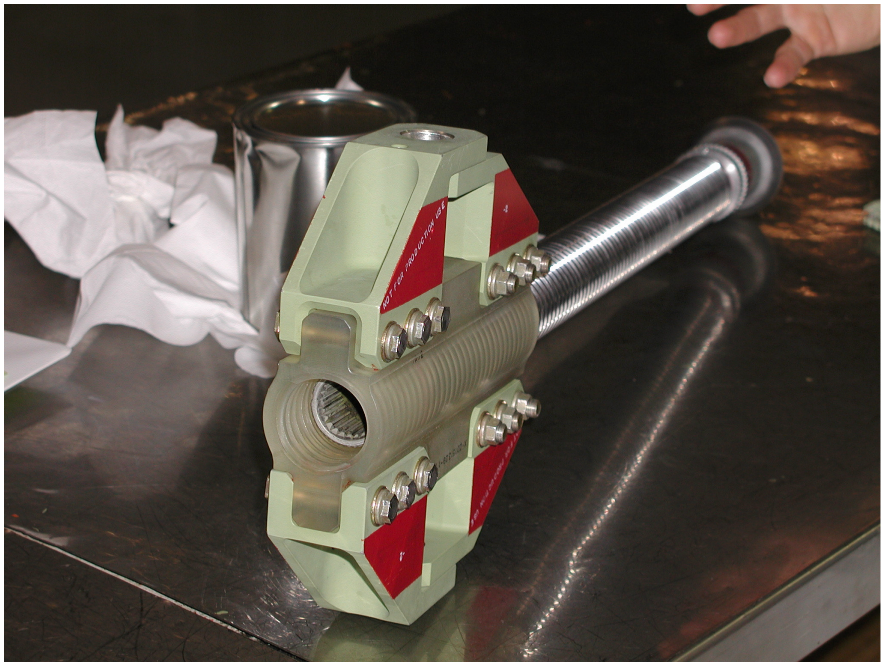
[redacted] 2/28/02

Addendum to Systems Group Chairman's Factual Report

Appendix A:

Photographs

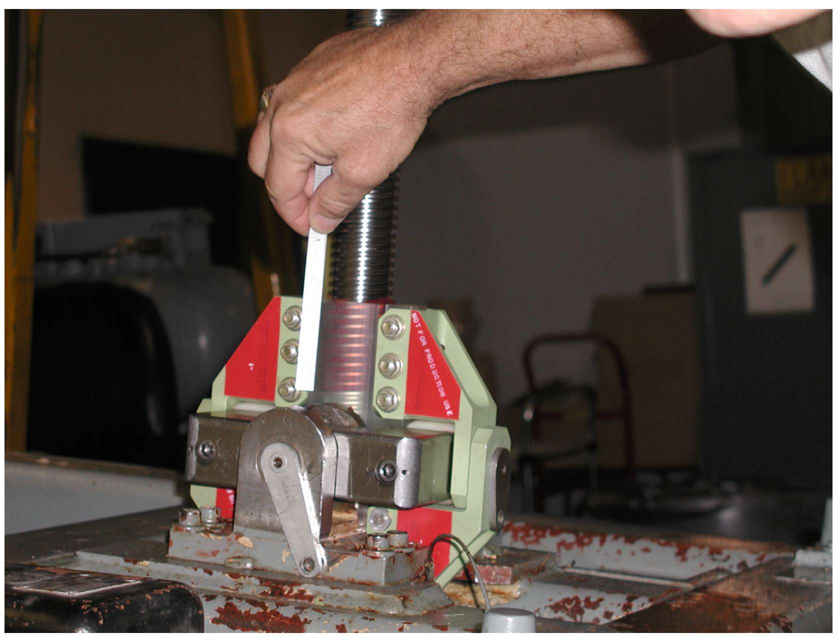
NTSB Aircraft Accident Case No. DCA00MA023
Pacific Ocean near Anacapa Island, California
January 31, 2000
McDonnell Douglas MD-83; N963AS



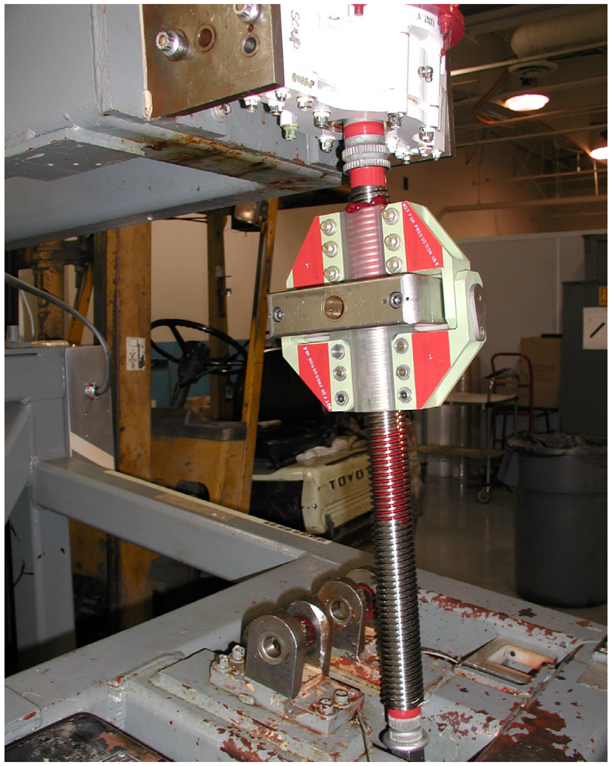
1. Translucent acme nut used in lubrication demonstration at Integrated Aerospace.

2. Acceptance Test Plan fixture used for acme nut demonstrations at Integrated Aerospace

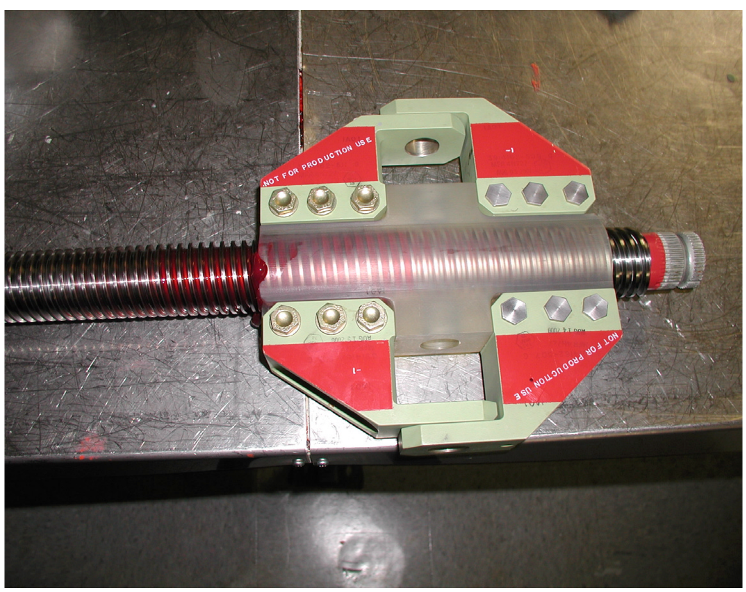
3. Application of Mobil 28 grease to translucent acme nut grease fitting only.



4. Mobile 28 grease after grease was applied into grease fitting until it was seen extruding out the top of the acme nut. Note that grease migrated through less than half the acme nut thread length.

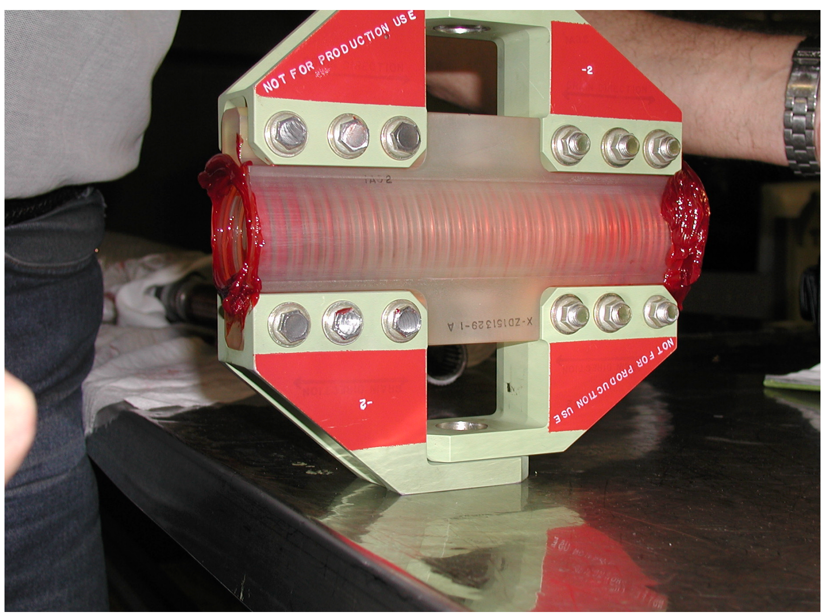


5. View of acme screw after it was cycled once up and down after grease was applied through fitting only. Note areas that are devoid of grease.

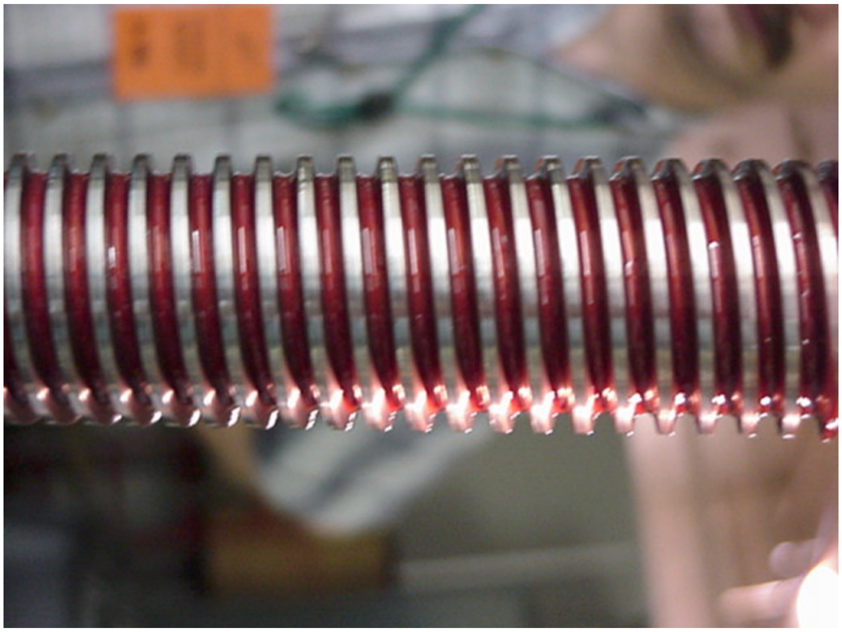


6. View of acme screw and nut after several cycles following grease application to fitting only.

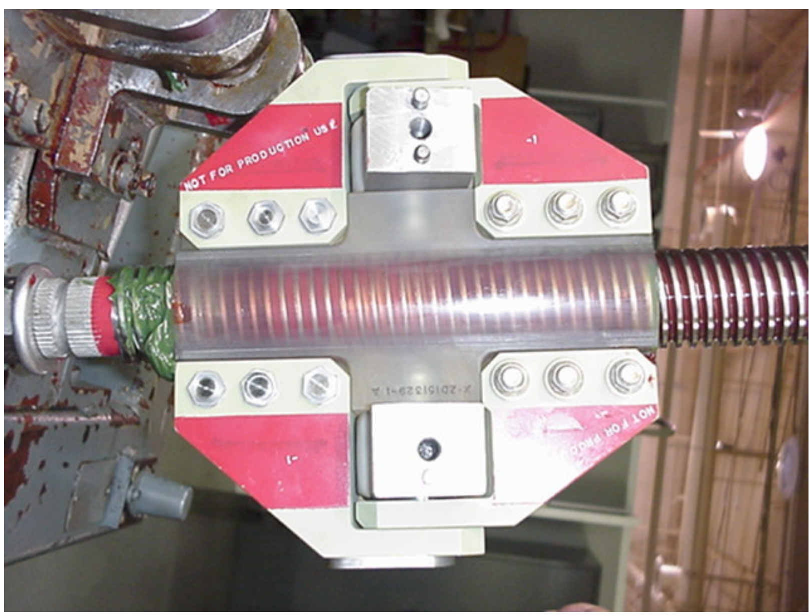
7. Demonstration of grease application onto acme screw only. Grease is being applied with a brush through a mockup of exterior aircraft skin and access panel (Panel is about 10 inches closer to the acme screw on an actual MD-83 aircraft)



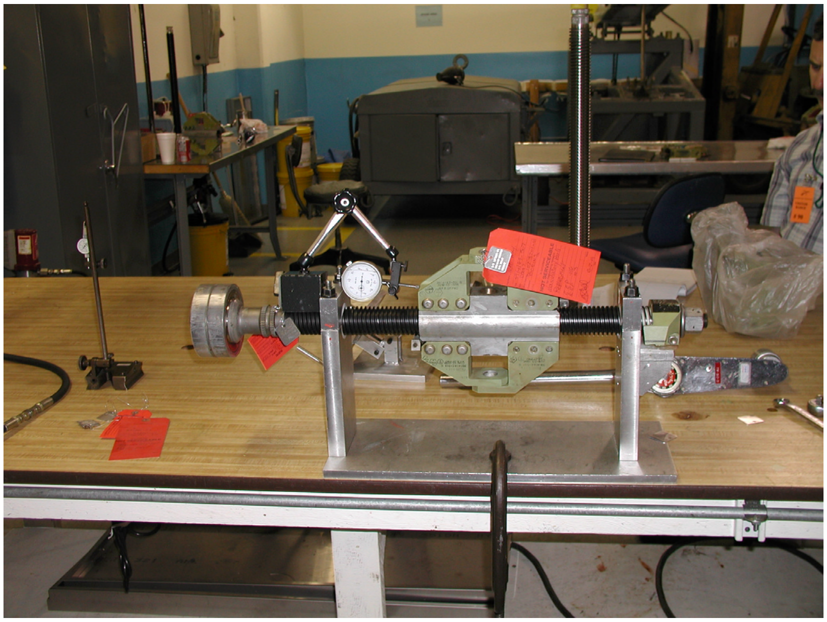
8. View of translucent acme nut after the "butter lube" of acme screw only. Note that entire length of acme nut thread bore shows the presence of grease.



9. Close-up view of acme screw threads after a few cycles of the “butter lube” only. Note that all valleys of threads have grease in them.

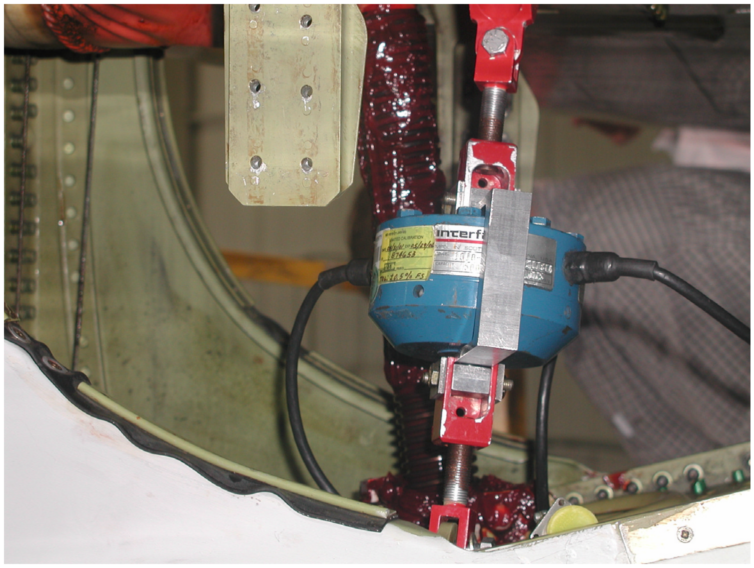


10. View of acme screw and translucent nut after Mobil 28 (red) grease was injected into the acme nut grease fitting, and Aeroshell 33 (green) was used to “butter lube” the acme screw.



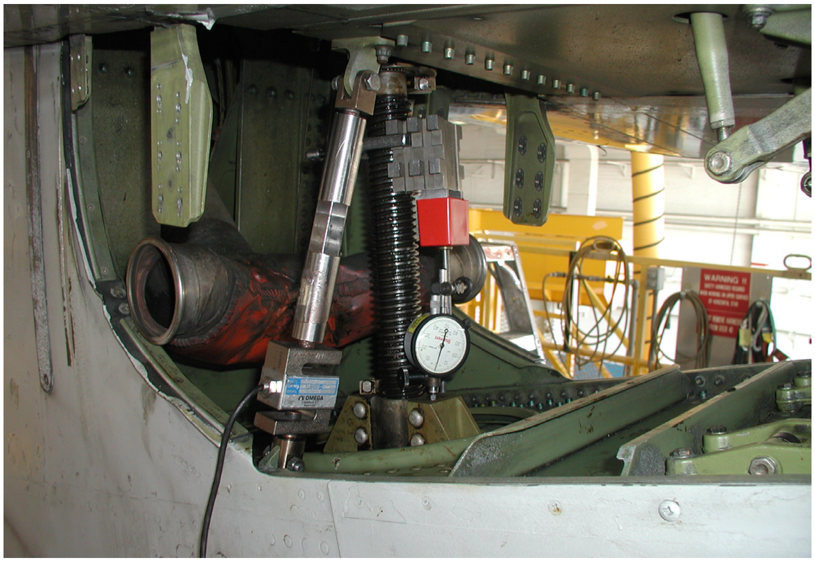
11. Bench test set-up used to perform end-play checks for varying tightness values on the torque tube nut.

12. View of the 2 Alaska Airlines fabricated restraining fixture tools (top) and the 3 Boeing restraining fixture tools used during the Huntington Beach Laboratory Force Output tests. Note the differenced in length, shape, and configuration between the two types of tools.



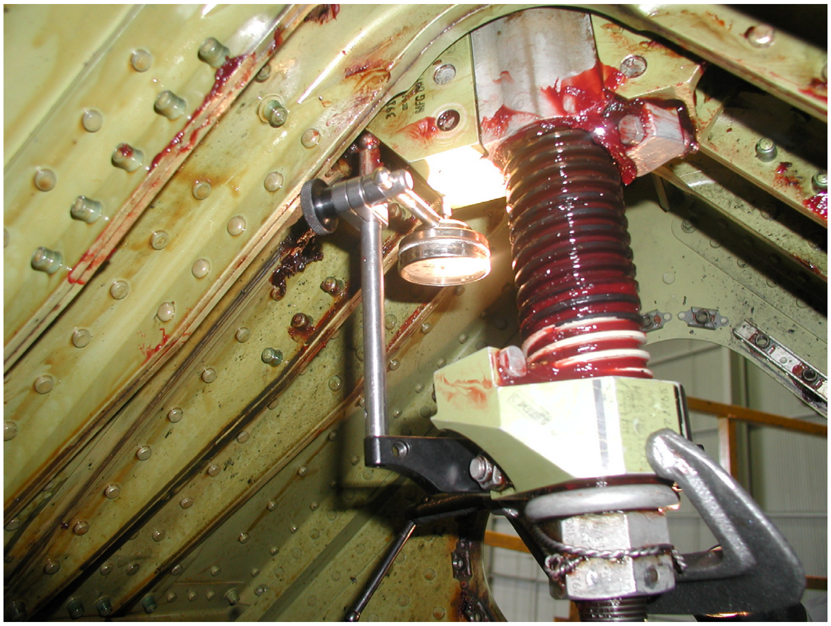
13. Boeing-fabricated restraining fixture tool used during on-wing force tests. Note the blue load cell device imbedded into the tool.

14. Alaska-fabricated strain gauge device imbedded into a Boeing restraining fixture used during on-wing force output tests.

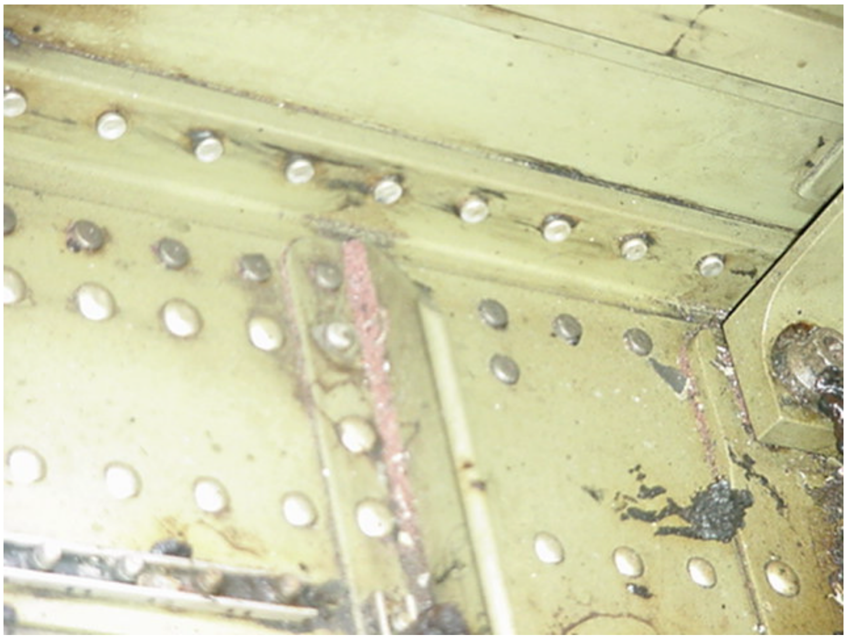


15. Alaska-fabricated strain gauge device imbedded into an Alaska Airlines restraining fixture used during on-wing force output tests.

16. NTSB Systems Group Chairman holding an MD-80 "dog house" that fits on top of the vertical stabilizer. The dog house from the accident airplane was missing from the tail assembly and never recovered.



17. Close-up view of a typical dial indicator set-up for endplay checks performed at Tulsa. Note close proximity of mounting hardware to structure, orientation of the dial indicator face, size of the access hole, and the attachment of the C-clamp to the lower stop.



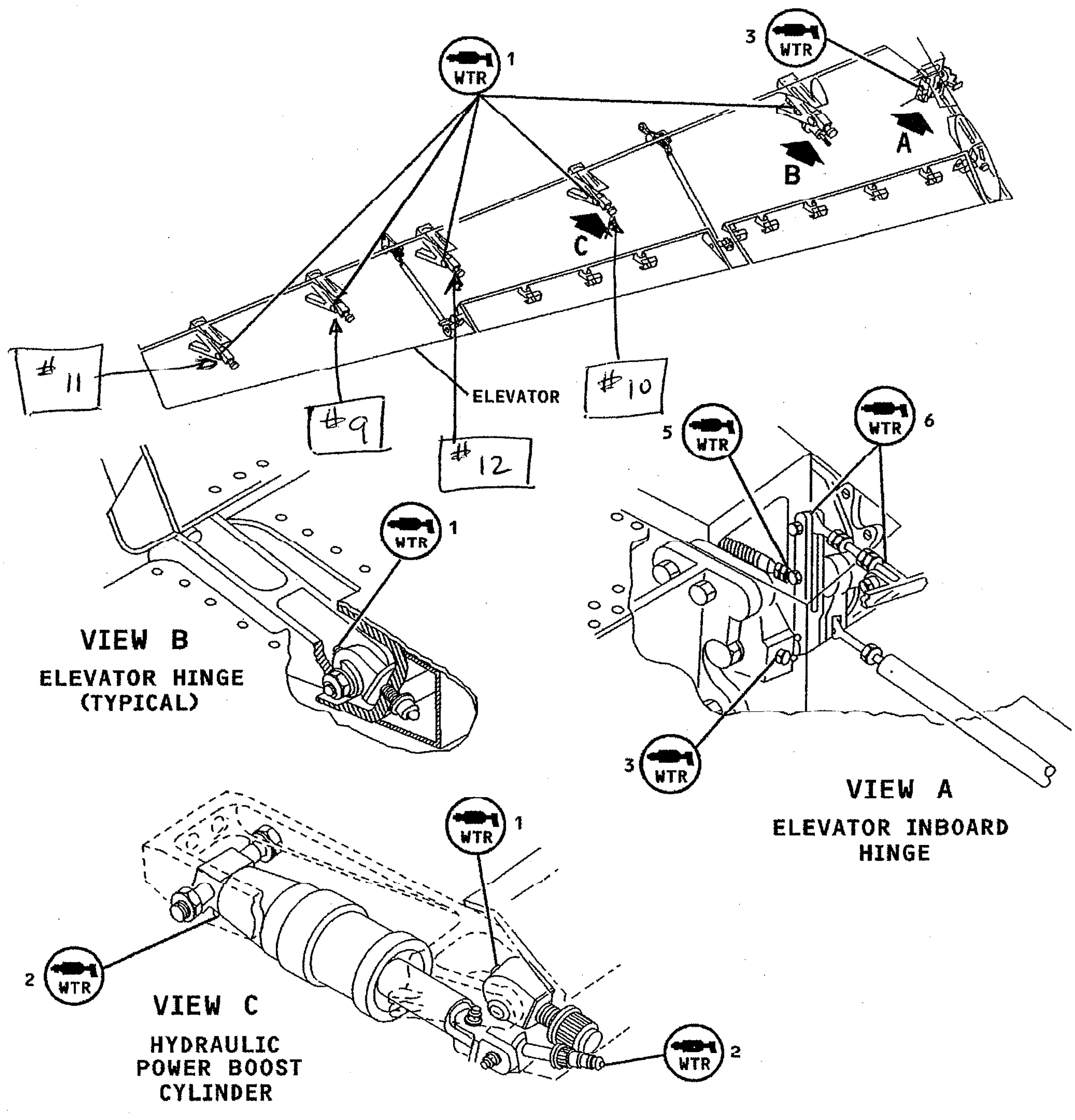
18. View of interior of the vertical stabilizer of a Hawaiian Airlines DC-9. This view shows the area just beneath the jackscrew assembly. Note pink granular material.

Addendum to Systems Group Chairman's Factual Report

Appendix B:

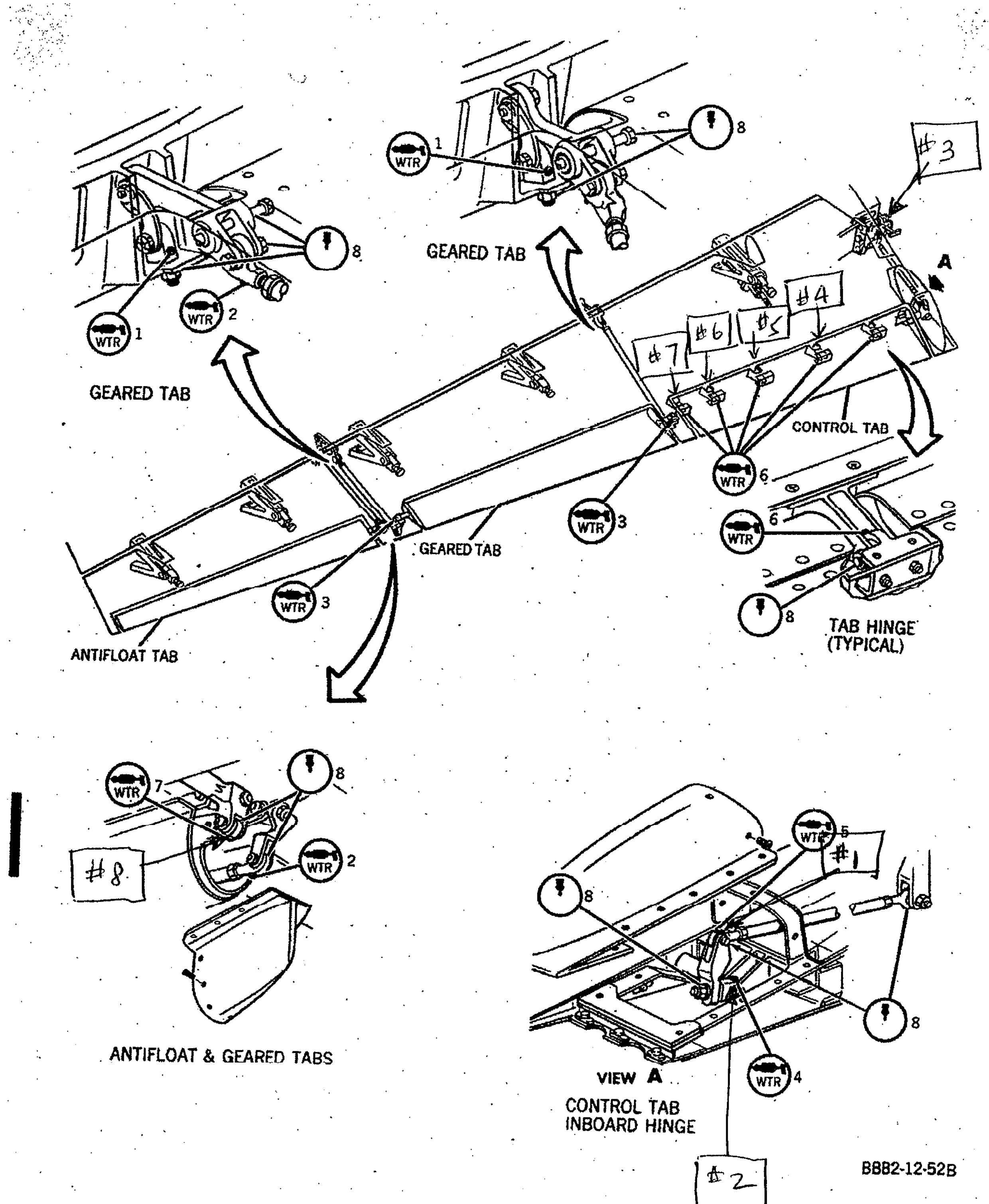
Diagrams of Grease Fitting Locations

NTSB Aircraft Accident Case No. DCA00MA023
Pacific Ocean near Anacapa Island, California
January 31, 2000
McDonnell Douglas MD-83; N963AS

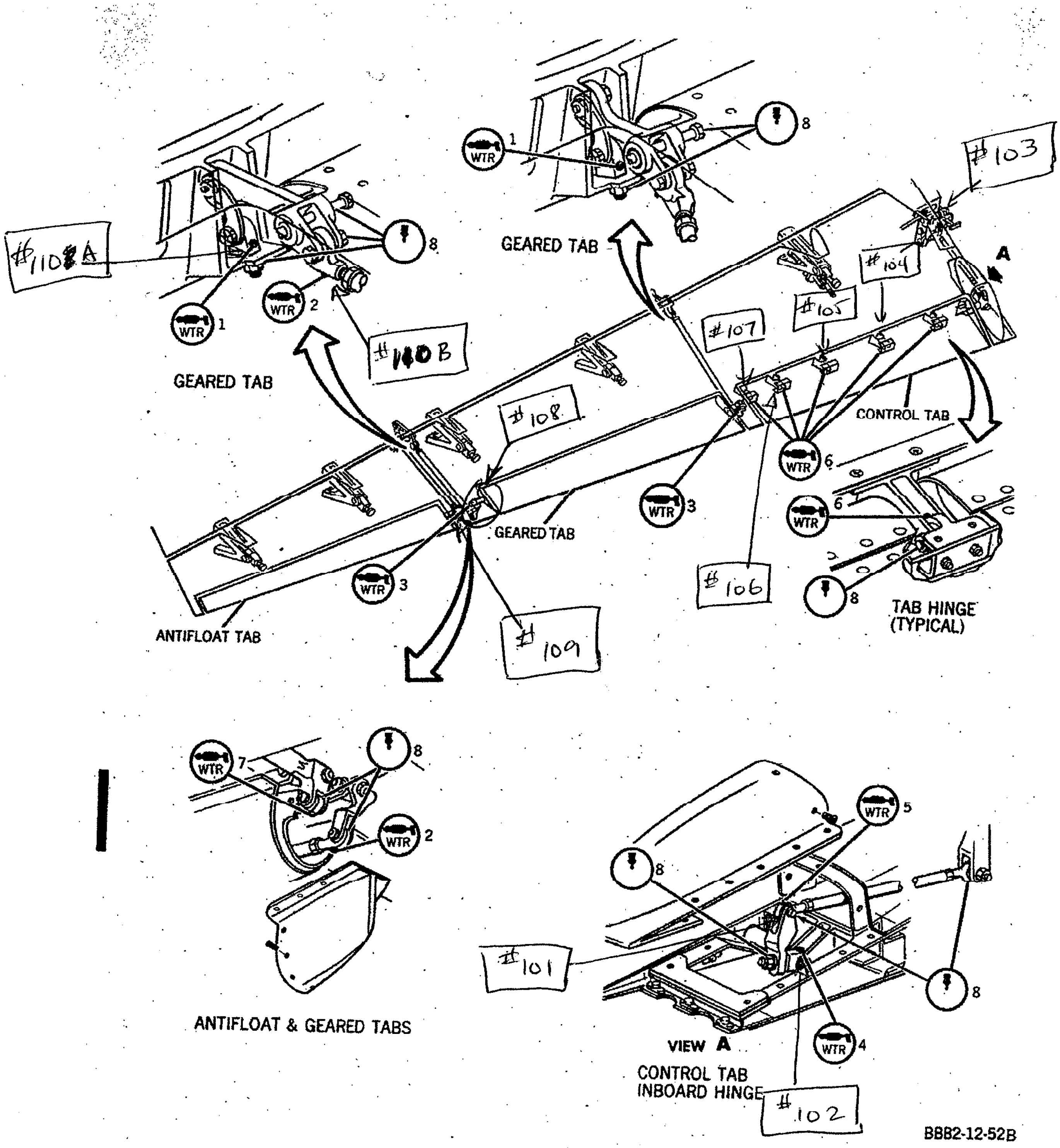


CAG(IGDS) BBB2-12-387

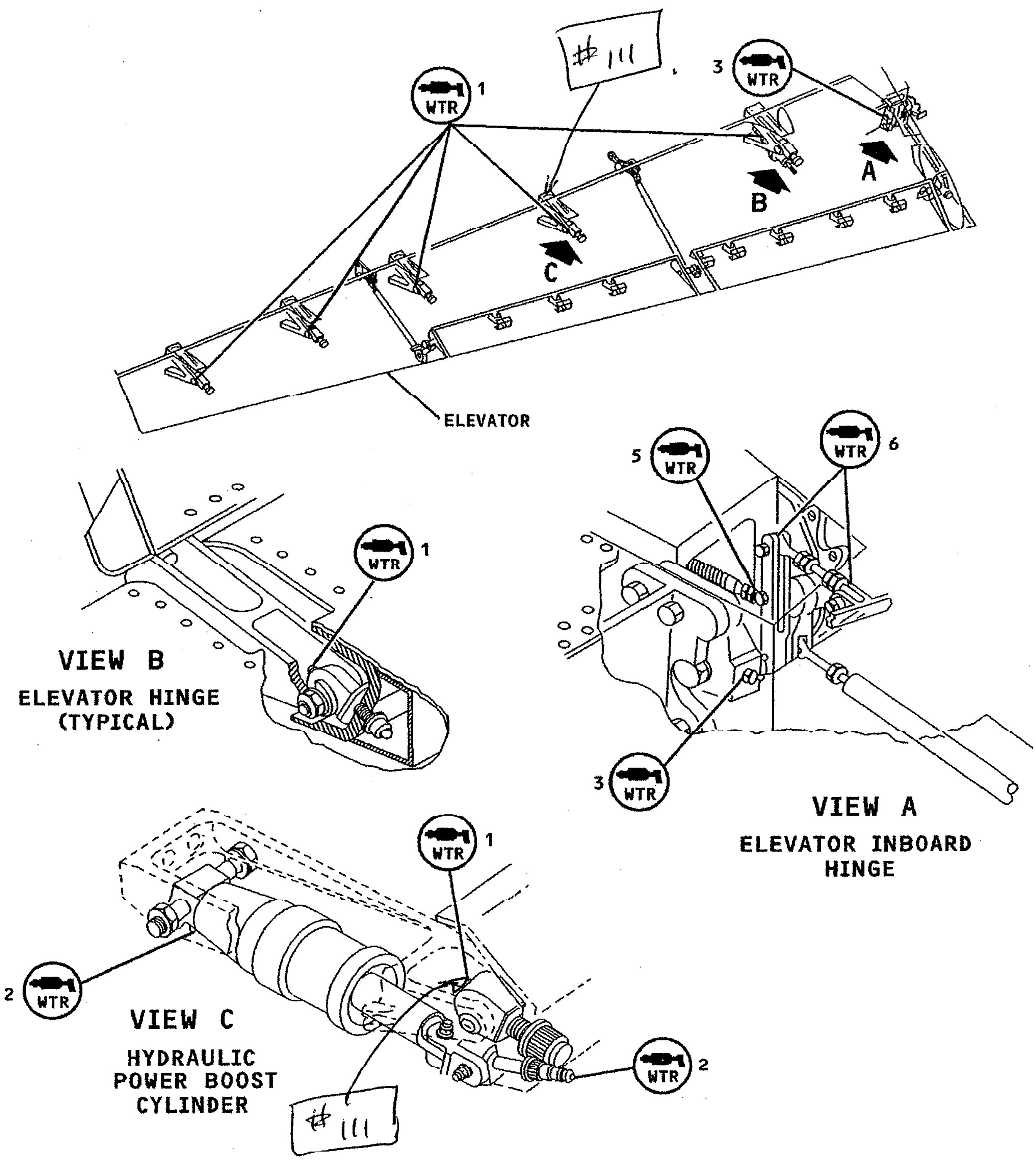
LEFT HAND Elevator -- Lubrication
Figure 306 (Sheet 1)



LEFT HAND Elevator Tabs -- Lubrication
Figure 307 (Sheet 1)



RIGHT HAND Elevator Tabs -- Lubrication
Figure 307 (Sheet 1)

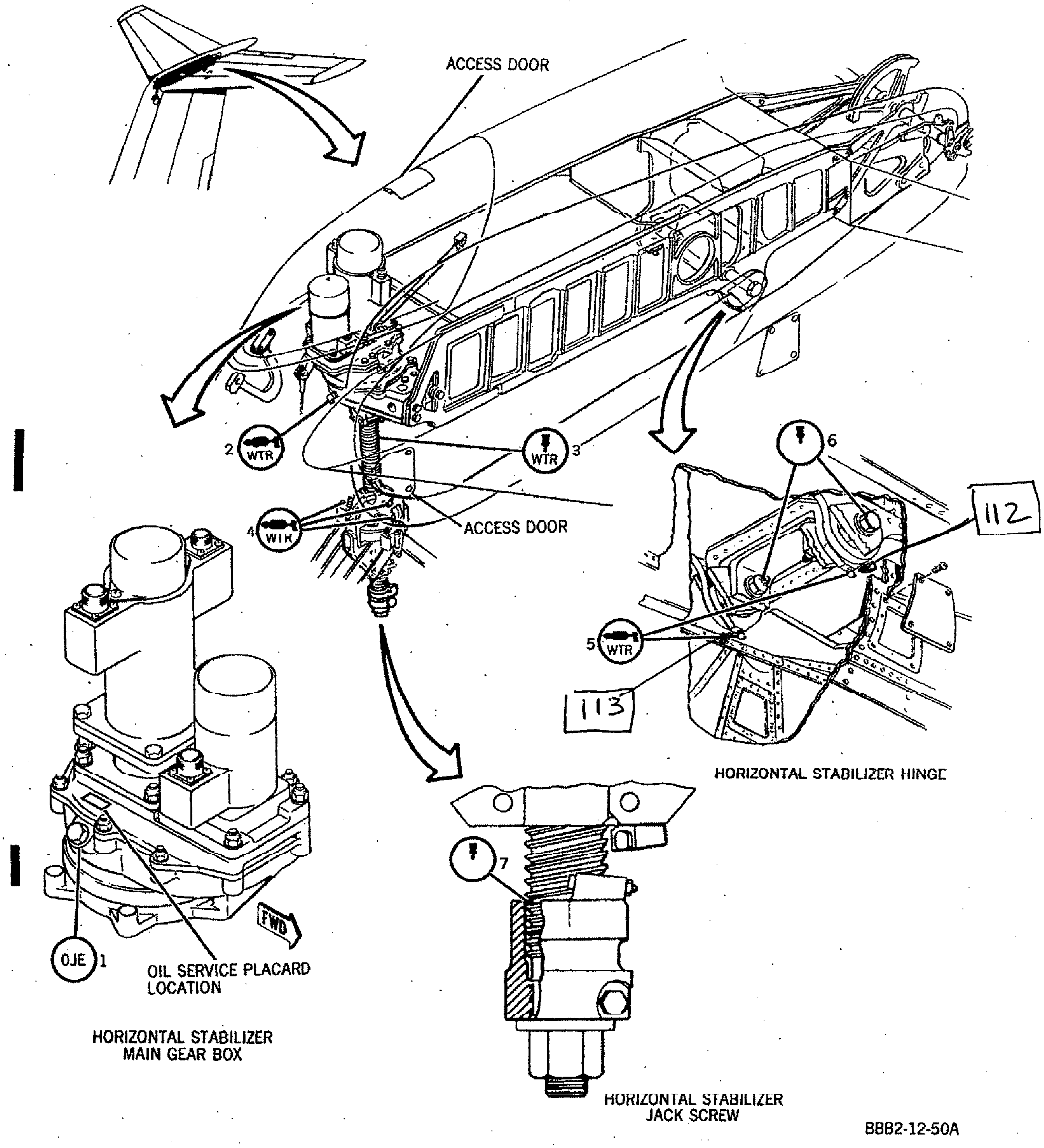


CAG(IGDS)

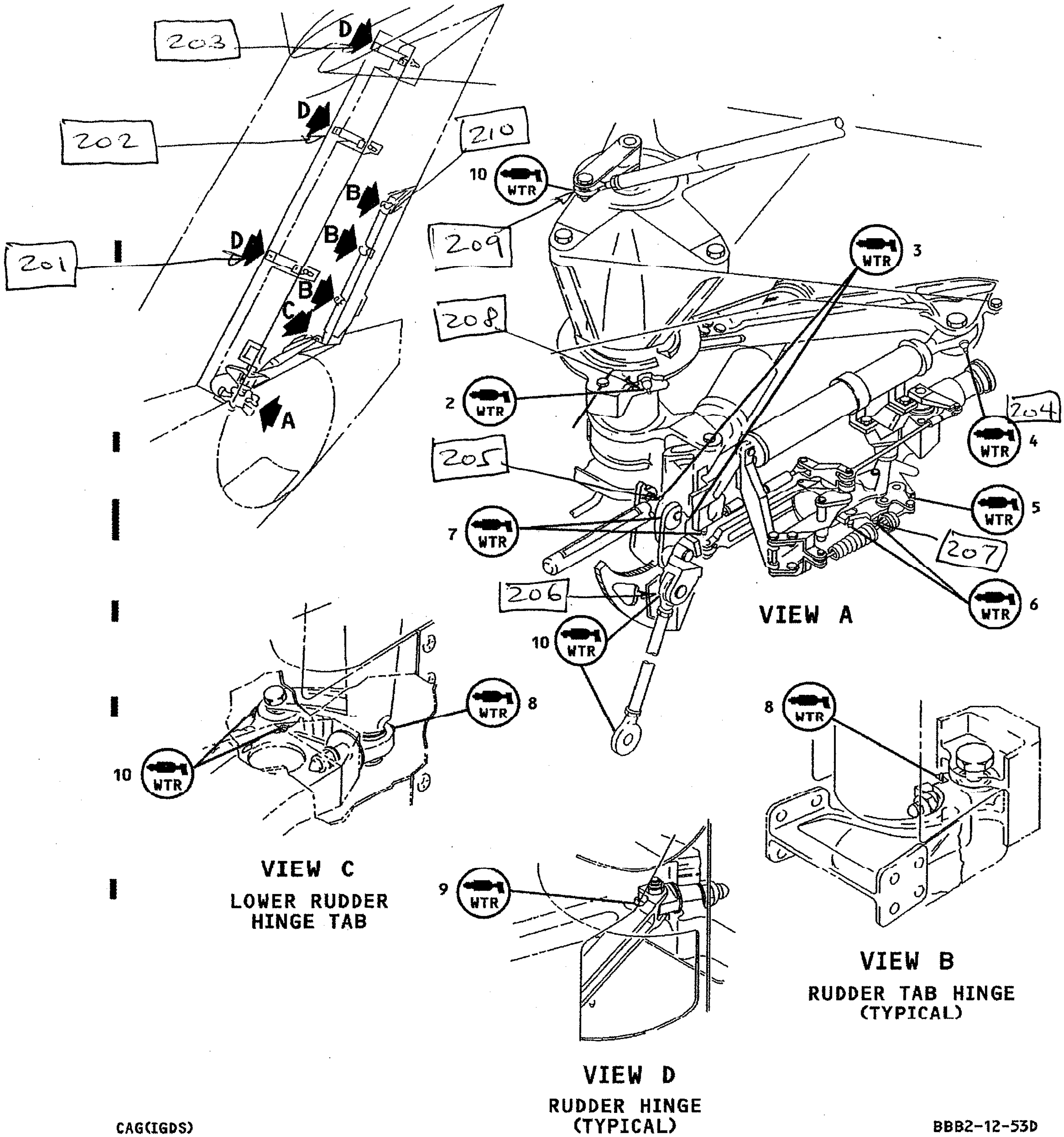
BBB2-12-387

RIGHT HAND Elevator -- Lubrication
Figure 306 (Sheet 1)

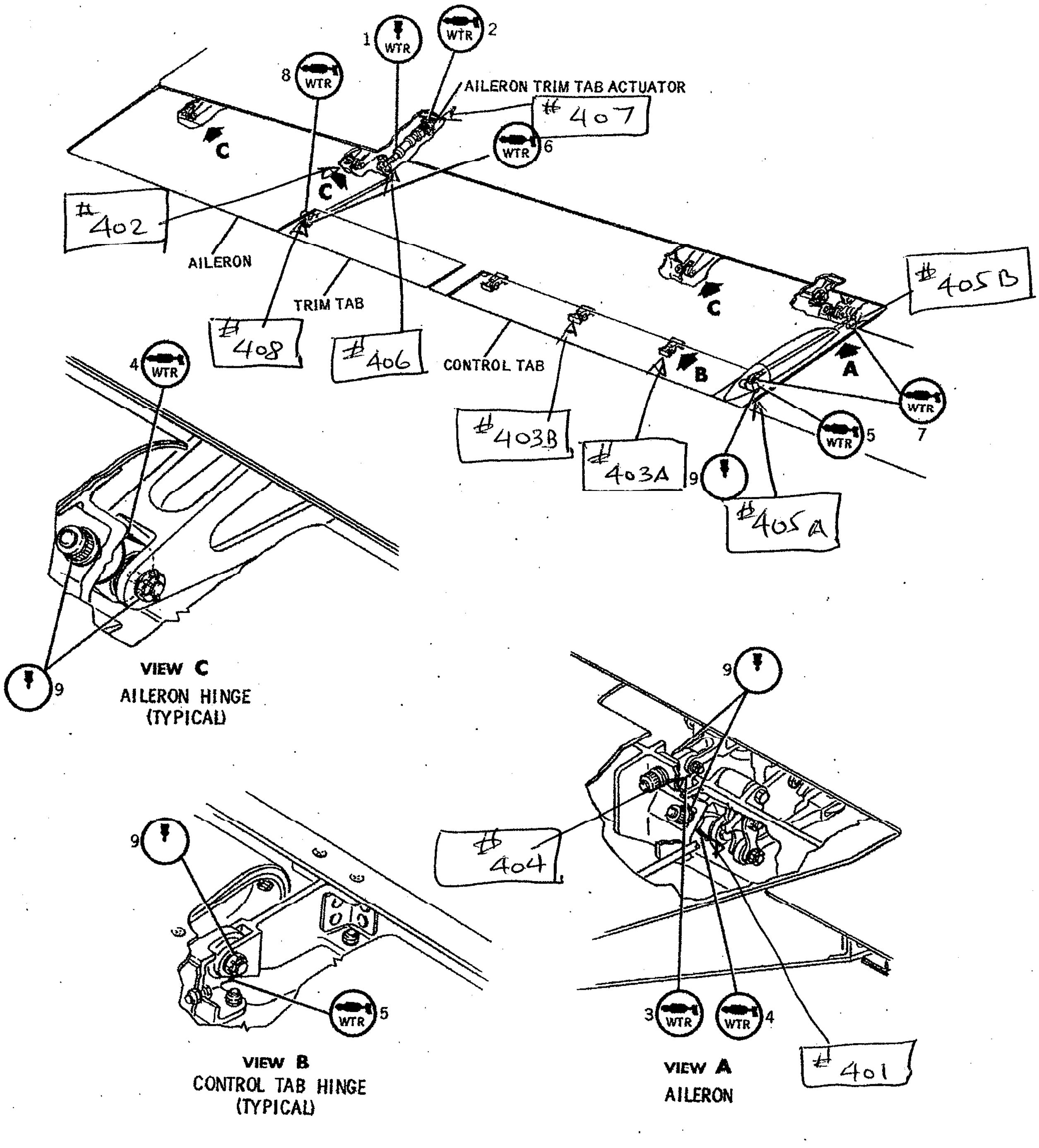
EFFECTIVITY: AS ALL



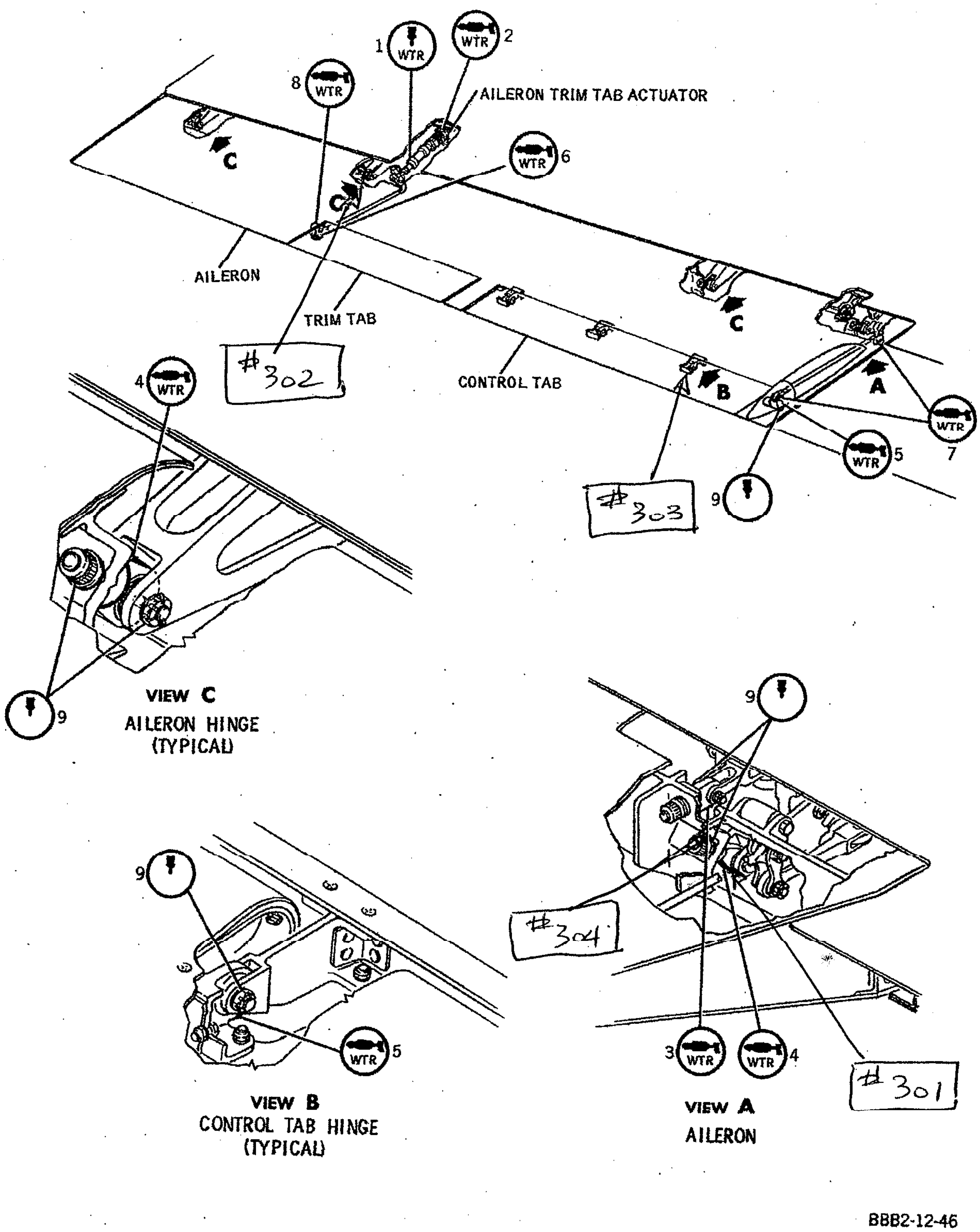
Horizontal Stabilizer -- Lubrication
Figure 305 (Sheet 1)



Rudder and Tab -- Lubrication
Figure 308 (Sheet 1)

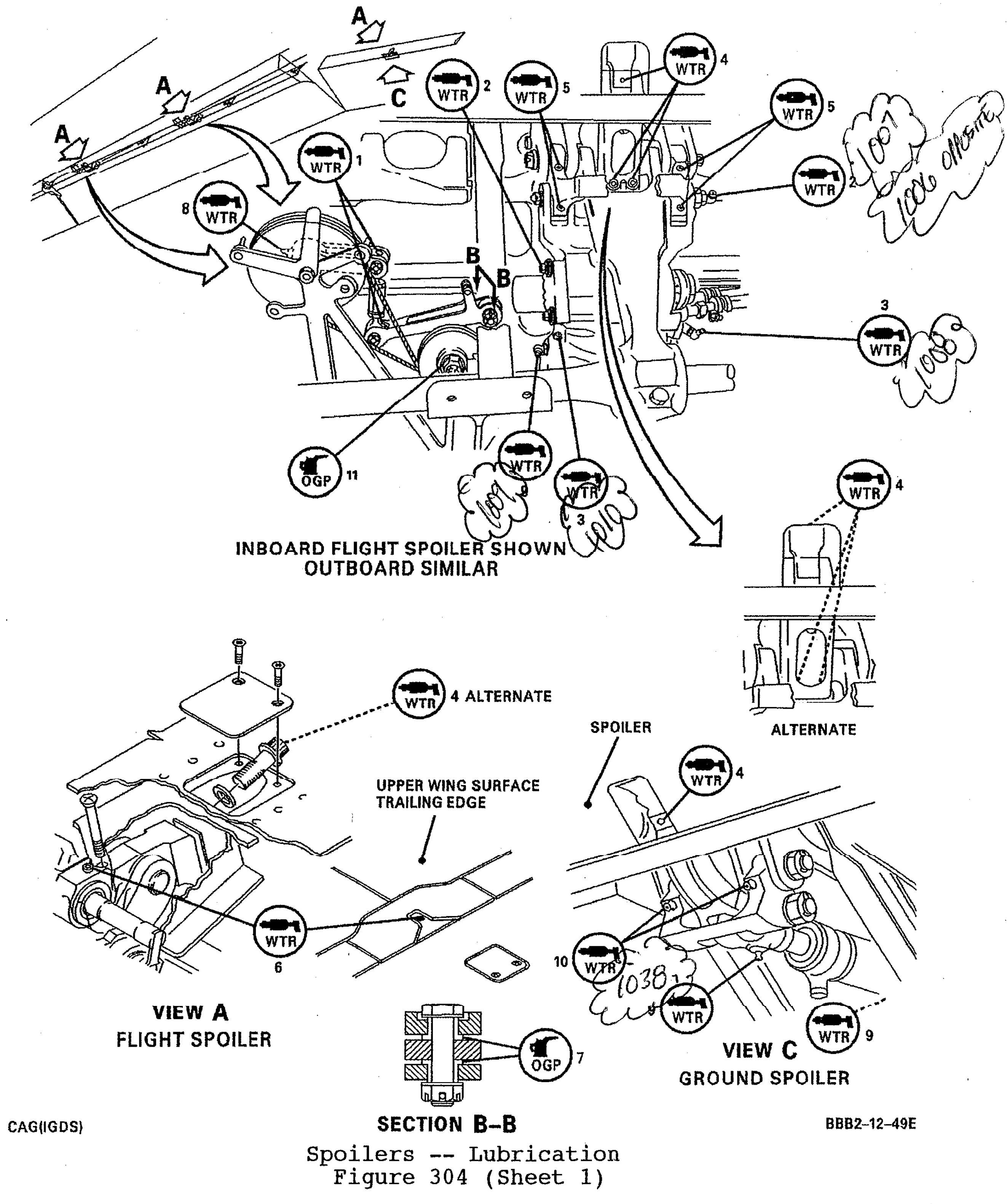


LEFT HAND Aileron and Tabs -- Lubrication
Figure 301 (Sheet 1)

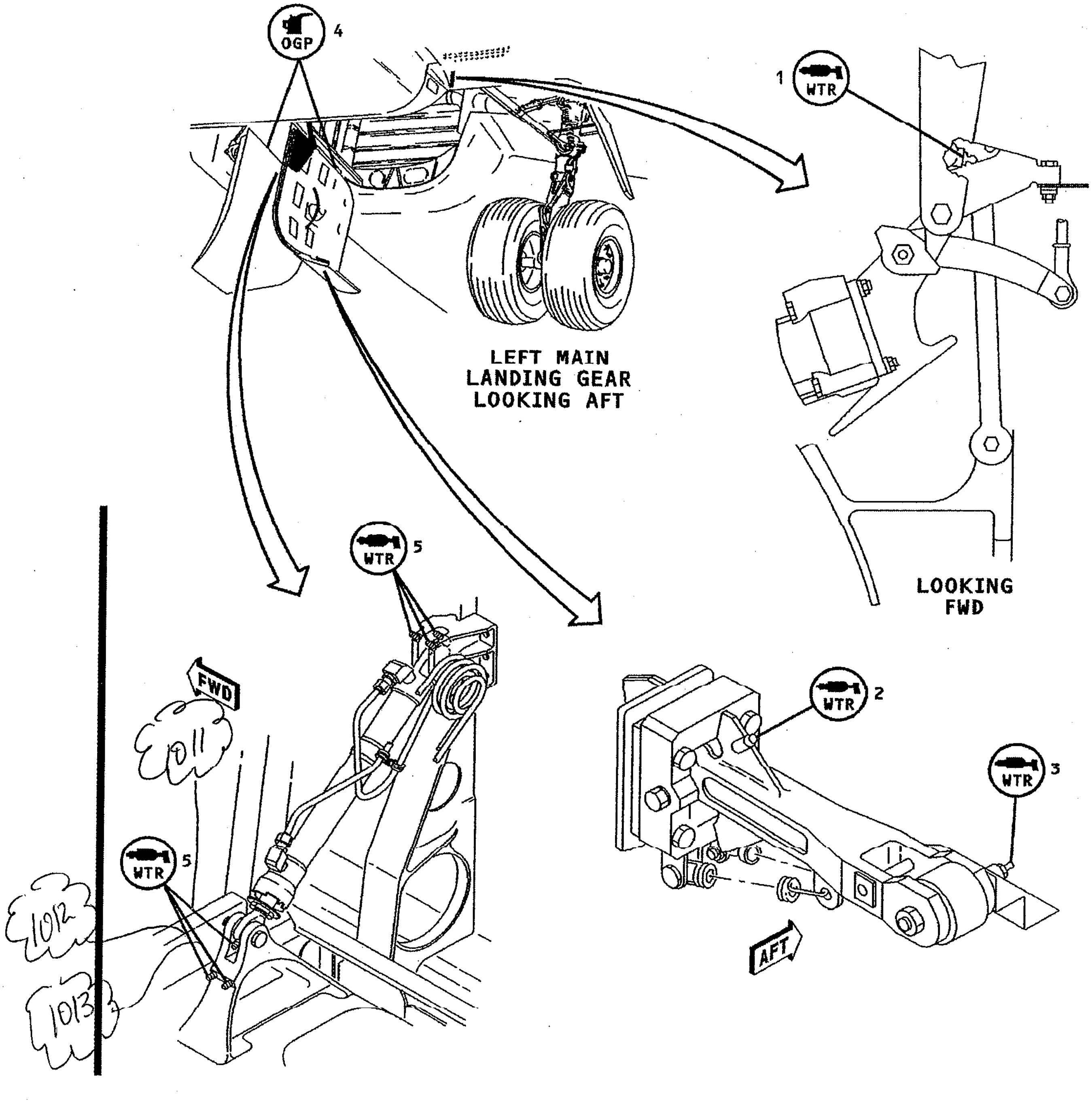


RIGHT HAND Aileron and Tabs -- Lubrication
Figure 301 (Sheet 1)

EFFECTIVITY: AS ALL

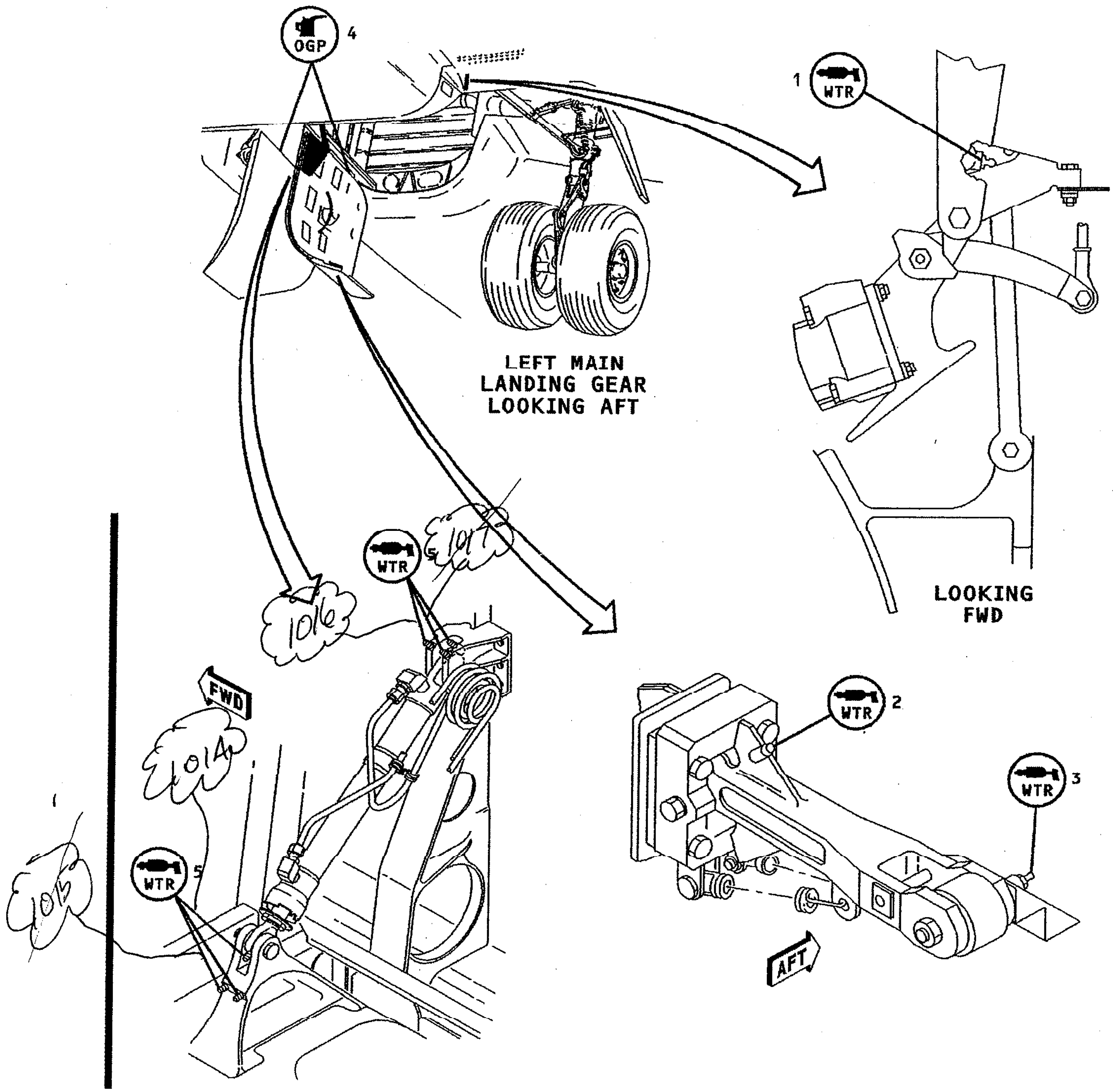


Spoilers -- Lubrication
Figure 304 (Sheet 1)

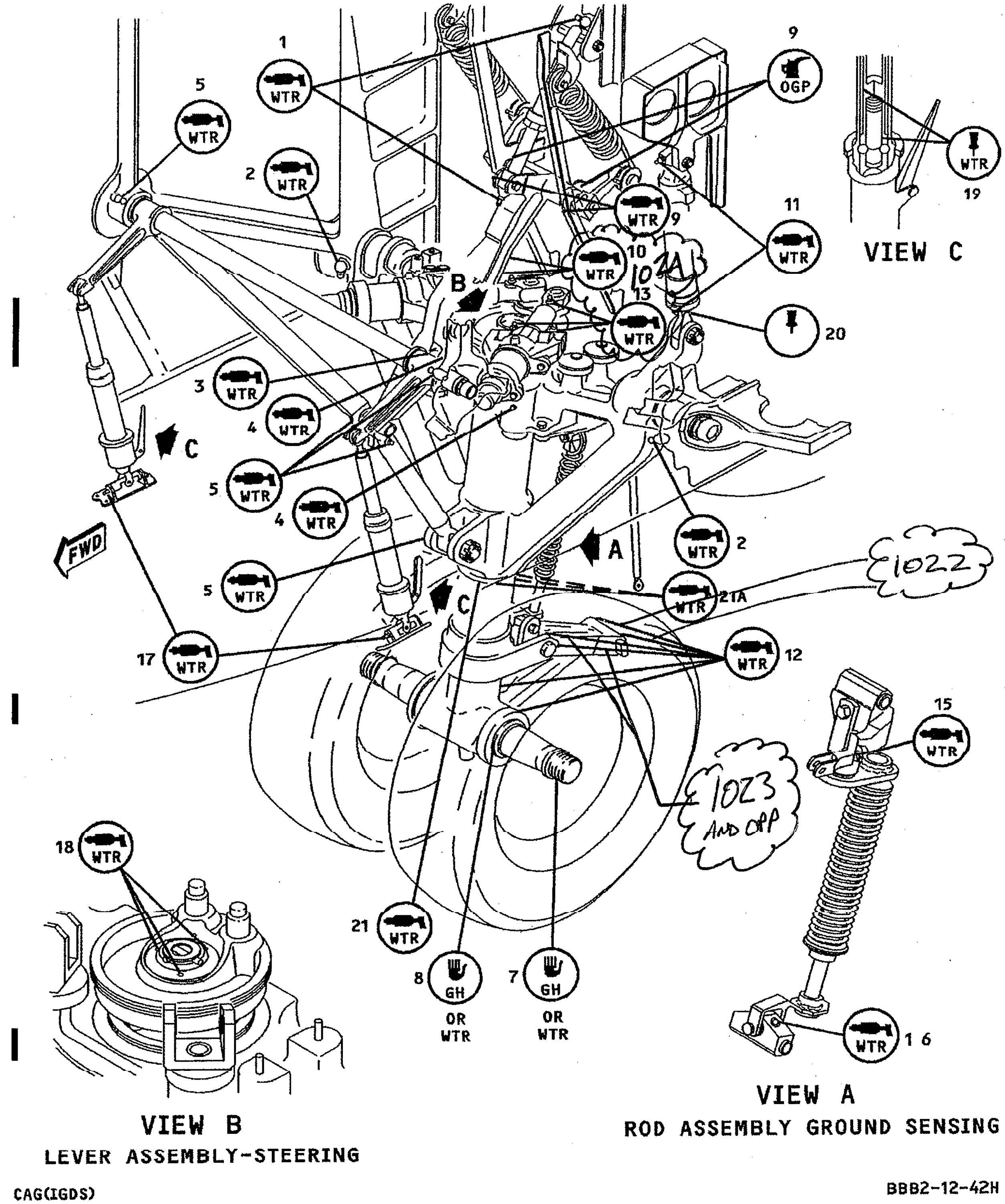


Main Landing Gear Inboard Door -- Lubrication
Figure 304 (Sheet 1)

EFFECTIVITY: AS 101-109, 116-999, and 110-115
with SB 32-192 incorp.

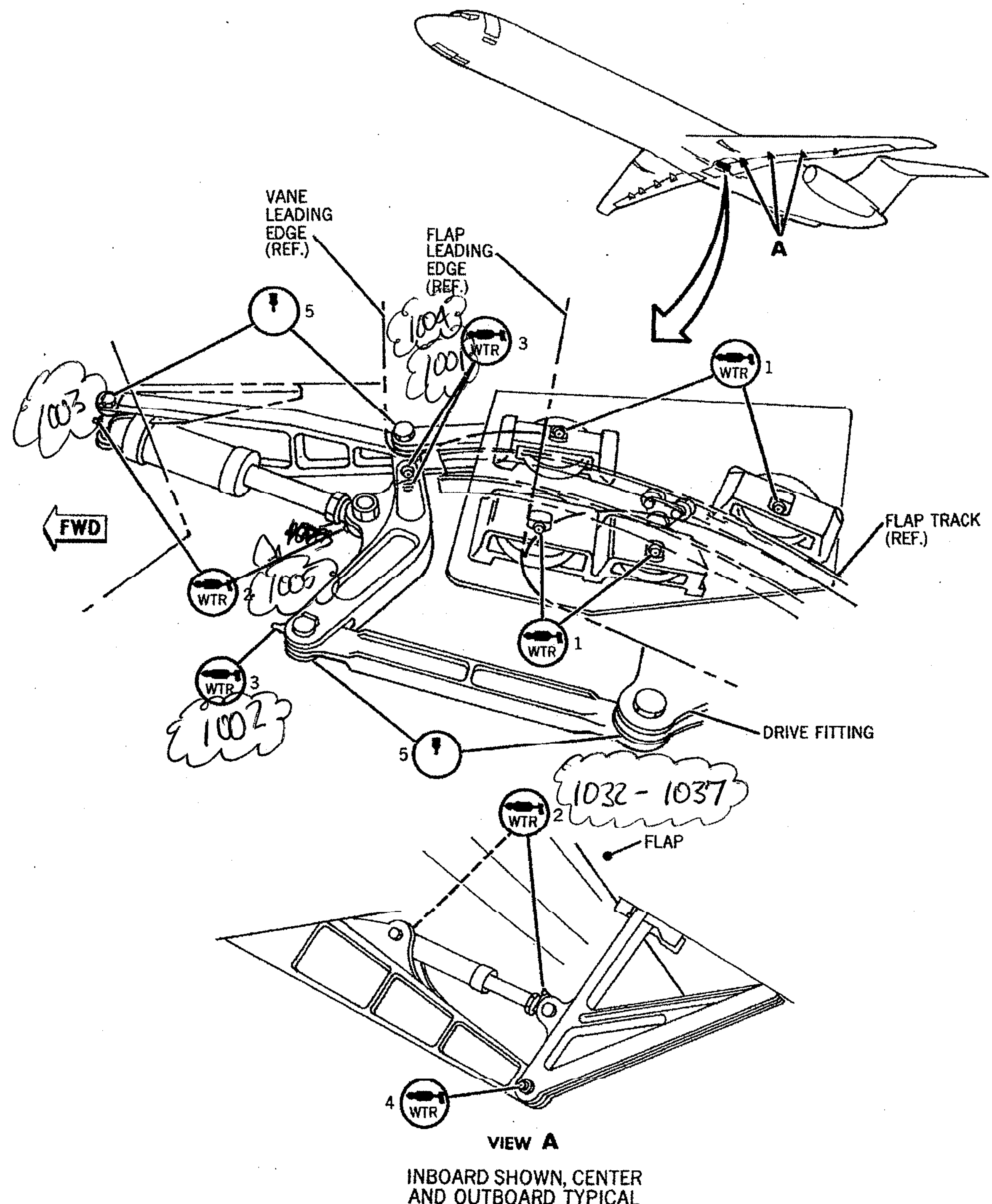


Main Landing Gear Inboard Door -- Lubrication
Figure 304 (Sheet 1)

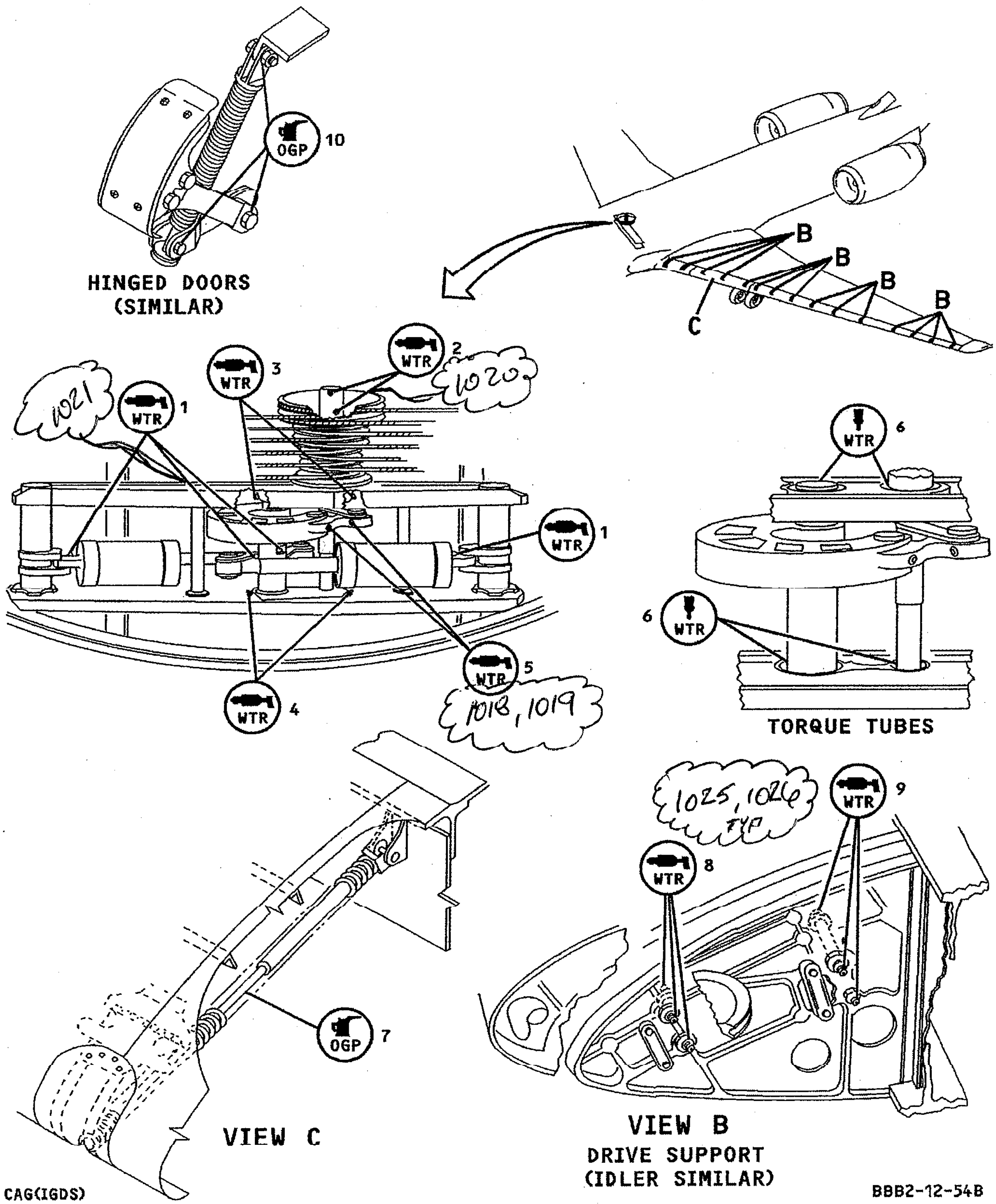


Nosegear -- Lubrication
Figure 301 (Sheet 1)

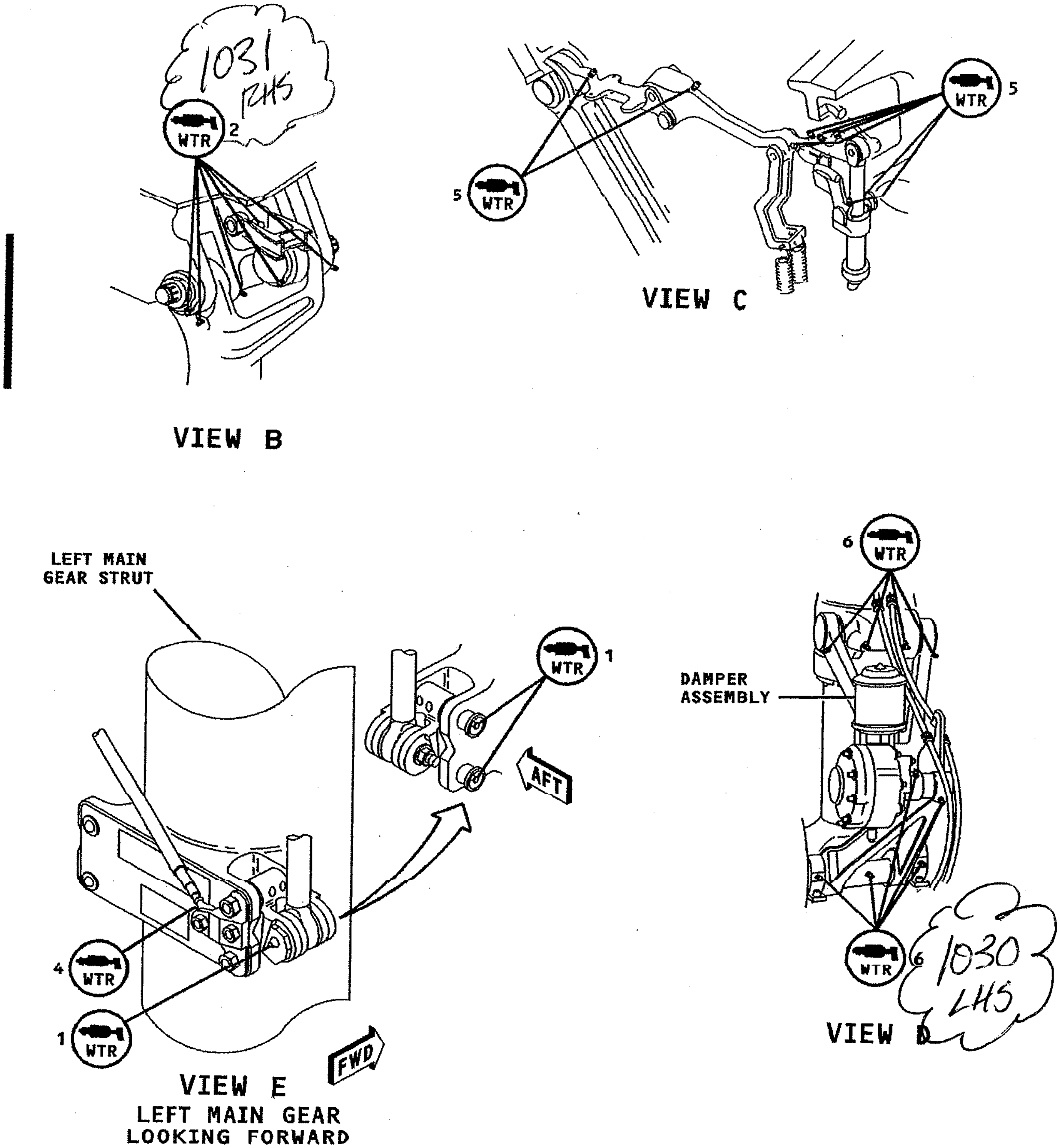
EFFECTIVITY: AS ALL



Flaps -- Lubrication
Figure 303 (Sheet 1)



Wing Leading Edge Slat -- Lubrication
Figure 309 (Sheet 1)



CAG(IGDS) BBB2-12-318B

Main Gear and Gear Outboard Door -- Lubrication
Figure 303 (Sheet 2)

Addendum to Systems Group Chairman's Factual Report

Appendix C:

Results of Huntington Beach Lab Testing of Restraining Fixtures

NTSB Aircraft Accident Case No. DCA00MA023
Pacific Ocean near Anacapa Island, California
January 31, 2000
McDonnell Douglas MD-83; N963AS

RESULTS

04/04/2001

		LUBRICATED TOOL THREADS (DPM 5481)								UNLUBRICATED (DRY) TOOL THREADS							
		seq	Symmetric Tool Position (50/50)			seq	Asymmetric Too Position (75/25)			seq	Symmetric Tool Position (50/50)			seq	Asymmetric Tool Position (75/25)		
			250 in-#	275 in-#	300 in-#		250 in-#	275 in-#	300 in-#		250 in-#	275 in-#	300 in-#		250 in-#	275 in-#	300 in-#
Boeing Tool #1	Nom. Length	1	3039	3419	3935	5	4076	4725 (4740)	4920	1	3675	3830	3680	4	3170	2647	2472
(ASA - used)	Nom + .80 in	2	3385	3897	4247												
CE9122	Nom - .80 in	3	3730	4310	4675												
	Nom repeat	4	4000	4292	4675					2	2071	2122	2242	5*	2978	2111	1855
	Nom repeat									3&	2600	2314	2086				
Boeing Tool #2	Nom. Length	1	2592	3260	3800					1	3530	3930	4488				
(ASA - used)	Nom repeat	2	3150	3575	3794					2	3903	4320	4660				
CE9150	Nom + .80 in	3	2894	3340	3923												
	Nom - .80 in	4	3400	3766	4350												
Boeing Tool #3	Nom. Length	1#	3802	4274	4476					1	3810	4240	4758				
(BCAG - new)	Nom repeat	A2	3975	4377	4915					2	3820	4180	4674				
RAMS #1	Nom repeat	A3	4110	4310	4815												
	Nom + .80 in	1$	3825	4520	4900												
	Nom - .80 in	2$	3960	4460	4900												
ASA Tool #1	Nom. Length	1	1490	1616	1787	5	1469	1634	1800	1	1740	1976	2352	5	1762	1855	2077
(NTSB - used)	Nom repeat	2	1550	1780	1943					2	2005	2325	2525				
CE0826	Nom + .80 in	3	1250	1502	1770 (1768)	6	1514	1650	1802	3	1716	1790	2077				
	Nom - .80 in	4	1275	1566	1714	7	1494	1562	1751	4	1855	2133	2403				
ASA Tool #1	Nom. Length																
(NTSB - used)	Nom + 1.60 in	1	1264	1484	1724												
(2x HS tolerance)	Nom - 1.60 in^	2	1446	1535	1708												
ASA Tool #2	Nom. Length	1	1650	1780	1856					1	2049	2208	2351				
(ASA - used)	Nom + .80 in	2	1420	1508	1585												
CE070811	Nom - .80 in	3	1668	1754	1911												
	Nom repeat	4	1682	1788	1871					2	2072	2379	2480				
ASA Tool #2	Nom. Length	1	1470	1476	1590												
(ASA - used)	Nom repeat	2	1295	1384	1540												
(Hydraulic Lock)	Nom repeat	3	1310	1394	1600 (1660%)												

NOTES: N/A

Nominal Tool Length (span at 1 deg ANU HS) = **9.625** inches. Assumed HS position tolerance for test: +/- 1 deg = +/- .80 inches axially @ tool.
Tools lubricated once at the start of the each test sequence group. No relubes during sequence.
Boeing tool part number: 4916750-1 (with straight clevis ends to match ASA tool).
Apply torque to body of tool in shortening direction with "clicker" torque wrench; measure force output. Torque wrench calibrated 4-3-01. Tolerance +/- 4%.
* asymmetry reversed (25/75)
$ last test sequence at the end of the day
& tool removed from test fixture; unthreaded; rethreaded; tested
"Hydraulic Lock' test: fill each end of tool body with oil prior to installing clevis ends. Determine if phenomena is possible. It is not: oil leaks from the threads. "Very well lubed" case.
\# load sequence: 0-250-275-300; all remaining tests accomplished 0-250-0-275-0-300.

C-1

RESULTS 04/04/2001 SPECIAL CASES		DPM 377 LUBE (C5A)				UNLUBRICATED (DRY)				DPM 5481 LUBE			
		seq	Symmetric Tool Position (50/50)			seq	Symmetric Tool Position (50/50)			seq	Symmetric Tool Position (50/50)		
			250 in-#	275 in-#	300 in-#		250 in-#	275 in-#	300 in-#		250 in-#	275 in-#	300 in-#
Boeing Tool #1	Nom. Length	1	3918	4295	4520	1	3390	3357	3111	1	3450	3820	4300
(ASA - used)	Nom repeat	2	4077	4317	4526	2	2130	2391	2372	2	3478	3940	4347
CE9122	Nom repeat	3	3968	4278	4500	3	1847	1752	2240	3	3688	4100	4352
Boeing Tool #2	Nom. Length	1	3885	4030	4385								
(ASA - used)	Nom repeat	2	3752	3885	4150								
CE9150	Nom repeat	3	3625	3890	4090								
Boeing Tool #3	Nom. Length					1	3520	3825	4335				
Frozen 20 min	Nom repeat					2	3600	4160	4290				
(5F)	Nom repeat					3	3786	4270	4530				
Boeing Tool #3	Nom. Length					1	3790	4159	4725				
Heated 20 min	Nom repeat					2	4004	4280	4710				
(124F)	Nom repeat					3	3760	4130	4870				
ASA Tool #2	Nom. Length	1	2339	2630	2748								
(ASA - used)	Nom repeat	2	2454	2673	2810								
CE070811	Nom repeat	3	2395	2667	2818								

NOTES: Boeing Tool #1 sequence: cleaned; greased; tested; cleaned again; oiled; tested.
Boeing Tool #3 sequence: frozen; tested; baked; tested.

C-2

06/01/2001

Torque/Force Mapping - Modified Tools

		ZIP AEROSOL		(DPM 5481)		C5A GREASE		(DPM 377)	
APPLIED TORQUE		Restraining Tool Load Cell		Lab Test Fixture		Restraining Tool Load Cell		Lab Test Fixture	
50 in-lb-A		455		459		845		867	
50 in-lb-B		453		460		742		762	
50 in-lb-C		444		450		702		722	
100 in-lb-A		1000	*	955		1415		1431	
100 in-lb-B		960		970		1385		1400	
100 in-lb-C		975		995		1375		1395	
150 in-lb-A		1640		1662		2090		2130	
150 in-lb-B		1560		1577		2025		2060	
150 in-lb-C		1530		1554		2015		2048	
200 in-lb-A	#	1760		1792		2900		2940	
200 in-lb-B	#	2290		2321		2922		2955	
200 in-lb-C	#	2240		2276		2900		2938	
250 in-lb-A	#	3115		3156		3365		3417	
250 in-lb-B	#	3085		3135		3710		3758	
250 in-lb-C	#	2940		2980		3660		3713	
275 in-lb-A	#	3220	**	3423		3925		3960	
275 in-lb-B	#	3160	**	3360		4068		4085	
275 in-lb-C	#	3315	**	3525		3975		4002	
300 in-lb-A	#	3690		3740		4300		4330	
300 in-lb-B	#	3765		3810		4115		4160	
300 in-lb-C	#	3710		3756		4493		4530	

TOOL #: Modified Boeing Tool #3 with Load Cell

* Value was decreasing to ~950
** Test started before the load cell was "zeroed", post test verified load cell was offset by ~150 lbs low
\# Switched to a higher range torque wrench.

Note: Test was performed with ZIP Lube (DPM 5481) first, then the tool was cleaned and C5A (DPM 377) was applie

C-3

06/13/2001

Torque/Force Mapping - Modified Tools

APPLIED TORQUE	ZIP AEROSOL (DPM 5481)*		C5A GREASE (DPM 377)	
	Load Cell	Test Fixture	Load Cell	Test Fixture
50 in-#			565	573
			574	583
		last test run	593	603
100 in-#			1130	1140
			1133	1147
150 in-#			1642	1662
			1670	1688
200 in-#			2575	2602
			2570	2596
250 in-#			3180	3210
			3158	3190
275 in-#			3389	3421
			3364	3397
300 in-#			3715	3750
			3590	3623

TOOL #: Boeing Rams #3 Modified; spot check, 1st run — 9.625" tool span

tool not relubed prior to test

* Not applicable to ASA provided restraining fixtures.

C-4

06/13/2001

Torque/Force Mapping - Modified Tools

APPLIED TORQUE	ZIP AEROSOL (DPM 5481)*		C5A GREASE (DPM 377)	
	Load Cell	Test Fixture	Load Cell	Test Fixture
50 in-#			609	615
			579	582
100 in-#			1192	1200
			1136	1143
150 in-#			1681	1691
			1668	1680
200 in-#			2510	2530
			2460	2477
250 in-#			2163	2180
			2978	3000
			3075/3107	3100/3130
275 in-#			3356	3386
			3391	3420
300 in-#			3715	3740
			3745	3775

TOOL #: Boeing Rams #3 Modified; spot check, 2nd run, regrease with C5A

* Not applicable to ASA provided restraining fixtures. 9.625" tool span

06/13/2001

Torque/Force Mapping - Modified Tools

APPLIED TORQUE	ZIP AEROSOL (DPM 5481)*		C5A GREASE (DPM 377)	
	Load Cell	Test Fixture	Load Cell	Test Fixture
50 in-#			443	445
			430	431
			439	440
100 in-#			889	890
			896	896
			867	868
150 in-#			1278	1278
			1281	1281
			1294	1298
200 in-#			1806	1803
			1879	1877
			1852	1849
225 in-#			2042	2044
(ilo 250)			2042	2040
			2057	2058
250 in-#			2206	2207
(ilo 275)			2270	2268
			2210	2210
300 in-#			pushed the lmit of the	
			load cell max load rating;	
			stopped test	

C-6

TOOL #: ASA Clone Tool s/n 0809 with load cell   tool span: 11.55"

06/13/2001

Torque/Force Mapping - Modified Tools

APPLIED TORQUE	ZIP AEROSOL (DPM 5481)*		C5A GREASE (DPM 377)	
	Load Cell	Test Fixture	Load Cell	Test Fixture
50 in-#			761	762
			744	744
			755	754
100 in-#			1372	1371
			1385	1385
			1397	1398
150 in-#			1977	1978
			1869	1869
			1911	1911
200 in-#			testing stopped;	
			did not want to exceed	
			load cell max rating	
250 in-#			of 2000 pounds	
275 in-#				
300 in-#				

TOOL #: ASA Boeing style tool, s/n 079115

tool span: 11"

lubed with C5A prior to test

* Not applicable to ASA provided restraining fixtures.

C-7

Addendum to Systems Group Chairman's Factual Report

Appendix D:

Results of Oakland On-wing Tests of Restraining Fixtures

NTSB Aircraft Accident Case No. DCA00MA023
Pacific Ocean near Anacapa Island, California
January 31, 2000
McDonnell Douglas MD-83; N963AS

Oth SERIES TESTS: HS static weigh: measurement & tool performance mapping; Boeing tool #3 (modified); ASA tool #TBD1 and #TBD2 (both modified).

Aircraft #: N976AS | **Plunger Radial Distance: unk** | **HS at 1 degree ANU** (actually at 1 degree AND)**
Tool #: Rams #3 modified | **Tool lubrication: C5A anti-seize grease** | **Acme Nut Flat: Lower FWD**
JS Data/Info: tbd | **Tool Span: ~10"**

Seq.	Torque Reading*	Force Output*	
1	dial torque wrench	1600	* @ first movement of
2	not available; used	1602	dial indicator at acme
3	clicker style	1602	nut
4	set at 300 in-#		
5	300	3070	EP: .016"

Seq.	EP Reading - ASA #1	Seq.	EP Reading - ASA #1	EP Reading - ASA #1
6	.016 @ 250 in-#; .015 @ 300	11	000 @ 250; na @ 300	.004 @ 250; .0155 @ 300
7	000 @ 250***; na @ 300	12	000 @ 250; 000 @ 300	.0155 @ 250; na @ 300
8	.0155 @ 250; 000 @ 300***	13		.0155 @ 250; na @ 300
9		14		
10		15		
	unlubed, as delivered		with zip lube	with C5A grease

Notes: Sequence 1-5 uses dial indicator torque wrench. Apply torque slowly; record both readings. Apply 300 in-# torque then back off to zero.
After sequence #5, apply 300 in-# torque and hold for 5 minutes. Release torque and install ASA unmodified clone tools. Do not move HS or disturb dial indicator set up.
Sequence 6-15 uses dial indicator torque wrench as well. Slowly apply torque; record wrench reading.

Seq.	Torque	Force Output	EP Reading
16	50 in-#	620	0
17	100 in-#	1196	0
18	150 in-#	1990	0.016
19	200 in-#	2120	0.016
20	250 in-#	2576	0.016
	110 in-#	1380	0
	120 in-#	1452	0
	130 in-#	1540	0.006
	140 in-#	1680	0.014
	150 in-#	1865	0.0155
	160 in-#	1970	0.016
21	275 in-#	2920	0.016
22	300 in-#	3023	0.0163

***apparent thd damage on tool; clevis seized; tool in dry condition from NTSB labs

** Achieve HS test point by running HS to full ANU
then returning to 1 degree ANU
NOTE: HS preset when we arrived at Oakland
NOTE: JS lubed prior to beginning tests

Notes: Reinstall modified (load cell) tool. Do not move HS or disturb dial indicator set up.
Sequence 16-22 uses clicker style torque wrench. Apply torque until click is heard. Record readings.
This sequence provides on-wing comparison data for tool mapping accomplished at HB test labs.
On any aircraft, begin by testing ASA modified clone tool.

OAKLAND 6/14/01
Sequence I Tests

D-1

Oth SERIES TESTS: HS static weight measurement & tool performance mapping; Boeing tool #3 (modified); ASA tool #TBD1 and #TBD2 (both modified).

Aircraft #: N976AS | **Plunger Radial Distance: unk** | **HS at 1 degree ANU** (actually at 2.1 degree AND)**

Tool #: ASA Boeing## | **Tool lubrication: C5A anti-seize grease** | **Acme Nut Flat: Lower FWD**

JS Data/Info: tbd | ## s/n 079115 | **Tool Span: unk**

Seq.	Torque Reading*	Force Output*
1	dial torque wrench	1576
2	not available; used	1472 (.002 EP)
3	clicker style	1510 (.007 EP)
4	set at 300 in-3	
5		

* @ first movement of dial indicator at acme nut

Seq.	EP Reading - ASA #1	Seq.	EP Reading - ASA #1
6		11	
7		12	
8		13	
9		14	
10		15	

Notes: Sequence 1-5 uses dial indicator torque wrench. Apply torque slowly; record both readings. Apply 300 in-# torque then back off to zero.
After sequence #5, apply 300 in-# torque and hold for 5 minutes. Release torque and install ASA unmodified clone tools. Do not move HS or disturb dial indicator set up.
Sequence 6-15 uses dial indicator torque wrench as well. Slowly apply torque; record wrench reading.

Seq.	Torque	Force Output	EP Reading
16	50 in-#	686	0
17	100 in-#	1375	0
18	150 in-#	2202	0.016
19	200 in-#	limited by load cell	
20	250 in-#		
	110 in-#	1450	0
	120 in-#	1724	0.015
	130 in-#	1936	0.015
	140 in-#	2066	0.016
	150 in-#		
	115 in-#	1660	0.015
	110 in-#	1620	0.016
21	275 in-#		
22	300 in-#		

Notes: Reinstall modified (load cell) tool. Do not move HS or disturb dial indicator set up.
Sequence 16-22 uses clicker style torque wrench. Apply torque until click is heard. Record readings.
This sequence provides on-wing comparison data for tool mapping accomplished at HB test labs.
On any aircraft, begin by testing ASA modified clone tool.

OAKLAND 6/14/01
Sequence II Tests

D-2

Oth SERIES TESTS: HS static weight measurement & tool performance mapping; Boeing tool #3 (modified); ASA tool #TBD1 and #TBD2 (both modified).

Aircraft #: N976AS **Plunger Radial Distance: unk** **HS at 1 degree ANU** (actually at 2.1 degree AND)**

Tool #: ASA clone **Tool lubrication: C5A anti-seize grease** **Acme Nut Flat: Lower FWD**

JS Data/Info: tbd **Tool Span: unk**

Seq.	Torque Reading*	Force Output*
1	dial torque wrench	1478
2	not available; used	1460
3	clicker style	
4	set at 300 in-#	
5		

* @ first movement of dial indicator at acme nut

Seq.	EP Reading - ASA #1	Seq.	EP Reading - ASA #1
6		11	
7		12	
8		13	
9		14	
10		15	

Notes: Sequence 1-5 uses dial indicator torque wrench. Apply torque slowly; record both readings. Apply 300 in-# torque then back off to zero.
After sequence #5 apply 300 in-# torque and hold for 5 minutes. Release torque and install ASA unmodified clone tools. Do not move HS or disturb dial indicator set up
Sequence 6-15 uses dial indicator torque wrench as well. Slowly apply torque; record wrench reading.

Seq.	Torque	Force Output	EP Reading
16	50 in-#	430	0
17	100 in-#	870	0
18	150 in-#	1270	0
19	200 in-#	1460	0
20	250 in-#	1800	0.0155
	210 in-#	1480	0.004
	220 in-#	1512	0.013
	230 in-#	1590	0.0155
	240 in-#	1634	0.0155
	250 in-#	1765	0.016
21	275 in-#	1945	0.0155
22	300 in-#	2000	0.016

Notes: Reinstall modified (load cell) tool. Do not move HS or disturb dial indicator set up.
Sequence 16-22 uses clicker style torque wrench. Apply torque until click is heard. Record readings.
This sequence provides on-wing comparison data for tool mapping accomplished at HB test labs.
On any aircraft, begin by testing ASA modified clone tool.

OAKLAND 6/14/01

Sequence III Tests

D-3

1st SERIES TESTS: baseline, vertical dial indicator, 2 plunger radial distances, ASA tools #1 and #2, Boeing tools #1 and #2.

Aircraft #: N976AS | **Plunger Radial Distance: I:_5/8_ II:_1 3/8 (max)_** | **JS Data/Info: tbd**

Tool #: ASA Boeing&&& | **Tool lubrication: VV-L-800** | **Acme Nut Flat: Lower FWD**

HS at 1 degree ANU

		I. Plunger in close to JS			II. Plunger further away from JS	
Seq.	**Torque**	**EP Reading**	**JS Rotate (Y/N)**	**Seq.**	**EP Reading**	**JS Rotate (Y/N)**
1	100 in-# (lengthening)	0 (null)	na	**18**	0 (null)	na
2	250 in-#	0.019	Y	**19**	0.018%%	Y
3	250 in-#			**20**		
4	250 in-#			**21**		
5	250 in-#			**22**		
6	250 in-# Restrained	0.015	na	**23**	.0175##	na
7	250 in-# Restrained		na	**24**	0.0155	na
8	250 in-# Restrained		na	**25**		na
9	250 in-# Restrained		na	**26**		na
10	300 in-#	0.0205	Y	**27**	0.02	Y
11	300 in-#			**28**		
12	300 in-#			**29**		
13	300 in-#			**30**		
14	300 in-# Restrained	0.0155	na	**31**	0.0165	na
15	300 in-# Restrained		na	**32**		na
16	300 in-# Restrained		na	**33**		na
17	300 in-# Restrained		na	**34**		na

Notes: Obtain HS test point by moving HS to full ANU then to returning to 1 degree ANU.
Between tests I and II, remove EP restraining fixture and dial indicator. Cycle HS and reset 1 degree ANU test NOT DONE.
At Systems Group discretion, entire test may be repeated by approaching HS test position from full AND HS.
&&& Serial number CE067616
Section II accomplished first; followed by Section I
%% C clamp/indicator bracketry contacted structure
dial indicator not nulled out properly

D-4

OAKLAND 6/14/01
Sequence IV

1st SERIES TESTS: baseline, vertical dial indicator, 2 plunger radial distances, ASA tools #1 and #2, Boeing tools #1 and #2.

Aircraft #: N976AS | **Plunger Radial Distance: I:_5/8_ II: na** | **JS Data/Info: tbd**

Tool #: ASA clone #2 | **Tool lubrication: VV-L-800** | **Acme Nut Flat: Lower FWD**

HS at 1 degree ANU

		I. Plunger in close to JS			II. Plunger further away from JS	
Seq.	**Torque**	**EP Reading**	**JS Rotate (Y/N)**	**Seq.**	**EP Reading**	**JS Rotate (Y/N)**
1	100 in-# (lengthening)	0 (null)	na	18	0 (null)	na
2	250 in-#	0.0165	N	19		
3	250 in-#	0.016	N	20		
4	250 in-#			21		
5	250 in-#			22		
6	250 in-# Restrained	0.015	na	23		na
7	250 in-# Restrained		na	24		na
8	250 in-# Restrained		na	25		na
9	250 in-# Restrained		na	26		na
10	300 in-#	0.0175	Y	27		Y
11	300 in-#	0.0185	Y	28		
12	300 in-#			29		
13	300 in-#			30		
14	300 in-# Restrained	0.015	na	31		na
15	300 in-# Restrained		na	32		na
16	300 in-# Restrained		na	33		na
17	300 in-# Restrained		na	34		na

Notes: Obtain HS test point by moving HS to full ANU then to returning to 1 degree ANU. DONE.
Between tests I and II, remove EP restraining fixture and dial indicator. Cycle HS and reset 1 degree ANU test NOT DONE.
At Systems Group discretion, entire test may be repeated by approaching HS test position from full AND HS.

D-5

OAKLAND 6/14/01

Sequence VIIa

4th SERIES TESTS: vertical dial indicator, regrease; ASA tool #2, Boeing tool #2.

Aircraft #: N976AS **Plunger Radial Distance: 5/8** **JS Data/Info: tbd**
Tool #: ASA clone tool **Tool lubrication: VV-L-800** **Acme Nut Flat: Lower FWD**
HS at 1 degree ANU

		I. Baseline			II. Regrease JS, Cycle, Regrease	
Seq.	**Torque**	**EP Reading**	**JS Rotate (Y/N)**	**Seq.**	**EP Reading**	**JS Rotate (Y/N)**
1	100 in-# (lengthening)	0 (null)	na	**18**	0 (null)	na
2	250 in-#			**19**	0.0165	Y
3	250 in-#			**20**	0.018	Y
4	250 in-#			**21**		
5	250 in-#			**22**		
6	250 in-# Restrained		na	**23**	0.015	na
7	250 in-# Restrained		na	**24**		na
8	250 in-# Restrained		na	**25**		na
9	250 in-# Restrained		na	**26**		na
10	300 in-#			**27**	0.0185	
11	300 in-#			**28**		
12	300 in-#			**29**		
13	300 in-#			**30**		
14	300 in-# Restrained		na	**31**	0.0145	na
15	300 in-# Restrained		na	**32**	0.015	na
16	300 in-# Restrained		na	**33**		na
17	300 in-# Restrained		na	**34**		na

Notes: Obtain HS test point by moving HS to full ANU then to returning to 1 degree ANU.
Between runs, JS shall be liberally greased, cycled, positioned to the desired test point, then lubricated liberally once again.
For test II, dial indicator set up shall be identical to test I.
Could use data from Series 1 tests for baseline portion of this matrix.
Recommend accomplishing this test on atleast one "fresh" aircraft having no other prior EP tests accomplished (ie, can't use Series 1 data).
Mark plunger contact point after 100 in-# lengthening torque input.

OAKLAND 6/14/01
Sequence VIII

D-6

3rd SERIES TESTS: vertical dial indicator, opposite nut flat; ASA tool #2, Boeing tool #2.

Aircraft #: N976AS | **Plunger Radial Distance: II. .75"** | **JS Data/Info: TBD**

Tool #: ASA Boeing | **Tool lubrication: VV-L-800** | **HS at 1 degree ANU**

CE067616 | && Plunger on Lower Aft Flat (ie, acme nut stop boss lug)

		I. Lower FWD Acme Nut Flat			II. Lower Aft Acme Nut Flat&&	
Seq.	**Torque**	**EP Reading**	**JS Rotate (Y/N)**	**Seq.**	**EP Reading**	**JS Rotate (Y/N)**
1	100 in-# (lengthening)	0 (null)	na	18	0 (null)	na
2	250 in-#			19	0.0135	Y
3	250 in-#			20	0.0125	Y
4	250 in-#			21		
5	250 in-#			22		
6	250 in-# Restrained		na	23	0.015	na
7	250 in-# Restrained		na	24		na
8	250 in-# Restrained		na	25		na
9	250 in-# Restrained		na	26		na
10	300 in-#			27	0.0135	Y
11	300 in-#			28		
12	300 in-#			29		
13	300 in-#			30		
14	300 in-# Restrained		na	31	0.016	na
15	300 in-# Restrained		na	32		na
16	300 in-# Restrained		na	33		na
17	300 in-# Restrained		na	34		na

Notes: Obtain HS test point by moving HS to full ANU then to returning to 1 degree ANU.

Between tests I and II, remove EP restraining fixture and dial indicator. Cycle HS and reset 1 degree ANU test point.

At Systems Group discretion, entire test may be repeated by approaching HS test position from full AND HS.

Could use data from Series 1 tests for one half of this matrix.

Plunger should be located the same radial distance on each side for consistency.

Mark plunger contact point after 100 in-# lengthening torque input.

OAKLAND 6/14/01

Sequence V

D-7

2nd SERIES TESTS: skewed dial indicator plunger; 2 plunger radial distances; ASA tool #1, Boeing tool #1.

Aircraft #: N976AS | **Plunger Radial Distance: I: na II: 1/2 in** | **JS Data/Info: tbd**

Tool #: CE067616 | **Tool lubrication: VV-L-800** | **Acme Nut Flat: Lower AFT**

HS at 1 degree ANU | **Plunger 30 degrees from vertical**

		I. Plunger in close to JS				II. Plunger further away from JS		
Seq.	**Torque**	**EP Reading**	**JS Rotate (Y/N)**	**Plunger Move (Y/N)**	**Seq.**	**EP Reading**	**JS Rotate (Y/N)**	**Plunger Move (Y/N)**
1	100 in-# (lengthening)	0 (null)	na	na	18	0 (null)	ra	na
2	250 in-#				19	0.015	Y	
3	250 in-#				20			
4	250 in-#				21			
5	250 in-#				22			
6	250 in-# Restrained		na		23	0.019	na	
7	250 in-# Restrained		na		24		na	
8	250 in-# Restrained		na		25		na	
9	250 in-# Restrained		na		26		na	
10	300 in-#				27	0.015	Y	
11	300 in-#				28			
12	300 in-#				29			
13	300 in-#				30			
14	300 in-# Restrained		na		31	0.0195	na	
15	300 in-# Restrained		na		32		na	
16	300 in-# Restrained		na		33		na	
17	300 in-# Restrained		na		34		na	

Notes: Obtain HS test point by moving HS to full ANU then to returning to 1 degree ANU.
Between tests I and II, remove EP restraining fixture and dial indicator. Cycle HS and reset 1 degree ANU test point.
At Systems Group discretion, entire test may be repeated by approaching HS test position from full AND HS.
Plunger skew angle TBD. Mark plunger contact point after 100 in-# lengthening torque input.
"Plunger Move": plunger contact point with acme nut should move laterally during EP test - measure if possible amount of translation.

OAKLAND 6/14/01

Sequence VIa

D-8

2nd SERIES TESTS: skewed dial indicator plunger; 2 plunger radial distances; ASA tool #1, Boeing tool #1.

Aircraft #: N976AS | **Plunger Radial Distance: I: na II: 1 1/8** | **JS Data/Info: tbd**

Tool #: CE 067616 | **Tool lubrication: VV-L-800** | **Acme Nut Flat: Lower FWD**

HS at 1 degree ANU | **Plunger 30 degrees from vertical**

		I. Plunger in close to JS				II. Plunger further away from JS		
Seq.	**Torque**	**EP Reading**	**JS Rotate (Y/N)**	**Plunger Move (Y/N)**	**Seq.**	**EP Reading**	**JS Rotate (Y/N)**	**Plunger Move (Y/N)**
1	100 in-# (lengthening)	0 (null)	na	na	18	0 (null)	na	na
2	250 in-#				19	0.0205	Y	
3	250 in-#				20			
4	250 in-#				21			
5	250 in-#				22			
6	250 in-# Restrained		na		23	0.0165	na	
7	250 in-# Restrained		na		24		na	
8	250 in-# Restrained		na		25		na	
9	250 in-# Restrained		na		26		na	
10	300 in-#				27	0.021	Y	
11	300 in-#				28			
12	300 in-#				29			
13	300 in-#				30			
14	300 in-# Restrained		na		31	0.0165	na	
15	300 in-# Restrained		na		32		na	
16	300 in-# Restrained		na		33		na	
17	300 in-# Restrained		na		34		na	

Notes: Obtain HS test point by moving HS to full ANU then to returning to 1 degree ANU. DONE.
Between tests I and II, remove EP restraining fixture and dial indicator. Cycle HS and reset 1 degree ANU test point.
At Systems Group discretion, entire test may be repeated by approaching HS test position from full AND HS.
Plunger skew angle TBD. Mark plunger contact point after 100 in-# lengthening torque input.
"Plunger Move": plunger contact point with acme nut should move laterally during EP test - measure if possible amount of translation.

OAKLAND 6/14/01

Sequence VIb

D-9

Addendum to Systems Group Chairman's Factual Report

Appendix E:

Results of Tulsa On-wing Restraining Fixture Tests

NTSB Aircraft Accident Case No. DCA00MA023
Pacific Ocean near Anacapa Island, California
January 31, 2000
McDonnell Douglas MD-83; N963AS

0th SERIES TESTS: HS static weight measurement & tool performance mapping.

Aircraft #:408 | **Plunger Radial Distance: 3/4 bottom, 1 1/8 top**

Tool #: ASA clone 070809 | **Tool lubrication: C5A anti-seize grease**

JS Data/Info:

HS at 1 degree ANU** | top indicator larger diameter & slightly skewed

Acme Nut Flat: Lower FWD & top AFT

NOTE: ASA tools might require deviation to HS neutral or AND HS settings.
Tool span should be: 9.625in. **actual 11 3/8**

Seq.	Torque	Force Output	EP Reading lower/upper
1	50 in-#	760	0/0
2	100 in-#	825	0/0
3	150 in-#	1140/1230	0/0 0/.001
4	200 in-#	1530	.0045/.006
5	250 in-#	1860	.018/.021
6	275 in-#	2080	.021/.023
7	300 in-#	2288	.021/.0235
8	140	1220	0/.001
9	150	1300	0/.001
10	160	1410	.0005/.0005
11	170	1450	.0005/.0005
12	180	1525	.012/.013
13	190	1535	.016/.018
14			
15			
16			
17			

TULSA
WED 7-11-01
Sequence # 1

MD-82
46,147 hours
24,837 cycles
fuselage 1266
466 hours since last lube
jackscrew rotation observed above 1200# output force

dash-1 airplane

NOTES:

This sequence provides on-wing comparison data for tool mapping accomplished at HB test labs.
On any aircraft, begin by testing ASA modified clone tool. (Tool Sequence: ASA clone, ASA Boeing, Boeing)
Sequence 1-7 uses clicker style torque wrench. Apply torque until click is heard. Record readings.
Once required torque/force is estimated, remap by 10 in-# increments. (Sequence 8 - tbd).
JS should NOT be lubricated prior to beginning these tests.
JS should NOT have EP tests accomplished by operator prior to these test sequences.

Previous endplay data 5/22/00: 42,557 hours, .024
12/15/00: 44,348 hours .020

E-1

Oth SERIES TESTS: HS static weight measurement & tool performance mapping.

Aircraft #:408 **Plunger Radial Distance: same as sequence 1**
Tool #: ASA Boeing 079115 **Tool lubrication: C5A anti-seize grease**
JS Data/Info:

HS at 1 degree ANU** top indicator reset to vertical
Acme Nut Flat: Lower FWD

NOTE: ASA tools might require deviation to HS neutral or AND HS settings.
Tool span should be: 9.625in. **actual 11 3/8**

Seq.	Torque	Force Output	EP Reading lower/upper
1	50 in-#	720	0/.001
2	100 in-#	1280	0/.001
3	150 in-#	1760	.017/.0205
4	200 in-#	2350	.021/.024
5	250 in-#		
6	275 in-#		
7	300 in-#		
8	100	1328	0/.001
9	110	1350	0/.001
10	120	1440	0/.001
11	130	1530	.0165/.020
12			
13			
14			
15			
16			
17			

TULSA
WED 7-11-01
Sequence # 2

MD-82
46,147 hours
24,837 cycles
fuselage 1263

NOTES:

This sequence provides on-wing comparison data for tool mapping accomplished at HB test labs.
On any aircraft, begin by testing ASA modified clone tool. (Tool Sequence: ASA clone, ASA Boeing, Boeing)
Sequence 1-7 uses clicker style torque wrench. Apply torque until click is heard. Record readings.
Once required torque/force is estimated, remap by 10 in-# increments. (Sequence 8 - tbd).
JS should NOT be lubricated prior to beginning these tests.
JS should NOT have EP tests accomplished by operator prior to these test sequences.

E-2

Oth SERIES TESTS: HS static weight measurement & tool performance mapping.

Aircraft #:408 | **Plunger Radial Distance: both 1 1/8 inch**
Tool #: ASA Boeing RAMS #3 | **Tool lubrication: C5A anti-seize grease**
JS Data/Info:

HS at 1 degree ANU** actual .75 ANU
Acme Nut Flat: Lower FWD & top AFT

NOTE: ASA tools might require deviation to HS neutral or AND HS settings.
Tool span should be: 9.625in. **actual 9 7/8**

stabilizer and dial indicator positions reset

TULSA
WED 7-11-01
Sequence # 3

MD-82
46,147 hours
24,837 cycles
fuselage 1266

Seq.	Torque	Force Output	EP Reading lower/upper	
1	50 in-#	625	0/.0005	
2	100 in-#	1090	.0005/.001	
3	150 in-#	1620	.0175/.019	
4	200 in-#	2190	.0185/.020	
5	250 in-#	2680	.0195/.021	
6	275 in-#	3075	.022/.025	rotation
7	300 in-#	3675	.022/.026	rotation
8	100	1185	0/.001	
9	110	1300	0/.001	
10	120	1460	0/.001	
11	130	1470	.0005/.001	
12	140	1585	.018/.020	
13				
14				
15				
16				
17				

NOTES:

This sequence provides on-wing comparison data for tool mapping accomplished at HB test labs.
On any aircraft, begin by testing ASA modified clone tool. (Tool Sequence: ASA clone, ASA Boeing, Boeing)
Sequence 1-7 uses clicker style torque wrench. Apply torque until click is heard. Record readings.
Once required torque/force is estimated, remap by 10 in-# increments. (Sequence 8 - tbd).
JS should NOT be lubricated prior to beginning these tests.
JS should NOT have EP tests accomplished by operator prior to these test sequences.

E-3

1st SERIES TESTS: baseline, vertical dial indicator, 2 plunger radial distances.

Aircraft #: 408 **Plunger Radial Distance: I:__1 3/16_____ II:__1 3/16_____** **JS Data/Info:**

Tool #: Alaska clone 070811 **Tool lubrication: C5A anti-seize grease** **Acme Nut Flat: Lower FWD & top AFT**

HS at 1 degree ANU

MD-82
46,147 hours
24,837 cycles
fuselage 1266

		I. Plunger in close to JS			II. Plunger further away from JS	
Seq.	**Torque**	**EP Reading lower/upper**	**JS Rotate (Y/N)**	**Seq.**	**EP Reading**	**JS Rotate (Y/N)**
1	100 in-# (lengthening)	0 (null)	na	**18**	0 (null)	na
2	250 in-#	.019/.021	N	**19**		
3	250 in-#			**20**		
4	250 in-#			**21**		
5	250 in-#			**22**		
6	250 in-# Restrained	.018/.0205	na	**23**		na
7	250 in-# Restrained		na	**24**		na
8	250 in-# Restrained		na	**25**		na
9	250 in-# Restrained		na	**26**		na
10	300 in-#	.0195/.0215	N	**27**		
11	300 in-#			**28**		
12	300 in-#			**29**		
13	300 in-#			**30**		
14	300 in-# Restrained	.0185/.0205	na	**31**		na
15	300 in-# Restrained		na	**32**		na
16	300 in-# Restrained		na	**33**		na
17	300 in-# Restrained		na	**34**		na

Notes: Obtain HS test point by moving HS to full ANU then to returning to 1 degree ANU.
Repeat torque applications as required at discretion of Systems Group. Minimum 1 attempt.
At Systems Group discretion, entire test may be repeated by approaching HS test position from full AND HS.

1 3/16 plunger distance both lower and u

WED 7-11-01
TULSA
Sequence # 4

same dial indicators (small) top & bottor

same HS position as sequence 3

E-4

1st SERIES TESTS: baseline, vertical dial indicator, 2 plunger radial distances.

Aircraft #: 408 | **Plunger Radial Distance: I:__1 3/16_____ II:__1 3/16_____** | **JS Data/Info:**

Tool #: Boeing CE9122 | **Tool lubrication: C5A anti-seize grease** | **Acme Nut Flat: Lower FWD**

HS at 1 degree ANU

MD-82
46,147 hours
24,837 cycles
fuselage 1266

		I. Plunger in close to JS			II. Plunger further away from JS	
Seq.	**Torque**	**EP Reading lower/upper**	**JS Rotate (Y/N)**	**Seq.**	**EP Reading**	**JS Rotate (Y/N)**
1	100 in-# (lengthening)	0 (null)	na	18	0 (null)	na
2	250 in-#	.0225/.026	Y	19		
3	250 in-#			20		
4	250 in-#			21		
5	250 in-#			22		
6	250 in-# Restrained	.018/.020	na	23		na
7	250 in-# Restrained		na	24		na
8	250 in-# Restrained		na	25		na
9	250 in-# Restrained		na	26		na
10	300 in-#	.0225/.0245	Y	27		
11	300 in-#			28		
12	300 in-#			29		
13	300 in-#			30		
14	300 in-# Restrained	.018/.021	na	31		na
15	300 in-# Restrained		na	32		na
16	300 in-# Restrained		na	33		na
17	300 in-# Restrained		na	34		na

Notes: Obtain HS test point by moving HS to full ANU then to returning to 1 degree ANU.
Repeat torque applications as required at discretion of Systems Group. Minimum 1 attempt.
At Systems Group discretion, entire test may be repeated by approaching HS test position from full AND HS.

1 3/16 plunger distance both lower and

same as sequence 4 except for tool use

WED 7-11-01
TULSA
Sequence # 5

E-5

1st SERIES TESTS: baseline, vertical dial indicator, 2 plunger radial distances.

Aircraft #: 408 — **Plunger Radial Distance: I:_7/8______ II:__7/8_____** — **JS Data/Info:**

Tool #: Boeing CE9122 — **Tool lubrication: C5A anti-seize grease** — **Acme Nut Flat: Lower FWD & upper FWD**

HS at 1 degree ANU

MD-82
46,147 hours
24,837 cycles
fuselage 1266

stabilizer same as previous

both dial indicators on forward side

		I. Plunger in close to JS			II. Plunger further away from JS	
Seq.	**Torque**	**EP Reading lower/upper**	**JS Rotate (Y/N)**	**Seq.**	**EP Reading**	**JS Rotate (Y/N)**
1	100 in-# (lengthening)	0 (null)	na	18	0 (null)	na
2	250 in-#	.0225/.018	Y (lots)	19		
3	250 in-#	(not a typo)		20		
4	250 in-#			21		
5	250 in-#			22		
6	250 in-# Restrained	.018/.021	na	23		na
7	250 in-# Restrained		na	24		na
8	250 in-# Restrained		na	25		na
9	250 in-# Restrained		na	26		na
10	300 in-#	.023/.019	Y (lots)	27		
11	300 in-#	(not a typo)		28		
12	300 in-#			29		
13	300 in-#			30		
14	300 in-# Restrained	.0185/.022	na	31		na
15	300 in-# Restrained		na	32		na
16	300 in-# Restrained		na	33		na
17	300 in-# Restrained		na	34		na

Notes: Obtain HS test point by moving HS to full ANU then to returning to 1 degree ANU.
Repeat torque applications as required at discretion of Systems Group. Minimum 1 attempt.
At Systems Group discretion, entire test may be repeated by approaching HS test position from full AND HS.

WED 7-11-01
TULSA
Sequence # 6

E-6

2nd SERIES TESTS: vertical dial indicator plungers

Aircraft #: 408 | **Plunger Radial Distance: I:__7/8___ II:__7/8____**
Tool #: Boeing CE9122 | **Tool lubrication: C5A anti-seize grease**
HS at 1 degree ANU

JS Data/Info:
Acme Nut Flat: Lower AFT & upper FWD

MD-82
46,147 hours
24,837 cycles
fuselage 1266

		I. Plunger in close to JS				II. Plunger further away from JS		
Seq.	Torque	EP Reading lower/upper	JS Rotate (Y/N)	Plunger Move (Y/N)	Seq.	EP Reading	JS Rotate (Y/N)	Plunger Move (Y/N)
1	100 in-# (lengthening)	0 (null)	na	na	18	0 (null)	na	na
2	250 in-#	.017/.018	N	na	19			na
3	250 in-#			na	20			na
4	250 in-#			na	21			na
5	250 in-#			na	22			na
6	250 in-# Restrained	.021/.022	na	na	23		na	na
7	250 in-# Restrained		na	na	24		na	na
8	250 in-# Restrained		na	na	25		na	na
9	250 in-# Restrained		na	na	26		na	na
10	300 in-#	.017/.0185	Y	na	27			na
11	300 in-#			na	28			na
12	300 in-#			na	29			na
13	300 in-#			na	30			na
14	300 in-# Restrained	.021/.022	na	na	31		na	na
15	300 in-# Restrained		na	na	32		na	na
16	300 in-# Restrained		na	na	33		na	na
17	300 in-# Restrained		na	na	34		na	na

Notes: Obtain HS test point by moving HS to full ANU then to returning to 1 degree ANU.
Repeat torque applications as required at discretion of Systems Group. Minimum 1 attempt.
At Systems Group discretion, entire test may be repeated by approaching HS test position from full AND HS.

WED 7-11-01
TULSA
Sequence # 7

vertical dial indicator plungers

M1-7

2nd SERIES TESTS: vertical dial indicator plungers, bottom skewed

Aircraft #: 408 **Plunger Radial Distance: I:___7/8____ II:_7/8______**
Tool #: Boeing CE9122 **Tool lubrication: C5A anti-seize grease**
HS at 1 degree ANU

JS Data/Info:
Acme Nut Flat: Lower AFT & upper FWD

MD-82
46,147 hours
24,837 cycles
fuselage 1266

		I. Plunger in close to JS				II. Plunger further away from JS		
Seq.	Torque	EP Reading lower/upper	JS Rotate (Y/N)	Plunger Move (Y/N)	Seq.	EP Reading	JS Rotate (Y/N)	Plunger Move (Y/N)
1	100 in-# (lengthening)	0 (null)	na	na	18	0 (null)	na	na
2	250 in-#	.012/.018	Y	na	19			na
3	250 in-#			na	20			na
4	250 in-#			na	21			na
5	250 in-#			na	22			na
6	250 in-# Restrained	.012/.0215	na	na	23		na	na
7	250 in-# Restrained		na	na	24		na	na
8	250 in-# Restrained		na	na	25		na	na
9	250 in-# Restrained		na	na	26		na	na
10	300 in-#	.012/.018	Y	na	27			na
11	300 in-#			na	28			na
12	300 in-#			na	29			na
13	300 in-#			na	30			na
14	300 in-# Restrained	.012/.021	na	na	31		na	na
15	300 in-# Restrained		na	na	32		na	na
16	300 in-# Restrained		na	na	33		na	na
17	300 in-# Restrained		na	na	34		na	na

Notes: Obtain HS test point by moving HS to full ANU then to returning to 1 degree ANU.
Repeat torque applications as required at discretion of Systems Group. Minimum 1 attempt.
At Systems Group discretion, entire test may be repeated by approaching HS test position from full AND HS.

WED 7-11-01
TULSA
Sequence # 8

vertical dial indicator plungers, bottom skewed

11-8

0th SERIES TESTS: HS static weight measurement & tool performance mapping.

Aircraft #:438 **Plunger Radial Distance: 1 inch**
Tool #: ASA clone 070809 **Tool lubrication: C5A anti-seize grease**
JS Data/Info:

HS at 1 degree ANU** actual HS about 2 degrees AND
Acme Nut Flat: Lower FWD

NOTE: ASA tools might require deviation to HS neutral or AND HS settings.
Tool span should be: 9.625in. **actual span is 11 3/8 in.**

Seq.	Torque	Force Output	EP Reading
1	50 in-#	500	0
2	100 in-#	800	0
3	150 in-#	1210	0.0001
4	200 in-#	1450	0.017
5	250 in-#	1800	0.019
6	275 in-#	1980	0.019
7	300 in-#	2150	0.019
8	140	1250	0
9	150	1200	0
10	160	1350	0
11	170	1360	0
12	180	1360	0
13	190	1445	0.01
14	200	1510	0.0185
15			
16			
17			

TULSA
TUE 7-10-01
Sequence # 1

fuselage # 1393
44,986 hours
21,608 cycles
original MD82 modified to MD83

451 hours since last lube

NOTES:

This sequence provides on-wing comparison data for tool mapping accomplished at HB test labs.
On any aircraft, begin by testing ASA modified clone tool. (Tool Sequence: ASA clone, ASA Boeing, Boeing)
Sequence 1-7 uses clicker style torque wrench. Apply torque until click is heard. Record readings.
Once required torque/force is estimated, remap by 10 in-# increments. (Sequence 8 - tbd).
JS should NOT be lubricated prior to beginning these tests.
JS should NOT have EP tests accomplished by operator prior to these test sequences. It was (.020 morning of 7-10).
American's previous endplay was .019.

E-9

Oth SERIES TESTS: HS static weight measurement & tool performance mapping.

Aircraft #: 438 | **Plunger Radial Distance: 1 inch** | **HS at 1 degree ANU**** | actual 2 degrees AND

Tool #: Boeing 079115 | **Tool lubrication: C5A anti-seize grease** | **Acme Nut Flat: Lower FWD**

JS Data/Info:

NOTE: ASA tools might require deviation to HS neutral or AND HS settings.
Tool span should be: 9.625in.

Seq.	Torque	Force Output	EP Reading
1	50 in-#	780	0
2	100 in-#	1250	0.0005
3	150 in-#	1900	0.019
4	200 in-#	2490	0.0195
5	250 in-#		
6	275 in-#		
7	300 in-#		
8	90	1180	0
9	100	1290	0.0005
10	110	1415	0.001
11	120	1580	0.019
12			
13			
14			
15			
16			
17			

TULSA
TUE 7-10-01
Sequence # 2

NOTES:

This sequence provides on-wing comparison data for tool mapping accomplished at HB test labs.
On any aircraft, begin by testing ASA modified clone tool. (Tool Sequence: ASA clone, ASA Boeing, Boeing)
Sequence 1-7 uses clicker style torque wrench. Apply torque until click is heard. Record readings.
Once required torque/force is estimated, remap by 10 in-# increments. (Sequence 8 - tbd).

E-10

Oth SERIES TESTS: HS static weight measurement & tool performance mapping.

Aircraft #: 438 **Plunger Radial Distance: 1 inch** **HS at 1 degree ANU**** actual 0.5 ANU

Tool #: Boeing RAMS 3 **Tool lubrication: C5A anti-seize grease** **Acme Nut Flat: Lower FWD**

JS Data/Info:

NOTE: ASA tools might require deviation to HS neutral or AND HS settings.
Tool span should be: 9.625in. **(confirmed)**

Seq.	Torque	Force Output	EP Reading
1	50 in-#	560	0
2	100 in-#	1070	0
3	150 in-#	1620	0.0205
4	200 in-#	2165	0.021
5	250 in-#	2865	0.0205
6	275 in-#	3200	0.022
7	300 in-#	3540	0.022
8	100	1125	0
9	110	1225	0
10	120	1325	0
11	130	1405	0.0005
12	140	1570	0.02
13			
14			
15			
16			
17			

TULSA
TUE 7-10-01
Sequence # 3

NOTES:

This sequence provides on-wing comparison data for tool mapping accomplished at HB test labs.
On any aircraft, begin by testing ASA modified clone tool. (Tool Sequence: ASA clone, ASA Boeing, Boeing)
Sequence 1-7 uses clicker style torque wrench. Apply torque until click is heard. Record readings.
Once required torque/force is estimated, remap by 10 in-# increments. (Sequence 8 - tbd).

E-11

1st SERIES TESTS: baseline, vertical dial indicator, 2 plunger radial distances.

Aircraft #: 438 **Plunger Radial Distance: I:__1 "_____ II:__n/a_____** **JS Data/Info:**

Tool #:Alaska clone 070811 **Tool lubrication: C5A anti-seize grease** **Acme Nut Flat: Lower FWD**

HS actually at 0.5

		I. Plunger in close to JS			II. Plunger further away from JS	
Seq.	**Torque**	**EP Reading**	**JS Rotate (Y/N)**	**Seq.**	**EP Reading**	**JS Rotate (Y/N)**
1	100 in-# (lengthening)	0 (null)	na	**18**	0 (null)	na
2	250 in-#	0.021	N	**19**		
3	250 in-#			**20**		
4	250 in-#			**21**		
5	250 in-#			**22**		
6	250 in-# Restrained	0.021	na	**23**		na
7	250 in-# Restrained		na	**24**		na
8	250 in-# Restrained		na	**25**		na
9	250 in-# Restrained		na	**26**		na
10	300 in-#	0.021	N	**27**		
11	300 in-#			**28**		
12	300 in-#			**29**		
13	300 in-#			**30**		
14	300 in-# Restrained	0.021	na	**31**		na
15	300 in-# Restrained		na	**32**		na
16	300 in-# Restrained		na	**33**		na
17	300 in-# Restrained		na	**34**		na

Notes: Obtain HS test point by moving HS to full ANU then to returning to 1 degree ANU.
Repeat torque applications as required at discretion of Systems Group. Minimum 1 attempt.
At Systems Group discretion, entire test may be repeated by approaching HS test position from full AND HS.

TUE 7-10-01
TULSA
Sequence # 4

E-12

1st SERIES TESTS: baseline, vertical dial indicator, 2 plunger radial distances.

Aircraft #:438 | **Plunger Radial Distance: I:_1 "______ II:__n/a_____** | **JS Data/Info:**

Tool #:Boeing CE9122 | **Tool lubrication: C5A anti-seize grease** | **Acme Nut Flat: Lower FWD**

HS actually at 0.5

		I. Plunger in close to JS			II. Plunger further away from JS	
Seq.	**Torque**	**EP Reading**	**JS Rotate (Y/N)**	**Seq.**	**EP Reading**	**JS Rotate (Y/N)**
1	100 in-# (lengthening)	0 (null)	na	**18**	0 (null)	na
2	250 in-#	0.022	N	**19**		
3	250 in-#			**20**		
4	250 in-#			**21**		
5	250 in-#			**22**		
6	250 in-# Restrained	0.021	na	**23**		na
7	250 in-# Restrained		na	**24**		na
8	250 in-# Restrained		na	**25**		na
9	250 in-# Restrained		na	**26**		na
10	300 in-#	0.022	N	**27**		
11	300 in-#			**28**		
12	300 in-#			**29**		
13	300 in-#			**30**		
14	300 in-# Restrained	0.021	na	**31**		na
15	300 in-# Restrained		na	**32**		na
16	300 in-# Restrained		na	**33**		na
17	300 in-# Restrained		na	**34**		na

Notes: Obtain HS test point by moving HS to full ANU then to returning to 1 degree ANU.
Repeat torque applications as required at discretion of Systems Group. Minimum 1 attempt.
At Systems Group discretion, entire test may be repeated by approaching HS test position from full AND HS.

TUE 7-10-01
TULSA
Sequence # 5

E-13

4th SERIES TESTS: vertical dial indicator, regrease.

Aircraft #:438 | **Plunger Radial Distance: unknown** | **JS Data/Info:**

Tool #:Boeing CE9122 | **Tool lubrication: C5A anti-seize grease** | **Acme Nut Flat: Lower FWD**

HS at .5-1.0 degree ANU

span 9.65"

		I. Baseline (see series 1, sequence 5)			II. Regrease JS, Cycle, Regrease	
Seq.	**Torque**	**EP Reading**	**JS Rotate (Y/N)**	**Seq.**	**EP Reading**	**JS Rotate (Y/N)**
1	100 in-# (lengthening)	0 (null)	na	18	0 (null)	na
2	250 in-#			19	0.02	Y
3	250 in-#			20		
4	250 in-#			21		
5	250 in-#			22		
6	250 in-# Restrained		na	23	0.02	na
7	250 in-# Restrained		na	24		na
8	250 in-# Restrained		na	25		na
9	250 in-# Restrained		na	26		na
10	300 in-#			27	0.02	N
11	300 in-#			28		
12	300 in-#			29		
13	300 in-#			30		
14	300 in-# Restrained		na	31	0.02	na
15	300 in-# Restrained		na	32		na
16	300 in-# Restrained		na	33		na
17	300 in-# Restrained		na	34		na

Notes: Obtain HS test point by moving HS to full ANU then to returning to 1 degree ANU.
Between runs, JS shall undergo the following grease and cycling procedure: 1) brush lube exposed screw above acme nut; 2) run HS to full ANU; 3) brush lube exposed screw beneath acme nut; 4) run HS to 1 degree ANU; 5) grease acme nut zerk fitting.
Repeat torque applications as required at discretion of Systems Group. Minimum 1 attempt.
For test II, dial indicator set up shall be identical to test I.
Could use data from Series 1 tests for baseline portion of this matrix.
Recommend accomplishing this test on atleast one "fresh" aircraft having no other prior EP tests accomplished (ie, can't use Series 1 data).

DRAFT 6/25/01
TULSA
Sequence # 6

E-14

Oth SERIES TESTS: HS static weight measurement & tool performance mapping.

Aircraft #: 487 **Plunger Radial Distance: 1 inch for both**
Tool #: 070809 clone **Tool lubrication: dry**
JS Data/Info:

HS at 1 degree ANU**
Acme Nut Flat: Lower FWD & upper AFT

NOTE: ASA tools might require deviation to HS neutral or AND HS settings.
Tool span should be: 9.625in. **actual 11 1/4**

Seq.	Torque	Force Output	EP Reading lower/upper
1	50 in-#	335	0/0
2	100 in-#	550	0/0
3	150 in-#	850	0/0
4	200 in-#	1140	0/.001
5	250 in-#	1480	.001/.001
6	275 in-#	1780	.013/.015
7	300 in-#		
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			

TULSA
THU 7-12-01
Sequence # 1

37,840 hours
19,712 cycles
fuselage 1558

observed strain gauge movement

152 hours since last lube

NOTES:

This sequence provides on-wing comparison data for tool mapping accomplished at HB test labs.
On any aircraft, begin by testing ASA modified clone tool. (Tool Sequence: ASA clone, ASA Boeing, Boeing)
Sequence 1-7 uses clicker style torque wrench. Apply torque until click is heard. Record readings.
Once required torque/force is estimated, remap by 10 in-# increments. (Sequence 8 - tbd).
JS should NOT be lubricated prior to beginning these tests.
JS should NOT have EP tests accomplished by operator prior to these test sequences.

American's endplay after our tests was .018

E-15

0th SERIES TESTS: HS static weight measurement & tool performance mapping.

Aircraft #: 487
Tool #: 070809 clone
JS Data/Info:

Plunger Radial Distance: 1 inch for both
Tool lubrication: dry

HS at 1 degree ANU**
Acme Nut Flat: Lower FWD & upper AFT

NOTE: ASA tools might require deviation to HS neutral or AND HS settings.
Tool span should be: 9.625in. **actual 11 1/4**

Seq.	Torque	Force Output	EP Reading lower/upper
1	50 in-#	345	0/0
2	100 in-#	670	0/0
3	150 in-#	1005	0/.0005
4	200 in-#	1355/1365	.0003/.001 twice
5	250 in-#	1600	.013/.015
6	275 in-#	1840	.0125/.0155
7	300 in-#	1935	.013/.0155
8	180	1270	0/.001
9	190	1375	0/.001
10	200	1450	0/.001
11	210	1495	0/.001
12	220	1525	.003/.004
13	230	1610	.0125/.015
14	300	2025	.0125/.016
15			
16			
17			

TULSA
THU 7-12-01
Sequence # 1A

37,840 hours
19,712 cycles
fuselage 1558

restrained strain gauge to prevent movement

NOTES:

This sequence provides on-wing comparison data for tool mapping accomplished at HB test labs.
On any aircraft, begin by testing ASA modified clone tool. (Tool Sequence: ASA clone, ASA Boeing, Boeing)
Sequence 1-7 uses clicker style torque wrench. Apply torque until click is heard. Record readings.
Once required torque/force is estimated, remap by 10 in-# increments. (Sequence 8 - tbd).
JS should NOT be lubricated prior to beginning these tests.
JS should NOT have EF tests accomplished by operator prior to these test sequences.

E-16

3rd SERIES TESTS: vertical dial indicator, opposite nut flat.

Aircraft #: 487 | **Plunger Radial Distance: I:__7/8_____ II:__7/8_____** | **JS Data/Info:**

Tool #: Boeing CE9122 | **Tool lubrication: C5** | **HS at .5 degree ANU**

		I. Lower FWD Acme Nut Flat (per MM)			II. Lower Aft Acme Nut Flat	
Seq.	**Torque**	**EP Reading**	**JS Rotate (Y/N)**	**Seq.**	**EP Reading**	**JS Rotate (Y/N)**
1	100 in-# (lengthening)	0 (null)	na	18	0 (null)	na
2	250 in-#	0.016	N	19	0.015	N
3	250 in-#			20		
4	250 in-#			21		
5	250 in-#			22		
6	250 in-# Restrained	0.015	na	23	0.015	na
7	250 in-# Restrained		na	24		na
8	250 in-# Restrained		na	25		na
9	250 in-# Restrained		na	26		na
10	300 in-#	0.019	Y	27	0.017	Y
11	300 in-#			28		
12	300 in-#			29		
13	300 in-#			30		
14	300 in-# Restrained	0.0155	na	31	0.016	na
15	300 in-# Restrained		na	32		na
16	300 in-# Restrained		na	33		na
17	300 in-# Restrained		na	34		na

37,840 hours
19,712 cycles
fuselage 1558

span 9 5/8

Notes: Obtain HS test point by moving HS to full ANU then to returning to 1 degree ANU.
Repeat torque applications as required at discretion of Systems Group. Minimum 1 attempt.
At Systems Group discretion, entire test may be repeated by approaching HS test position from full AND HS.

Plunger should be located the same radial distance on each side for consistency.

THU 7-12-01
TULSA
Sequence # 2

E-17

3rd SERIES TESTS: vertical dial indicator, opposite nut flat.

Aircraft #: 487 **Plunger Radial Distance: I:__7/8_____ II:__7/8_____** **JS Data/Info:**

Tool #: 070811 clone **Tool lubrication: C5** **HS at .5 degree ANU**

		I. Lower FWD Acme Nut Flat (per MM)			II. Lower Aft Acme Nut Flat	
Seq.	**Torque**	**EP Reading**	**JS Rotate (Y/N)**	**Seq.**	**EP Reading**	**JS Rotate (Y/N)**
1	100 in-# (lengthening)	0 (null)	na	**18**	0 (null)	na
2	250 in-#	0.0175	Y	**19**	0.013	Y
3	250 in-#			**20**		
4	250 in-#			**21**		
5	250 in-#			**22**		
6	250 in-# Restrained	0.014	na	**23**	0.0155	na
7	250 in-# Restrained		na	**24**		na
8	250 in-# Restrained		na	**25**		na
9	250 in-# Restrained		na	**26**		na
10	300 in-#	0.016	Y	**27**	0.014	Y
11	300 in-#			**28**		
12	300 in-#			**29**		
13	300 in-#			**30**		
14	300 in-# Restrained	0.015	na	**31**	0.016	na
15	300 in-# Restrained		na	**32**		na
16	300 in-# Restrained		na	**33**		na
17	300 in-# Restrained		na	**34**		na

37,840 hours
19,712 cycles
fuselage 1558

same setup as sequence 2

Notes: Obtain HS test point by moving HS to full ANU then to returning to 1 degree ANU.
Repeat torque applications as required at discretion of Systems Group. Minimum 1 attempt.
At Systems Group discretion, entire test may be repeated by approaching HS test position from full AND HS.
Could use data from Series 1 tests for one half of this matrix.
Plunger should be located the same radial distance on each side for consistency.

THU 7-12-01
TULSA
Sequence # 3

E-18

3rd SERIES TESTS: vertical dial indicator, opposite nut flat.

Aircraft #: 487 | **Plunger Radial Distance: I:__13/16__ II:__13/16_____** | **JS Data/Info:** span same as previous
Tool #: 070811 clone | **Tool lubrication: C5** | **HS at .5 degree ANU**

		I. Upper FWD Acme Nut Flat			II. Upper Aft Acme Nut Flat	
Seq.	**Torque**	**EP Reading**	**JS Rotate (Y/N)**	**Seq.**	**EP Reading**	**JS Rotate (Y/N)**
1	100 in-# (lengthening)	0 (null)	na	18	0 (null)	na
2	250 in-#	0.0145	Y	19	0.016	Y
3	250 in-#			20		
4	250 in-#			21		
5	250 in-#			22		
6	250 in-# Restrained	0.0145	na	23	0.0155	na
7	250 in-# Restrained		na	24		na
8	250 in-# Restrained		na	25		na
9	250 in-# Restrained		na	26		na
10	300 in-#	0.0125	Y	27	0.0185	Y
11	300 in-#			28		
12	300 in-#			29		
13	300 in-#			30		
14	300 in-# Restrained	0.014	na	31	0.0165	na
15	300 in-# Restrained		na	32		na
16	300 in-# Restrained		na	33		na
17	300 in-# Restrained		na	34		na

37,840 hours
19,712 cycles
fuselage 1558

Notes: Obtain HS test point by moving HS to full ANU then to returning to 1 degree ANU.
Repeat torque applications as required at discretion of Systems Group. Minimum 1 attempt.
At Systems Group discretion, entire test may be repeated by approaching HS test position from full AND HS.

Plunger should be located the same radial distance on each side for consistency.

THU 7-12-01
TULSA
Sequence # 4

E-19

3rd SERIES TESTS: vertical dial indicator, opposite nut flat.

Aircraft #: 487 | **Plunger Radial Distance: I:__13/16__ II:__13/16_____** | **JS Data/Info:**

Tool #: Boeing CE9122 | **Tool lubrication: C5** | **HS at .5 degree ANU**

		I. Upper FWD Acme Nut Flat			II. Upper Aft Acme Nut Flat	
Seq.	**Torque**	**EP Reading**	**JS Rotate (Y/N)**	**Seq.**	**EP Reading**	**JS Rotate (Y/N)**
1	100 in-# (lengthening)	0 (null) **	na	18	0 (null) **	na
2	250 in-#	0.013	Y	19	0.0195	Y
3	250 in-#			20		
4	250 in-#			21		
5	250 in-#			22		
6	250 in-# Restrained	0.014	na	23	0.0175	na
7	250 in-# Restrained		na	24		na
8	250 in-# Restrained		na	25		na
9	250 in-# Restrained		na	26		na
10	300 in-#	0.013	Y	27	0.019	Y
11	300 in-#			28		
12	300 in-#			29		
13	300 in-#			30		
14	300 in-# Restrained	0.0155	na	31	0.016	na
15	300 in-# Restrained		na	32		na
16	300 in-# Restrained		na	33		na
17	300 in-# Restrained		na	34		na

37,840 hours
19,712 cycles
fuselage 1558
152hours since last lube

** noticed .0005 bias

span same as previous

Notes: Obtain HS test point by moving HS to full ANU then to returning to 1 degree ANU.
Repeat torque applications as required at discretion of Systems Group. Minimum 1 attempt.
At Systems Group discretion, entire test may be repeated by approaching HS test position from full AND HS.

Plunger should be located the same radial distance on each side for consistency.

THU 7-12-01
TULSA
Sequence # 5

E-20

0th SERIES TESTS: HS static weight measurement & tool performance mapping.

Aircraft #: 560, fuselage 1858 | **Plunger Radial Distance: 7/8**

Tool #: ASA clone 070809 | **Tool lubrication: C5A anti-seize grease**

JS Data/Info:

Seq.	Torque	Force Output	EP Reading
1	50 in-#	468	0
2	100 in-#	820	0
3	150 in-#	1230	0
4	200 in-#	1500	0.013
5	250 in-#	1880	0.013
6	275 in-#	1965	.0135 *
7	300 in-#	2150	0.0135
8	150	1060	0
9	160	1210	0.0005
10	170	1280	0.0005
11	180	1415	0.001
12	190	1425	0.003
13	200	1435	0.005
14	210	1490	0.013
15			
16			
17			

TULSA
TUE 7-10-01
Sequence # 1

original aircraft jackscrew
31,049 aircraft hours
15,610 cycles
2 degrees AND, span 11.25"
MD-82

137 hours since last lube

* dial indicator did not return to zero; .003 under.

NOTES:

This sequence provides on-wing comparison data for tool mapping accomplished at HB test labs.
On any aircraft, begin by testing ASA modified clone tool. (Tool Sequence: ASA clone, ASA Boeing, Boeing)
Sequence 1-7 uses clicker style torque wrench. Apply torque until click is heard. Record readings.
Once required torque/force is estimated, remap by 10 in-# increments. (Sequence 8 - tbd).
JS should NOT be lubricated prior to beginning these tests. **It was.**
JS should NOT have EP tests accomplished by operator prior to these test sequences. It was, and was measured as .015.

E-21

Oth SERIES TESTS: HS static weight measurement & tool performance mapping.

Aircraft #: 560, fuselage 1858 **Plunger Radial Distance: 7/8**
Tool #: ASA Boeing 079115 **Tool lubrication: C5A anti-seize grease**
JS Data/Info:

HS not moved since sequence #1 (sheet 5)

Seq.	Torque	Force Output	EP Reading
1	50 in-#	880	0
2	100 in-#	1275	0
3	150 in-#	2085	0.013
4	200 in-#		
5	250 in-#		
6	275 in-#		
7	300 in-#		
8	100	1375	0.0005
9	90	1200	0
10	100	1425	0.0005
11	110	1615	0.013
12	120		
13	130		
14			
15			
16			
17			

TULSA
TUE 7-10-01
Sequence # 2

NOTES:

This sequence provides on-wing comparison data for tool mapping accompished at HB test labs.
On any aircraft, begin by testing ASA modified clone tool. (Tool Sequence: ASA clone, ASA Boeing, Boeing)
Sequence 1-7 uses clicker style torque wrench. Apply torque until click is heard. Record readings.
Once required torque/force is estimated, remap by 10 in-# increments. (Sequence 8 - tbd).

E-22

Oth SERIES TESTS: HS static weight measurement & tool performance mapping.

Aircraft #: 560, fuselage 1858 **Plunger Radial Distance: 3/4 inch.**
Tool #: Boeing RAMS #3 **Tool lubrication: C5A anti-seize grease**
JS Data/Info:

Tool span should be: 9.625in. **actual 9 3/8 inches**

Seq.	Torque	Force Output	EP Reading
1	50 in-#	840	0
2	100 in-#	1130	0
3	150 in-#	1776	0.014
4	200 in-#	2270	0.014
5	250 in-#	2925	0.016
6	275 in-#		
7	300 in-#	3470	0.0175
8	100	1115	0
9	110	1245	0
10	120	1420	0.0001
11	130	1450	0.0005
12	140	1650	0.014
13	150	1780	0.014
14			
15			
16			
17			

TULSA
TUE 7-10-01
Sequence # 3

stab at 0 degrees

At 300 in-# the jackscrew rotated slightly.

NOTES:

This sequence provides on-wing comparison data for tool mapping accomplished at HB test labs.
On any aircraft, begin by testing ASA modified clone tool. (Tool Sequence: ASA clone, ASA Boeing, Boeing)
Sequence 1-7 uses clicker style torque wrench. Apply torque until click is heard. Record readings.
Once required torque/force is estimated, remap by 10 in-# increments. (Sequence 8 - tbd).

E-23

1st SERIES TESTS: baseline, vertical dial indicator, 2 plunger radial distances.

Aircraft #: 560, fuselage 1858 **Plunger Radial Distance: I:_3/4______ II:_n/a______** **JS Data/Info:**

Tool #:Alaska clone 070811 (NTSB Tool lubrication: C5A anti-seize grease **Acme Nut Flat: Lower FWD**

HS at 0 degree ANU

aka NTSB tool #6

		I. Plunger in close to JS			II. Plunger further away from JS	
Seq.	**Torque**	**EP Reading**	**JS Rotate (Y/N)**	**Seq.**	**EP Reading**	**JS Rotate (Y/N)**
1	100 in-# (lengthening)	0 (null)	na	18	0 (null)	na
2	250 in-#	0.016	Y	19		
3	250 in-#			20		
4	250 in-#			21		
5	250 in-#			22		
6	250 in-# Restrained	0.0135	na	23		na
7	250 in-# Restrained		na	24		na
8	250 in-# Restrained		na	25		na
9	250 in-# Restrained		na	26		na
10	300 in-#	0.015	Y	27		
11	300 in-#			28		
12	300 in-#			29		
13	300 in-#			30		
14	300 in-# Restrained	0.014	na	31		na
15	300 in-# Restrained		na	32		na
16	300 in-# Restrained		na	33		na
17	300 in-# Restrained		na	34		na

Notes: Obtain HS test point by moving HS to full ANU then to returning to 1 degree ANU.
Repeat torque applications as required at discretion of Systems Group. Minimum 1 attempt.
At Systems Group discretion, entire test may be repeated by approaching HS test position from full AND HS.

stabilizer & indicators not moved since sequence #3

TUE 7-10-01
TULSA
Sequence # 4

E-24

1st SERIES TESTS: baseline, vertical dial indicator, 2 plunger radial distances.

Aircraft #: 560, fuselage 1858 **Plunger Radial Distance: I:_3/4______ II:_n/a______** **JS Data/Info:**

Tool #:Boeing CE9122 **Tool lubrication: C5A anti-seize grease** **Acme Nut Flat: Lower FWD**

HS at 0 degree ANU

		I. Plunger in close to JS			II. Plunger further away from JS	
Seq.	**Torque**	**EP Reading**	**JS Rotate (Y/N)**	**Seq.**	**EP Reading**	**JS Rotate (Y/N)**
1	100 in-# (lengthening)	0 (null)	na	18	0 (null)	na
2	250 in-#	0.018	Y (lots)	19		
3	250 in-#			20		
4	250 in-#			21		
5	250 in-#			22		
6	250 in-# Restrained	0.013	na	23		na
7	250 in-# Restrained		na	24		na
8	250 in-# Restrained		na	25		na
9	250 in-# Restrained		na	26		na
10	300 in-#	0.018	Y (lots)	27		
11	300 in-#			28		
12	300 in-#			29		
13	300 in-#			30		
14	300 in-# Restrained	0.014	na	31		na
15	300 in-# Restrained		na	32		na
16	300 in-# Restrained		na	33		na
17	300 in-# Restrained		na	34		na

Notes: Obtain HS test point by moving HS to full ANU then to returning to 1 degree ANU.
Repeat torque applications as required at discretion of Systems Group. Minimum 1 attempt.
At Systems Group discretion, entire test may be repeated by approaching HS test position from full AND HS.

TUE 7-10-01
TULSA
Sequence # 5

E-25

Addendum to Systems Group Chairman's Factual Report

Appendix F:

Lubrication Specifications for Restraining Fixtures

NTSB Aircraft Accident Case No. DCA00MA023
Pacific Ocean near Anacapa Island, California
January 31, 2000
McDonnell Douglas MD-83; N963AS

(3) Remove panel and stabilizer fairing to gain access to work area.

R (4) Clamp dial indicator mounting bracket to lower stop on
R jackscrew and position dial indicator probe against acme nut as shown in View A, Figure 601.

(5) Clamp dial indicator mounting bracket to upper stop on jackscrew and position dial indicator probe against lower plate of support assembly as shown in Figure 601, View C.

(6) Install horizontal stabilizer restraining fixture (Ref. Figure 601, View B).

NOTE: Prior to installation, restraining fixture should be checked for general condition and freedom of operation. Fixture should be free of defects such as damaged or contaminated threads that could restrict movement. Fixture ends must rotate easily, using light hand effort, through entire range of travel.

R (a) On aircraft 1326 and subs, install bracket on lower
R surface of horizontal stabilizer at leading edge.

R **WARNING:** LUBRICANT IS AN AGENT THAT IS AN IRRITANT. MAKE
R SURE ALL PERSONS OBEY ALL OF THE PRECAUTIONS
R WHEN LUBRICANT IS USED.
R - DO NOT USE IN AREAS WHERE THERE IS HIGH HEAT,
R SPARKS, OR FLAMES.
R - USE IN AN AREA OPEN TO THE AIR.
R - CLOSE THE CONTAINER WHEN NOT USED.
R - DO NOT GET LUBRICANT IN THE EYES, ON THE
R SKIN, OR ON YOUR CLOTHES.
R - DO NOT BREATHE THE MIST.

R **WARNING:** REFER TO THE APPLICABLE MANUFACTURER'S OR
R SUPPLIER'S MSDS FOR:
R - MORE PRECAUTIONARY DATA
R - APPROVED SAFETY EQUIPMENT
R - EMERGENCY MEDICAL AID.

R TALK WITH THE LOCAL SAFETY DEPARTMENT OR
R AUTHORITIES FOR THE PROCEDURES TO DISCARD THIS
R HAZARDOUS AGENT.

(b) Ensure restraining fixture threads are clean and
R lubricated with lubricant (VV-L-800, DPM 5481).

F-1

(3) Remove panel and stabilizer fairing to gain access to work area.

(4) Clamp dial indicator mounting bracket to jackscrew torque tube retaining nut and position dial indicator probe against acme nut as shown in View A, Figure 601.

(5) Clamp dial indicator mounting bracket to upper stop on jackscrew and position dial indicator probe against lower plate of support assembly as shown in Figure 601, View C.

(6) Install horizontal stabilizer restraining fixture (Ref. Figure 601, View B).

NOTE: Prior to installation, restraining fixture should be checked for general condition and freedom of operation. Fixture should be free of defects such as damaged or contaminated threads that could restrict movement. Fixture ends must rotate easily, using light hand effort, through entire range of travel.

(a) Install brackets on lower surface of horizontal stabilizer at leading edge and top web of vertical stabilizer adjacent and left of actuator.

(b) Ensure restraining fixture threads are clean and lubricated with antiseize lubricant (DPM 377).

(c) Install restraining fixture between brackets.

(7) Apply 100 inch-pounds (11.3 N·m) torque to restraining fixture in lengthening direction.

(8) Preload both indicator probes to at least 0.100 inch (2.54 mm) while maintaining probe preload, adjust dials to read zero.

(9) Apply 300 inch-pounds (33.9 N·m) torque to restraining fixture in shortening direction.

(10) Perform step (7). Check that dial indicator has returned to zero preload reading.

NOTE: If dial indicator does not return to zero setting, acme screw may be rotating slightly during test. Should this condition be found, screw should be prevented from rotating.

F-2

2

[redacted] [redacted] [redacted]

DPM NO.	TITLE	SPECIFICATION	ST. TEMP.	TOX.	FL.PT.	S.L.	CUSTODIAN
366 F	FLUID, HYDRAULIC, PETROLEUM-BASE	MIL-H-5606	Ambient	3B	200°F	12 mos.	Menke

PO NOTES: PO to specify code (1) and the super clean solid particle contamination requirement as given in MIL-H-5606 is waived.
GEN. NOTES: The super clean solid particle contamination requirement as given in MIL-H-5606 is waived. Recertify per DMQR No. 1742. Used by DPS 1.151-2; 1.22; 2.431-2; 2.47; 3.310; 3.310-4; 3.314-7,-11,-13; 3.334; 3.339; 3.572-2,-4; 3.80-5; 30.102.

SUPPLIER: 1. Castrol Industrial North America, Inc.; Specialty Products Division, city of Commerce, CA, #Brayco 756 C/D/E.

2. Chevron USA, Inc., San Francisco, CA, #Chevron Aviation Hydraulic Fluid E.

3. Mobil Oil Corp., Fairfax, VA, #Mobil Aero HFE.

4. Royal Lubricants Co., Hanover, NJ, #Royco 756.

5. Any product in compliance with specification except the particle contamination reqmt.

DPM NO.	TITLE	SPECIFICATION	ST. TEMP.	TOX.	FL.PT.	S.L.	CUSTODIAN
375	LUBRICANT, ANTISEIZE. SUPERSEDED BY DPM 5891 - January 1995.						Menke
376 N	LUBRICANT, ANTISEIZE	MIL-T-5544	Ambient	4C	None	12 mos.	Phillips

PO NOTES: PO to specify code (1) and 1-lb. cans. GEN. NOTES: Recertify per DMQR #1756. Used by DPS 1.151-2; 1.18; 3.17-54; 3.575.

SUPPLIER: 1. Castrol, Inc., Irvine, CA, #Braycote 655.

2. E/M Corporation, North Hollywood, CA, #ME-56.

DPM NO.	TITLE	SPECIFICATION	ST. TEMP.	TOX.	FL.PT.	S.L.	CUSTODIAN
377 F	ANTISEIZE, HIGH TEMPERATURE	MIL-A-907	Ambient	3B	None	*	Phillips

PO NOTES: PO to specify code (1). GEN. NOTES: Shelf life for Loctite C5-A is two years from date of manufacture or one year from receipt. Shelf life for other products is 6 months. Recertify per DMQR No. 1754A. Used by DPS 1.151-2; 1.22; 30.102. (Superseded DPM 1252 & 5618).

SUPPLIER: 1. Loctite, Rocky Hill, CT, #C5-A.

2. Ramco Specialty Products, Bakersfield, CA, #Anti-Seize.

3. "All MDC facilities shall purchase from the sources listed above. All others may purchase any product in compliance with the listed specification if the product complies with local, state and federal environmental regulations."

DPM NO.	TITLE	SPECIFICATION	ST. TEMP.	TOX.	FL.PT.	S.L.	CUSTODIAN
379-1 N	TALC, POWDERED	See Gen. Notes	Ambient	4C	None	Unltd.	Wade

PO NOTES: PO to specify code (3). GEN. NOTES: Minimum Talc Spec: Mesh 325 (98% min. pass through); Particle Structure - Acicular-platey; Loss on ignition - maximum 6.5%; or U.S.P. Grade Talc. Used by DPS 1.34-8; 1.448; 1.834-8; 2.50; 2.50-17; 2.510-6,-6.1,-12.1; 2.535; 2.590-4,-6; 3.069; 3.310-12; 3.57; 4.50-23.

SUPPLIER: 1. Any product meeting requirements listed in Gen. Notes.

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DPM NO.	TITLE	SPECIFICATION	ST. TEMP.	TOX.	FL.PT.	S.L.	CUSTODIAN
5475 N	RAGS, TAC	Commercial	Ambient	4C	None	Unltd.	Hart

PO NOTES: PO to specify code (3). GEN. NOTES: Used by DPS 1.094; 4.462; 4.50-9,-36,-62,-89,-109,-138,-143,-144, -163,-165,-187-189,-190,-193,-195. (Superseded DPM 1866).
SUPPLIER: 1. Johnson & Johnson, Montreal, Quebec, Canada, #1-6119 Tack Cloth.
2. Kent H. Landsberg Co., Montebello, CA, #2100 Pro-Tac; #1202 (Gold) Detroit Handy.

DPM NO.	TITLE	SPECIFICATION	ST. TEMP.	TOX.	FL.PT.	S.L.	CUSTODIAN
5476 N	ICE, DRY (SOLID CARBON DIOXIDE)	Commercial	Ambient	3A	None	Unltd.	Phillips

PO NOTES: PO to specify code (3) and maximum oil content to be four parts per million. GEN. NOTES: Used by DPS 1.33; 2.70-2,-15. (Superseded DPM 1871).
SUPPLIER: 1. Commercially available.

DPM NO.	TITLE	SPECIFICATION	ST. TEMP.	TOX.	FL.PT.	S.L.	CUSTODIAN
5477 F	COMPOUND, MOLDING, PHENOLIC	See GEN. NOTES	Ambient	3B	None	2 yr.	Bonnar

PO NOTES: PO to specify code (1) and color. Specify the following on container label - batch number and procurement specification & type. GEN. NOTES: Recertify per DMQR No. 1600. Spec.: MIL-M-14, Type CFI-20. Suitable for compression molding. Used by DPS 1.443. (Superseded DPM 1872).
SUPPLIER: 1. ICI Fiberite Winona, Winona, MN, #FM-3510.

5478 CAPS, SEALING. DELETED - NOT REPLACED - March 1980. (Superseded DPM 1876).

DPM NO.	TITLE	SPECIFICATION	ST. TEMP.	TOX.	FL.PT.	S.L.	CUSTODIAN
5479 N	OIL, PRESERVATIVE LUBRICATING	MIL-L-21260, Grade 10	Ambient	4C	400°F	3 yr.	Phillips Menke

PO NOTES: PO to specify code (1). GEN. NOTES: Spec.: MIL-L-21260, Grade 10. Recertify per DMQR No. 1744. Used by DPS 1.151-2; 3.310; 3.310-4. (Superseded DPM 1877 & -1).
SUPPLIER: 1. Gard Corporation, Kansas City, Kansas, #Gard Anti Rust SAE 10W.
2. Valvoline, Inc., Division of Ashland Oil, Inc., Lexington, Kentucky, #Tectyl 910.

5480 FILLER, RESIN. SUPERSEDED BY DPM 5608 - July 1977. (Superseded DPM 1883).

DPM NO.	TITLE	SPECIFICATION	ST. TEMP.	TOX.	FL.PT.	S.L.	CUSTODIAN
5481 E	LUBRICANT, OIL, PRESERVATIVE	VV-L-800	Ambient	3C	275°F	12 mos.	Bonnar Menke

PO NOTES: PO to specify code (1) using a solvent-resistant marking material. GEN. NOTES: Recertify per DMQR No. 1748A. Used by DPS 1.151-2; 1.22; 1.33; 2.431-2; 3.17-49,-51,-54,-55; 3.171; 3.173; 3.310; 3.310-1,-4,-12; 3.314.1-16; 3.315; 3.315-2; 3.317; 3.320; 3.67-15; 4.713. (Superseded DPM 308, 1139 & 1890).
SUPPLIER: 1. Castrol Industrial North America, Inc., Specialty Products Division, City of Commerce, CA, #Brayco 300.
2. E.F. Houghton & Co., Santa Ana, CA, #Cosmoline 1116.
3. "All MDC facilities shall purchase from the sources listed above. All others may purchase any product in compliance with the listed specification if the product complies with local, state and federal environmental regulations."

DPM NO.	TITLE	SPECIFICATION	ST. TEMP.	TOX.	FL.PT.	S.L.	CUSTODIAN
481-1	LUBRICANT, OIL, PRESERVATIVE, AEROSOL	Commercial	Ambient	3C	275°F	2 yr.	Menke

PO NOTES: PO to specify codes (1) (2) and to be formulated with preservative oil qualified to Federal Specification VV-L-800.
GEN. NOTES: Recertify per DMQR No. 1532. Used by DPS 3.317.
SUPPLIER: 1. Zip-Chem Products, Morgan Hill, CA, #D-5253 NS.

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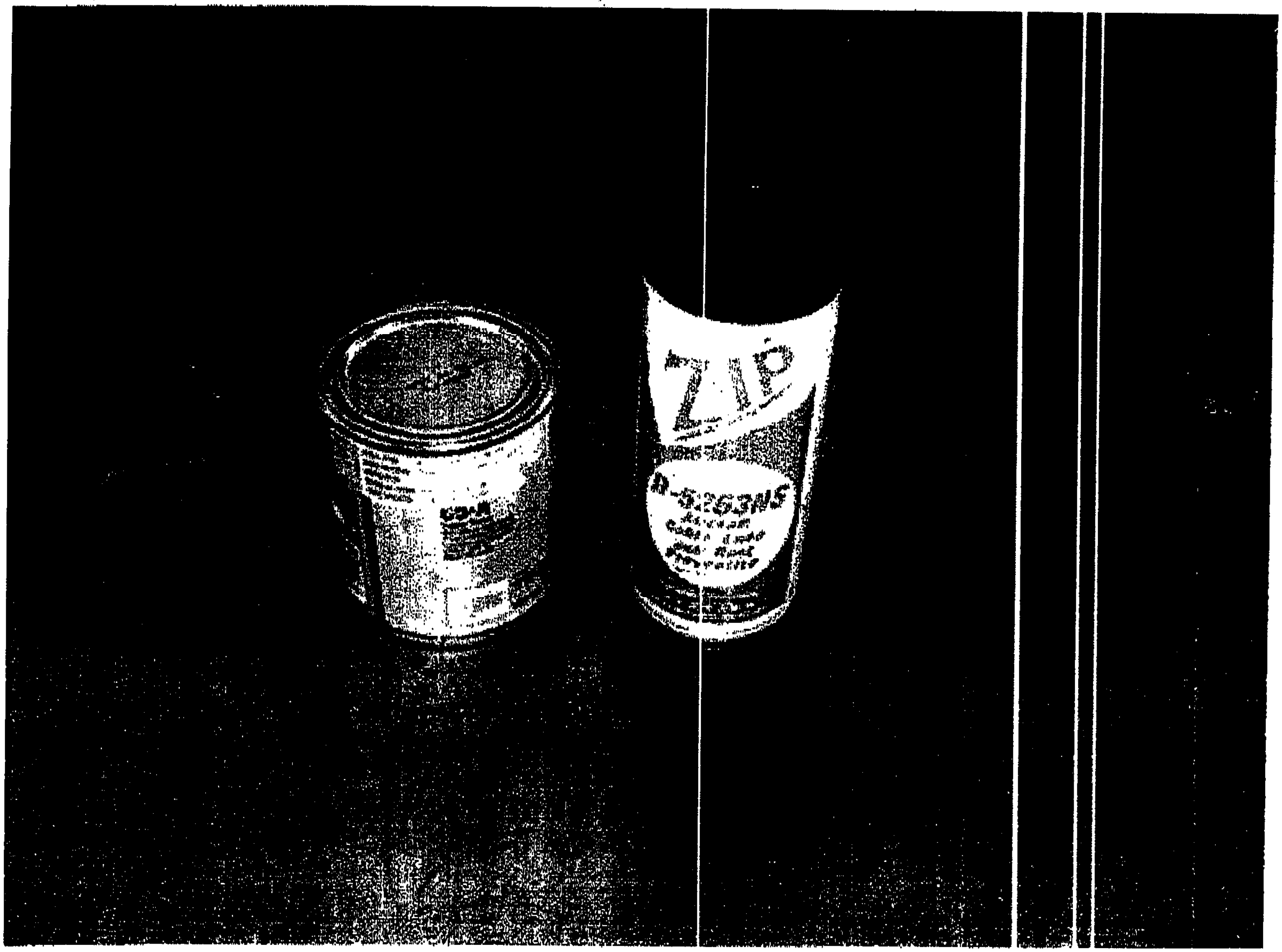

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Addendum to Systems Group Chairman's Factual Report

Appendix G:

Douglas Service Bulletin and AOL Regarding DC-9 Torque Tube Nut

NTSB Aircraft Accident Case No. DCA00MA023
Pacific Ocean near Anacapa Island, California
January 31, 2000
McDonnell Douglas MD-83; N963AS

DOUGLAS AIRCRAFT COMPANY

MCDONNELL DOUGLAS CORPORATION

3855 Lakewood Boulevard
Long Beach, California 90801

DC-9 SERVICE BULLETIN

BULLETIN 27-144
DC-9 SC 1935

FLIGHT CONTROLS - Horizontal Stabilizers - Modify Jackscrew Washer And Increase Torque Requirement.

1. Planning Information:

A. Effectivity:

(1) Aircraft Affected:

Models, All DC-9 Series and C-9A

(a) Operator and Aircraft Number:

Operator	Factory Serial No.
AC	45845 and 45846
	47019 thru 47024
	47068 thru 47071
	47195 thru 47200
	47265 and 47266
	47289 and 47290
	47292 thru 47294
	47340 thru 47342
	47348 thru 47350
	47353 and 47354
	47422 thru 47424
AL	47050 thru 47052
	47099
	47130
	47146
	47207 thru 47210
	47212
	47310
	47332 thru 47336
	47371 thru 47375
	47420 and 47421
	47429
	47505 thru 47508
AM	45785
	47059
	47085
	47100
	47122 thru 47127
AN	47003 thru 47005
	47065
	47202
	47325
	47501
	47526 and 47527
	47547 and 47548
AY	45711 thru 45713
	45725
	45729
AZ	47038 and 47039
	47046 and 47047
	47101
	47118
	47128 and 47129
	47220 thru 47238

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Operator	Factory Serial No.
AZ (Cont)	47283
	47311
	47339
	47355
	47432 and 47433
	47502
	47518 and 47519
BM	47431
	47434 thru 47438
	47474
	47477
CB	47098
	47120 and 47121
CO	45826
	45828
	47010 thru 47018
	47086 and 47087
	47152 thru 47156
	47240
DL	45696 thru 45710
	45797
	47025 thru 47032
	47103 thru 47109
	47172 thru 47177
	47257 thru 47262
	47273 thru 47278
	47284 and 47285
	47317 thru 47324
	47356 thru 47359
	47377 thru 47381
	47426 and 47427
	47443 thru 47445
	47466
	47486
	47516
	47525
	47529
EA	45733 and 45734
	45749
	45770 and 45771
	45825
	45829 thru 45840

Operator	Factory Serial No.
EA (Cont)	45863 thru 45876
	47036
	47074
	47119
	47139 thru 47145
	47157 and 47158
	47161 thru 47167
	47181 thru 47189
	47214 thru 47217
	47267 thru 47272
	47327 thru 47331
	47399 thru 47403
EC	47430
	47468
	47478
FD	45732
GA	47385 and 47386
	47481
HA	45717
	45724
	47149 and 47150
	47171
	47362
	47369
	47517
HS	47241 and 47242
	47295 thru 47300
	47366 and 47367
	47448 and 47449
IB	47037
	47076 and 47077
	47079 and 47080
	47084
	47088 thru 47093
	47312 thru 47314
	47364 and 47365
	47368
	47446 and 47447
	47453 thru 47456
	47522

Operator	Factory Serial No.		
JM	47351	and	47352
JP	47239		
	47392		
	47503		
	47530		
JU	47425		
	47460		
	47469	and	47470
	47472	and	47473
	47482		
	47532		
KE	45787		
	45827		
KL	45718	thru	45720
	47102		
	47131	thru	47133
	47168	thru	47170
	47190	thru	47194
	47201		
	47279		
	47462		
	47476		
LM	45721	thru	45723
LV	47309		
MH	47291		
	47363		
	47410		
	47514		
NE	47053	and	47054
	47057	and	47058
	47066		
	47075		
	47082		
	47095	thru	47097
	47134	thru	47137
NO	47067		
	47073		
	47083		
	47159	and	47160

Operator	Factory Serial No.		
NO (Cont)	47252	thru	47256
	47405	and	47406
	47415	thru	47417
ON	47040	and	47041
	47147	and	47148
	47408	and	47409
OS	47520	and	47521
	47524		
	47531		
	47539		
OZ	45772	and	45773
	45798	and	45799
	45841		
	47033		
	47035		
	47248	thru	47251
	47343	thru	47345
	47411	and	47412
	47491		
PL	47394		
RW	45795	and	45796
	47049		
	47081		
	47138		
	47246	and	47247
	47263	and	47264
	47337	and	47338
	47346	and	47347
	47376		
	47382		
	47389	thru	47391
	47439	and	47440
SK	47114	thru	47117
	47178	thru	47180
	47286	thru	47288
	47301	thru	47308
	47360	and	47361
	47395	and	47396
	47413	and	47414
	47464		
	47492	thru	47494
	47497	thru	47499

Operator	Factory Serial No.	Operator	Factory Serial No.
SO	47042	TN	47007 thru 47009
	47063 and 47064		47072
	47078		47203
	47204 thru 47206		47326
	47244		47418 and 47419
	47280		47528
	47393		47550 and 47551
SR	45788 thru 45793	TT	45695
	45847		45842 and 45843
	47094		47043 thru 47045
	47110 thru 47113		47055
	47218 and 47219		47061 and 47062
	47281 and 47282		47315 and 47316
	47383 and 47384		47487
	47479 and 47480		47490
	47523		
	47535	TW	45714 thru 45716
SV	47000 thru 47002		45735 thru 45741
			45775 and 45776
			45778 thru 45784
TI	47151		
		VE	47006
TK	45774		47056
	47048		47060
	47213		
	47397	YW	47450
	47442		47457
	47451		47459
	47488 and 47489		
		YX	47465

(b) Other Aircraft:

Factory Serial No.	Factory Serial No.
45726 thru 45728	45844
45730 and 45731	47370
45742 thru 45748	47404
45786	

Affected aircraft other than those listed above will be modified prior to delivery or included in a subsequent revision to this Service Bulletin.

(2) Spares Affected:

Spare Part No.	Key Word
2919060-1	Washer

B. Reason:

Three operators have reported finding the nut assembly on the bottom of the horizontal stabilizer jackscrew assembly loose. This condition results in excessive wear in the splined area at the upper end of the assembly. Increasing the torque requirement for the nut assembly, and installing double lockwire will alleviate this condition.

C. Description:

This modification accomplishes the following on the horizontal stabilizer actuator.

(1) Increases torque requirements for jackscrew nut assembly.

(2) Double safeties jackscrew nut assembly.

(3) Adds a radius edge to jackscrew washer.

D. Compliance:

Recommended.

E. Approval:

This Service Bulletin is FAA approved.

F. Manpower:

This modification may be accomplished in the following approximate man-hours or elapsed hours per aircraft.

Work Phases	Man-Hours
Gain Access	.5
Removal	1.5
Modify (Aircraft)	.5
Install	1.5
Close Up	.5
Functional Check	.5
Total Man-Hours	5.0
Total Elapsed Hours	2.5

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G. Material - Cost and Availability:

(1) Aircraft:

Material required to accomplish this modification is to be procured from operator's stock.

(2) Spares:

None.

H. Tooling - Price and Availability:

None.

I. Weight and Balance:

None.

J. References:

(1) Douglas Letter C1-7-286/TS/DAD (AOL 9-613) dated July 30, 1971
ATA File Code 9-27-40-0.

(2) DC-9 Maintenance Manual, Chapters 6 and 27.

2. Accomplishment Instructions:

NOTE: Chapters within parentheses refer to sections of the Maintenance Manual.

CAUTION: STATICALLY GROUND THE AIRCRAFT.

A. Gain access to modification area by removing and retaining access panel 6401A left side or 6402A right side and attaching parts. (See Chapter 6-11-6.)

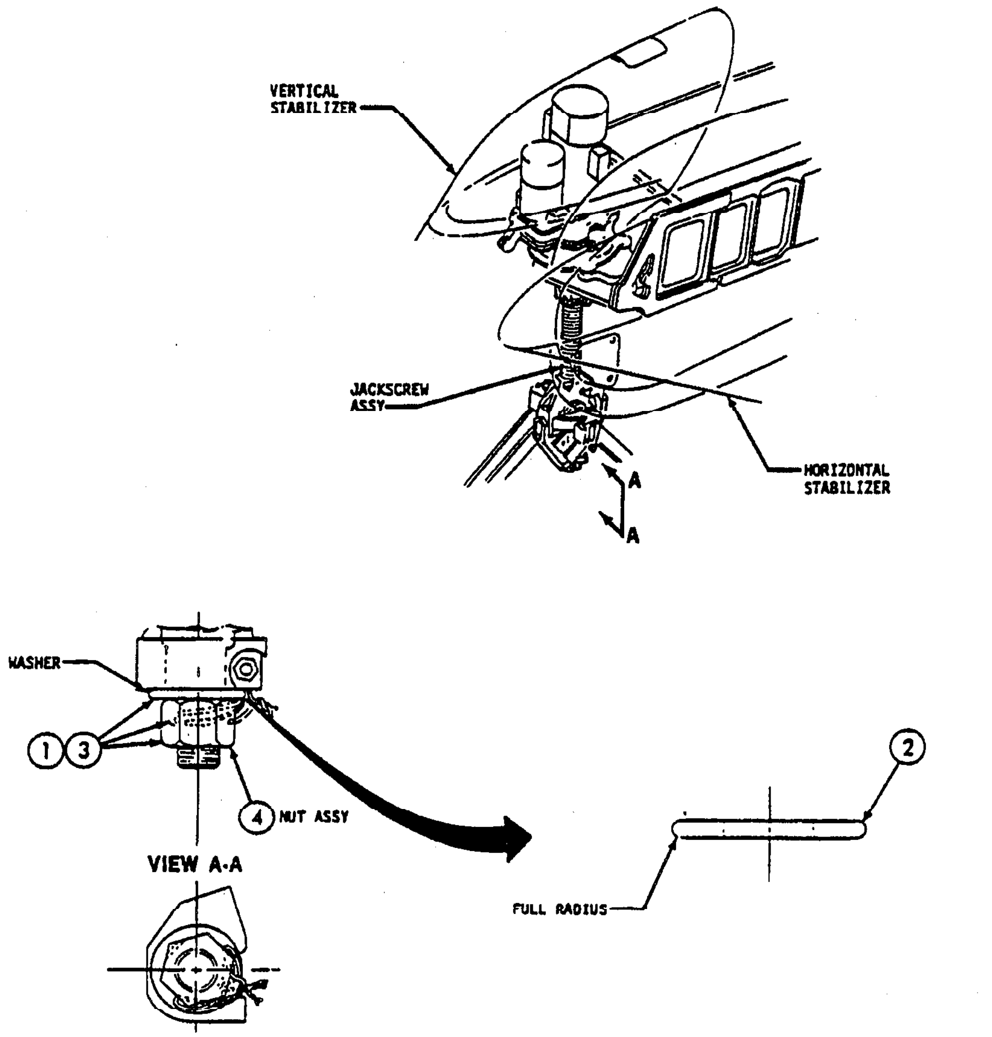
B. Position horizontal stabilizer at approximately 1-degree aircraft noseup position.

C. Install horizontal stabilizer restraining fixture. Apply a torque of approximately 200 inch-pounds on restraining fixture turnbuckle to unload tension that is normally on jackscrew assembly. (See Chapter 27-40-1.)

D. Modify and reidentify jackscrew washer as shown on Figure 1.

E. Remove horizontal stabilizer restraining fixture.

F. Install retained access panel using retained attaching parts.



(1) REMOVE AND RETAIN NUT ASSEMBLY AND 2919060-1 WASHER FROM JACKSCREW ASSEMBLY.

(2) MODIFY 2919060-1 WASHER BY ADDING A FULL RADIUS SURFACE TO OUTBOARD EDGE. REIDENTIFY MODIFIED WASHER AS 2919060-501 BY INK STAMPING.

(3) INSTALL MODIFIED AND REIDENTIFIED WASHER USING RETAINED NUT ASSEMBLY. TIGHTEN NUT ASSEMBLY TO A TORQUE OF 110 FOOT-POUNDS. BACK OFF NUT ASSEMBLY UNTIL 2919060-501 WASHER IS FREE TO ROTATE.

(4) TIGHTEN NUT ASSEMBLY TO A TORQUE OF 50 TO 60 FOOT-POUNDS. DOUBLE SAFETY NUT ASSEMBLY WITH MS20995NC51 LOCKWIRE.

JACKSCREW WASHER - MODIFICATION

3. Material Information:

A. The basis for the following material data is per aircraft.

Lockwire is to be procured from operator's stock.

New Part No.	Qty	Key Word	Old Part No.	Instructions-Disposition
MS20995NC51	As Reqd	Lockwire		
2919060-501	1	Washer	2919060-1	1/

1/ To be modified and reidentified by the operator.

B. The basis for the following material data is per spares.

Modify and reidentify spare 2919060-1 washer per this Service Bulletin. No parts are required.

JFD
CWF

30 July 1971
C1-7-286/TS/DAD
9-27-40-0
AOL 9-613

TO: All DC-9 Operators

SUBJECT: HORIZONTAL STABILIZER ACTUATOR ASSEMBLY

APPLICABLE TO: All Models DC-9 Aircraft

Gentlemen:

Several DC-9 Operators have reported that during overhaul of the subject actuator assembly, the nut assembly, P/N 2915792-1, at the bottom of the torque tube, P/N 5914170-1, has been found to be loose. This condition has resulted in wear of the torque tube where it contacts the upper portion of the screw, and allows oscillation of the assembly during flight causing additional wear in the splined areas. As a result of these reports, Douglas has established the following corrective action which should alleviate the wear problems:

1. The present torque requirement of thirty (30) foot pounds for the nut assembly on the bottom of the jackscrew assembly has been increased to 55 foot pounds.

2. After proper torque, the nut assembly will be secured with a double safety wire (.051 inch steel corrosion resistant wire) to preclude loss of torque.

3. Washer, P/N 2919060-1, has been reworked on the outer diameter to provide a full radius to preclude cutting the safety wire. The washer is then reidentified as P/N 2919060-501.

The improvement changes noted above will be incorporated on DC-9 production aircraft beginning with Fuselage No. 639 and subsequent. Also, Douglas will issue Service Bulletin 27-144 (S/C 1935) to cover in-service DC-9 aircraft Fuselage Numbers 1 through 638. It is estimated that this Service Bulletin will be distributed to all DC-9 operators on/or before 27 October 1971.

The primary purpose of this letter is to apprise all DC-9 operators of the improvement changes previously described herein. Also to advise that in the event certain operators should elect to incorporate these changes on their DC-9 aircraft prior to receipt of the aforementioned forthcoming Service Bulletin, this letter will serve as your authority to proceed. However should such a decision be made, it is important that the following procedure be utilized during accomplishment:

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A. Position the horizontal stabilizer at approximately one (1) degree in the airplane nose up position. (ANU)

B. Install a horizontal stabilizer restraining fixture. (Reference Chapter 27-40-1 of DC-9 Maintenance Manual).

C. Apply a torque of 200 inch pounds or slightly more on the restraining fixture turnbuckle to unload the tension that is normally on the jackscrew assembly.

D. Torque the nut assembly, on the bottom of the torque tube to 110 foot pounds. Back off the torque on the nut assembly until washer, P/N 2919070-1 (or P/N 2919060-501 if washer has been fully radiused on the O.D.), is free to rotate.

E. Retorque the nut assembly to 55 foot pounds, plus or minus 5 foot pounds.

F. Double lockwire the nut assembly with .051 inch (MS20995) wire.

Further details and/or explanation, if they are required, will be furnished upon request.

Very truly yours,

McDonnell Douglas Corporation

[redacted]

R. H. LaCombe, Director
Technical Services
Douglas Aircraft Company

DAD/CMP:mc

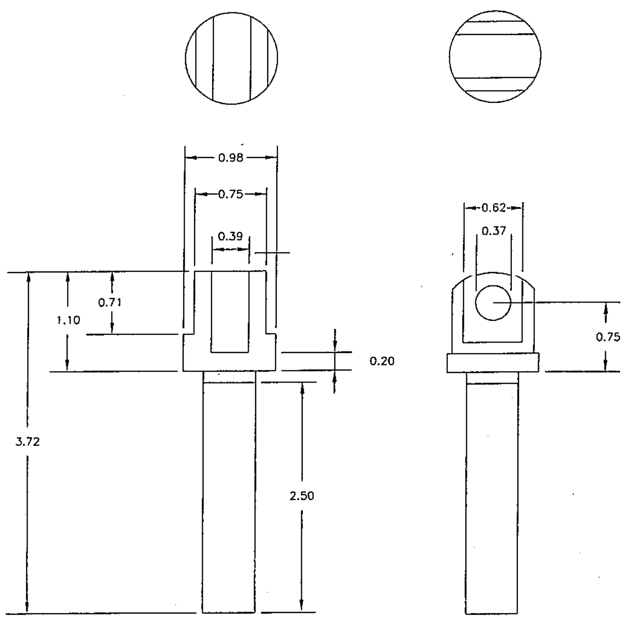
Addendum to Systems Group Chairman's Factual Report

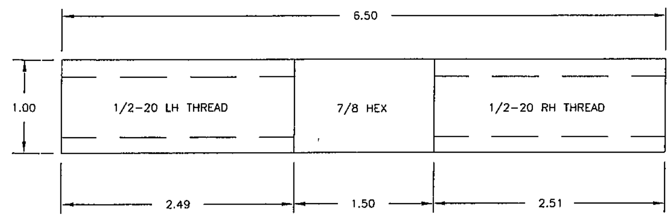
Appendix H:

Alaska Airlines Technical Drawing for Fabricated Restraining Fixture

NTSB Aircraft Accident Case No. DCA00MA023
Pacific Ocean near Anacapa Island, California
January 31, 2000
McDonnell Douglas MD-83; N963AS

REV	REVISION DATA	APPROVED





1. FABRICATE FROM 4130 OFR 17-4-PH STEEL.
2. H.T. TO KSI/MIN.
3. PERMENENTLY IDENTIFY AS TOOL #0-01301-0-0169.
   BREAK SHARP EDGES 125 RMS/MIN FINISH.

REF: DAC TOOL #4916750-503
REF: MM

SCALE 1:1
TOLERANCE ±.02

DRAWING SHEET	REV
SHEET 1	-

DRAFTER		TITLE	Alaska Airlines
CHECKER		TOOLING DWG.	DRAWING NUMBER B-0-1301-0-0169 REV
ENGINEER			
APPROVED		EFFECTIVITY: MD-80	SHEET 1 OF 1

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Addendum to Systems Group Chairman's Factual Report

Appendix I:

FAA Flight Standards Handbook Bulletin for Airworthiness no. 00-2A, addressing Tool Equivalency

NTSB Aircraft Accident Case No. DCA00MA023
Pacific Ocean near Anacapa Island, California
January 31, 2000
McDonnell Douglas MD-83; N963AS

ORDER:	8300.10
APPENDIX:	3
BULLETIN TYPE:	Flight Standards Handbook Bulletin for Airworthiness (HBAW)
BULLETIN NUMBER:	HBAW 00-20A (AMENDED)
BULLETIN TITLE:	Equivalency of Special Equipment or Test Apparatus as provided by Parts 43 and 145
EFFECTIVE DATE:	12-01-00
AMENDED DATE:	12-04-00
TRACKING NUMBER:	N/A

APPLICABILITY:

M/M	ATA Code	14 CFR	PTRS
N/A	N/A	43/121/135/ 145	3626/3658 5626/5658

NOTE: THIS BULLETIN REQUIRES PTRS INPUT. SEE PARAGRAPH #5.

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1. PURPOSE. This bulletin provides guidance for the Flight Standards Principal Inspectors (PI) when making a determination of acceptability for equivalency of special equipment and/or test apparatus used in maintaining aircraft and their associated components as provided under Title 14 Code of Federal Regulations (14 CFR) parts 43 and 145.

A. The term equivalency as used throughout this bulletin means equivalent to that recommended by the Original Equipment Manufacturer (OEM). For determining equivalency, a comparison should be made between the technical data of the special equipment or test apparatus recommended by the manufacturer and those proposed by the repair station or the air carrier. (The special equipment or test apparatus may look different, be made of different materials, be a different color, etc. However, as long as the tool is functionally equivalent, the tool may be used.)

B. The special equipment or test apparatus must be capable of performing all normal tests and checking all parameters of the equipment under test. The level of accuracy should be equal to or better than that recommended by the manufacturer.

2. BACKGROUND. On February 17, 2000, the Federal Aviation Administration (FAA) issued an emergency Airworthiness Directive (AD), AD 2000-03-51, which mandated a check for excessive wear of the acme screw and nut assembly on the McDonnell Douglas, DC-9-80 series aircraft. The AD incorporated Boeing's Alert SB DC9-27A362, which outlines the methods for accomplishment, including a horizontal stabilizer-restraining fixture (tool) necessary to accomplish the required check. The Alert SB advised that this tool was unavailable from Boeing at that time, however, Boeing would supply the drawing necessary for the operators to produce the tool. Thus, if the operator chose to manufacture the tool it became the operator's responsibility to determine if the tool was equivalent to that of the manufacturer.

A. The use of equivalent equipment was first addressed in the Civil Aeronautics Manual 52 (CAM 52), Repair Station Certificates, which preceded 14 CFR part 145. Specifically, CAM 52, section 52.30-1 contained the statement, "The applicant will have the responsibility for choosing suitable tools and equipment (which may be either equipment or tools recommended by a manufacturer in the overhaul or repair of his product or the equivalent of such equipment or tools). The inspecting Civil Aeronautics Authority (CAA) agent will determine if these tools, equipment and materials are satisfactory within the intent of this regulation." This appears to imply the CAA inspector was to make a determination of equivalency, however, it simply established that the CAA inspector determined if the equipment was satisfactory. The intent remains the same today. Title 14 CFR section 43.13(a) states, "If special equipment or test apparatus is recommended by the manufacturer involved, he must use that equipment or apparatus or its equivalent acceptable to the Administrator."

B. In either case, a finding of equivalency can only be made based upon an evaluation of a technical data file. Additionally, there may be cases that demonstrating functionality of the special equipment or test apparatus is also required. The technical data file may include, but is not limited to data, drawings, specifications, instructions, photographs, templates, certificates, and reports. In the case of calibration equipment the technical data file should also include data sheets attesting to the accuracy when calibration standards are necessary and any special manufacturing processes that are used including gauges and recording equipment in the controlling processes. If calibration equipment is involved, adequacy of that calibration system shall be established with documented procedures to evaluate the adequacy of that calibration equipment and traceable to the National Institute of Standards and Technology (NIST) or to a standard provided by the equipment manufacturer. In the case of foreign equipment, a

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standard of the country of manufacture may be used if approved by the FAA.

3. DISCUSSION. While the practice of allowing the industry to fabricate their own equipment and/or apparatus (test fixtures, jigs, tooling, etc.) has for the most part gone without much FAA assessment, experience has shown that many repair stations and air carriers, especially those which employ engineering departments are very well versed in fabricating special equipment or test apparatus. In some cases, the fabricated special equipment or test apparatus has exceeded the component manufacturer's requirements for accuracy, reliability, etc.

A. Some recent instances have arisen where a tool that was manufactured by the air carrier did not always produce the same results as the tool from the OEM. Further, an industry-wide validation revealed some tools that were not equivalent to the OEM's data (blueprints), thus causing the tool to be removed from service.

B. Some tools had been manufactured by a method known as reverse engineering. Reverse engineering alone without data, drawings, testing or reports is not considered to be an equivalent method of manufacturing for special equipment or test apparatus for aviation products.

C. With the advent of recent technological advances, the use of highly specialized test equipment or test apparatus is continually being required to support the continued airworthiness of aircraft systems and components to the manufacturer's specifications and tolerances. However, the cost of obtaining such test equipment and tools, if made available by the manufacturer, is typically prohibitive, or the OEM may refuse to offer concurrence for any apparatus other than what they recommend.

D. In instances involving the use of equivalent equipment and/or apparatus, the determination of equivalency for such equipment is the primary responsibility of the repair station or the air carrier, not the FAA. The basis of equivalency for equipment or apparatus as it relates to products being maintained must meet the manufacturer's standards and specifications with all respects regarding tolerances and accuracy.

4. ACTION. When the PI is making a determination of adequacy of equivalency for special equipment or test apparatus the following will be used:

A. Ensure that the limitations, parameters, and reliability of the equipment are equivalent to that of the manufacturer's recommended equipment. This may include data from the OEM or another source of data used to manufacture the equipment.

B. Compare the technical data used to that of the manufacturer's (if obtainable, often manufacturers are reluctant to release technical information regarding tools and test equipment) and that used by the repair station or air carrier. If the OEM technical data is not available, then the repair station or air carrier must perform an evaluation to make a determination of functionally equivalency. If needed, observe test demonstrations of the equipment.

C. Standard industry practice would dictate that any special equipment or test apparatus would be given a unique part number and serial number to identify it with the repair station's or air carrier's inventory system, should any deficiencies arise thus allowing for traceability.

D. When making an acceptance of *equivalency*, and the PI is unable to make a determination based on the technical data submitted or through testing, the PI will coordinate through the Aircraft Evaluation Group with respect to the appropriate Aircraft/Rotorcraft/Engine Certification Office to assist in making the finding of equivalency.

> **NOTE: Aircraft Engineering Division, AIR-100 memorandum dated December 21, 1999, states that, "Designated Engineering Representative (DER) may not approve or determine equivalency of tooling and test equipment." Furthermore, neither the FAA nor a DER, may approve equipment and/or test apparatus. The FAA and DER's may only make an acceptance of functional *equivalency* for special equipment or test apparatus. It is important to emphasize that the burden of demonstrating "*equivalency*" is borne by the repair station or air carrier and not the FAA.**

E. Within 15 working days of the effective date of this bulletin the PI shall provide a copy of this bulletin to the repair station or air carrier for which they have certificate management responsibility. *Enter date given to operator.*

F. Within 60-calendar days the PI shall conduct a review of the repair station's inspection procedures manual (IPM) or air carrier's continuous airworthiness maintenance program (CAMP) to ensure they have adequate procedures in place for manufacturing and/or determining for *equivalency* of any special equipment or test apparatus in use. The repair station or air carrier may want to reference in their IPM or CAMP the special equipment or

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test apparatus for which a determination of equivalency has been performed. Enter results of review into PTRS.

G. Ensure that specific instructions pertaining to the proper use of any special equipment or test apparatus are provided for, and adequately described in the repair station's IPM or the air carrier's CAMP.

H. Ensure that the repair station or air carrier has procedures in their IMP or CAMP on calibration of any special equipment or test apparatus which establishes specific periodic inspection criteria at specified intervals, and that addresses the regular calibration of any special equipment or test apparatus used for making final airworthiness determinations.

5. PROGRAM TRACKING AND REPORTING SUBSYSTEM (PTRS) INPUT. In order to track the accomplishment of this bulletin the following entries shall be made by the PI. The activity code number for part 121/135 shall be 3626/5626 and for 145 code 3658/5658, and the "National Use" field entry shall be HBAW0020A, and comments will be provided in Section IV as stated below:

- PI's shall open a PTRS, which shall remain open until all action is completed, not to exceed 60-calendar days from the effective date of this bulletin.

6. INQUIRIES. This bulletin was developed by the Flight Standards, Air Carrier Maintenance Branch, AFS-330. Any questions related to this material should be directed to Steve Douglas at (202) 267-3440.

7. LOCATION. This bulletin will remain in effect until incorporated in a future chapter of FAA Order 8300.10, Airworthiness Inspector's Handbook. Until this bulletin is incorporated into the handbook, inspectors should make reference to this bulletin in the appropriate margin of their handbook.

/s/
[redacted]e, Manager
Continuous Airworthiness Maintenance Division

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Addendum to Systems Group Chairman's Factual Report

Appendix J:

Hawaiian Airlines Jackscrew Maintenance Information

NTSB Aircraft Accident Case No. DCA00MA023
Pacific Ocean near Anacapa Island, California
January 31, 2000
McDonnell Douglas MD-83; N963AS

Discrepancy Card

NO. 176279	Aircraft No./Engine Type: 59	Date: 12/04/99	System/Serial No.: STAB	Code: 65-30

☒ 1107 CLEARED

Inspection

☒ C Check
☐ Engine Change
☐ F/C, E/O, AD
☐ Other

Man Hours

Est. ______

Actual ______

Deferment Acknowledgment:

Maintenance:

DISCREPANCY	CORRECTIVE ACTION
GRIT BLAST ACCUMULATED	Cleaned AREA 12/8/99
IN VERTICAL STAB AS	5817 [redacted]
SEEN THRU ACCESS	Inspected area. No
PANEL 6401A AND	discrepancies noted
PANEL 3703 (LT LOWER ~~BANANA~~ FAIRING)	12/08/99 [redacted]
	# 1157
*AREA TO BE INSPECTED	See TASK Card # 3176
AFTER CLEANING*	For Close up. 12/9/99
	[redacted]

Entered By [redacted] Time [redacted] INSP. [redacted]

Inspection:

UNIT NAME:	SERIAL NO. OFF	SERIAL NO. ON

INSPECTOR'S [illegible]

[redacted]

J-1

03	7-16-96	FLC	27

Discrepancy HAL M48

☒ 1107 CLEARED	DISCREPANCY	CORRECTIVE ACTION
Inspection		INFO NOTED - PER DCAG
☒ C Check	REFER C CHK CARD	STANDARD PRACTICE CHAPTER 2740
☐ Engine Change	C-200 HORIZONTAL STAB	HORIZONTAL STAB. JACKSCREW
☐ F/C, E/O, AD	JACKSCREW END PLAY	ASSY IS SERVICEABLE, REINSPECT
☐ Other	CHECK - END PLAY READS .035	JACKSCREW END PLAY AT
Man Hours		INTERVALS WHICH DO NOT
Est. ______		EXCEED 1000 FLIGHT HOURS
Actual ______	{ .003 MIN - .040 MAX }	FURTHER ACTION C/O
Deferment Acknowledgment:		XCRIBED TO [redacted]
Maintenance: 3686		2/06/96
	Entered By [redacted]	Mech: —— INSP. 2687

Inspection: 2687	UNIT NAME:	SERIAL NO. OFF	SERIAL NO. ON

INSPECTOR TO Q.A./RECORDS

J-2

TAG 056863 | DC-9 [X] L1011 [ ] USED ON [redacted] | DHC-7 [ ] OTHER [ ]

NEW [ ] REP [ ] CAL [ ] OVH [X] BC [X] MOD [ ] SOS [ ]

TLB/OC dump

TSO 0:00 | SHELF LIFE N/A | ROBBED FROM A/C | POS | BORROW | XCH [ ]

MFG P/N 5910962-35

HAL CCN 2701755

SERIAL # DCA991

NOMENCLATURE HORIZ STAB ACT SCREW &

REPAIR SHOP / VENDOR VDR ROJRT AERO CON

EMPLOYEE NBR / P.O. # 2741755-03R

DATE SIGNED / REC'D 1/8/96

QUALITY CONTROL - CHECKED BY 7552

DATE CHECKED 1/8/96

COMPLETE SHADED SECTION BELOW — CHECK ONE: INSTALL / REMOVE [X] INSTALL ONLY [ ] REMOVE ONLY [ ]

JOB #	A/C - NHA	POSITION	STATION	INSTALLED BY EMPLOYEE #	INSTALLED DATE
2-6-ON2763	063	TOP	ANL	6091	07-09-97

MFG P/N (FULL P/N)	REMOVED SERIAL #	REMOVAL CODE	SOS YES / NO	REMOVED BY EMPLOYEE #	REMOVED DATE
5910962-35	DCA 110	012	YES [X] NO [ ]	6091	07-09-97

[redacted]

REMOVAL REASON / REMARKS: END PLAY OUT OF Limits

TAG CHECKED BY LEAD / INSP [redacted]

MAINTENANCE RECORDS COPY

QC
Oct 7 '97
2707

J-3

☐ Other

Man Hours

Est. ____________

Actual ____________

Deferment Acknowledgment:

Maintenance: ✓

[redacted]

Entered By 6333 | Time | Mech: 6685 | INSP. | I-14

UNIT NAME:	SERIAL NO. OFF	SERIAL NO. ON
HORIZ STAB ACT SCREW	0110 ✓	DCA110 ✓

Inspection:

INSPECTOR TO Q.A./RECORDS

COMPONENT SERVICEABLE / UNSERVICEABLE TAG
HAL-M1175 (10/95)

Changed

TAG # 086928

DC-☒ OTHER ☐ ____________

USED ONLY ON: ____________

NEW ☐ REP ☐ CAL ☐ OVH ☒ RC ☒ MOD ☐ SOS ☐

TSO 0:00 | SHELF LIFE | ROBBED FROM A/C [redacted] POS | BORROW | XCH ☐

MFG P/N 5910962-35

HAL CCN 2701755

SERIAL # DCA110

NOMENCLATURE HORIZ STAB ACT SCREW &

REPAIR SHOP / VENDOR VDR R2110 DERLAN I

EMPLOYEE NBR / P.O. # 2741755-04R

DATE SIGNED / REC'D 9/26/97

QUALITY CONTROL - CHECKED BY [redacted]

DATE CHECKED 9/26/97

COMPLETE SHADED SECTION BELOW – CHECK ONE: INSTALL/REMOVE ☒ INSTALL ONLY ☐ REMOVE ONLY ☐

JOB #: 26XN2759

A/C - NHA 059 | POSITION AFT | STATION HNL | INSTALLED BY EMPLOYEE # 6685 | INSTALLED DATE 6/22/98

MFG P/N (FULL / P/N) 5910962-35

REMOVED SERIAL # 0110 | REMOVAL CODE 02 | SOS YES ☐ NO ☒ | REMOVED BY EMPLOYEE # 6685 | REMOVED DATE 6/22/98

[redacted]

REMOVAL REASON / REMARKS: No - End Play

TAG CHECKED BY LEAD / INSP [redacted]

MAINTENANCE RECORDS COPY

J-4

Discrepancy Card HAL M46 (9/92)

HAWAIIAN AIRLINES

NO. 180445	Aircraft No./Engine Type: 59	Date: 2-20-00	System/Serial No.: HORIZ STAB	Code: 5510

	DISCREPANCY	CORRECTIVE ACTION
☑ 1107 CLEARED	X-CRIBED FROM 46# 180344	REMOVED ACME SCREW & NUT
Inspection	HORIZONTAL STAB JACKSCREW	ATTACHING PARTS PER MM 27-40-1
☑ C Check	AND NUT FAILED END	SEE ~~4765~~ ATTACHED M133 FOR
☐ Engine Change	PLAY CHECK	ITEMS REMOVED <4465> 2/20/00
☐ F/C, E/O, AD		INSTALLATION OF JACKSCREW
☐ Other	.043	AND ACCYS ACCOMPLISHED ON
Man Hours		ATTACH M133
Est.	NOTE: NEED TO COMPLY WITH	~~ALSO SEE~~ 46S 180487, 180481
Actual	MM 27-40-1 7A. REFER TO	2/25/00
Deferment Acknowledgment:	46# 180443.	
Maintenance:	Part on Order 2-20-00	AL AUDIT
	Entered By [redacted] Time	Mech [redacted] INSP. [redacted]

Inspection:	UNIT NAME:	SERIAL NO. OFF	SERIAL NO. ON
	NUT ASSY	DCA 110	D3351
	ALT TRIM MOTOR	81879	-303

INSPECTOR TO Q.A./RECORDS

J-5

TRIG AEROSPACE

07:37:07 02/26/00 *** WORK ORDER *** REPORT: 7275 SECTION 1 PAGE: 1

'. RT NUMBER: 5914169-505OVH REV: WORK ORDER: 992401-001
DESC: NUT AND SCREW ASSY. PROM-DATE: 03/15/00
DRAWING: QUANTITY: 1.000
WORK CENTER: DUE DATE: 03/15/00
REL-TO-STK: 01/03/00 DISTB DATE: 01/04/00 START DATE: 01/05/00
JOB NUMBER: 992401 DATE ROUTING SET: 02/25/00 LABOR U/M: PLANNER:
ROUTING NO: 5914169-505OVH ALT: OV5 WIP ROUT REV:
KIT LOC: BIN: BATCH NO:

*** WORK ORDER NOTES ***

CPO 2728810005R

CUSTOMER HAWAIIAN AIRLINES

S/N DCA-110

MRR 23901

Closed.

LNE	OPER NO	WORK CNTR	COST CNTR	OPER/DESCRIPTION	DES TST	TOTAL SET UP	MAN HOURS	YIELD%	PLANNED QUANTITY-IN
1	00	99	1100	OPERATIONS CONTROL					1.000

QUEUE: WAIT: MOVE: OVRLP CD: QTY:
TIMED/EST: MULTI-MACH: MULTI-OPER: DELAY:
PLAN START: 01/05/00 COMP: 01/05/00 ACT START: COMP:
MOVED IN: QTY COMP: MOVED OUT:
SCRAP: P/C:

N --
N
N NEXT ASSY: NONE
N
N FINAL ASSY: END ITEM
N
N Q.A. BUYOFF OF ROUTING: TAC QAE 1 2/26/00
N
N SKETCH AVAILABLE: YES, SKETCH #1.
N
N %%
N WORK TO BE COMPLETED PER DC-9 OVERHAUL MAINTENANCE MANUAL.
N CHAPTER: 27-41-1, LATEST REVISION APPLIES.
N RECORD REVISION NUMBER AND REVISION DATE USED:
N REVISION: 24 DATED: APR 15/98 STAMP:

J-6

WORK ORDER: 992401-001 ...CONTINUED.

LNE	OPER NO	WORK CNTR	COST CNTR	OPER/DESCRIPTION	DES TST	TOTAL SET-UP	MAN HOURS	YIELD%	PLANNED QUANTITY-IN

N
N WHERE APPLICABLE, USE DC-9 CHAPTER 20 STANDARD
N PRACTICE PROCEDURES.
N RECORD REVISION NUMBER AND REVISION DATE USED:
N REVISION: 40 DATED: 4/15/90 STAMP: TAC FT 2
N %%
N
N
N

LNE	OPER NO	WORK CNTR	COST CNTR	OPER/DESCRIPTION	DES TST	TOTAL SET-UP	MAN HOURS	YIELD%	PLANNED QUANTITY-IN
2	10	TEMP	2300	DIS-ASSEMBLY		0.200	0.500		1.000

QUEUE: 1.000 WAIT: 1.000 MOVE: OVRLP CD: QTY:
TIMED/EST: MULTI-MACH: MULTI-OPER: DELAY:
PLAN START: 01/06/00 COMP: 01/06/00 ACT START: COMP:
MOVED IN: QTY COMP: MOVED OUT:
SCRAP: P/C:

N --
N IF NECESSARY, CLEAN ASSEMBLY TO REMOVE GREASE AND MAKE
N SUITABLE FOR HANDLING IN INSPECTION.
N
N REMOVE NUT FROM SCREW. VISUALLY INSPECT SCREW TO VERIFY THE
N DASH NUMBER MATCHES PAPER WORK, SEE SKETCH #1. NOTIFY
N PROGRAM MANAGER IMMEDIATELY IF PAPER WORK DOES NOT MATCH.
N
N RECORD SERIAL NUMBER OF SCREW: DCA-110
N
N RECORD SERIAL NUMBER OF NUT: DCA-110
N
N RECORD AXIAL END PLAY AND RADIAL CLEARANCE OF NUT ASSEMBLY.
N
N AXIAL: ~~.028~~ CT .048 RADIAL: ~~.003~~ CT .015 (44 ✓)
N
N ** N O T E S:
N 1. TRIG AEROSPACE REQUIRES A MANATORY NUT REPLACEMENT.
N
N 2. IF THE AXIAL END PLAY IS GREATER THAN 0.0400" THE SCREW
N ASSEMBLY (ITEM 50) MUST BE REPLACED. REF: PAR 7.A.2
N
N 3. F O R A L A S K A A I R L I N E S O N L Y - COMPLETE
N THE MD-80 OVERHAUL EVALUATION REPORT, DOC # TA-MFG009.
N

WORK ORDER: 992401-001 ...CONTINUED.

LNE	OPER NO	WORK CNTR	COST CNTR	OPER/DESCRIPTION	DES TST	TOTAL SET-UP	MAN HOURS	YIELD%	PLANNED QUANTITY-IN

N VISUALLY INSPECT AND RECORD ANY DAMAGE OR DISCREPANT
N PARTS (NICKS, GOUGES, SCATCHES, MODIFICATION, ETC.)
N GOUGES AND SHARP EDGES ON NUT THREADS
N
N ____________________
N
N ____________________
N
N ____________________
N
N NOTE: NOTIFY THE ASSEMBLY M.E. OF DAMAGED OR DISCREPANT
N PARTS FOR CUSTOMER/FAA NOTIFICATION BY THE DIRECTOR
N OF QUALITY, AS APPLICABLE.
N
N STEEL TAG IDENTIFY SCREW AND NUT ASSEMBLY WITH DASH AND
N SERIAL NUMBERS.
N
N BAG AND TAG THE NUT ASSEMBLY. PLACE IN BOND.
N
N SUP./OPER.________ DATE: 2/28/00, QTY: 1
N ***
N
N ____________________
N

LNE	OPER NO	WORK CNTR	COST CNTR	OPER/DESCRIPTION	DES TST	TOTAL SET-UP	MAN HOURS	YIELD%	PLANNED QUANTITY-IN
3	20	DB1	2100	PLASTIC BEAD CLEAN			0.300		1.000

QUEUE: 1.000 WAIT: 1.000 MOVE: OVRLP CD: QTY:
TIMED/EST: MULTI-MACH: MULTI-OPER: DELAY:
PLAN START: 01/06/00 COMP: 01/06/00 ACT START: COMP:
MOVED IN: QTY COMP: MOVED OUT:
SCRAP: P/C:
N --
N IF REQUIRED:
N PLASTIC BEAD CLEAN SCREW. SURFACES ARE TO BE SUITABLE FOR
N VISUAL INSPECTION. THROUGHLY CLEAN SCREW TO REMOVE ANY
N RESIDUAL DUST.
N
N SUP./OPER.____________ DATE:__/__/__, QTY:________
N ***
N
N ____________________

J-8

LNE	OPER NO	WORK CNTR	COST CNTR	OPER/DESCRIPTION	DES TST	TOTAL SET-UP	MAN HOURS	YIELD%	PLANNED QUANTITY-IN
	N								
4	30	4050	4000	INSPECTION			0.200		1.000

QUEUE: 24.000 WAIT: 0.000 MOVE: OVRLP CD: QTY:
TIMED/EST: MULTI-MACH: MULTI-OPER: DELAY:
PLAN START: 01/10/00 COMP: 01/10/00 ACT START: COMP:
MOVED IN: QTY COMP: MOVED OUT:
SCRAP: P/C:

N
N NOTE: SECTION AND PAGE REFERENCES ARE RELATED TO OVERHAUL
N MANUAL 27-41-1. VERIFY LATEST REVISION IS USED.
N
N VISUALLY INSPECT SCREW FOR EXCESSIVE CORROSION, REFERENCE
N SECTION 5L1, PAGE 14A.
N
N IF CORROSION IS PRESENT, RECORD MAXIMUM DEPTH AND
N APPROXIMATE PERCENTAGE OF AREA COVERED:
N
N DEPTH: ___—___ %: ___—___
N
N NOTE: CLEARLY MARK ANY AREAS OF CORROSION FOR REWORK AT BURR
N BENCH. IF ONLY A VERY LIGHT POLISH IS REQUIRED (LESS
N THAN .002" STOCK REMOVAL), IT WILL NOT BE NECESSARY TO
N SHOT PEEN THOSE AREAS.
N
N INSPECT AND RECORD CONCENTRICITY OF SCREW PER SECTION
N 4B-1A, PAGE 6B.
N
N CONCENTRICITY: .002 — (.011 HEAD END)
N
N NOTE: FLUCTUATION IN CONCENTRICITY OF SCREW SHALL NOT
N EXCEED REQUIREMENT OF SECTION 7A-3, PAGE 22A.
N
N CHECK AND RECORD SCREW SURFACE FINISH. ✓
N
N SURFACE FINISH: 44
N
N INSPECT AND RECORD PITCH DIAMETER OF SCREW.
N REF: 1.5591 TO 1.5629".
N
N PITCH: STEP on Thd FLANKS.

1.554 HIGHEST
1.544
1.536
1.536
1.550.

SCRAP
NCMR 4057 CLEARED — DATE —
IPC 3/1/00 —

J-9

SCRAP TAG

OVH

W.O. NO. 992401-001 PT. NO. 5914169-505 DATE 3/1/00 4057

PT. NAME NUT & SCREW ASSY QTY. INSP. 1 QTY. REJ. 1 REV. —

W.O. OPER. 30 DEPT. RESP. FOR SCRAP

DISCREPANCY

-500 NUT ASSY EXCESSIVE END PLAY .048

RADIAL PLAY .015

5914168-503 SCREW SURF. FIN. 44 ✓

STEP ON THD FLANKS .005

C'BORE CONC .011

DISPOSITION

HAWAIIAN AIRLINES

DCA-110

QUALITY CONTROL	MANUFACTURING	PLANNING	4000-105 (1-97)
[redacted]			

QUALITY CONTROL

J-10

DERLAN INC.

13:22:15 08/15/97 *** WORK ORDER *** REPORT: 7275 SECTION 1 PAGE: 1

PART NUMBER: 5914169-505OVH REV: WORK ORDER: 677101-002
DESC: NUT AND SCREW ASSY. PROM-DATE: 09/05/97
DRAWING: QUANTITY: 1.000
WORK CENTER: DUE DATE: 09/05/97
REL-TO-STK: 08/14/97 DISTB DATE: 08/15/97 START DATE: 08/16/97
JOB NUMBER: 677101 DATE ROUTING SET: 06/18/97 LABOR UNIT OF MEASURE: EA
ROUTING NO: 5914169-505OVH ALTERNATE: OV1

*** WORK ORDER NOTES ***

HAWAIIAN AIRLINES, P.O. 2741755-04R, S/N DCA110
DETAIL OF TOP ASSY. 5910962-35
REF; R&R 3329, MRR #22248

LNE	OPER NO	WORK CNTR	COST CNTR	OPER/DESCRIPTION	DES TST	TOTAL SET-UP	MAN HOURS	YIELD%	PLANNED QUANTITY-IN
1	0	99	1100	OPERATIONS CONTROL					1.000

QUEUE: WAIT: MOVE: OVRLP CD: QTY:
TIMED/EST: MULTI-MACH: MULTI-OPER: DELAY:
PLAN START: 08/16/97 COMP: 08/16/97 ACT START: COMP:
MOVED IN: QTY COMP: MOVED OUT:
SCRAP: P/C:

CLOSED

N
N CUSTOMER:
N
N NEXT ASSY:
N N/A
N FINAL ASSY:
N END ITEM
N
N Q.A. BUYOFF OF ROUTING:
N 91092 (MMA) DATE 3/21/97
N SKETCH AVAILABLE ?
N YES, SKETCH #1.
N %%
N ISSUE OVERHAUL REQUEST & A COPY OF O/HAUL MANUAL, 27-41-1,
N REV. 23 DATED MAY 1/93.
N ISSUE A COPY OF SKETCH #1.
N ISSUE A COPY OF P.O. PART SPEC'S. 5914169-505OVH\80
N 5914169-505OVH\120
N %%
N
N

HOT

J-11

WORK ORDER: 677101-002

...CONTINUED.

LNE	OPER NO	WORK CNTR	COST CNTR	OPER/DESCRIPTION	DES TST	TOTAL SET-UP	MAN HOURS	YIELD%	PLANNED QUANTITY-IN

N
N

2	10	AY2	2300	DIS-ASSY			0.333		1.000

QUEUE: 1.000 WAIT: 1.000 MOVE: OVRLP CD: QTY:
TIMED/EST: MULTI-MACH: MULTI-OPER: DELAY:
PLAN START: 08/16/97 COMP: 08/16/97 ACT START: COMP:
MOVED IN: QTY COMP: MOVED OUT:
SCRAP: P/C:

N
N IF NECESSARY:
N CLEAN ASSY. TO REMOVE HEAVY BUILD UP OF GREASE, SUITABLE
N FOR HANDLING IN INSPECTION.
N REMOVE SCREW FROM NUT.
N
N VISUAL INSPECT SCREW TO VERIFY DASH NO. MATCHES PAPERWORK,
N SEE SKETCH #1. NOTIFY PROG. MGR. IMMEDIATELY IF PAPERWORK
N DOES NOT MATCH.
N
N RECORD S/N OF ASSY. Same
N
N WRAP SCREW & NUT & PLACE IN BOX FOR MOVEMENT TO NEXT
N WORK CENTER.
N
N
N
N SUP./OPER. [redacted] DATE: 8/15/97, QTY: 1
N **
N 5914169-505OVH ALT.OV1
N
N
N

3	20	DB1	2100	PLASTIC BEAD CLEAN			0.085		1.000

N/A. DI INSP 14

QUEUE: 1.000 WAIT: 1.000 MOVE: OVRLP CD: QTY:
TIMED/EST: MULTI-MACH: MULTI-OPER: DELAY:
PLAN START: 08/16/97 COMP: 08/16/97 ACT START: COMP: J-12
MOVED IN: QTY COMP: MOVED OUT:
SCRAP: P/C:

WORK ORDER: 677101-002 ...CONTINUED.

LNE	OPER NO	WORK CNTR	COST CNTR	OPER/DESCRIPTION	DES TST	TOTAL SET-UP	MAN HOURS	YIELD%	PLANNED QUANTITY-IN

N --
N PLASTIC BEAD CLEAN SCREW.
N SURFACES TO BE SUITABLE FOR VISUAL INSPECTION.
N THOROUGHLY CLEAN SCREW TO REMOVE ANY RESIDUAL DUST.
N
N
N
N SUP./OPER.______________________DATE:__/__/__, QTY:________
N **
N 5914169-505OVH ALT.OV1
N
N
N
N ____

LNE	OPER NO	WORK CNTR	COST CNTR	OPER/DESCRIPTION	DES TST	TOTAL SET-UP	MAN HOURS	YIELD%	PLANNED QUANTITY-IN
4	30	4050	4000	INSPECT		0.000	0.200		1.000

QUEUE: WAIT: MOVE: OVRLP CD: QTY:
TIMED/EST: MULTI-MACH: MULTI-OPER: DELAY:
PLAN START: 08/16/97 COMP: 08/16/97 ACT START: COMP:
MOVED IN: QTY COMP: MOVED OUT:
SCRAP: P/C:

N --
N NOTE. SECTION & PAGE REF'S. ARE RELATED TO O/HAUL MANUAL,
N 27-41-1, REV. 23.
N VERIFY THIS IS THE MOST CURRENT REVISION PRIOR TO
N INSPECTION.
N
N VISUAL INSPECT SCREW FOR EXCESSIVE CORROSION, REF. SECTION
N 5L1, (PG.14A).
N IF PRESENT, RECORD MAX. DEPTH OF CORROSION & APPROXIMATE
N PERCENTAGE OF AREA COVERED:
N CLEARLY MARK ANY AREAS OF CORROSION FOR RWK. AT BURR BENCH.
N IF ONLY VERY LIGHT POLISH IS REQ'D. (LESS THAN .002 STOCK
N REMOVAL), IT WILL NOT BE NECESSARY TO SHOT PEEN THESE AREAS.
N
N DEPTH.____0.____ %____0%.____
N
N INSPECT & RECORD CONCENTRICITY OF SCREW PER SECTION
N 4B-1A,B & C, (PG.6B).
N FLUCTUATIONS IN CONCENTRICITY OF SCREW SHALL NOT EXCEED
N REQ. OF SECT. 7A-3, (PG.22).

J-13

WORK ORDER: 677101-002 ...CONTINUED.

LNE	OPER NO	WORK CNTR	COST CNTR	OPER/DESCRIPTION	DES TST	TOTAL SET-UP	MAN HOURS	YIELD%	PLANNED QUANTITY-IN

N CONCENTRICITY. .003.
N
N MATCH S/N OF SCREW & NUT.
N INSPECT & RECORD AXIAL END PLAY & RADIAL CLEARANCE PER SECT.
N 4B-1 & 2A,B,C & D, (PG.6B).
N SEE SECT. 7A-1 & 2 (PG.22) FOR LIMITS.
N
N AXIAL END PLAY. .035. RADIAL CLEARANCE. .010.
N
N NOTE. IN CASE OF END PLAY BETWEEN .034 & .039, CONTACT
N COGNIZANT M.E., PROVIDED RADIAL CLEARANCE IS IN SPEC.
N IN CASE OF END & AXIAL PLAY BEING IN SERVICE LIMITS,
N CONTACT CONIZANT M.E.
N
N FOR OUT OF SPEC. COND., RETURN NUT ASSY. TO ASSY. DEPT. FOR
N DISPOSAL.
N
N
N
N SUP./OPER. [redacted] DATE: 8/18/97. QTY: 1.
N **
N 5914169-505OVH ALT.OV1
N
N
N
N

5	40	DB1	2100	GENERAL DEBURR		0.000	0.333		1.000

N/A.

DI INSP 14

QUEUE: WAIT: MOVE: OVRLP CD: QTY:
TIMED/EST: MULTI-MACH: MULTI-OPER: DELAY:
PLAN START: 08/16/97 COMP: 08/16/97 ACT START: COMP:
MOVED IN: QTY COMP: MOVED OUT:
SCRAP: P/C:
N --
N IF NECESSARY:
N LOCALLY POLISH/BLEND LIGHT CORROSION & ANY NICKS/DINGS AS
N OUTLINED BY INSPECTION.
N REMOVE MIN. AMOUNT OF MAT'L. POSSIBLE TO ACHIEVE CLEAN UP.
N AREAS OF REWORK TO HAVE A 16RA OR BETTER SURFACE FINISH.
N LIGHTLY POLISH TO REMOVE BLACK OXIDE AROUND AREAS OF REWORK
N USING SCOTCHBRITE ONLY.

HOT

J-14

WORK ORDER: 677101-002 ...CONTINUED.

LNE	OPER NO	WORK CNTR	COST CNTR	OPER/DESCRIPTION	DES TST	TOTAL SET-UP	MAN HOURS	YIELD%	PLANNED QUANTITY-IN

N **
N NOTE! USE EXTREME CARE WHILE PERFORMING THIS OPERATION.
N AVOID REMOVING MATERIAL FROM FINISH MACHINED AND
N CLOSE TOLERANCE, ADJACENT SURFACES.
N **
N
N
N
N SUP./OPER.________________________DATE:__/__/__, QTY:________
N **
N 5914169-5050VH ALT. OV1
N
N
N ____

LNE	OPER NO	WORK CNTR	COST CNTR	OPER/DESCRIPTION	DES TST	TOTAL SET-UP	MAN HOURS	YIELD%	PLANNED QUANTITY-IN
6	50	4050	4000	INSPECT		0.000	0.017		1.000

QUEUE: WAIT: MOVE: OVRLP CD: QTY:
TIMED/EST: MULTI-MACH: MULTI-OPER: DELAY:
PLAN START: 08/16/97 COMP: 08/16/97 ACT START: COMP:
MOVED IN: QTY COMP: MOVED OUT:
SCRAP: P/C:
N --
N VISUAL & DIMENSIONAL INSPECT OPERATION 40 100%, IF
N PERFORMED.
N
N
N
N INSPECTOR: [redacted] QTY: 1 DATE: 8/18/97 STAMP: DI INSP 14
N **
N 5914169-5050VH ALT.OV1
N
N
N
N ____

J-15

...wear or damage to the jack screw. Additionally, information from databases concerning scheduled or unscheduled maintenance to the jack screw or associated areas is requested.

Please contact your FAA PMI *during the inspection* if abnormalities are noted during the accomplishment of this inspection. Circumstances permitting, this will allow your PMI to visit your facility to view the assembly.

	Fill in this column
Air Carrier four letter Designator	HALA
Aircraft Serial Number #59 N601AP	47659
Aircraft Hours/Cycles 45996 HRS	67617
FH accumulated on jack screw assembly since installation	2591 HRS 6377 cyc
Is there evidence of metallic particles on the jack screw shaft and surrounding areas? [yes/no]	NO
Are there indications of jack screw shaft and acme nut lubrication? [yes/no]	YES
Check jack screw lower mechanical stop for condition and security. Is there evidence of contact between jack screw acme nut and the lower stop? [yes/no]	NO
Is the jack screw properly lubricated per AMM instructions? [yes/no]	YES

Please add any other observations or comments regarding general condition and security:

JACKSCREW DID NOT PASS WEAR LIMITS.
WEAR LIMITS .003 TO .040 – INSPECTION READINGS .043.
JACKSCREW BEING REPLACED.

Fax completed forms, including negative results, to the Northwest Mountain Region Long Beach Aircraft Evaluation Group at [redacted]

Inspector Name: [redacted] PMI Phone: [redacted]

Date: 2-17-2000

February 11, 2000

[redacted]

J-16

Hawaiian Airlines

HAL 267 (10/95)

ENGINEERING ORDER

Title: INSPECTION OF HORIZONTAL STABILIZER ACTUATOR SCREW AND NUT ASSEMBLIES (PHASE I)

Order Number: 27-00-01-91		**Issue Date:** 11 FEB 00	
SB No: 27A362	**AD No:** 2000-15-15/9/P1	**Revision:** E	**Revision Date:** 4 OCT 00

OCT 05 2000 MX PLANNING

Issued to A/C or P/N:	**Job Number:**	**Effectivity:**
059 (Issued by Mx Planning)	26XEPR06	ALL DC-9

MUST BE ACCOMPLISHED BEFORE FURTHER FLIGHT

HAWAIIAN AIRLINES OCT 11 2000 Quality Assurance Aircraft Records

Advanced Engineering Order: ☐ Yes ☒ No	**Retroactive:** ☐ Yes ☒ No
EO Type: ☐ Alteration ☐ Modification ☐ Repair ☒ Insp	**Classification:** ☐ Major ☒ Minor
AD or FAR Required: ☒ Yes ☐ No	

Weight Change: ☐ Yes ☒ No	**Pounds:** N/A	**Fuselage Station:** N/A
Prepared by: [redacted]	**Revised by:** [redacted]	**Checked by** [redacted]
Manager of Engineering [redacted] 10/5/00	**Director, QC:** [redacted] 10/5/00	

COMPLIANCE INFORMATION

	Date From	Hours/Cycles (As Applicable)	Days
INITIAL	11 FEB 00		3
REPETITIVE	11 FEB 00	650 FLIGHT HOURS	
TERMINATING			

☒ **RECORDS: If checked, see Section 2, Post Maintenance Accomplishment Instructions, for additional information.**

Airworthiness Directive

FAA / DER APPROVAL

FAA Approval Required: ☐ Yes ☒ No	**Name/Title (printed)** ________
Copy to FAA: ☐ Yes ☒ No	**Signature** ________ **Date** ________

INSPECTION AND APPROVAL

I certify that the unit(s) described above has been inspected and found to be in conformity with the contents of this Engineering Order.

Aircraft Number: 059 or Component Part Number: ________

Serial Number: ________

Log Book Entry A186296 (If Applicable) Accomplished By 186296 Inspected by [redacted] AUDIT Station HNL Date 10-11-00

J-17

waiian Airlines

ENGINEERING ORDER

HAL 267 (10/95)

Title: INSPECTION OF HORIZONTAL STABILIZER ACTUATOR SCREW AND NUT ASSEMBLIES (PHASE I)			
Order Number: 27-00-01-91		**Issue Date:** 11 FEB 00	
SB No: 27A362	**AD No:** 2000-15-15	**Revision:** E	**Revision Date:** 4 OCT 00

1.0 ACCOMPLISHMENT INSTRUCTIONS:

1.1 Maintenance Planning

1.1.1 Issue this Engineering Order (EO) in accordance with the Effectivity and Compliance Information indicated on the cover page of this EO. Fill in the block "Issued to A/C or P/N" as applicable. Verify in C.H.A.M.P. that this EO is the latest release and that all applicable Engineering Order Change Notices (EOCN) are attached.

ACCOMPLISHED MX 15 PLANNING

1.2 Aircraft Maintenance

1.2.1 Gain access to the horizontal stabilizer actuator jackscrew and support assembly located in the vertical stabilizer by removing access panels as necessary. (Access doors 6401 and 6402 and L/H lower fairing panel).

MECH [redacted]

NOTE: FOR THE PURPOSES OF THIS E.O, A DETAILED VISUAL INSPECTION IS DEFINED AS: "AN INTENSIVE VISUAL EXAMINATION OF A SPECIFIC STRUCTURAL AREA, SYSTEM, INSTALLATION, OR ASSEMBLY TO DETECT DAMAGE, FAILURE, OR IRREGULARITY. AVAILABLE LIGHTING IS NORMALLY SUPPLEMENTED WITH A DIRECT SOURCE OF GOOD LIGHTING AT INTENSITY DEEMED APPROPRIATE BY THE INSPECTOR. INSPECTION AIDS SUCH AS MIRROR, MAGNIFYING LENSES, ETC. MAY BE USED. SURFACE CLEANING AND ELABORATE ACCESS PROCEDURES MAY BE REQUIRED.

1.2.2 Verify that a fine residue of grease exists on jackscrew threads. Perform a detailed visual inspection for the presence of metal dust/shavings/flakes/slivers in the lubricating grease on the horizontal stabilizer actuator jackscrew assembly and the area directly below the horizontal stabilizer jackscrew assembly and surrounding areas.

RECORD FINDINGS √ OK

MECH [redacted] INSP [redacted]

1.2.3 If no metal dust/shavings/flakes/slivers are evident proceed to step 1.2.6.

MECH [redacted] INSP [redacted]

J-18

BOEING®

DC9 TASK CARD

Hawaiian Airlines

AIRLINE CARD NO. 1229	TITLE HORIZONTAL STABILIZER DRIVE ACME SCREW AND NUT	BOEING CARD NO.
DATE: 2/25/00 / TASK: 9/DI		RELATED CARD
TAIL NUMBER: 59 / WORK AREA	VERSION: 0 / THRESHOLD / REPEAT: 2C	APPLICABILITY AIRPLANE: DC9-51 / ENGINES
LOCATION: 538 / SKILL		BODY STATION / STRINGER
ATA CHAPTER: 27	ACCESS:	ZONE: 63

Equipment and Materials

Note: Equivalent substitutes may be used instead of the following items:

Name and Number	Manufacturer
Horizontal Stabilizer Restrainer Fixture	4916750
Dial Indicator Starrett	Not Specified

CARD COMPLIED WITH	SOURCE	
		Page 1 of 4 October 1999

BOEING®

DC9
TASK CARD

Hawaiian Airlines

DATE	TAIL NUMBER	LOCATION	AIRLINE CARD NO.		BOEING CARD NO.
2/25/00		538	1229		

	MECH	INSP

TASK NO. 9-10120

1. Do a Detailed Inspection of the Horizontal Stabilizer Acme Screw and Nut End Play. (Refer to Figure 1) [redacted]

WARNING: BEFORE YOU MOVE THE TRIM SWITCHES, MAKE SURE THE AREA AROUND THE HORIZONTAL STABILIZER IS CLEAR OF PERSONS AND EQUIPMENT. INJURY TO PERSONS AND DAMAGE TO EQUIPMENT CAN OCCUR.

A. Using control wheel trim switches, move horizontal stabilizer to approximately 1¯ aircraft noseup (ANU) position.

B. Open, tag and safety the following circuit breakers. [redacted] [redacted]

Circuit Breaker	Panel Location	Panel Area
AUTOPILOT & ALTERNATE LONGITUDINAL TRIM (3)	Upper EPC	RIGHT RADIO AC BUS
PRIMARY LONGITUDINAL TRIM (2)	Upper EPC	LEFT RADIO DC BUS

C. Clamp dial indicator mounting bracket to jackscrew torque tube retaining nut and position dial indicator probe against acme nut as shown in Figure 1, View A.

D. Clamp dial indicator mounting bracket to upper stop on jackscrew and position dial indicator probe against lower plate of support assembly as shown in Figure 1, View C.

E. Preload both indicator probes to at least 0.100 inch (2.54 mm) and record dial indicator readings.

F. Install horizontal stabilizer restraining fixture. (Refer to Figure 1, View B)

1) Install brackets on lower surface of horizontal stabilizer at leading edge and top web of vertical stabilizer adjacent and left of actuator.

2) Install restraining fixture between brackets.

G. Apply ~~250~~ 150 to ~~300~~ 200 inch-pounds torque (28.3 to 33.9 N.m) to horizontal stabilizer by shortening restraining fixture. [redacted]

1) Record dial indicator readings. .043

SOURCE

J-20

Addendum to Systems Group Chairman's Factual Report

Appendix K:

Excerpts of from the DC-9 Structural Repair Manual, addressing Corrosion Treatment and Grit Blast

NTSB Aircraft Accident Case No. DCA00MA023
Pacific Ocean near Anacapa Island, California
January 31, 2000
McDonnell Douglas MD-83; N963AS

CORROSION CONTROL AND PREVENTION DESCRIPTION AND OPERATION (DC-9-ALL)

1. Description

A. The following information is provided to assist in the identification and control of the various types of corrosion that may occur on DC-9 aircraft. Detailed procedures are given for treatment of assemblies and areas which are exposed to severe corrosive environments.

B. Corrosion prevention and control is of prime importance. Corrosion of parts may cause deterioration of the structure to the point where replacements must be made in order to prevent serious failures.

C. The aircraft is designed and manufactured with many built-in corrosion-preventive features. In addition to the use of noncorrosive materials wherever possible, corrosion-protective treatments and finishes are applied to the aircraft during the manufacturing process. The corrosion prevention systems employed are detailed in the following list.

Materials and Treatment/Finishes		
Material	**Alloy and Form**	**Treatment/Finish**
Aluminum	Castings 1. 356 permanent mold or sand 2. Die castings 3. All other castings	 1. Anodize (chromic acid) 2. Alodine No. 1500 or Alodine No. 1200 3. Anodize (chromic acid) or Alodine No. 1200 or No. 1500
Aluminum	2000 and 7000 Series 1. Clad 2. Non-Clad a. All forms b. Hollow or tubular, structural members, holes other than fastener holes	 1. Alodine No. 1500 2. a. Anodize (chromic acid) b. Anodize (chromic acid), FR primer (epoxy) on interior surfaces where applicable
Aluminum	1000, 3000, 5000, and 6000 Series 1. All forms 2. Hollow or tubular structural members, holes other than fastener holes	 1. Alodine No. 1500 2. Alodine No. 1200, FR primer (epoxy) on interior surfaces

K-1

[redacted]

34. Chemical Removal of Corrosion from Magnesium

A. Remove

WARNING: CHROMIC ACID IS AN AGENT THAT IS POISONOUS, CARCINOGENIC, AND AN OXIDIZER. MAKE SURE ALL PERSONS OBEY ALL OF THE PRECAUTIONS WHEN CHROMIC ACID IS USED.
- DO NOT USE IN AREAS WHERE THERE IS HIGH HEAT, SPARKS, OR FLAMES.
- USE IN AN AREA OPEN TO THE AIR.
- CLOSE THE CONTAINER WHEN NOT USED.
- DO NOT GET CHROMIC ACID IN THE EYES, ON THE SKIN, OR ON YOUR CLOTHES.
- DO NOT BREATHE THE GAS.

(1) To chemically remove corrosion from magnesium assemblies, or from installed parts which are not readily removable, prepare chromic acid solution, 10 percent by weight, in distilled water.

(2) Remove all loose corrosion with stiff-bristle brush and mask off nearby operating mechanisms, joints, and plated steel.

(3) Apply chromic acid solution, hot if possible, sparingly to corroded area. Agitate with nonmetallic brush for 5 minutes.

(4) Rinse thoroughly with clean water, Repeat treatments as necessary, and allow surface to dry.

(5) Apply Dow No. 19 chemical surface treatment (Dow Chemical Co., Midland, Mich.) and organic finish to area involved.

35. Mechanical Removal of Corrosion

A. Remove Mild Surface Corrosion and Light Pitting by Hand Rubbing

CAUTION: STEEL WOOL OR A STEEL WIRE BRUSH SHOULD NEVER BE USED FOR REMOVING CORROSION FROM ALUMINUM. STEEL PARTICLES, WHICH MAY BE INVISIBLE TO THE NAKED EYE, WILL BECOME IMBEDDED IN THE ALUMINUM AND THUS INVITE CORROSION IN THE PRESENCE OF MOISTURE.

NOTE: This method is particularly adaptable to cleaning contours of aluminum tubing, stringers, and similar items with recesses.

(1) Remove mild surface corrosion and light pitting with aluminum wool and aluminum oxide abrasive paper. Dip aluminum wool in kerosene before rubbing.

J-2

B. Remove Light Surface Corrosion by Buffing

(1) Using a cloth or brush, spread a thin coat of polishing compound over a small area. Avoid coating too large an area if the compound is a type that solidifies too quickly.

(2) Attach a cotton pad or lamb's-wool cover to the buffing machine. When buffing, use a side-to-side motion to minimize heat generation since excessive heat can alter the heat treatment and cause corrosion susceptibility in the skin.

(3) Remove residue around rivets and seams by hand polishing with the same compound.

(4) After buffing, wash the area with a one-to-one mixture of water and petroleum base solvent. Since such mixtures settle into two levels, dip cloth through the lighter solvent into the water below.

(5) Wipe the surface dry and polish it with soft cloths.

C. Remove Deep Pitting and Intergranular Corrosion by Scraping

(1) Remove deep pitting and intergranular corrosion by using a carbide-tip scraper.

(2) Use a 10-power magnifying glass to determine if all corrosion has been removed.

CAUTION: TO AVOID SETTING UP STRESS CONCENTRATIONS, BLEND SCRAPED AREA INTO SURROUNDING METAL TO FORM A SAUCER-SHAPED DEPRESSION.

(3) Scrape away an additional 0.002 inch of clean metal to ensure that removal was complete.

(4) After scraping, polish first with No. 280 grit aluminum oxide abrasive paper and then with No. 400 grit.

(5) Apply the chemical surface treatment and final protective finish indicated for the area.

D. Remove Surface Corrosion from Large Areas by Abrasive Blasting

CAUTION: TO PREVENT PEENING OF CORROSION PRODUCTS INTO ALUMINUM SKINS, CONTAMINATION OF ABRASIVE SHOULD BE KEPT BELOW 2 PERCENT. ABRASIVES THAT HAVE BEEN USED ON STEEL MUST NEVER BE USED ON ALUMINUM.

NOTE: Abrasive blasting may be considered only if a complete organic finish is to be applied. This is because of the possibility of removing cladding from aluminum and cadmium plating from fasteners.

(1) Remove general surface corrosion from relatively large areas, including fasteners, by using abrasive-air-blasting equipment such as "Vacu-Blast".

J-3

NOTE: The abrasive material should be aluminum oxide or glass beads -- never silicon carbide. Particle size of the abrasive should not be over 180 mesh (0.08 mm) for coarse, rapid removal of corrosion. For better control of corrosion removal, material in the 400-600 mesh (0.038 to 0.025 mm) range is desirable.

36. Chemical Treatment after Mechanical Removal of Corrosion (Surfaces to Be Repainted)

A. Apply Alodine No. 1200 in accordance with instructions given in paragraph 30.

37. Corrosion Removal on Steel Alloys (Below 200,000 PSI)

A. Apply

(1) For removing corrosion on steel alloy assemblies, or installed parts not readily removed, lightly apply phosphoric acid-type rust remover Turco WO-1 (Turco products, Inc., Box 1055, Wilmington, Calif.) to rusted area with bristle brush or cloth until rust is removed. Avoid trapping rust remover in joints or in inaccessible areas. On cadmium-plated parts, contain rust remover to immediate area of corrosion, as remover will also strip plating.

NOTE: The final protective paint finish is applied immediately after drying of the chemical surface treatment. Before applying paint, the surface must be clean, dry, and free from any contamination. Do not attempt to remove the stained appearance resulting from the chemical surface treatment,

(2) Rinse away rust remover with water. Rinse again with denatured alcohol, and wipe dry.

(3) If replating of previously plated parts cannot be accomplished, apply two coats of FR primer and one coat of FR aluminized topcoat.

38. Removal of Minor Corrosion from High-Strength (200,000 to 240,000 PSI) Steels

NOTE: For parts that are extensively corroded, see Chapter 20 of DC-9 Overhaul Manual.

A. Clean

(1) Clean surface with Stoddard solvent.

CAUTION: DO NOT USE CHEMICAL RUST REMOVERS OR OTHER ACIDIC MATERIALS THAT COULD CAUSE HYDROGEN EMBRITTLEMENT ON STEELS IN THIS HEAT-TREAT RANGE.

(2) Blend out minor scratches, dings, and corrosion damage with No. 150 grade silicon carbide paper.

J-4

WARNING: METHYL ETHYL KEYTONE IS AN AGENT THAT IS FLAMMABLE, EXPLOSIVE, POISONOUS, AND AN IRRITANT. MAKE SURE THAT ALL PERSONS OBEY ALL OF THE PRECAUTIONS WHEN METHYL ETHYL KEYTONE IS USED.
- GAS/AIR MIXTURES MORE THAN THE LOWER EXPLOSIVE LIMIT (LEL) CAN CAUSE AN EXPLOSION IF HIGH HEAT, SPARKS, OR FLAMES SUPPLY IGNITION.
- USE IN AN AREA OPEN TO THE AIR.
- CLOSE THE CONTAINER WHEN NOT USED.
- DO NOT GET METHYL ETHYL KEYTONE IN THE EYES, ON THE SKIN, OR ON YOUR CLOTHES.
- DO NOT BREATHE THE GAS.

(3) Clean surface with methyl ethyl ketone (TT-M-261) or technical grade toluene (TT-T-548).

B. Apply

(1) Apply coat of Cat-A-Lac primer 463-6-l (Finch Paint and Chemical Co., 1536 W. 228th St., Torrance, Calif.)

(2) Apply Cat-A-Lac topcoat 443-3-2.

39. Mechanical Removal of Corrosion Products from Steel Alloys

A. Remove

(1) Use files, steel wire brushes, or motor-driven steel wire wheels to remove pitting or severe corrosion on steel alloys.

(2) Blend the cleaned area into the surrounding zone with aluminum oxide abrasive paper to eliminate stress concentrations.

(3) Refinish as described in paragraph 37, step A. (3).

40. Corrosion Removal from Lower Wing Panels

CAUTION: TO PREVENT POSSIBLE DAMAGE TO HIGH-STRENGTH STEELS IN LANDING GEAR AREA, PLACE AIRCRAFT ON JACKS AND RETRACT GEARS WITH DOORS CLOSED DURING CLEANING, CORROSION REMOVAL, AND REFINISHING PROCESSES OF LOWER WING PANELS.

A. Remove

(1) Mask off surfaces surrounding area to be cleaned and treated. Cover all openings.

(2) Clean area to be inspected as described in paragraph 17.

(3) After thoroughly rinsing the area as described in paragraph 17, carefully inspect for corrosion and mechanical damage.

J-5

[redacted]

Addendum to Systems Group Chairman's Factual Report

Appendix L:

Statistical Analyses of Torque Tube Wear Band Data

NTSB Aircraft Accident Case No. DCA00MA023
Pacific Ocean near Anacapa Island, California
January 31, 2000
McDonnell Douglas MD-83; N963AS

TORQUE TUBE WEAR BAND v. END PLAY DATA

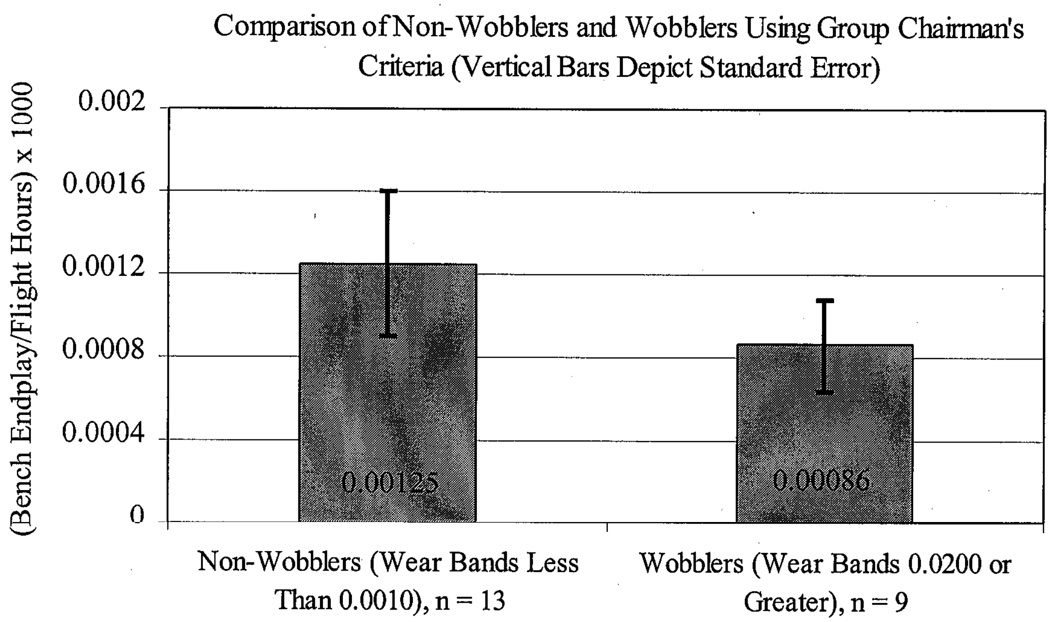
Aircraft Registration Number	End Play Check on Bench @ Integrated	Airline on Aircraft End Play Check	DCA #	Flight Hours	Nut Wear Rate using bench EP (per 1K hours)	tt wear band depth calculated
N947AS	**0.029**	N/A	DCA 1935	27860	0.00079	**0.012**
N961AS	**0.029**	0.055	DCA 2184	27392	0.0008	**0.02**
N935AS	**0.040**	0.041	**"AC935"**	45860	0.00072	**0.006**
N973AS	**0.036**	0.023	DCA 2264	20640	0.0014	**0**
N954AS	**0.033**	0.043	DCA 1467	42192	0.00062	**0**
N933AS	**0.032**	0.033	DCA 1365	46499	0.00052	**0.01**
N934AS	**0.031**	0.037	DCA1400	45170	0.00053	**0.003**
N931AS	**0.029**	0.036	DCA 1315	46834	0.00047	**0.0066**
N960AS	**0.032**	0.039	DCA 2163	27502	0.00091	**0**
N953AS	**0.020**	0.034	DCA 1475	43670	0.0003	**0.0014**
N955AS	**0.010**	0.018	**"AC955"**	61769	0.00005	**0.022**
N968AS	**0.025**	0.050	DCA 1876	27551	0.00065	**0.009**
N932AS	**0.033**	0.036	DCA 1364	45521	0.00055	**0.009**
N972AS	**0.028**	0.031	DCA 2251	23123	0.0009	**0.0036**
B-2150	**0.048**	0.053	DCA 2247	13649	0.0032	**0.01**
B-2126	**0.043**	0.042	DCA 1700	23556	0.0018	**0.0095**
	0.011	**0.410**	"9501"	33955	0.0001	**0.033**
	0.029	0.041	DCA 1325	49802	0.00044	**0.002**
	0.032	0.042	DCA 2060	44333	0.00056	**0.017**
	0.023	0.001	"9508"	45363	0.00035	**0.0041**
	0.035	0.046	"9503"	57137	0.0005	**0.0016**
	0.020	**0.076**	DCA 262	50949	0.00024	**0.0019**
	0.035	0.036	DCA 1417	35751	0.00078	**0.0009**
	0.030	0.030	"12987"	35098	0.00066	**0.01**
N975AS	**0.030**	0.039	DCA 2272	19960	0.0012	**0**
N964AS	**0.023**	N/A	DCA 2192	26348	0.00061	**0.036**
N949AS	**0.015**	N/A	DCA 1974	29599	0.00037	**0.0066**
	0.022	N/A	DCA 1204	44059	0.00034	**0.028**
	0.019	N/A	DCA 1510	42000	.0003	**0.016**
N/A	**0.017**	N/A	DCA 1143	45000	.0002	**0.0004**
	0.027	0.029	DCA 1328	44803	0.00045	**0.0006**
	0.022	0.031	"999"	53572	0.00028	**0.0016**
	0.021	0.025	DCA 1376	13319	0.00105	**0.011**
	0.018	0.030	"33087"	35387	0.0003	**0.002**
	0.015	N/A	DCA 1730	35408	0.00023	**0.016**
71-0875	**0.034**	N/A	DCA 322	32000	0.0008	**0**
159118	**0.026**	0.027	DCA 952	64915	0.0003	**0**
	0.014	N/A	DCA 1609	38000	0.0002	**0.016**
B-2147	**0.042**	N/A	DCA 2210	17747	0.00197	**0.039**
N943AS	**0.018**	N/A	DCA 1934	30853	0.00043	**0**
N973AS	**0.022**	0.036	DCA 1840	22767	**0.0005**	**0.025**
N965AS	**0.015**		DCA 2120	28710	0.00038	**0.028**
	0.062	N/A	DCA 302	60738	0.0009	**0**
N951AS	**0.045**	0.046	**"AC951"**	52894	0.00074	**0.0046**
	0.015	N/A	"010"	6675	0.0012	**0.01**
	0.013	N/A	DCA 1155	13226	0.00045	**0.031**
Stk	**0.014**	0.023	DCA 1927	17041	0.00041	**0**
N981AS	**0.053**	0.055	DCA 3008	10201	**0.0045**	**0**
N982AS	**0.048**	.082 (.051)	DCA 3000	9980	**0.0041**	**0.0065**

L-1

Comparison of Non-Wobblers and Wobblers Using Group Chairman's Criteria[1]

Non-Wobblers: Any wear band less than 0.0010 (n=13)
Wobblers: Any wear band greater than or equal to 0.0200 (n=9)
Wear Formula: (Bench end play / flight hours) x 1,000

T-Test comparing means for Non-Wobblers and Wobblers is non-significant.
$t(20) = 0.849$, $p = 0.406$ (p would need to be less than 0.05 to be considered significant)[2]



[1] These criteria were established by the Systems Group Chairman to delineate jackscrews that have wear band depths deep enough to cause a perceptible wobble; from jackscrews that have no wear band or wear band depths that are shallow enough to cause an imperceptible wobble.
[2] Neither calculating a wear rate that subtracts an initial constant (e.g., .007) nor removing possibly removed jackscrews changes the (non) significance of these findings.

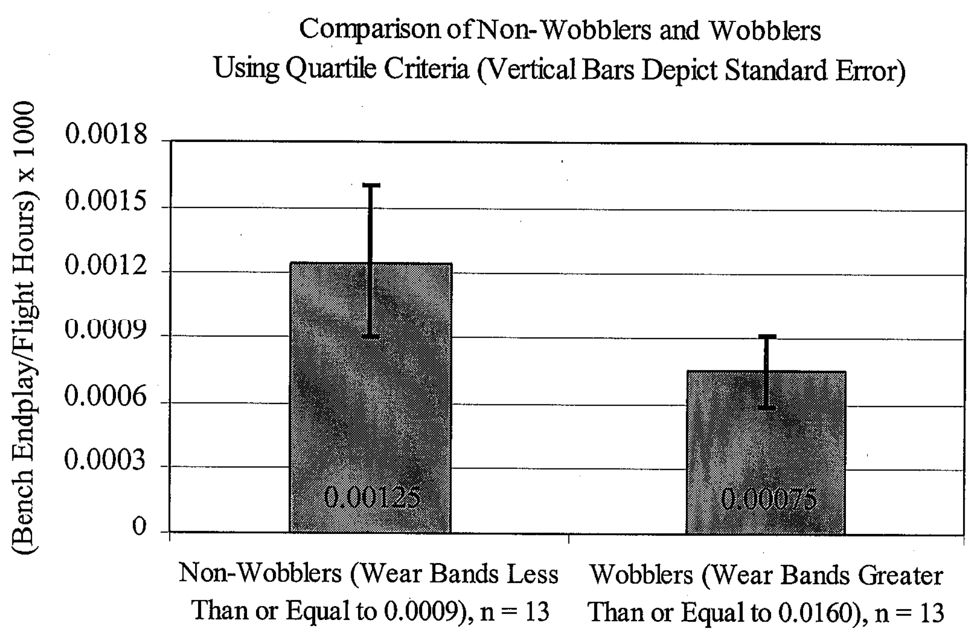
L-2

Comparison of Non-Wobblers and Wobblers Using "Quartile Criteria"

Quartiles are scores that may be used to separate a distribution into four parts according to their size. There were 49 cases in the torque tube wear band data sample, therefore we could not divide the group into four equal-sized sets. Instead, we ranked all wear bands by size and selected 13 with the lowest wear band depths as non-wobblers and 13 with the highest wear band depths as wobblers (13 cases represent 26.5% of the total set.)

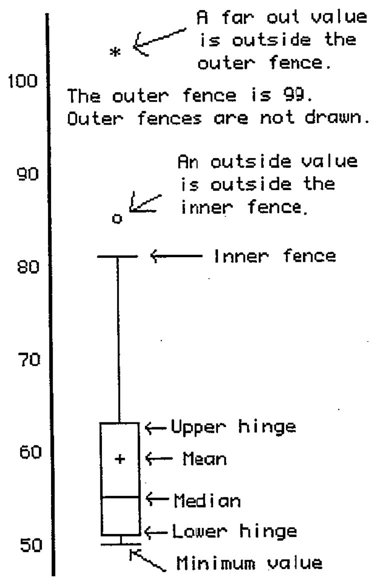
Non-Wobblers: Any wear band less than or equal to .0009 (n=13)
Wobblers: Any wear band greater than or equal to .0160 (n=13)
Wear Formula: (Bench end play / flight hours) x 1,000

T-Test comparing means for Non-Wobblers and Wobblers is non-significant.
$t(24) = 1.317$, $p = .200$ (p would need to be less than .05 to be considered significant)[3]



3 Neither calculating a wear rate that subtracts an initial constant (e.g., .007) nor removing possibly removed jackscrews changes the (non) significance of these findings.

Box Plot (1 of 2)



A box plot provides an excellent visual summary of many important aspects of a distribution. The box stretches from the lower hinge (defined as the 25th percentile) to the upper hinge (the 75th percentile) and therefore contains the middle half of the scores in the distribution.

The median is shown as a line across the box. Therefore 1/4 of the distribution is between this line and the top of the box and 1/4 of the distribution is between this line and the bottom of the box.

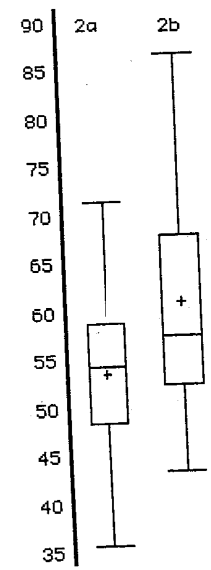
The "H-spread" is defined as the difference between the hinges and a "step" is defined as 1.5 times the H-spread.

Inner fences are 1 step beyond the hinges. Outer fences are 2 steps beyond the hinges.

If the largest value is larger than the inner fence, a line is drawn to the inner fence as in the figure. If the largest value is less than the higher inner fence, a line is drawn from the upper hinge to the largest value. Similarly, a line is drawn from the lower hinge to either the lower inner fence of the lowest value, whichever is closer to the lower hinge.

Box plots (2 of 2)

Next Chapter: Describing Bivariate Data



Every score between the inner and outer fences is indicated by an "o"; a score beyond the outer fences is indicated by a "*".

It is often useful to compare data from two or more groups by viewing boxplots from the groups side by side. Plotted are data from Example 2a and Example 2b . The data from 2b are higher, more spread out, and have a positive skew. That the skew is positive can be determined by the fact that the mean is higher than the median and the upper whisker is longer than the lower whisker.

Some computer programs present their own variations on box plots. For example, SPSS does not include the mean. JMP distinguishes betweeen "outlier" box plots which are the same as those described here and quantile box plots that show the 10th, 25th, 50th, 75th, and 90th p ercentiles.

L-4

Appendix M:

Exemplar Survey Form Sent to Airlines for Pre-accident Jackscrew Data

NTSB Aircraft Accident Case No. DCA00MA023
Pacific Ocean near Anacapa Island, California
January 31, 2000
McDonnell Douglas MD-83; N963AS

Nov. 7, 2000

NTSB SURVEY

DC-9 / MD-80/90 / B-717 MAINTENANCE INFORMATION

The purpose of this brief, 2-page survey is to obtain basic information related to the maintenance of the horizontal stabilizer jackscrew assemblies of DC-9, MD-80/90, and B-717 airplanes. This information will be correlated with the end-play check information that you have been submitting to the FAA and Boeing (as per AD 2000-15-15) so that the NTSB can evaluate all possible causes for premature acme screw wear. This information is critical to our efforts in solving the Alaska Airlines flight 261 accident, and will also help us determine if there are any recommendations that can be made to make your fleet safer. These survey forms will be used by the NTSB for safety purposes only. The NTSB urges you to complete this survey before ***Nov. 22, 2000. Please contact Jeff Guzzetti, NTSB Aerospace Engineer, at*** [redacted] ***if you have any questions.***

NAME of AIRLINE : ______________________________

1. In ***calendar year 1999*** (i.e. immediately prior to the Alaska Airlines accident), what were the **time intervals** used by your airline for the following maintenance actions that are associated with the DC-9 / MD80/90 / B717 horizontal stabilizer jackscrew assembly ?

   [*Please be very specific and indicate exact flight hours, exact number of months, and which one of the intervals that you use as the driving interval. For example, the answer should be written in the following format "XXXX flight hours or every X months, whichever comes first."*]

   (a) End-play Check (Acme Screw and Nut Wear Check) ?

   ____

   ____

   (b) General Visual / Operational Inspection ?

   ____

   ____

   (c) Lubrication (of Acme Screw and Nut) ?

   ____

   ____

M-1

2. In **calendar year 1999** (just prior to the Alaska Airlines accident), **check the type(s) of grease** that your airline specified on the maintenance work cards related to the lubrication the horizontal stabilizer jackscrew assembly (***specifically, the acme nut***) of DC-9 / MD80/90 / B717 airplanes ?

Mobilegrease 28 _____
Aeroshell 7 _____
Aeroshell 17 _____
Aeroshell 22 _____
Aeroshell 33 _____
Other _____ **(please indicate grease type(s) if "other": ______________________________)**

3. Check the **type(s) of grease** that your airline ***currently*** uses to lubricate the horizontal stabilizer jackscrew assemblies (specifically, the acme nut) for your DC-9 / MD80/90 / B717 airplanes ?

Mobilegrease 28 _____
Aeroshell 7 _____
Aeroshell 17 _____
Aeroshell 22 _____
Aeroshell 33 _____
Other _____ **(please indicate grease type if "other": ______________________________)**

4. Prior to the Alaska Airlines accident in January 2000, did your airline have a program in place which recorded previous end-play checks for trending ? **Yes** ____ **No** ____

   (a) If "yes", would you be willing to share that data with us ? **Yes** ___ **No** ___ **N/A**___

5. **How many** DC-9 / MD80/90 / B717 horizontal stabilizer jackscrew assemblies did your airline remove and replace during the following calendar years:
   1998 ? ________
   1999 ? ________

6. If your airline replaced any jackscrews, **what was the most common reason** for replacement ?

   ____
   ____

7. During **calendar year 1999, what was the *maximum end-play check reading*** that your airline would normally accept prior to removing and/or replacing the jackscrew ? (i.e. 0.032 inches ? 0.034 inches ? 0.040 inches ? other ?) ____________**inches of end-play**

8. Do you have **any comments**, suggestions, or recommendations related to the maintenance of horizontal stabilizer jackscrew assemblies and the recent attention to this issue ? If so, write them here (or you may attach them). This is OPTIONAL !

____
____
____

9. **Please enclose a copy of your airline's *previous* maintenance *work card* and *maintenance manual excerpts*, (that were used during calendar year 1999, immediately *prior* to the Alaska Airlines accident 0n January 31, 2000) addressing:**

- **The lubrication of the horizontal stabilizer jackscrew assembly, and**
- **The horizontal stabilizer end-play check**

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Addendum to Systems Group Chairman's Factual Report

Appendix N:

Spirit Airlines Maintenance Records

NTSB Aircraft Accident Case No. DCA00MA023
Pacific Ocean near Anacapa Island, California
January 31, 2000
McDonnell Douglas MD-83; N963AS

[redacted]

SPIRIT AIRLINES
Catch the Spirit!

SPIRIT AIRLINES, INC.
Quality Control Department
11700 Metro Airport Center
Building D, Suite 101
Romulus, Michigan 48174
[redacted]

March 29, 2000

Manager, Los Angeles (ACO)
FAA, Transport Airplane Directorate
3960 Paramount Boulevard
Lakewood, California 90712-4137

Via Facsimile: (562) 627-5210

Boeing Long Beach Division
P.O. Box 1771
Long Beach, California 90801
Attn. Sr. Mgr. Sys. Tech & Flt. Support.

Via Facsimile: (562) 497-5811

To Whom It May Concern:

Pursuant to the requirements of paragraph C of Airworthiness Directive 00-03-51, Spirit Airlines, Inc. (GTIA – 770S), submits the following information with respect to its current effective aircraft fleet:

Single Fleet Discrepancy

FSN: 47131 TAT: 60738.1 TAC: 52407 – Jackscrew assembly endplay was .057 and average free play was .003. End-play determined to be out of limits by .017. Jackscrew assembly was removed and replaced with an overhauled unit prior to further flight.

Non-Discrepant Aircraft

FSN	TAT	TAC	FSN	TAT	TAC
47526	67169.6	59631	48111	53654.3	41242
47605	46759.3	58003	48087	31382.2	20939
49504	25245.4	16274	47514	60608.4	38408
47604	47275.9	59093	47326	68359.8	65938
49144	41674.1	19780	48058	29393.5	45572
49104	48933.7	29021	47526	67169.6	59631
48051	30689.2	44915	48048	34835.6	21935
47113	74630.2	69966	48017	56368.4	37027

Regards,

[redacted]
Director of Quality Control
Spirit Airlines, Inc.
[redacted]

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Attachments: (3 Pages, Reports per S.B. DC-9-27A362)

Addendum to Systems Group Chairman's Factual Report

Appendix O:

Excerpts from the DC-9 Overhaul Manual addressing Jackscrew Overhauls

NTSB Aircraft Accident Case No. DCA00MA023
Pacific Ocean near Anacapa Island, California
January 31, 2000
McDonnell Douglas MD-83; N963AS

R	Solvent	P-D-680, Type 1
	Wipers, cotton, lint-free	Commercially available
R	Lubricant, grease	MIL-G-81322
	Gloves, cotton, lint-free	Commercially available
	Barrier material	MIL-B-121, Type II, Grade A Class 2

R NOTE: A. Equivalent substitutes may be used for above items.

R B. It is possible that some materials in the Materials List cannot be used for some or all of their necessary applications. Before you use the materials, make sure the types, quantities, and applications of the materials necessary are legally permitted in your location. All persons must obey all applicable federal, state, local, and provincial laws and regulations when it is necessary to work with these materials.

Cleaning Materials
Figure 2

4. Inspection/Check

A. General Visual Check

(1) Check parts for general condition, corrosion, deterioration, damage, and wear.

(2) Check condition of chrome and cadmium plating. See Figure 4 for plating dimensions.

(3) Check threads for stripping, cross-threading, and wear.

(4) Check wear tolerances (see Figure 9).

(5) Check paint for chipping and damage.

(6) Check parts for mismatch of serrations and tooth damage.

(7) Check bearing (95) for binding, damage, and excessive wear.

B. Check Fits and Clearances (See paragraph 7)

(1) Check radial clearance of nut (51) and screw (52).

(1a) Check concentricity of screw (52) as follows:

(a) On surface table, place screw (52) on V-blocks.

(b) Measure concentricity of screw (52).

(c) Repeat measurement at various places on screw (52).

(2) Check axial end play of screw assembly (50) as follows:

(a) Install nut (51) on screw (52).

(b) With screw assembly (50) in vertical position, manually slip nut (51) up and down without imparting any rotation.

(c) Measure axial end play.

(d) Repeat measurement with nut (51) at various places on screw (52).

(3) Check diameters of torque tube (84), support assembly (87), and screw (52) for concentricity.

<u>NOTE</u>: If wear on 2.1240- to 2.1245-inch diameter does not exceed 0.025 inch, repair of torque tube (84) is not required. If wear exceeds 0.025 inch, see Repair, paragraph J2.

(4) Replace nut assembly (40) as a unit if wear tolerances are exceeded (see paragraph 7). Units worn beyond maximum may be returned to Douglas Aircraft Co. for rework.

B. Gear Assembly (124)

(1) Press plug (127) in gear (128).

C. Install Bushings and Bearings

• (1) Install the following bushings in accordance with Chapter 20:

(a) Bushings (10 and 11) in crank (12).

(b) Line-ream bushings (10 and 11) to 0.2495- to 0.2505-inch diameter.

(c) Bushing (63) in stop (64).

(d) Ream bushing (63) to 1.7495- to 1.7510-inch diameter.

(2) Install the following bearings in accordance with Chapter 20:

(a) Deleted.

(b) Bearings (122 and 123) in cover (116) and housing assembly (129).

<u>NOTE</u>: Bearings (123) should be installed with seals toward outside of gear box.

(c) Bearings (125 and 126) in gear (128).

D. Repair Nut Assembly (22)

(1) If replacement of plugs (23) is necessary, remove plugs (23) from nut (24).

(2) Install new plugs (23) in nut (24).

(3) Peen edge of nut (24) to retain plugs (23).

E. Stop Assemblies

<u>NOTE</u>: Install pins in accordance with Chapter 20.

(1) Install pin (33) in stop (36 or 39A).

(2) Install pin (34) in stop (37 or 39).

ITEM NO.	DIAMETER BEFORE PLATING	DIAMETER AFTER PLATING	PLATING THICKNESS	TYPE OF PLATE	REMARKS
16	0.8685 0.8695	0.8715 0.8730	0.00100 0.00235	Hard chrome	Grind OD to meet diameter specified before and after plating, 32-microinch finish. Buff lightly.
100	0.8700 0.8710	0.8720 0.8730	0.0005 0.0015	Hard chrome	

Plating Dimensions
Figure 4

R L1. Repair Screw (52)

R (1) If necessary, repair corrosion on threaded area of screw
R (52), as follows:

R NOTE: Corrosion must be evenly distributed over threaded
R area, and pitting must not exceed 0.005-inch depth
R maximum.

R (a) Carefully blend corrosion up to 0.005-inch depth maximum
R over 20 percent of threads area.

R (b) Shotpeen reworked areas of threads. Refer to Chapter
R 20-10-10 for shotpeening procedures.

R (c) Blend threaded surface to 32 microinch finish, and break
R all sharp edges.

R NOTE: If black oxide coating is worn or damaged, black
R oxide coating must be completely stripped and part
R recoated.

(6) Install cover (116) and gasket (117) on housing assembly (129) with bolts (114 and 115), washers (113), and nuts (112). Tighten nuts (112). Maintain end play (see paragraph 7).

B. Screw and Support Assembly

(1) Apply grease to contacting surfaces of torque tube (84), bearing (95), and screw (52). Install torque tube (84) in support assembly (93).

R **WARNING:** GREASE LUBRICANT IS AN AGENT THAT IS AN IRRITANT.
R MAKE SURE ALL PERSONS OBEY ALL OF THE PRECAUTIONS
R WHEN GREASE LUBRICANT IS USED.
R - DO NOT USE IN AREAS WHERE THERE IS HIGH HEAT,
R SPARKS, OR FLAMES.
R - USE IN AN AREA OPEN TO THE AIR.
R - CLOSE THE CONTAINER WHEN NOT USED.
R - DO NOT GET GREASE LUBRICANT IN THE EYES, ON THE
R SKIN, OR ON YOUR CLOTHES.
R - DO NOT BREATHE THE GAS.

R REFER TO THE APPLICABLE MANUFACTURER'S OR
R SUPPLIER'S MSDS FOR:
R - MORE PRECAUTIONARY DATA
R - APPROVED SAFETY EQUIPMENT
R - EMERGENCY MEDICAL AID.

R TALK WITH THE LOCAL SAFETY DEPARTMENT OR
R AUTHORITIES FOR THE PROCEDURES TO DISCARD THIS
R HAZARDOUS AGENT.

(2) Install screw (52) on torque tube (84).

(3) Apply grease to inner spherical diameter of plate (88), and position shim (79) and plate (88) on screw (52) and support assembly (93).

NOTE: Plate (88) and support assembly (93) must be aligned as marked during disassembly.

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(4) Install plate assembly (89), shim (80), and support assembly (93) on plate (88) with bolts (70, 74, and 78), washers (69, 72, 73, 76, and 77) and nuts (68, 71, and 75). Tighten nuts (68, 71, and 75). Maintain clearance between screw (52) and plate (88) and between torque tube (84) and plate assembly (89) (see paragraph 7).

<u>NOTE</u>: Plate (88), plate assembly (89), and support assembly (93) are a matched set and should be kept together as support assembly (87). A feeler gage can be used to check clearance at 30-degree intervals between torque tube (84) and plate assembly (89). Maintain alignment of plate assembly (89), support assembly (93), and plate (88) as marked during disassembly. If bolts (78) are too long, due to in-service wear, NAS1306-58 bolts may be substituted or an additional washer, MS20002C6, may be added under each bolt head, and an additional washer, MS20002-6, may be installed under each nut if necessary.

(5) Apply grease to splines (81 and 83), and install spline (83) in torque tube (84) with ring (82).

(6) Install seal (86) and ring (85) on plate assembly (89), and install spline (81) in spline (83).

(7) Apply grease to screw (52) under stop assembly (61 or 65) taking care not to get grease on threads of screw (52).

(8) Align pin (62 or 66) with slot in screw (52), and install stop assembly (61 or 65) on screw (52) with bolt (60), washer (59), and nut (58). Tighten nut (58).

(d) Safety nut assembly (22) and washer (25) to stop assembly (29, 30, 31, 32, or 32A) with lockwire (13).

(e) With a 50-pound minimum reversing axial load applied to nut (51) and reacted at support assembly (87), check axial end play (see paragraph 7).

NOTE: See Step (14A) for alternate axial end play check.

(14a) Check axial end play as follows:

(a through d) Deleted.

(e) Install measuring device between screw (52) and support assembly (87).

(f) Push nut (51) downward by hand with a force of approximately 30 pounds.

(g) Lift nut (51) vertically until actuator assembly is off the bench, and check axial end play between support assembly (87) and screw (52) (see paragraph 7).

(14b) Apply light coat of grease to threads of screw (52), then run nut (51) through full range of travel to distribute lubricant over length of screw (52).

(5) Install gearbox assembly (111) on gearbox (147 or 148) with gasket (133), washers (110), and nuts (109). Tighten nuts (109).

(6) Install drive unit (107) on gearbox assembly (111) with gasket (108), bolts (105 and 106), washers (104), and nuts (103). Tighten nuts (103).

(7) Install clips (102) and pin assemblies (99) or nut assembly (40) with washers (98) and bolts (97). Tighten bolts (97) fingertight.

(7a) Install caution placard (96A) on former and cap (96B) on drive unit (107).

(8) Rotate screw (52) and check for maximum gear backlash by measuring rotational play of screw (52) (see paragraph 7).

R R R	FR primer, 463-12-42 with X-522 catalyst	Dexter/Crown Metro Aerospace Hayward, CA 94544
R R R	Enamel, epoxy topcoat, gloss (gray) 453-3-2 with X-304 catalyst	Dexter/Crown Metro Aerospace Hayward, CA 94544
	Lubricant, grease	MIL-G-81322

NOTE: A. Equivalent substitutes may be used for above items.

B. It is possible that some materials in the Materials List cannot be used for some or all of their necessary applications. Before you use the materials, make sure the types, quantities, and applications of the materials necessary are legally permitted in your location. All persons must obey all applicable federal, state, local, and provincial laws and regulations when it is necessary to work with these materials.

Assembly Materials
Figure 7

0-8

7. Fits and Clearances

A. Assembly Fits

(1) Radial clearance between nut (51) and screw (52) shall be 0.0013 to 0.0079 inch.

(2) Axial end play of screw assembly (50) shall be 0.0030-inch minimum to 0.0400-inch maximum. If axial end play exceeds 0.0400 inch, replace screw assembly (50). Screw assemblies with measured end play between 0.0340 and 0.0390 inch may be reinstalled in aircraft if wear check is made every 1000 flight hours maximum.

(3) Fluctuations in concentricity of screw (52) shall not exceed 0.004-inch full indicator reading.

(4) An interference fit of 0.0002 to 0.0020 inch exists between sleeve (100) and shaft assembly (101).

(5) Bushings (55) shall be flush to protruding 0.0150 inch.

(6) Deleted.

(7) Adjust washers (118 and 119) to provide 0.0100- to 0.0200-inch end play in gears.

(8) Centerlines of pins (20 or 20A) in stop assemblies (29, 30, or 32A and 61) must align with centerlines of pins (21) in nut (51) within 0.0900 inch.

D. Wear Tolerances (See Figure 9)

ITEM NO.	PART NO.		DESIGN (MANUFACTURING) LIMITS				SERVICE (WEAR) LIMITS		
			DIAMETER		DIAMETRICAL CLEARANCE		DIAMETER		DIAM CLEARANCE MAX.
			MIN.	MAX.	MIN.	MAX.	MIN.	MAX.	
55	4914175-1	ID	0.8745	0.8755	0.0015	0.0040		0.8775	0.0065
16	4914173-1	OD	0.8715	0.8730			0.8710		
55	4914175-1	ID	0.8745	0.8755	0.0015	0.0035		0.8775	0.0060
100	4914172-9	OD	0.8720	0.8730			0.8715		

Wear Tolerances
Figure 9

8. Testing

None

9. Trouble Shooting

None

10. Storage Instructions

NOTE: See Figure 10 for storage materials.

A. Storage Procedures

(1) Wrap actuator assembly in barrier material and heat seal.

(2) Evacuate approximately 80 percent of air from package.

R (2a) Mark part number on two tags. Attach one tag to unit and
R one tag to exterior of container.