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Visual Inspection Results of Aged Boeing 737 and 747 Single-Element, Dual-Load Path Flight Control Components

August 2007

Final Report

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16. Abstract

As part of the Federal Aviation Administration (FAA) Aging Aircraft Program's coverage of nonstructural systems, Sandia National Laboratories undertook an initial study of aged single-element, dual-load path (SE-DLP) linkages from primary flight control systems on recently retired Boeing 737 and 747 aircraft. This work was done in cooperation with the aircraft manufacturer and was accomplished at the FAA Airworthiness Assurance Nondestructive Inspection Validation Center, operated by Sandia National Laboratories. The SE-DLP flight control components tested are critical; their failure would affect the continued functionality of the flight control system or subsystem and consequently degrade the safety of flight. For example, the ability of the crew to safely land the aircraft in unusual operating conditions would be questionable. Furthermore, no prior studies have investigated aged Boeing SE-DLP flight control components. This report highlights the evaluation results of the aged SE-DLP flight control components investigated in this study.

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LIST OF ACRONYMS

NDI	Nondestructive inspection
FAA	Federal Aviation Administration
OEM	Original equipment manufacturer
P/N	Part number
SE-DLP	Single-element, dual-load path

EXECUTIVE SUMMARY

As part of the Federal Aviation Administration (FAA) Aging Aircraft Research Program's coverage of nonstructural systems, Sandia National Laboratories undertook a study of single-element, dual-load path linkages from primary flight control systems on Boeing 737 and 747 commercial aircraft retired in the previous 6 months. This work was done in cooperation with the airframe manufacturer and was accomplished at the FAA Airworthiness Assurance Nondestructive Inspection Validation Center, operated by Sandia National Laboratories.

Twenty-one dual-load path components were identified for this study. Three of each component were acquired from various recently retired (end of service life) aircraft. Once acquired, each specimen received three phases of in-depth visual inspections (aided by fiberscope when appropriate) that examined the component as installed on the aircraft, after removal and cleaning, and when completely disassembled. The inspections searched for any visual signs of erosion, corrosion, excessive wear or fretting, cracks, impact damage, or other signs of mechanical degradation. Some components were also inspected against original equipment manufacturer (OEM) specifications. Data collected included supporting photographic documentation and quantified information detailing, for example, length of crack, depth of impact damage, etc.

While the component level findings, in the authors' opinion, would not prevent the continued safe flight and landing of their respective aircrafts, inspection results did yield some findings that may be of interest to the industry. Notable were two B737 mach trim actuators, tested by the OEM, that performed sluggishly and were tagged nonairworthy. The B747 specimens of interest included three aileron actuator links (inboard aileron) with excessive bearing wear, one tube assembly (inboard elevator) that had numerous fatigue cracks ranging from 15-20 mm long on the outer load path, and one rod assembly (inboard elevator) that had a 25-mm fatigue crack on the outer load path. Since the inner and outer load paths of several components investigated in this study are permanently bonded together, a visual inspection is limited in that it cannot access all areas. Therefore, it is recommended that these components undergo additional testing, such as advanced nondestructive testing (radiography, eddy-current, ultrasonics etc.) structural testing, and/or destructive sectioning. Because it is unknown whether the findings above are the result of a trend or an anomaly, additional aged dual-load path inspection specimens will be acquired. This first phase of testing has identified subjects for further study. The small size of the sample set and source of the samples (retired, nonairworthy aircraft) make it inappropriate to draw any definitive conclusion concerning the condition of parts in current service. While one cannot draw any definitive conclusions from the relatively small sample size, based upon the frequency of damage found in this sample set and the fact that the sampled airplanes were stored in an area with a benign climate, a reasonable hypothesis would be that similar degradation exists on in-service aircraft.

1. INTRODUCTION.

1.1 PURPOSE.

The purpose of this effort was to assess the condition of aging flight control linkages and to determine if there were previously unidentified conditions that in the event of a subsequent failure in the component, could prevent the continued safe flight and landing of an airplane. Of particular interest are safety-critical, single-element, dual-load path components. Dual-load path components are defined by the Aging Transport Systems Rulemaking Advisory Committee[1] as "An assembly having primary and secondary load paths where both paths are in an integral part of a single component (element)." Generally, these are hardware components that are integral or collocated; intended to last the life of the aircraft; difficult to visually inspect; and which receive inputs from multiple, independent sources for redundancy and reliability. The issues are (1) an undetected degradation (e.g., corrosion) or failure will mean that the designed-in redundancy has been compromised so that a subsequent failure could create an unsafe condition and (2) common-mode failures leading to deterioration of both load paths due to collocation could cause an unsafe condition. Additional maintenance practices, including the application of advanced nondestructive inspection (NDI) techniques, can be proposed to further enhance the operational safety.

1.2 BACKGROUND.

The service history for mechanical nonstructural systems has not indicated any one unaddressed safety concern. But because the second generation of jets is older and because the operation and maintenance of aircraft systems are constantly changing, potential safety concerns may arise unexpectedly. There have been recent instances of dual-load path failures, for example, a Lear 45 jackscrew and an Embraer 145 rudder control rod. Several of these failures resulted from maintenance issues such as incorrect assembly; others were due to cascading failures such as a clogged grease port. In all cases, the recently seen failures of dual-load path components were previously deemed to be extremely improbable.

Appropriate identification of the aging-related, safety-critical aspects of the various mechanical and hydro-mechanical systems, requires a two part approach: (1) conduct a study to identify the safety-critical areas of the designs and the operating assumptions the designs were based on and (2) conduct a subsequent maintenance and operations evaluation to ensure that maintenance and operations tasks are defined sufficiently to maintain continued operational safety. In both cases, additional maintenance practices, including the application of advanced NDI techniques, can be proposed to further enhance the operational safety. This report is the result of an effort in the second area.

[1]ATSRAC is a Federal Advisory Committee and is tasked with providing public recommendations to the Federal Aviation Administration. The committee was chartered on January 19, 1999, by FAA Order 1110.127.

2. METHODOLOGY.

2.1 COMPONENTS TESTED AND ORIGIN.

The Boeing Company has provided a list of flight control components to be visually inspected, based on the following criteria:

- The component is a single-element, dual-load path component that could adequately represent the age or condition of the flight control system.
- The component is difficult to inspect.

The selected components for testing are from primary flight control systems on Boeing 737 and 747 commercial aircraft models and are listed in tables 1 and 2 respectively.

Table 1. Selected B737 Components Tested

Part Name	Part Number	Flight Control System
Bolt Assembly	69-27229-20	Rudder (Power unit)
Rod Assy Vernier Cont Dual Path	69-37290-13	Elevator (Control)
Rod Assy-Vernier Dual Path	69-37290-15	Rudder (Power unit)
Bolt Assy-Rud Actr Rod End	69-40718-8	Elevator (Control)
Bolt Assy Actr	69-43282-1	Elevator (Control)
Bolt Assy Cont	69-43956-1	Elevator (Control)
Rod Assy	69-44427-3	Elevator (Control)
Bolt Assy-Push Rod	69-44683-2	Elevator (Control)
Actuator Assy-Mach Trim	2A7-200A	Elevator (Feel and centering unit)
Actuator Assy-Mach Trim	2590653-901	Elevator (Feel and centering unit)

Table 2. Selected B747 Components Tested

Part Name	Part Number	Flight Control System
Quadrant Tube Assy	65B80481-1	Elevator (Quadrant)
Aileron Actuator Link	65B80832-4	In Board Aileron (Package)
Tube Assy (LH)	65B81011-414	In Board Elevator (Linkage)
Tube Assy (RH)	65B81011-413	In Board Elevator (Linkage)
Tube Assy (LH)	65B81011-513	In Board Elevator (Linkage)
Tube Assy (LH)	65B81011-509	In Board Elevator (Linkage)
Tube Assy (RH)	65B81011-510	In Board Elevator (Linkage)
Tube Assy (RH)	65B81011-518	In Board Elevator (Linkage)
Tube Assy (RH)	65B81011-523	In Board Elevator (Linkage)
Link Actuator Bolt Assy	69B82658-1	In Board Aileron (Package)
Rod Assy Input	93677	In Board Elevator (Control Package)

LH = Left hand RH = Right hand

The components identified and subsequently obtained were not selected because of any perceived concern on the part of Boeing or operators of these aircraft. They simply met the two criteria listed above. Should Boeing become aware of a common failure mode, that component is then redesigned to correct the condition, which is finally documented in service bulletins released to the operators.

Operators inspect and replace components using the Boeing Maintenance Planning Data Document. This document includes inspections and hard-time component replacement mandated by the Federal Aviation Administration (FAA) during initial airplane type certification. The document specifies a visual inspection of the components listed in tables 1 and 2 at C-checks (4000 hours for the B737 and 3600 hours for the B747), lubrication of the components at 4A (1000 hours), and functional tests at 10,000 hours. This functional test validates that the system is not only operating but also operating at the limitations established within the airplane maintenance manual. It is important to note that operators can alter these intervals upon FAA concurrence; therefore, the above intervals are typical, but can vary.

Components selected for visual inspection were removed from six airplanes, each recently retired (end of service life aircraft) in the previous 6 months. The components listed in tables 1 and 2 were obtained from the aircraft shown in tables 3 and 4 respectively. The airline and registration number of the aircraft has been de-identified with pseudo variables. All acquired components were obtained from United States registered and operated airplanes (contain an N-number) with the exception of KG-DDD, which was foreign registered.

Table 3. B737 Samples (Flight Histories and Age)

Airline	Registration Number	Flight Hours	Cycles	Year Manufactured
Airline A	N000A1	59,379	49,517	1978
Airline A	N000A2	58,245	45,256	1979
Airline B	N000B1	43,050	24,242	1988

Table 4. B747 Samples (Flight Histories and Age)

Airline	Registration Number	Flight Hours	Cycles	Year Manufactured
Airline A	N000A3	70,184	9,220	1978
Airline C	N000C1	80,787	18,465	1971
Airline D	KG-DDD	93,131	19,847	1979

Typically, three of each of the dual-load path items on the original equipment manufacturer (OEM)-provided lists were acquired for this study. These parts were acquired in the form of higher levels of assembly so that surrounding components could be considered.

2.2 INSPECTION PREPARATION.

When the higher-level assemblies were received, the dual-load path part was identified from the higher-level assembly and disassembled. Great care was taken to protect the dual-load path part from damage during disassembly. The dual-load path parts were each wired (tagged) with a

visual inspection sheet that identified the part and could later be used to record inspection results. In addition to the visual inspection sheet, corresponding drawings from the illustrated parts catalog and photographs of the parts installed on the aircraft, if available, were wired to each part. Once the parts were processed in this manner, they were grouped and shelved by airplane registration number for organization and easy retrieval.

Common aircraft visual inspection tools were acquired. Low-power magnifying lenses and various lighting devices were used to aid the naked eye during the visual inspection. Common aircraft cleaning products were also acquired to remove grease and dirt from the parts during the visual inspection process. Armakleen, a mild cleaner, was used as a primary cleaner. Any remaining surface contamination was removed with Skykleen, a more aggressive cleaner. Measuring devices such as a dial indicator, a scale, and depth gauges were used to quantify the extent of flaws found during the visual inspection. An Olympus IF6C5 fiberscope was used to visually inspect the interior of long, tubular-shaped parts that the human eye could not see. Fiberscope findings were photographed with a Canon 10D EOS digital camera that was linked to the fiberscope. All parts in tables 1 and 2 were photo documented with close-ups of findings, using a Sony MVC-FD91 digital camera. Visual inspection results were recorded in three places: the visual inspection sheet, a Microsoft® Excel® database, and a Microsoft® PowerPoint® presentation. In addition, the Microsoft PowerPoint presentation included the photographic documentation, along with quantified information detailing the findings.

2.3 VISUAL INSPECTION PROCEDURE.

A three-phase visual inspection procedure was implemented for every dual-load path part listed in tables 1 and 2. To visually inspect the interior of long tubular parts where the human eye could not see, an additional visual inspection procedure was executed. The complete visual inspection procedure is shown in table 5.

Table 5. Three-Phase Visual Inspection Procedure

Phase Number	Visual Inspection Procedure
1	Prior to cleaning—with accessibility issues considered
2	Postcleaning—with part removed from aircraft and cleaned
3	Disassembly—with all attachments removed
4	Fiberscope—performed on tubular shaped parts only

The purpose of this initial phase was to inspect only the portion of the dual-load path part that would be in the aircraft inspector's line of sight, during a C-check inspection in the field. When mounted on the aircraft, parts can, potentially, be partially or fully obstructed or be inaccessible to the inspector by other parts nearby, and they are not cleaned for the C-check inspection. These visually limiting conditions can prevent the inspector from achieving a thorough look at the part needing inspection unless the part was removed, cleaned, and disassembled. Educated assumptions were made about any visual limitations or obstructions an aircraft inspector would encounter in the field. These assumptions were based on drawings and available photographic documentation of the parts installed, before they were removed for acquisition. If a sound assumption could not be made, the B737 and B747 aircraft test specimens were referenced for

further detail. Conservatively, many of the findings were placed in the phase two or three category. If, after further review, one was convinced that a particular flaw could be seen while the part is mounted in place or prior to disassembly, that finding was moved to the appropriate category.

Therefore, if a flaw exists in a part, but it was assumed undetectable while installed, it would not be recorded in the phase one inspection. Flaws that would be detected when installed were documented on the visual inspection sheet, Microsoft Excel database, and a Microsoft PowerPoint presentation. In this report, the definition of flaw is any visual signs of erosion, corrosion, wear or fretting, cracks, and disbonds, or other signs of structural degradation that would signal any trends of concern.

The second inspection phase consisted of a visual inspection with the dual-load path part removed from the aircraft and cleaned as specified in section 2.2. Flaws that became visible after cleaning, which were not detected in phase one, were recorded in the phase two inspection. Findings discovered after postcleaning are critical since, in the author's opinion, they would not be found in an in situ inspection.

Subsequently, inspection phase three involved a complete disassembly of the dual-load path part, which provided optimal access to the component. Flaws that became visible after disassembly, which were not detected in the phase one or two inspection, were recorded in the phase three inspection.

3. VISUAL INSPECTION RESULTS.

3.1 B737 VISUAL INSPECTION RESULTS.

Tables 6-15 summarize the visual inspection results for the B737 dual-load path parts listed in table 1. The findings are listed and correspond to the inspection phase where they were detected, as outlined in section 2.3. The aircraft flight histories and age for these parts are listed in table 3. The highlighted portions of these tables are findings of particular interest and correspond to associated figures. All visual inspection results stated in tables 6-15 are shown in appendix A.

Table 6 presents the inspection results of eight B737, part number (P/N) 69-27229-20, bolt assemblies, four of which were removed and inspected from the N000B1 airplane, one from N000A1, and three from N000A2.

Table 6. B737 P/N 69-27229-20 (Bolt Assembly)

Airplane Origin	Inspection Phase	Visual Inspection Findings
N000B1	1	No defects noted (see figure A-1).
	2	No defects noted (see figure A-2).
	3	Adhesive coating hinders inspection of inner bolt. No other defects noted.
	1	No defects noted.
	2	No defects noted.
	3	Adhesive coating hinders inspection of inner bolt. No other defects noted.
	1	No defects noted.
	2	No defects noted.
	3	Adhesive coating hinders inspection of inner bolt. No other defects noted. (See figure 1)
	1	No defects noted.
	2	No defects noted.
	3	Adhesive coating hinders inspection of inner bolt. No other defects noted.
N000A1	1	No defects noted.
	2	No defects noted.
	3	Adhesive coating hinders inspection of inner bolt. No other defects noted.
N000A2	1	No defects noted.
	2	No defects noted
	3	Adhesive coating hinders inspection of inner bolt. No other defects noted.
	1	No defects noted.
	2	No defects noted.
	3	Adhesive coating hinders inspection of inner bolt. No other defects noted.
	1	No defects noted.
	2	No defects noted.
	3	Adhesive coating hinders inspection of inner bolt. No other defects noted.

No major findings were discovered in the 69-27229-20 bolt assemblies during the first and second inspection phases. However, during inspection phase three (disassembly—with all attachments removed), the inner bolt was pressed out of the outer bolt and the remaining adhesive coating visually conceals the mating surfaces on all eight bolts tested. The highlighted portion of table 6 corresponds to figure 1, which is an example showing the remaining adhesive coating on the inner bolt that could not be removed. Therefore, it was recommended that this area be further investigated using an alternative NDI method to ensure no defects or flaws exist beneath the adhesive coating.

Figure 1. B737 P/N 69-27229-20 Bolt Assembly
(Inspection Phase 3: Disassembly—with all attachments removed, airplane: N000B1.)

Visual inspection findings for the 69-37290-13 rod assy vernier cont dual path are shown in table 7. Inspection findings appear irregular with the parts from the N000B1 airplane showing little to no indication of defects. Yet, the parts originating from the N000A1 and N000A2, shown in figures 2(a)-2(f), 3(a)-3(d), and 4(a)-4(h) respectively, have extensive impact damage on the outer rod surface. No defects were found after disassembly of all 69-37290-13 rod assemblies. Figures 2(g), 3(e), and 4(i) show the 69-37290-13 rod assembly disassembled, showing its undamaged internal structure.

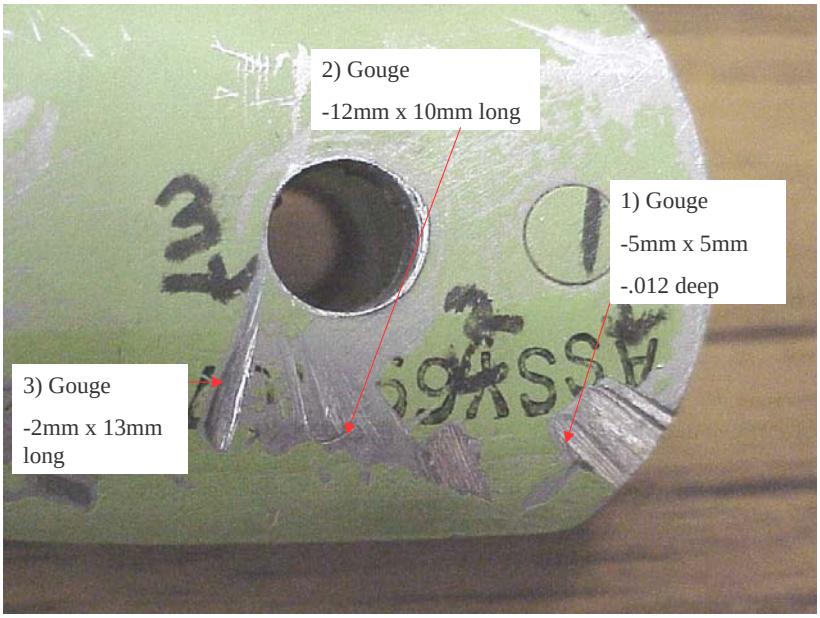
Table 7. B737 Test Results: P/N 69-37290-13 Rod Assy Vernier Cont Dual Path

Airplane Origin	Inspection Phase	Visual Inspection Findings
N000B1	1	Impact damage/nick near end of rod close to rod attach point, area damaged is 2 x 2 mm.
	2	No defects noted.
	3	No defects noted.
	4	No defects noted.
	1	No defects noted.
	2	No defects noted.
	3	1. Unidentified material on top of bolt assy 69-40727-2, 2. After removal discovered corrosion on bolt head, area corroded is 9 x 7 mm.
	4	No defects noted.

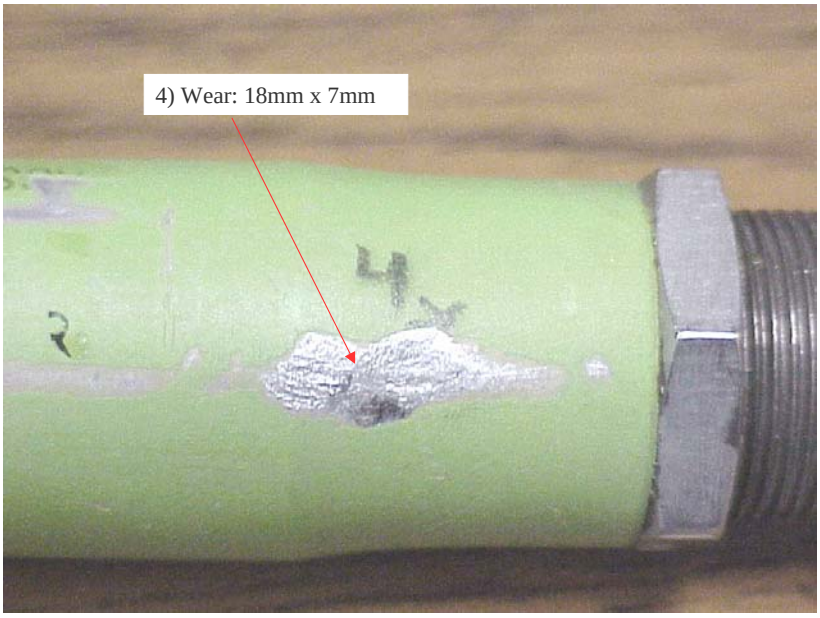
Table 7. B737 Test Results: P/N 69-37290-13 Rod Assy Vernier Cont Dual Path (Continued)

Airplane Origin	Inspection Phase	Visual Inspection Findings
N000A1	1	No defects noted.
	2	No defects noted.
	3	No defects noted.
	4	No defects noted.
	1	1. Gouge 5 x 5 mm x 0.012″ deep. 2. Gouge 12 x 10 mm. 3. Gouge 2 x 13 mm. 4. Wear 18 x 7 mm. 5. Impact damage 4 x 2 mm. 6. Impact damage 4 x 2 mm. 7. Impact damage 10 x 1 mm.
	2	8. Protective coating wear.
	3	No defects noted.
	4	No defects noted.
N000A2	1	1. Protective coating wearing. 2. Impact damage 9 x 1 mm. 3. Impact damage 16 x 1 mm. 4. Impact damage 3 x 3 mm.
	2	5. Impact damage 2 x 3 mm.
	3	No defects noted.
	4	No defects noted.
	1	1. Protective coating wearing. 2. Gouge 6 x 3 mm x 0.002″ deep. 3. Gouge 6 x 3 mm x 0.002″. 4. Gouge 28 x 2 mm. 5. Gouge 8 x 1.5 mm x 0.0025″ deep. 6. Impact damage 1 x 3 mm x 0.0025″ deep. 7. Impact damage 6 x 5 mm. 8. Impact damage 2 x 0.5 mm.
	2	9. Thread damage.
	3	No defects noted.
	4	No defects noted.

Figures 2(a)-2(g) depict all findings discovered for the second 69-37290-13 rod assembly removed from the N000A1 aircraft.

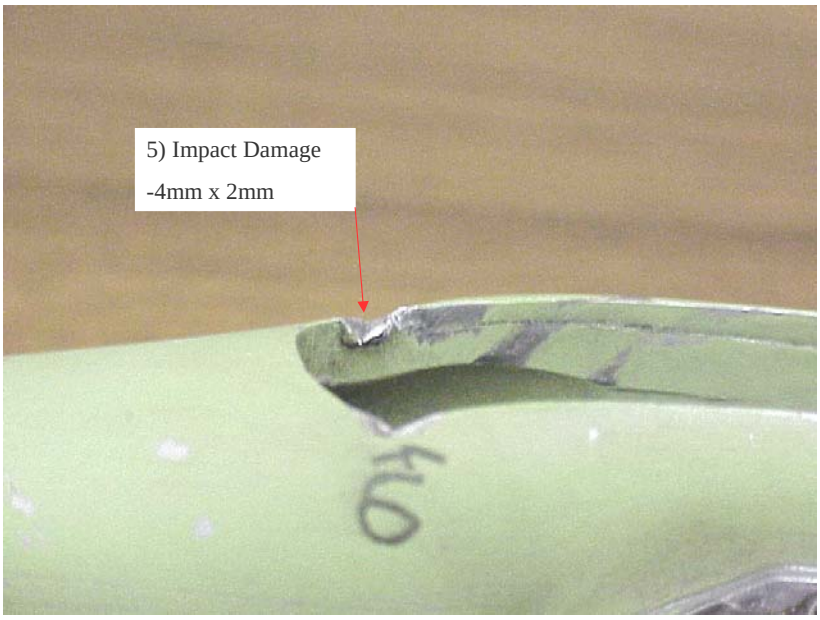


(a) Inspection Phase 1: Visual inspection prior to cleaning with accessibility issues considered, airplane: N000A1.

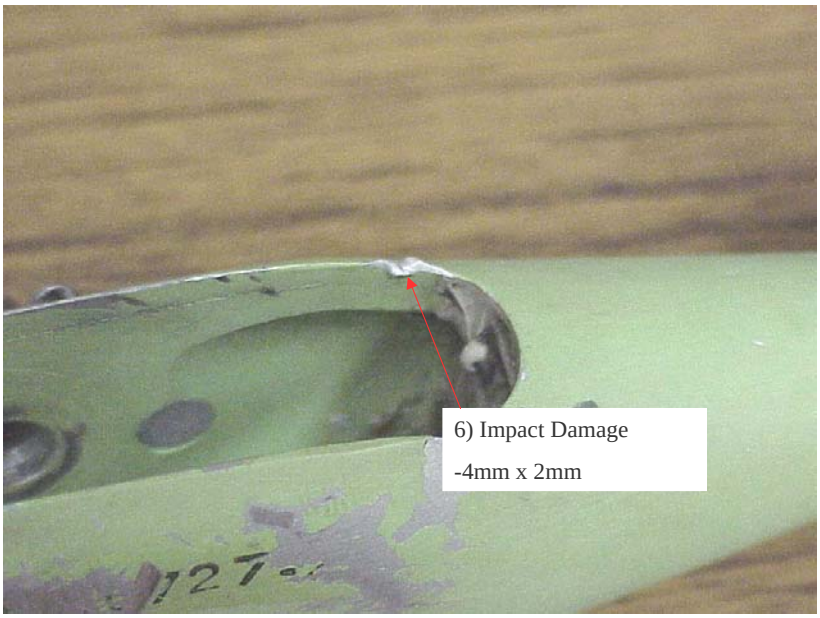


(b) Inspection Phase 1: Visual inspection prior to cleaning with accessibility issues considered, airplane: N000A1.

Figure 2. B737 P/N 69-37290-13 Rod Assy Vernier Cont Dual Path, N000A1, Inspection Phase 1

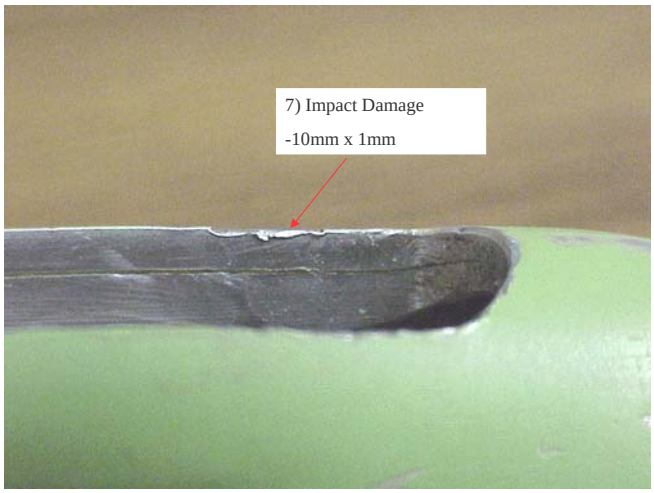


(c) Inspection Phase 1: Visual inspection prior to cleaning with accessibility issues considered, airplane: N000A1.

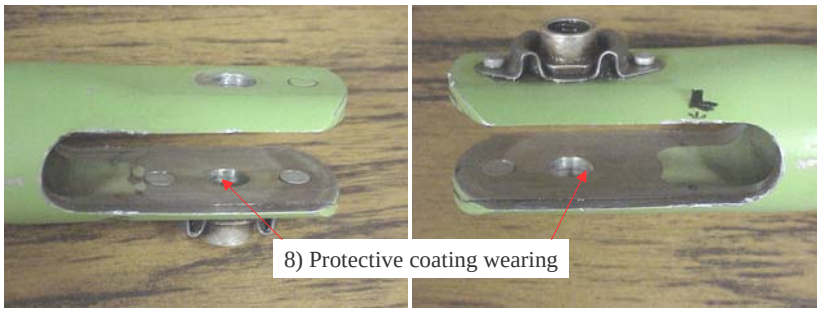


(d) Inspection Phase 1: Visual inspection prior to cleaning with accessibility issues considered, airplane: N000A1.

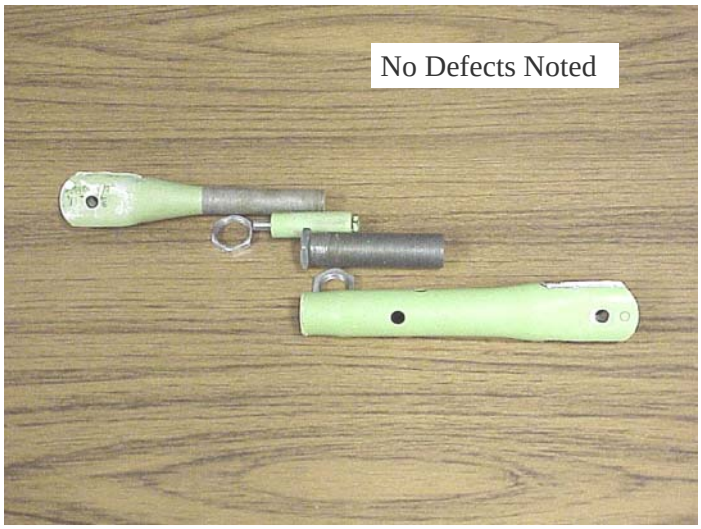
Figure 2. B737 P/N 69-37290-13 Rod Assy Vernier Cont Dual Path, N000A1, Inspection Phase 1 (Continued)



(e) Inspection Phase 1: Visual inspection prior to cleaning with accessibility issues considered, airplane: N000A1.



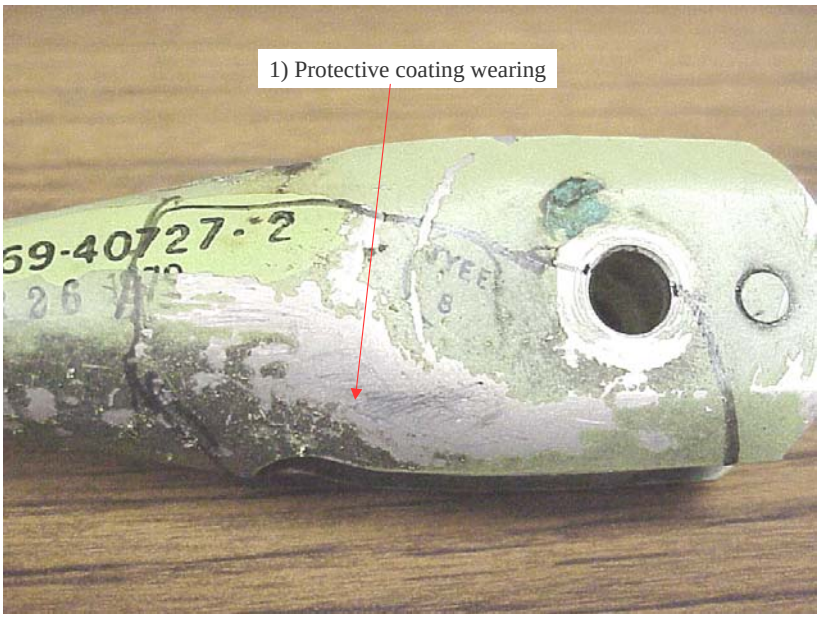
(f) Inspection Phase 2: Postcleaning with part removed from aircraft and cleaned, airplane: N000A1.



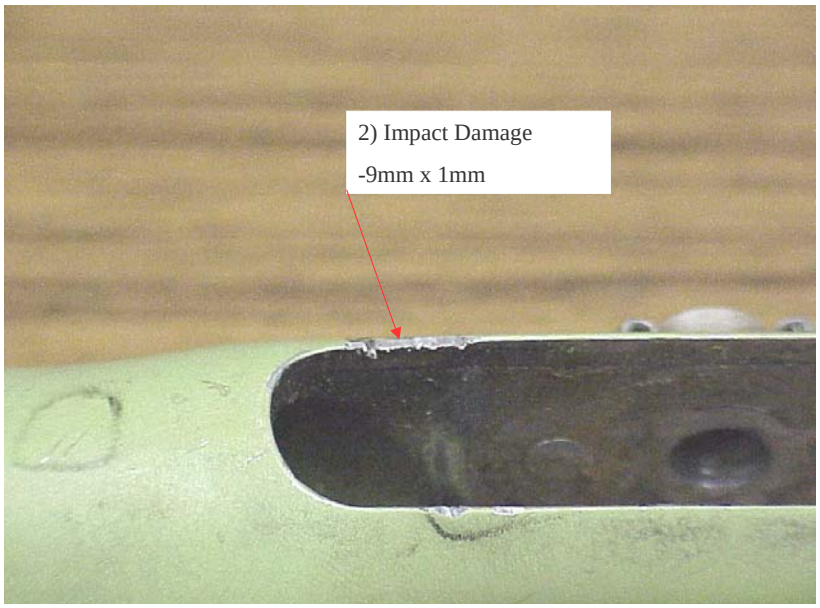
(g) Inspection Phase 3: Disassembly with all attachments removed, airplane: N000A1.

Figure 2. B737 P/N 69-37290-13 Rod Assy Vernier Cont Dual Path, N000A1, Inspection Phase 1 (Continued)

Figures 3(a)-3(e) depict all findings discovered for the first 69-37290-13 rod assembly that came from the N000A2 aircraft.

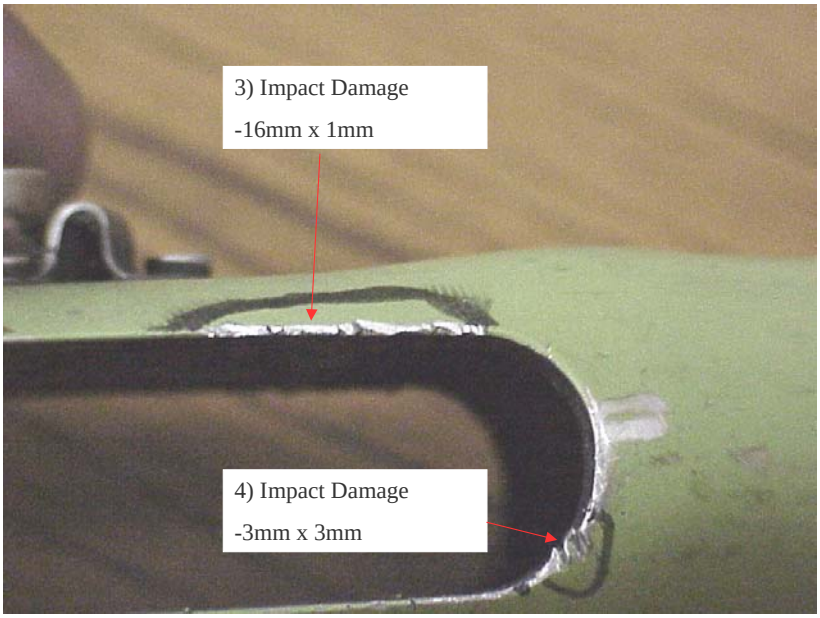


(a) Inspection Phase 1: Visual inspection prior to cleaning with accessibility issues considered, airplane: N000A2.

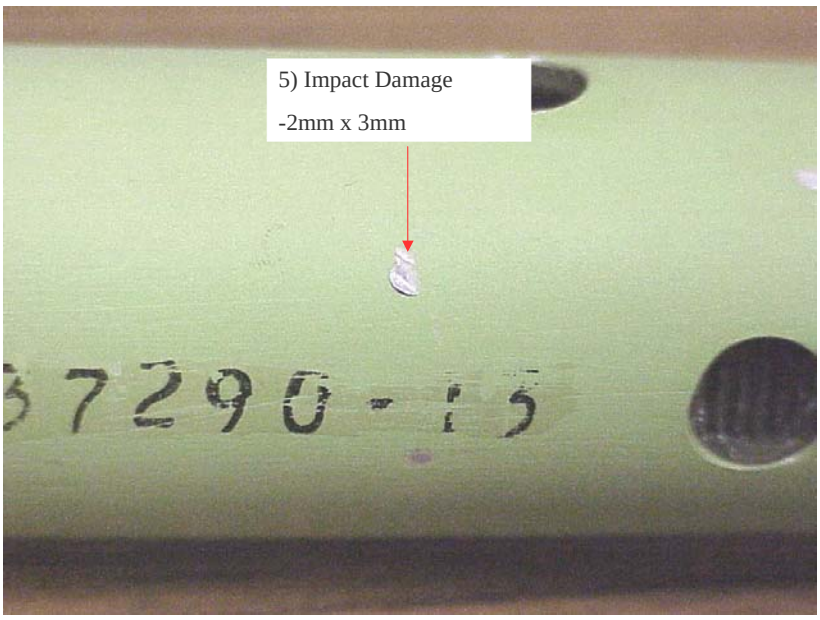


(b) Inspection Phase 1: Visual inspection prior to cleaning with accessibility issues considered, airplane: N000A2.

Figure 3. B737 P/N 69-37290-13 Rod Assy Vernier Cont Dual Path, N000A2



(c) Inspection Phase 1: Visual inspection prior to cleaning with accessibility issues considered, airplane: N000A2.



(d) Inspection Phase 2: Postcleaning—part removed from aircraft and cleaned, airplane: N000A2.

Figure 3. B737 P/N 69-37290-13 Rod Assy Vernier Cont Dual Path, N000A2 (Continued)

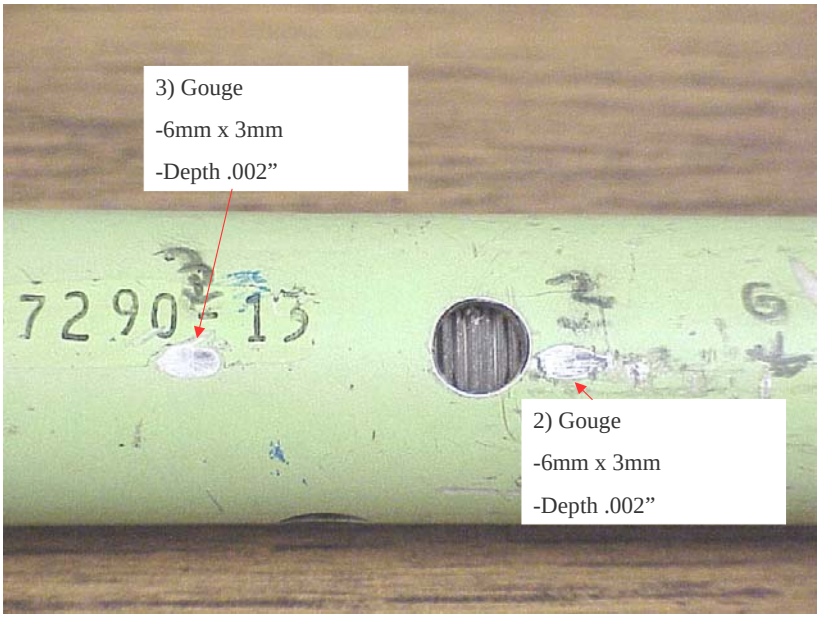
(e) Inspection Phase 3: Disassembly—with all attachments removed, airplane: N000A2.

Figure 3. B737 P/N 69-37290-13 Rod Assy Vernier Cont Dual Path, N000A2 (Continued)

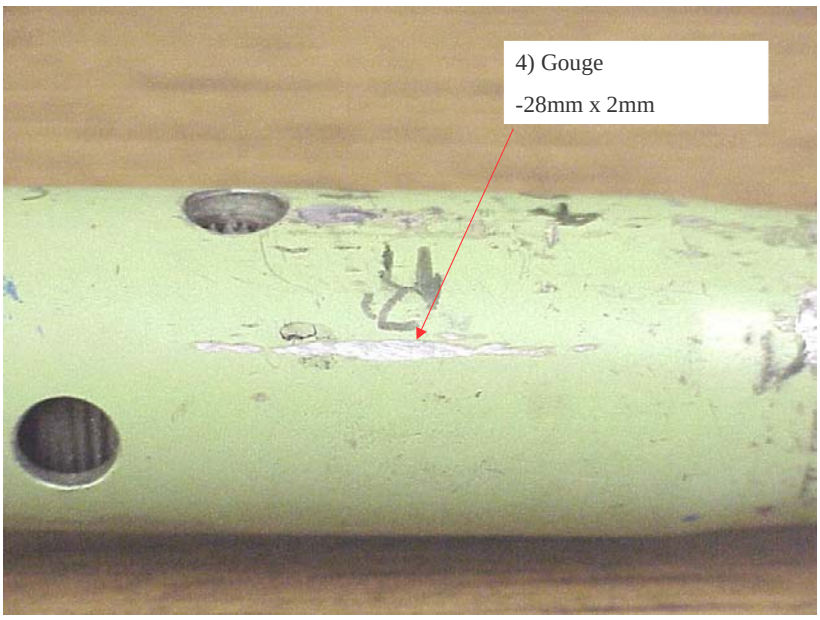
Figures 4(a)-4(i) depict all findings discovered for the second 69-37290-13 rod assembly that came from the N000A2 aircraft.

(a) Inspection Phase 1: Visual inspection prior to cleaning with accessibility issues considered, airplane: N000A2.

Figure 4. B737 P/N 69-37290-13 Rod Assy Vernier Cont Dual Path, N000A2, Second Rod Assembly

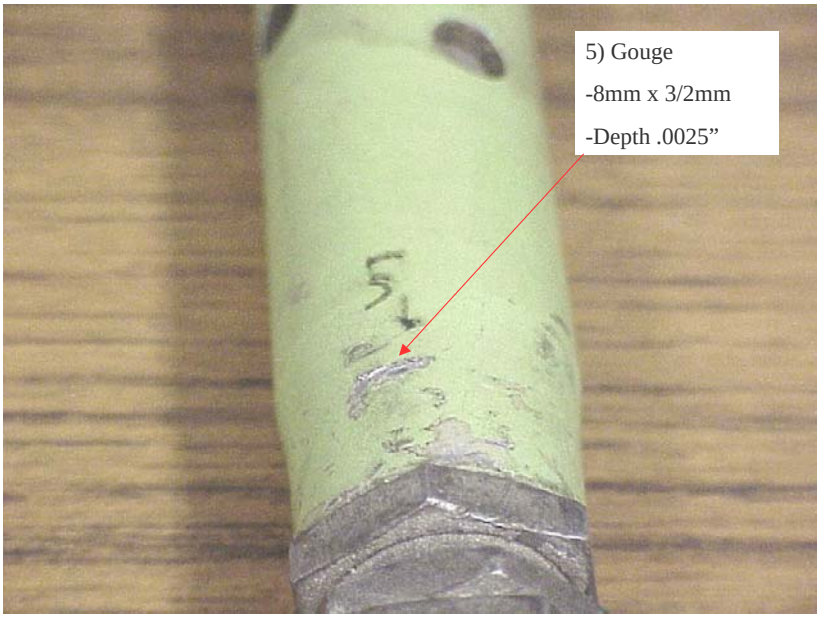


(b) Inspection Phase 1: Visual inspection prior to cleaning with accessibility issues considered, airplane: N000A2.

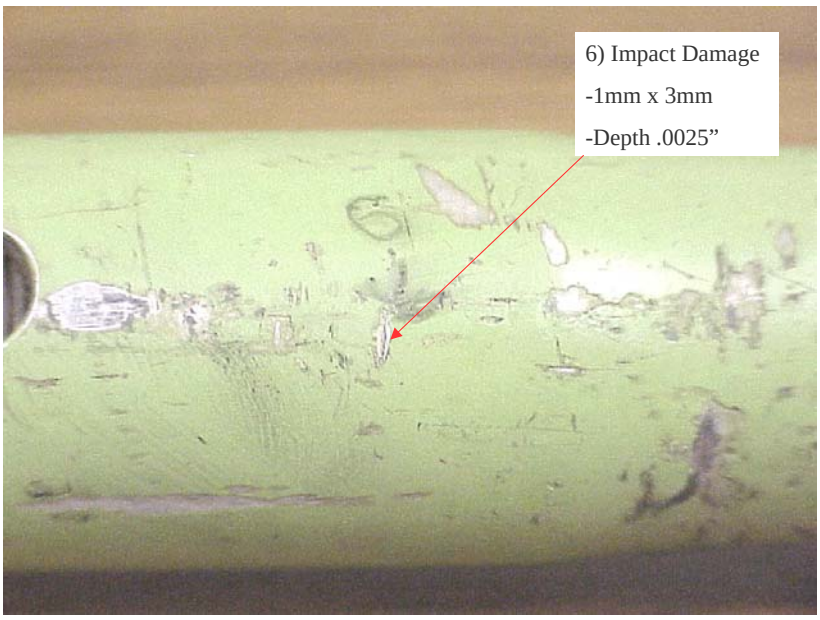


(c) Inspection Phase 1: Visual inspection prior to cleaning with accessibility issues considered, airplane: N000A2.

Figure 4. B737 P/N 69-37290-13 Rod Assy Vernier Cont Dual Path, N000A2, Second Rod Assembly (Continued)

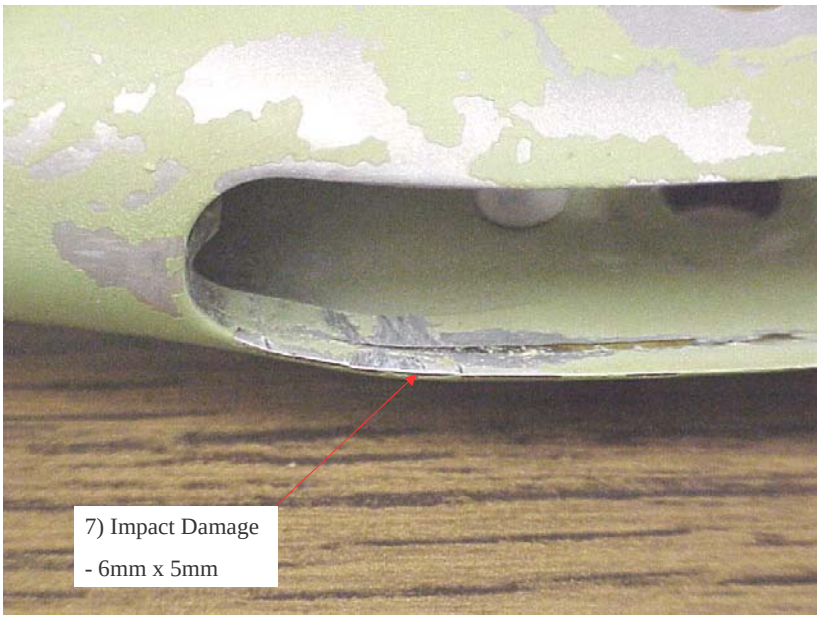


(d) Inspection Phase 1: Visual inspection prior to cleaning with accessibility issues considered, airplane: N000A2.

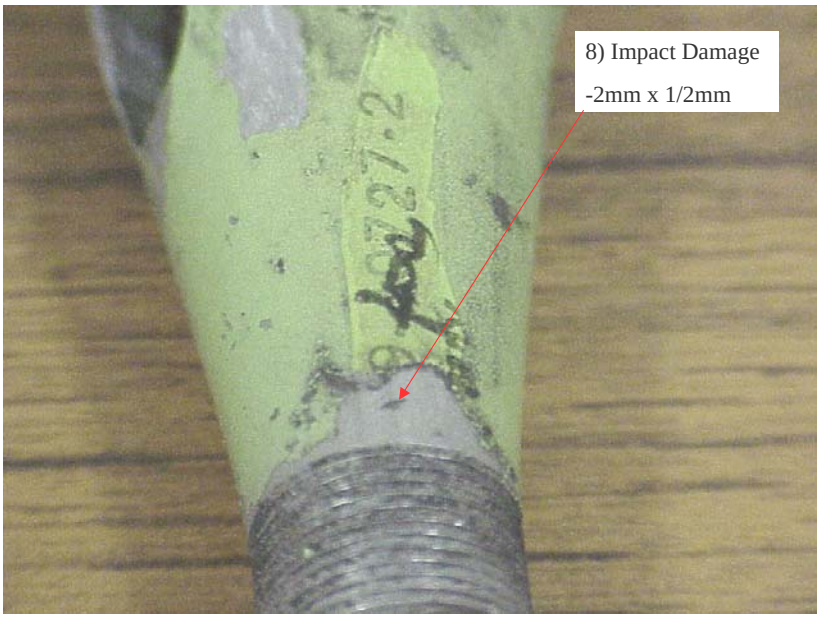


(e) Inspection Phase 1: Visual inspection prior to cleaning with accessibility issues considered, airplane: N000A2.

Figure 4. B737 P/N 69-37290-13 Rod Assy Vernier Cont Dual Path, N000A2, Second Rod Assembly (Continued)

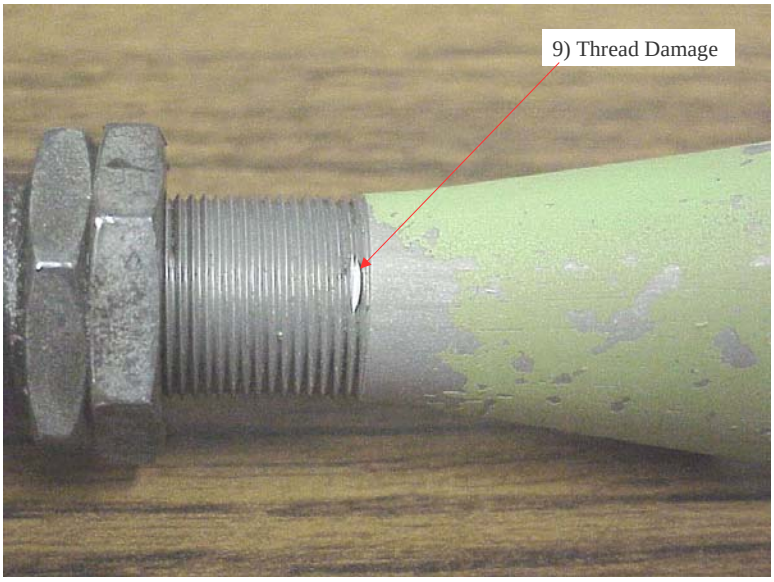


(f) Inspection Phase 1: Visual inspection prior to cleaning with accessibility issues considered, airplane: N000A2.

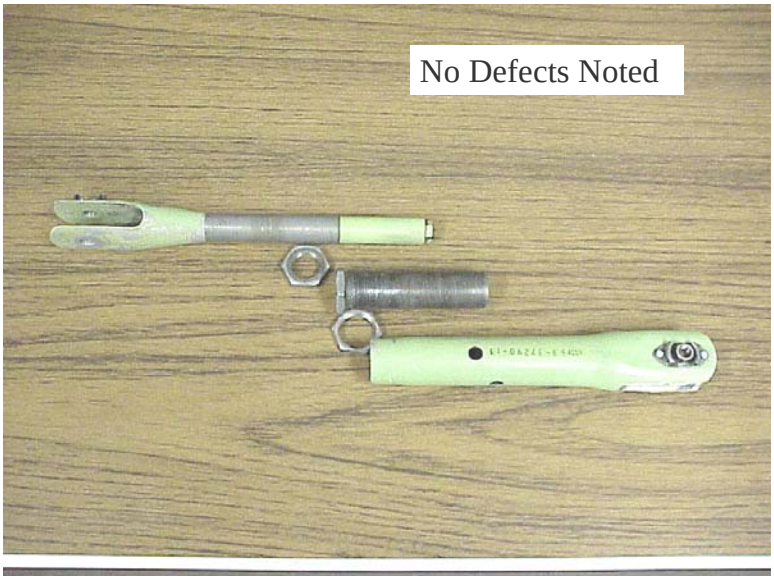


(g) Inspection Phase 1: Visual inspection prior to cleaning with accessibility issues considered, airplane: N000A2.

Figure 4. B737 P/N 69-37290-13 Rod Assy Vernier Cont Dual Path, N000A2, Second Rod Assembly (Continued)



(h) Inspection Phase 2: Postcleaning with part removed from aircraft and cleaned, airplane: N000A2.



(i) Inspection Phase 3: Disassembly with all attachments removed, airplane: N000A2.

Figure 4. B737 P/N 69-37290-13 Rod Assy Vernier Cont Dual Path, N000A2, Second Rod Assembly (Continued)

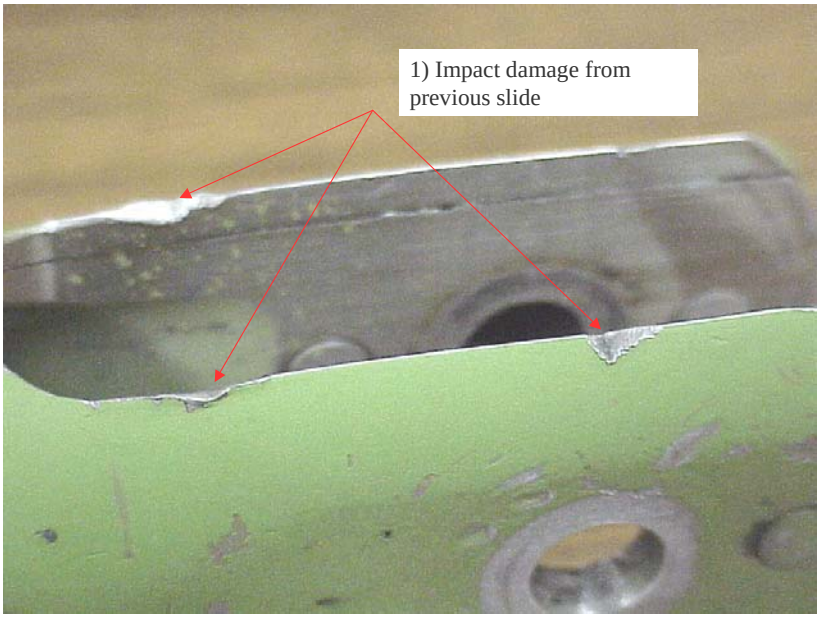
Four additional 69-37290-13 rod assemblies were stored and inspected separately because of their different location on the B737 aircraft compared to the rod assemblies listed in table 7. These four are connected to actuators in the elevator control installation at station 1156 on the aircraft. The visual inspection findings are shown in table 8. The highlighted portions of table 8

are supported by photographic documentation in figures 5(a)-5(b), 6, and 7(a) and 7(b), respectively.

Table 8. B737 Test Results: P/N 69-37290-13 Rod Assy Vernier Cont Dual Path (Station 1156)

Airplane Origin	Inspection Phase	Visual Inspection Findings
N000A2 Attached to Actuator S/N 0203	1	Protective coating wear.
	2	No defects noted.
	3	No defects noted.
	4	No defects noted.
N000A1 Attached to Actuator S/N 3649	1	Impact damage/nicks on three areas near end of rod close to rod attach point.
	2	Impact damage discovered after cleaning at rod end close to rod attach point.
	3	No defects noted.
	4	No defects noted.
N000A1 Attached to Actuator S/N 3879	1	No defects noted.
	2	Impact damage/nicks on two areas near end of rod close to rod attach point.
	3	No defects noted.
	4	No defects noted.
N000B1 Attached to Actuator S/N 2028	1	1. Circular abrasion mark. 2. Impact damage on two areas of rod.
	2	No defects noted.
	3	No defects noted.
	4	No defects noted.

S/N = Serial number



(a) Inspection Phase 1: Visual inspection prior to cleaning with accessibility issues considered, airplane: N000A1.

(b) Inspection Phase 2: Postcleaning with part removed from aircraft and cleaned, airplane: N000A1.

Figure 5. B737 P/N 69-37290-13 Rod Assy Vernier Cont Dual Path, N000A1, Inspection Phases 1 and 2

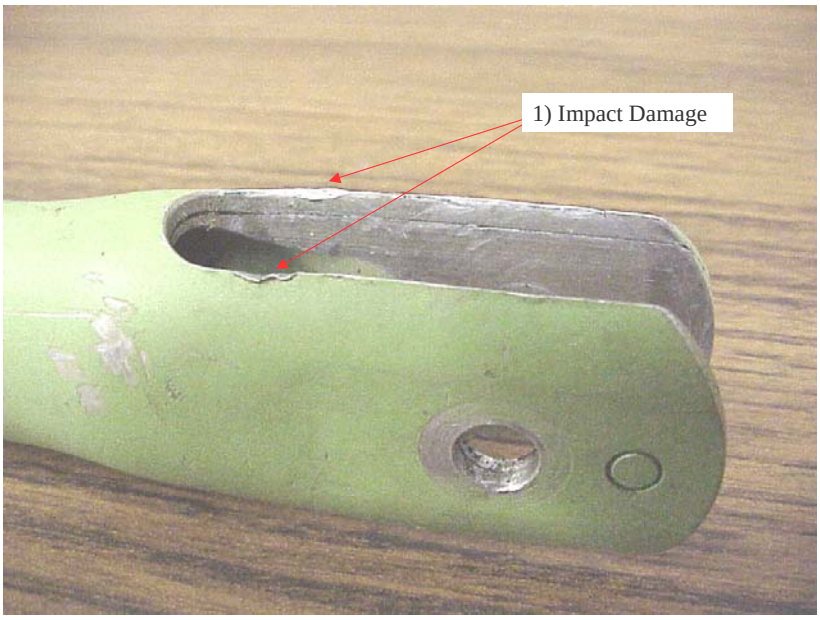
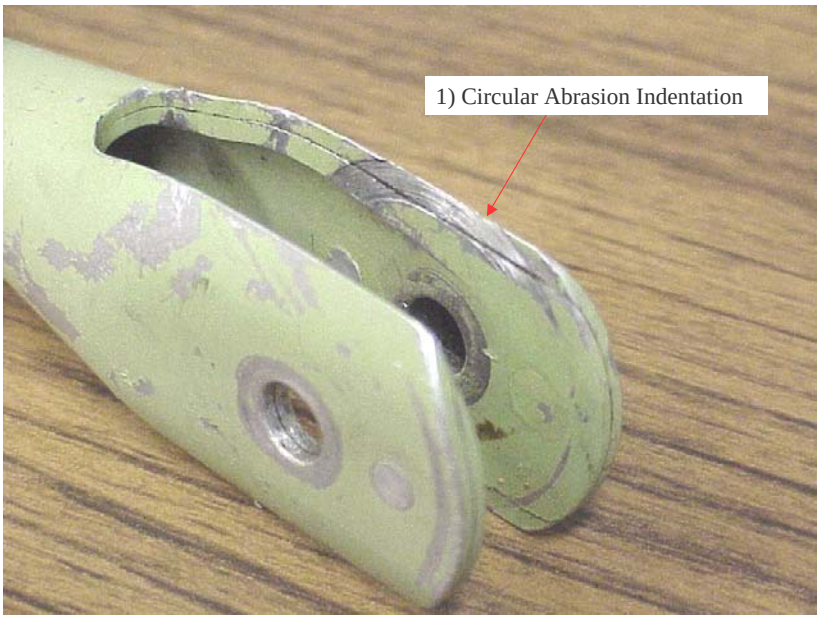
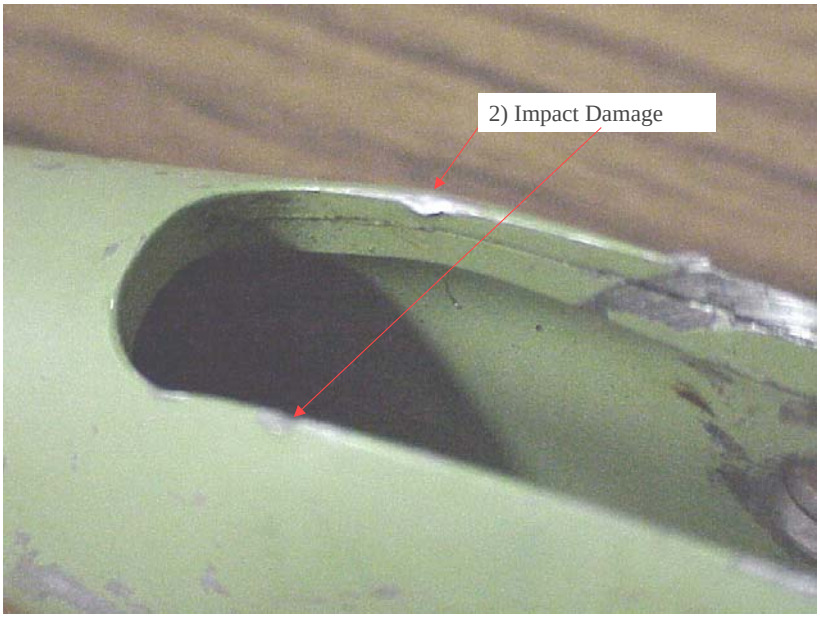


Figure 6. B737 P/N 69-37290-13 Rod Assy Vernier Cont Dual Path, Phase 2 (Inspection Phase 2. Postcleaning with part removed from aircraft and cleaned, airplane: N000A1.)



(a) Inspection Phase 1: Visual inspection prior to cleaning with accessibility issues considered, airplane: N000B1.

Figure 7. B737 P/N 69-37290-13 Rod Assy Vernier Cont Dual Path, Phase 1



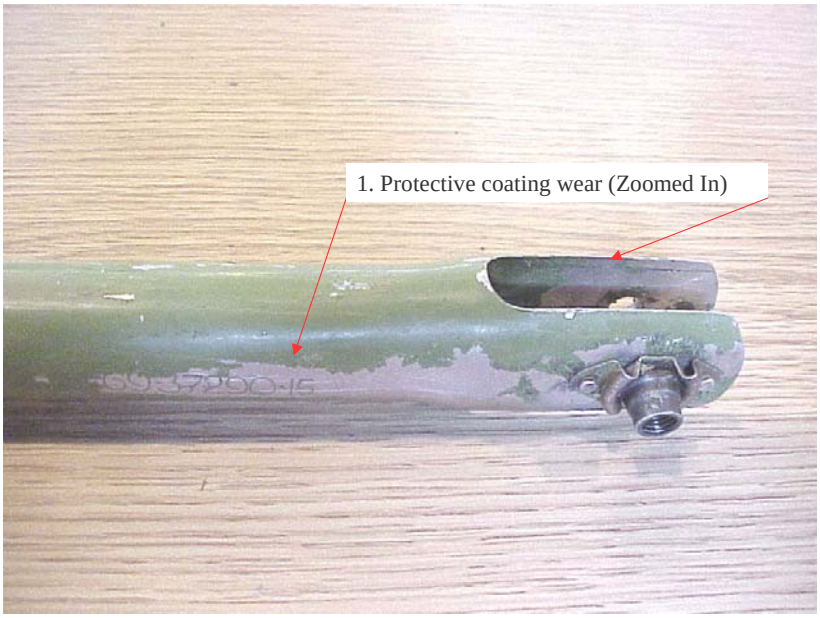
(b) Inspection Phase 1: Visual inspection prior to cleaning with accessibility issues considered, airplane: N000B1.

Figure 7. B737 P/N 69-37290-13 Rod Assy Vernier Cont Dual Path, Phase 1 (Continued)

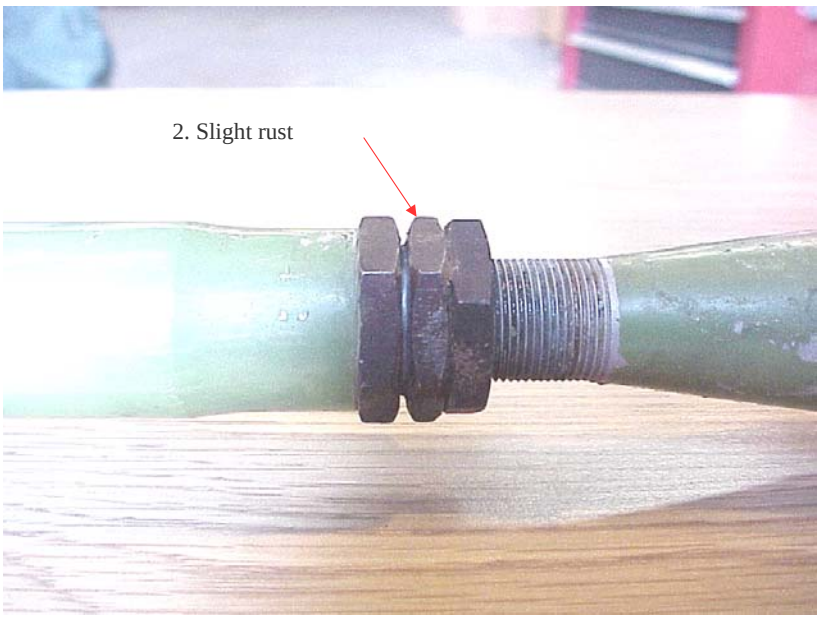
The visual inspection findings for 69-37290-15 rod assy vernier dual path are listed in table 9. Figures 8(a)-8(c) illustrate the highlighted findings. Sand found in inspection phase 3 is questionable. It could have been introduced during removal from the aircraft, prior to acquiring the part. The retired aircraft was stored in a desert environment. All other parts inspected in this study did not reveal any sand upon part disassembly.

Table 9. B737 Test Results: P/N 69-37290-15 Rod Assy Vernier Dual Path

Airplane Origin	Inspection Phase	Visual Inspection Findings
N000A1	1	1. Protective coating wear. 2. Rust on nut.
	2	No defects noted.
	3	Sand found on thread end where top of rod connects to the bottom rod.
	4	No defects noted.

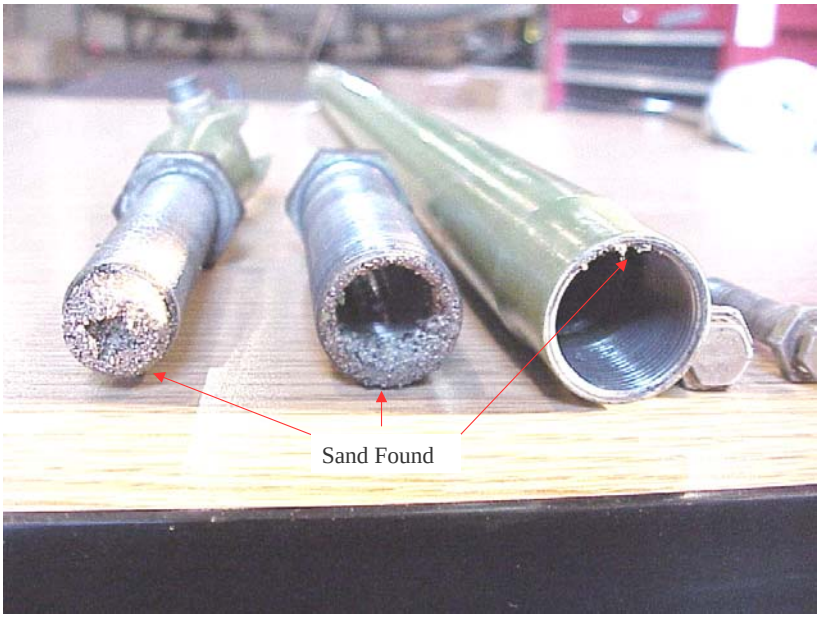


(a) Inspection Phase 1: Visual inspection prior to cleaning with accessibility issues considered, airplane: N000A1.



(b) Inspection Phase 1: Visual inspection prior to cleaning with accessibility issues considered, airplane: N000A1.

Figure 8. B737 P/N 69-37290-15 Rod Assy Vernier Dual Path



(c) Inspection Phase 3: Disassembly with all attachments removed, airplane: N000A1.

Figure 8. B737 P/N 69-37290-15 Rod Assy Vernier Dual Path (Continued)

The six 69-40718-8 bolt assemblies that were surveyed appear to be in good condition, as results show in table 10. However, during inspection phase 3 (disassembly with all attachments removed), the inner bolt was pressed out of the outer bolt and the remaining adhesive coating visually conceals the matting surfaces on all six bolts tested.

Table 10. B737 Test Results: P/N 69-40718-8 Bolt Assy Rud Actr Rod End

Airplane Origin	Inspection Phase	Visual Inspection Findings
N000A1	1	No defects noted.
	2	Various minor dents and scratches on outer bolt head.
	3	Adhesive coating hinders inspection of inner bolt. Slight wear marks on outer bolt.
	1	No defects noted.
	2	No defects noted.
	3	Adhesive coating hinders inspection of inner bolt. No other defects noted.
N000A2	1	No defects noted.
	2	No defects noted.

Table 10. B737 Test Results: P/N 69-40718-8 Bolt Assy Rud ACTR Rod End (Continued)

Airplane Origin	Inspection Phase	Visual Inspection Findings
N000A2 (Continued)	3	Adhesive coating hinders inspection of inner bolt. Discoloration on inner bolt shank, which appears to be a corrosive reaction.
	1	No defects noted.
	2	No defects noted.
	3	Adhesive coating hinders inspection of inner bolt. No other defects noted.
N000B1	1	No defects noted.
	2	No defects noted.
	3	Adhesive coating hinders inspection of inner bolt. No other defects noted.
	1	No defects noted.
	2	No defects noted.
	3	Adhesive coating hinders inspection of inner bolt. No other defects noted.

The highlighted portion of table 10 corresponds to figure 9. This figure shows the adhesive coating on the inner bolt, which could not be removed. As a result, it was recommended that a further investigation using other NDI methods be performed on these surfaces to ensure no defects or flaws exist beneath the adhesive coating. Figure 10 shows the N000A2 bolt assembly that is discolored.

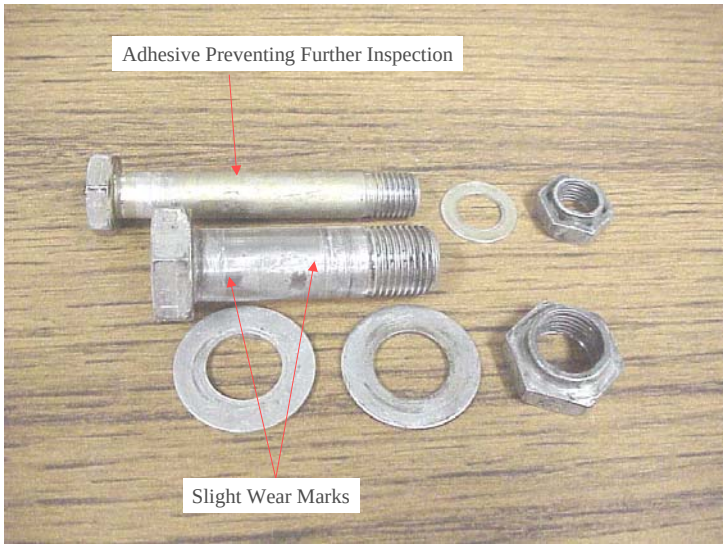


Figure 9. B737 P/N 69-40718-8 Bolt Assy Rud Actr Rod End, N000A1
(Inspection Phase 3: Disassembly with all attachments removed, airplane: N000A1.)

Figure 10. B737 P/N 69-40718-8 Bolt Assy Rud Actr Rod End, N000A2
(Inspection Phase 3: Postcleaning with part removed from aircraft and cleaned, airplane: N000A2.)

Five 69-43282-1 bolt assemblies were visually inspected, and their respective findings are listed in table 11. Note that the inner bolt could not be separated from the outer bolt, therefore, a full disassembly could not be achieved. As a result, it is recommended that this area (interface between inner and outer bolt) that could not be accessed be investigated using an alternative NDI method.

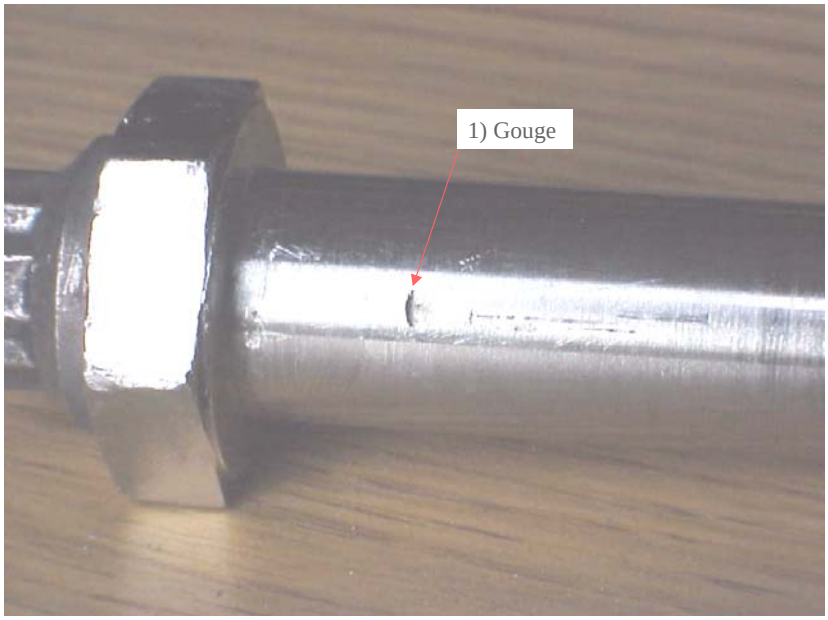
Table 11. B737 Test Results: P/N 69-43282-1 Bolt Assy Actr

Airplane Origin	Inspection Phase	Visual Inspection Findings
N000A2	1	No defects noted.
	2	Scratches and small gouge on outer bolt possibly the result of removal.
	3	Inner bolt could not be pressed out of outer bolt (further NDI required).
	1	No defects noted.
	2	1. Gouge on outer bolt shank. 2. Wear/brazing mark on outer bolt shank. 3. Wear/brazing mark on outer bolt shank.
	3	Inner bolt could not be pressed out of outer bolt (further NDI required).

Table 11. B737 Test Results: P/N 69-43282-1 Bolt Assy actr (Continued)

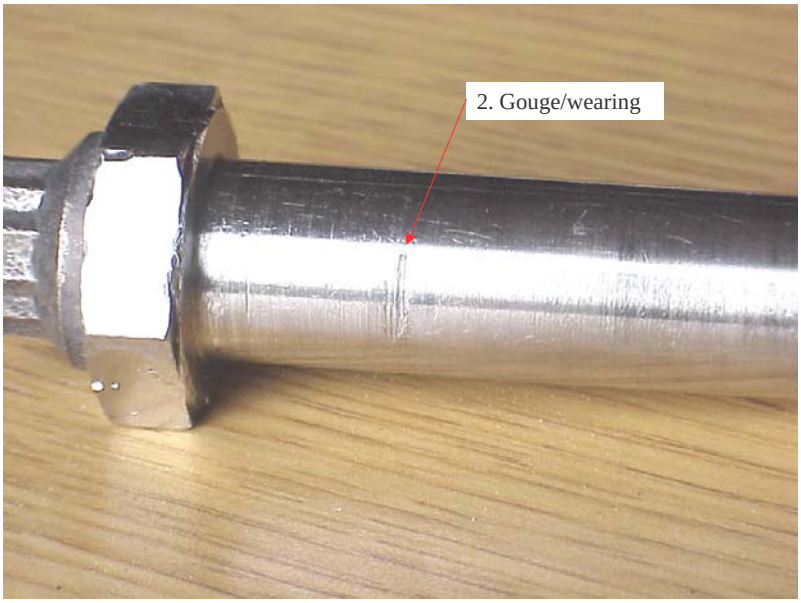
Airplane Origin	Inspection Phase	Visual Inspection Findings
N000A1	1	No defects noted.
	2	No defects noted.
	3	Inner bolt could not be pressed out of outer bolt (further NDI required).
	1	No defects noted.
	2	Thread damage on last thread of outer bolt.
	3	Inner bolt could not be pressed out of outer bolt (further NDI required).
N000B1	1	No defects noted.
	2	No defects noted.
	3	Inner bolt could not be pressed out of outer bolt (further NDI required).

The highlighted portion of table 11 corresponds to the findings shown in figures 11(a)-11(c) and 12 respectively.

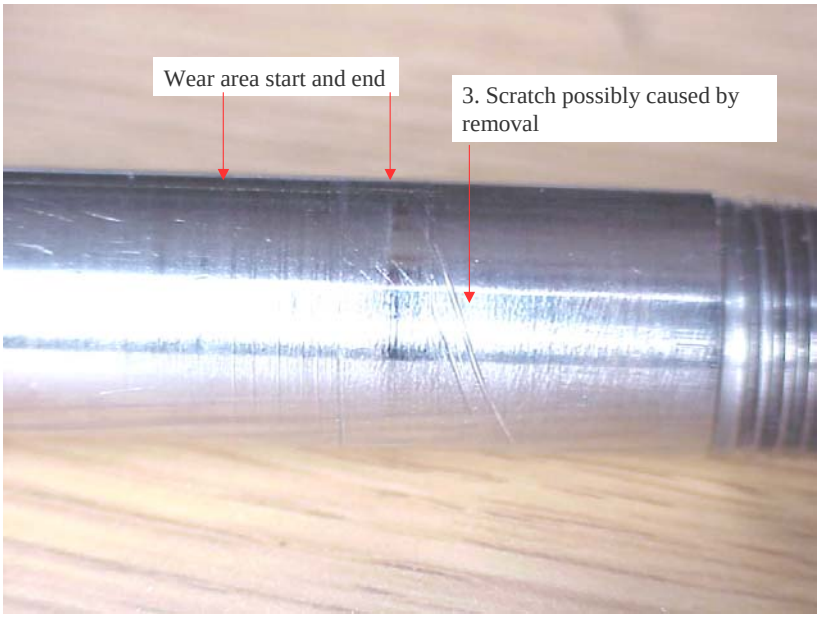


(a) Inspection Phase 2: Postcleaning with part removed from aircraft and cleaned, airplane: N000A2.

Figure 11. B737 P/N 69-43282-1 Bolt Assy Actr, N000A2



(b) Inspection Phase 2: Postcleaning with part removed from aircraft and cleaned, airplane: N000A2.



(c) Inspection Phase 2: Postcleaning with part removed from aircraft and cleaned, airplane: N000A2

Figure 11. B737 P/N 69-43282-1 Bolt Assy Actr, N000A2 (Continued)

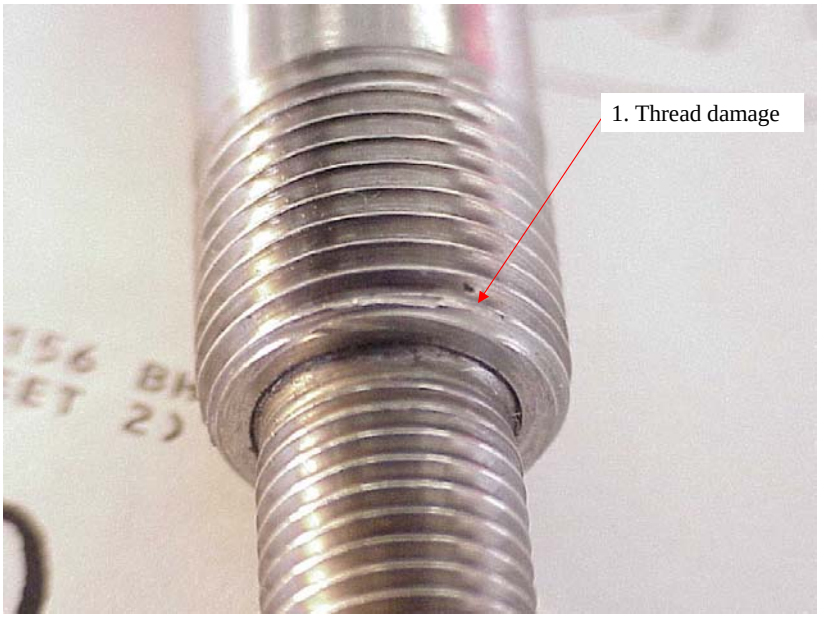
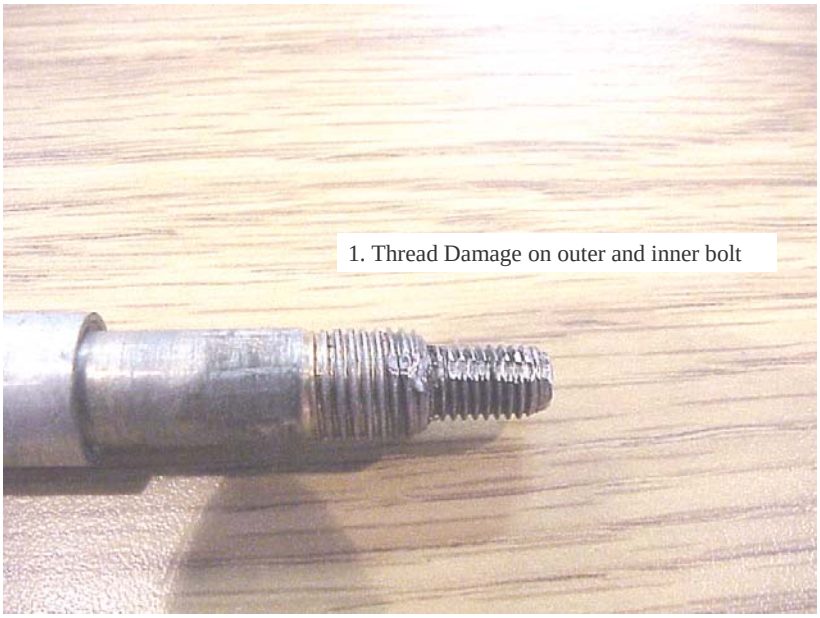


Figure 12. B737 P/N 69-43282-1 Bolt Assy Actr, N000A1
(Inspection Phase 2: Postcleaning with part removed from aircraft and cleaned, airplane: N000A1.)

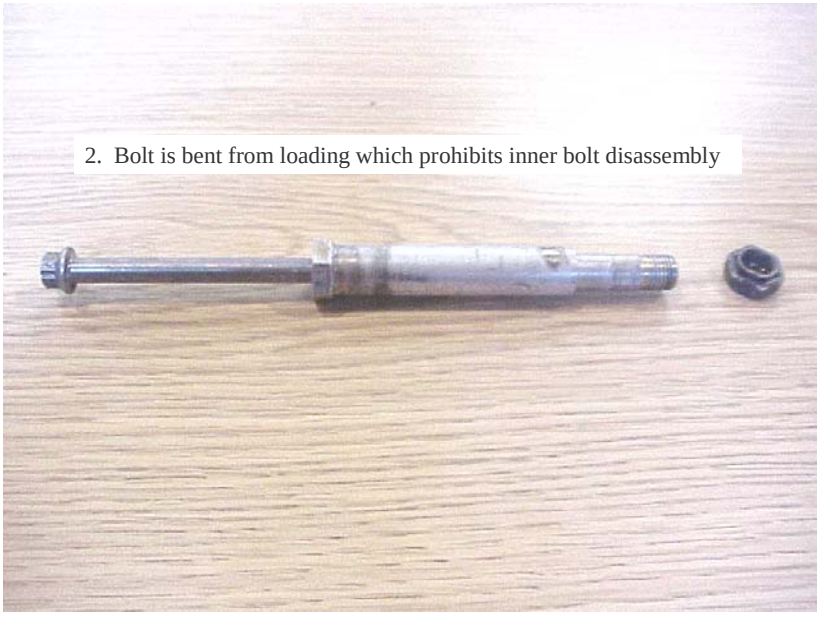
Four 69-43956-1 bolt assemblies were visually inspected, and their respective findings are listed in table 12. Note that the inner bolt could not be separated from the outer bolt on two of the four bolts inspected because they were slightly bent. Figures 13(a)-13(c) and 14 illustrate these findings. Figure 14 shows the complete disassembly of the 69-43956-1 bolt assembly, with no defects shown.

Table 12. B737 Test Results: P/N 69-43956-1 Bolt Assy Cont

Airplane Origin	Inspection Phase	Visual Inspection Findings
N000A1	1	No defects noted.
	2	Thread damage on inner and outer bolt.
	3	Bolt is slightly bent, which prohibits removal of inner bolt.
N000A1	1	No defects noted.
	2	No defects noted.
	3	Bolt is slightly bent, which prohibits removal of inner bolt.
N000A2	1	No defects noted.
	2	No defects noted.
	3	No defects noted.
N000A2	1	No defects noted.
	2	No defects noted.
	3	No defects noted.



(a) Inspection Phase 1: Visual inspection prior to cleaning with accessibility issues considered, airplane: N000A1.



(b) Inspection Phase 2: Postcleaning with part removed from aircraft and cleaned, airplane: N000A1.

Figure 13. B737 P/N 69-43956-1 Bolt Assy Cont, Inspection Phases 1, 2, and 3

(c) Inspection Phase 3: Disassembly with all attachments removed, airplane: N000A1

Figure 13. B737 P/N 69-43956-1 Bolt Assy Cont, Inspection Phases 1, 2, and 3 (Continued)

Figure 14. B737 P/N 69-43956-1 Bolt Assy Cont, Inspection Phase 3 (Inspection Phase 3: Disassembly with all attachments removed, airplane: N000A1.)

Six 69-44427-3 rod assemblies were visually inspected, and their respective findings are listed in table 13. A rod assembly originating from the N000A1 aircraft contained an internal hex head

bolt that does not meet the Boeing design specifications (see figure 15). The bolt that is specified for the rod assembly is an MS20006-64 or -68 (also known as NASM20006-64 or -68) internal wrenching bolt (not a hex head bolt), which is shown in figures 16(b) and 17(a). An internal corrosive reaction was discovered in two of the six rod assemblies inspected, which is most evident by the surface condition along the shank of the internal bolt shown in figures 16(b) and 17(a). Slight corrosion was also found on the inner rod in an area beneath the inner rod sleeve, as shown in figures 16(d) and 17(b).

Table 13. B737 Test Results: P/N 69-44427-3 Rod Assembly

Airplane Origin	Inspection Phase	Visual Inspection Findings
N000A1	1	Protective coating wear.
	2	No defects noted.
	3	Boeing confirms that either an MS20006-64 or -68 (NASM20006-64 or -68) internal wrenching bolt was specified for this assembly.
	4	No defects noted.
	1	Protective coating wear.
	2	No defects noted.
	3	No defects noted.
	4	No defects noted.
N000A2	1	No defects noted.
	2	No defects noted.
	3	No defects noted.
	4	No defects noted.
	1	Protective coating wear.
	2	No defects noted.
	3	1. Corrosion along shank of inner bolt that connects top rod to bottom rod. 2. Corrosion found on inside of rod.
	4	No defects noted.
N000B1	1	No defects noted.
	2	No defects noted.
	3	1. Corrosion along shank of inner bolt that connects top rod to bottom rod. 2. Corrosion found on inside of rod.
	4	No defects noted.
	1	No defects noted.
	2	No defects noted.
	3	No defects noted.
	4	No defects noted.

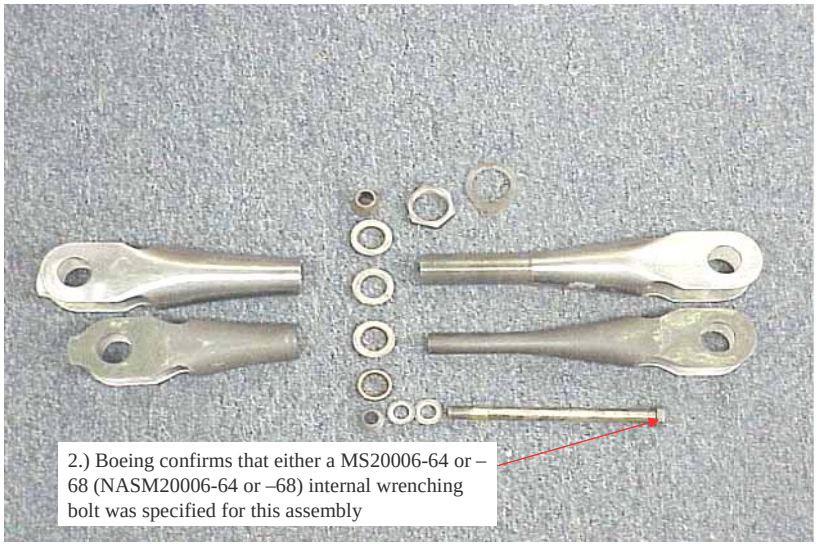
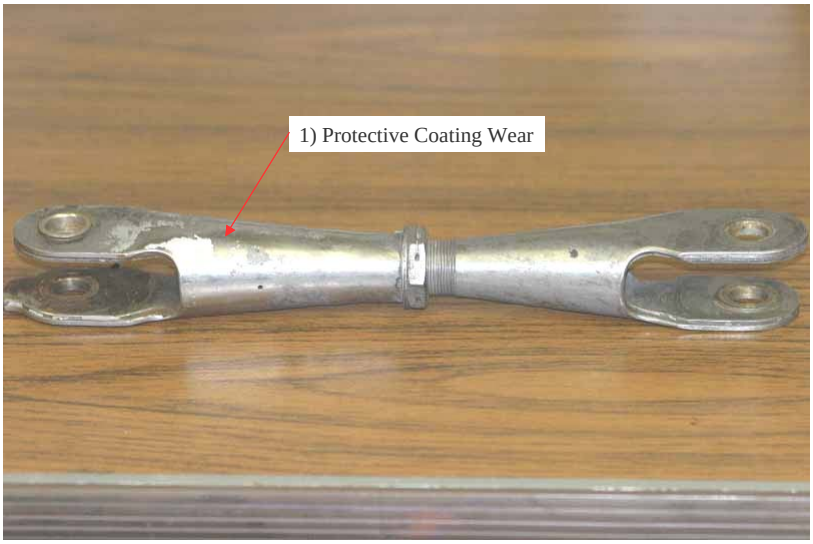
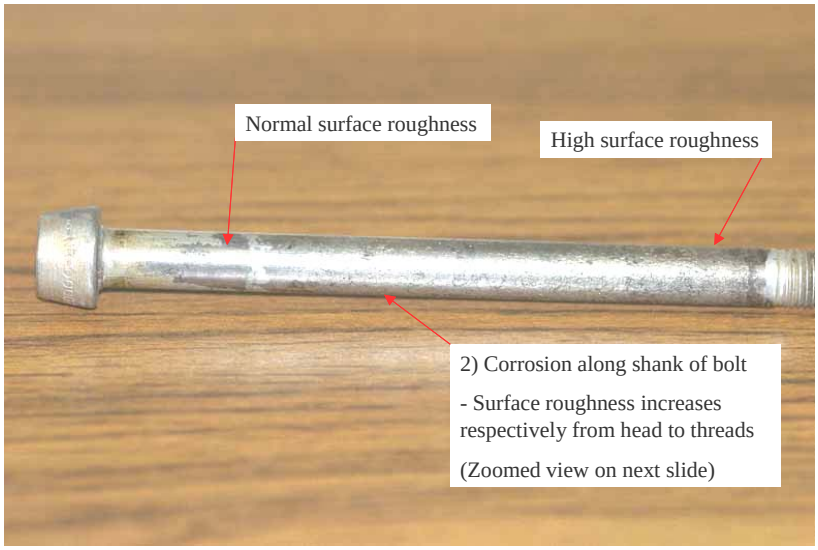


Figure 15. B737 P/N 69-44427-3 Rod Assy, N000A1
(Inspection Phase 3: Disassembly with all attachments removed, airplane: N000A1.)

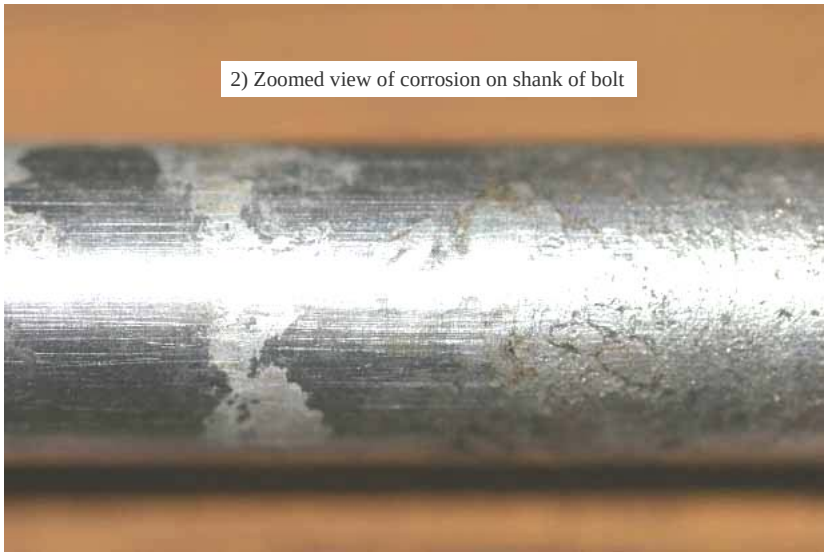


(a) Inspection Phase 1: Visual inspection prior to cleaning with accessibility issues considered, airplane: N000A2.

Figure 16. B737 P/N 69-44427-3 Rod Assy, N000A2

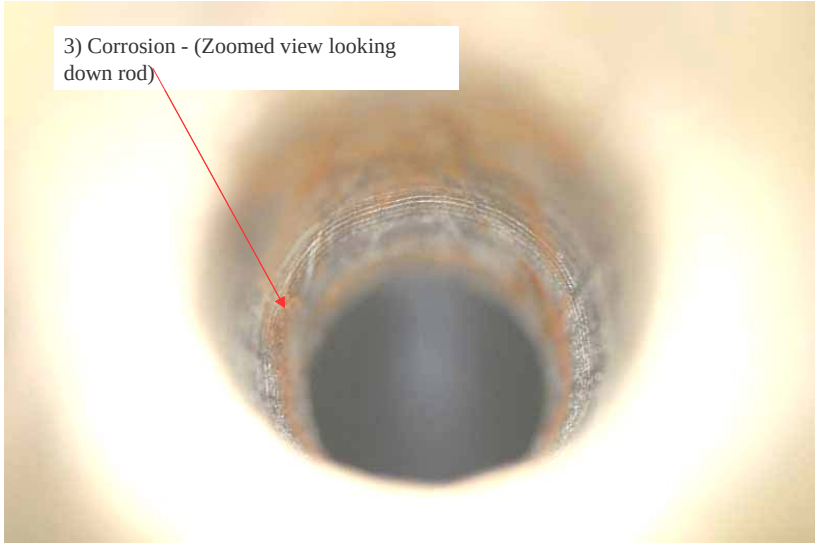


(b) Inspection Phase 3: Disassembly with all attachments removed, airplane: N000A2.



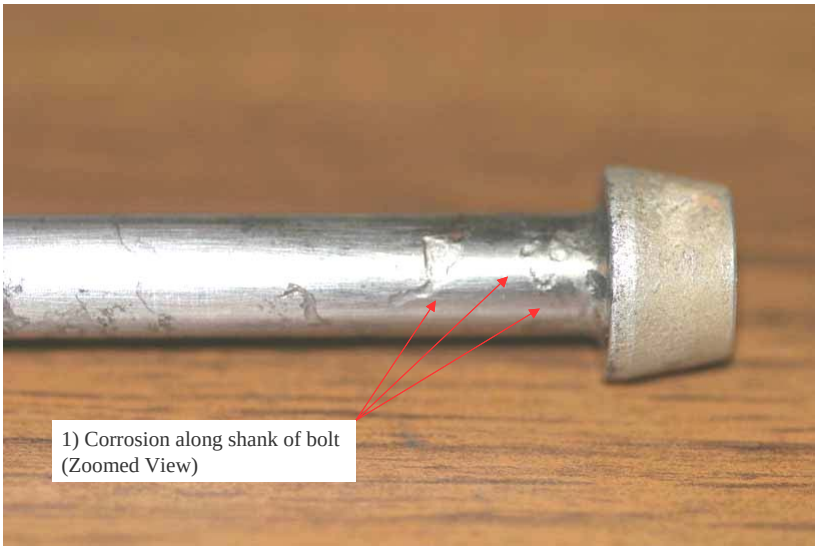
(c) Zoomed view

Figure 16. B737 P/N 69-44427-3 Rod Assy, N000A2 (Continued)



(d) Inspection Phase 3: Disassembly with all attachments removed, airplane: N000A2.

Figure 16. B737 P/N 69-44427-3 Rod Assy, N000A2 (Continued)



(a) Inspection Phase 3: Disassembly with all attachments removed, airplane: N000B1.

Figure 17. B737 P/N 69-44427-3 Rod Assy, N000B1

(b) Inspection Phase 3: Disassembly with all attachments removed, airplane: N000B1

Figure 17. B737 P/N 69-44427-3 Rod Assy, N000B1 (Continued)

Three 69-44683-2 bolt assembly push rods were inspected with no defects identified in phases 1 and 2, see table 14. The highlighted portion of table 14 corresponds to figure 18. This figure gives an example of the adhesive coating on the inner bolt, which could not be removed. As a result, it is recommended that further investigation using an alternative NDI method be performed on these surfaces to ensure no defects or flaws exist beneath the adhesive coating.

Table 14. B737 Test Results: P/N 69-44683-2 Bolt Assy Push Rod

Airplane Origin	Inspection Phase	Visual Inspection Findings
N000A1	1	No defects noted.
	2	No defects noted.
	3	Adhesive coating hinders inspection of inner bolt. No other defects noted.
N000A1	1	No defects noted.
	2	No defects noted.
	3	Adhesive coating hinders inspection of inner bolt. No other defects noted.
N000A2	1	No defects noted.
	2	No defects noted.
	3	Adhesive coating hinders inspection of inner bolt. No other defects noted.

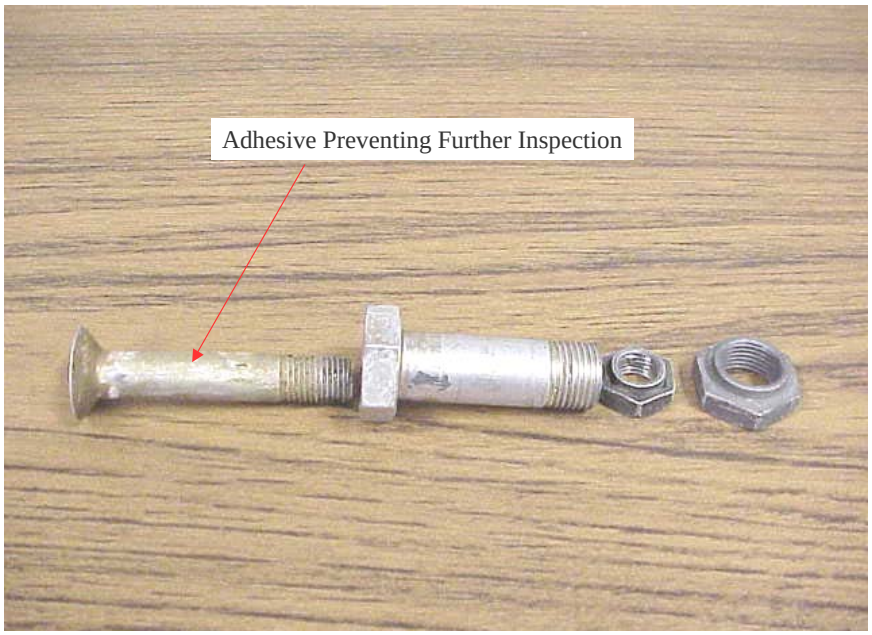


Figure 18. B737 P/N 69-44683-2 Bolt Assy Push Rod
(Inspection Phase 3: Disassembly with all attachments removed, airplane: N000A1.)

The mach trim actuator assemblies (figures 19-21) were returned to their respective manufacturers so that an acceptance and functional test could be performed on each unit. The purpose of the test was to determine whether each mach trim actuator operates at the required performance specifications provided in their respective component maintenance manuals. The FAA defines airworthiness as component meets its type design, either as produced or properly altered and is in a condition for safe operation. If the component is found to pass the acceptance test, then an FAA 8130-3 airworthy form/tag is issued for that component. The test results are presented in table 15. The load paths of the actuator arm are permanently bonded and could not be separated. Therefore, destructive sectioning of actuator arm is recommended.

Table 15. B737 Test Results: P/Ns 2A7-200A and 2590653-901 Mach Trim Actuator Assy

Airplane Origin	Part Number	Supplier	Acceptance and Functional Test Findings
N000B1	2A7-200A	MPC Products	**Passed**: Operates and passed all performance requirements. 1. Linear assembly seal worn. 2. Slider is scratched. 3. Connecter has small dent on the threaded area master key loc.

Table 15. B737 Test Results: P/Ns 2A7-200A and 2590653-901 Mach Trim Actuator Assy (Continued)

Airplane Origin	Part Number	Supplier	Acceptance and Functional Test Findings
N000A1	2590653-901	Honeywell	**Failed**: 1. Unit requires mod C FSB21-1231-02 for repair. 2. Motor sluggish and rough.. 3. Bearings dry. 4. Boot and gaskets required for repair. 5. Clean and relube gear train.
N000A2	2590653-901	Honeywell	**Failed**: 1. Motor sluggish. 2. Bearings dry. 3. Clean and relube gear train. 4. Boot and gaskets required for repair.

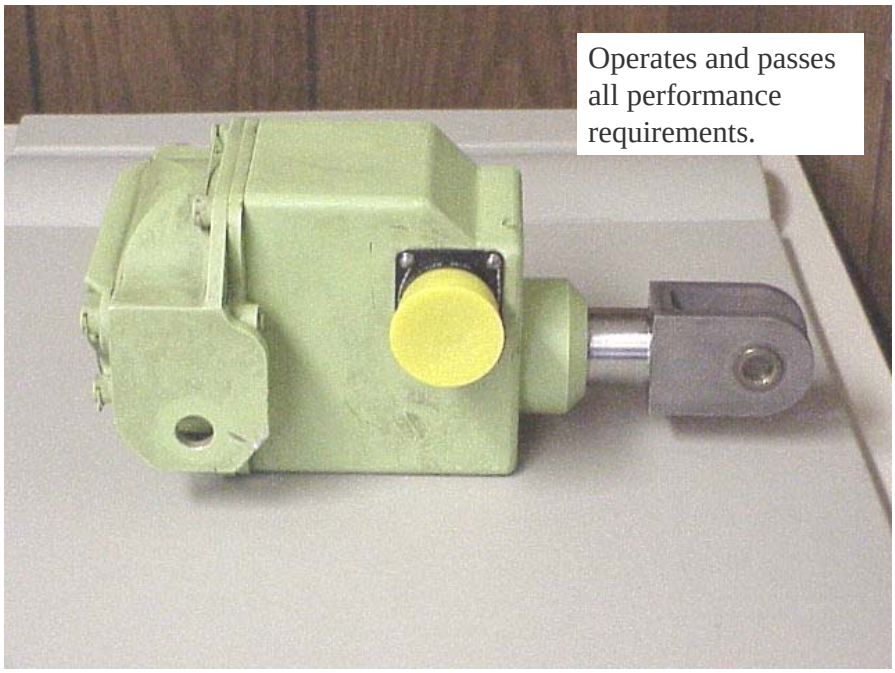


Figure 19. B737 P/N 2A7-200A Mach Trim Actuator Assy, Airplane: N000B1

Figure 20. B737 P/N 2590653-901 Mach Trim Actuator Assy, Airplane: N000A1

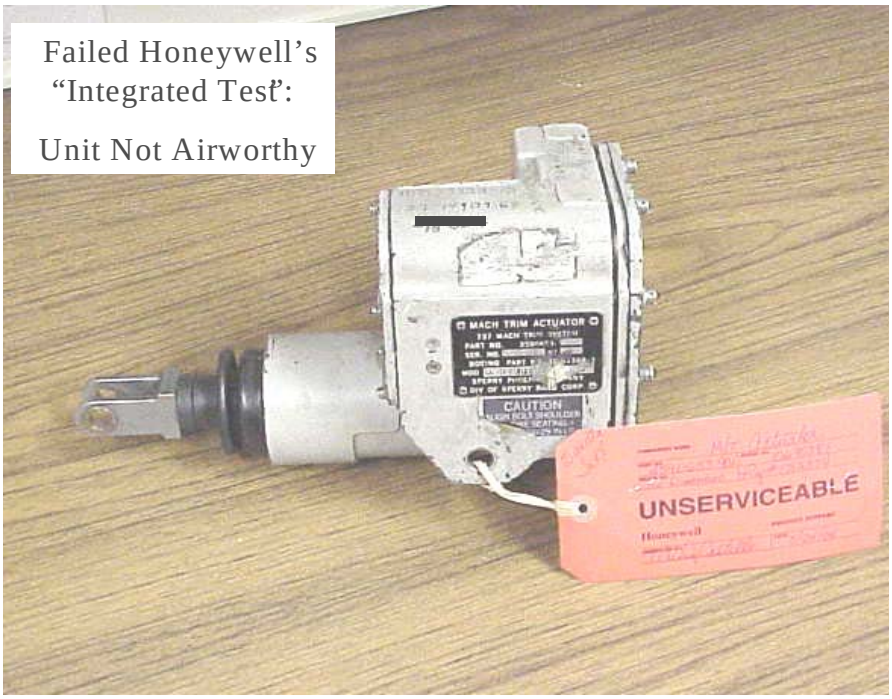


Figure 21. B737 P/N 2590653-901 Mach Trim Actuator Assy, Airplane: N000A2

3.2 B747 VISUAL INSPECTION RESULTS.

The tables in this section summarize the visual inspection results for the B747 dual-load path parts listed in table 2. These parts were acquired from the aircraft listed in table 4. Table 4 also specifies each aircraft's age and flight history. The highlighted portions of these tables are of particular interest and are documented in figures throughout the remainder of the report. All visual inspection results stated in tables 16 to 21 are shown in appendix A.

Four 65B80481-1 quadrant tube assemblies were inspected and showed little to no indication of defects. However, during the phase 3 inspections, the hydraulic press could not separate the inner and outer tube, which is bonded together with an epoxy polyamide adhesive. Therefore, the interface between the tubes could not be inspected. Further NDI is required to interrogate this area to ensure no defects exist. The outer portion of the outer tube and the inner portion of the inner tube were visually accessible and no flaws were found in these areas, except for the minor impact damage in the KG-DDD outer tube.

Table 16. B747 Test Results: P/N 65B80481-1 Quadrant Tube Assy

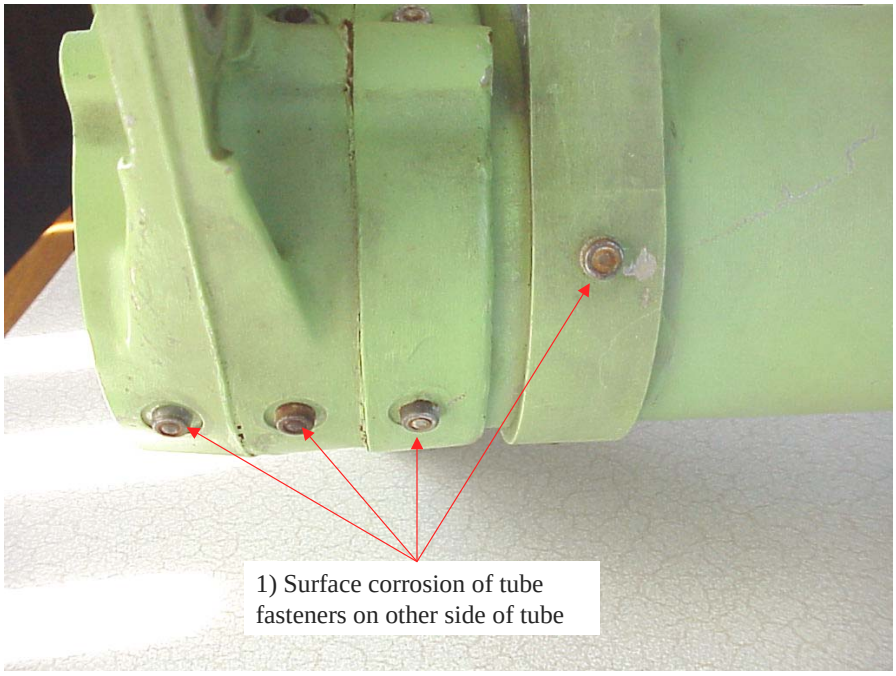
Airplane Origin	Inspection Phase	Visual Inspection Findings
N000A3	1	No defects noted.
	2	No defects noted.
	3	(Further NDI required for inner and outer tube interface.) No other defects noted.
N000C1	1	1. Corrosion of eight fasteners that attach various parts to the quadrant. 2. Paint removed near quadrant end from hydraulic fluid.
	2	No defects noted.
	3	(Further NDI required for inner and outer tube interface.) No other defects noted.
KG-DDD	1	No defects noted.
	2	Impact damage mark 2 mm wide by 0.003″ deep found after cleaning.
	3	(Further NDI required for inner and outer tube interface.) No other defects noted.
Extra	1	No defects noted.
	2	No defects noted.
	3	(Further NDI required for inner and outer tube interface.) No other defects noted.

Figure 22 shows the quadrant tube assembly installed on the airplane. This photograph, along with drawings from the illustrated parts catalog, were used to determine what an inspector could see during the C-check inspection, which was the phase 1 inspection. The highlighted areas in table 16, which depict the most significant findings, correspond to figures 23(a)-23(d).

B747 QUADRANT ASSY ELEVATOR CTRL INSTALLED P/N 65B80482-4
(PICTURE 01 "A1")

Photo courtesy of Evergreen Aircraft Sales and Leasing

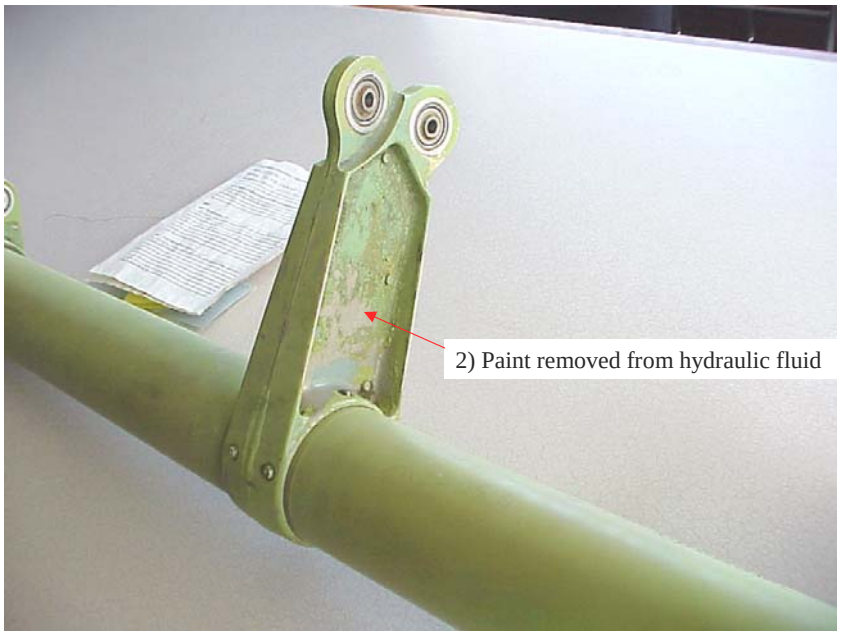
Figure 22. B747 P/N 65B80481-1 Quadrant Tube Assy



(a) Inspection Phase 1: Visual inspection prior to cleaning with accessibility issues considered, airplane: N000A3.

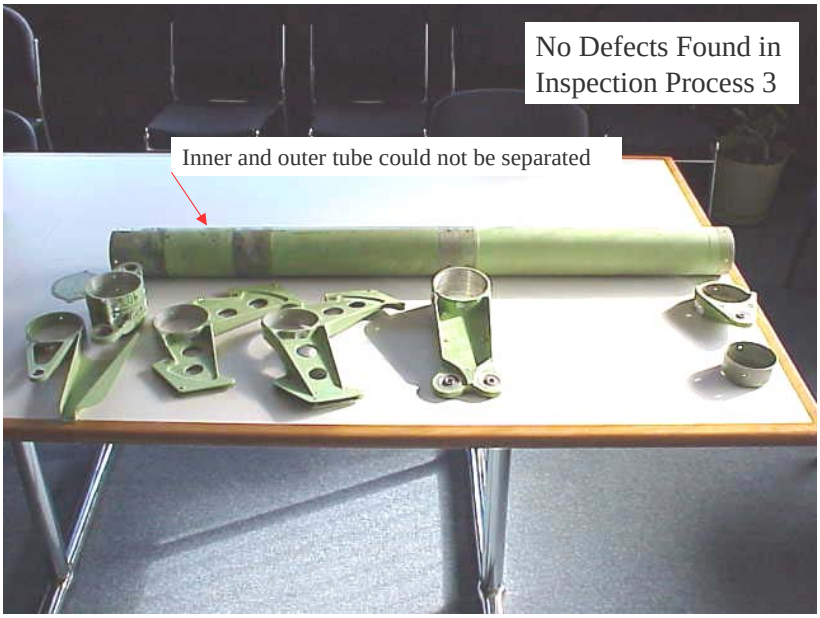
Figure 23. B747 P/N 65B80481-1 Quadrant Tube Assy, N000A3

(b) Inspection Phase 1: Visual inspection prior to cleaning with accessibility issues considered, airplane: N000A3.



(c) Inspection Phase 1: Visual inspection prior to cleaning with accessibility issues considered, airplane: N000A3.

Figure 23. B747 P/N 65B80481-1 Quadrant Tube Assy, N000A3 (Continued)



(d) Inspection Phase 3: Disassembly with all attachments removed, airplane: N000A3.

Figure 23. B747 P/N 65B80481-1 Quadrant Tube Assy, N000A3 (Continued)

Three 65B80832-4 aileron actuator links were inspected and the findings are shown in table 17. Figure 24 shows the actuator link installed. The most significant finding was the amount of bearing wear on all three parts inspected, which is shown in figures 25(b), 26(b), and 27(e). The bearing wear was undetected in service because inspectors could not see the bearing area as a result of the bolt that goes through the bearing. No defects were identified in the phase 3 inspection, as shown in figures 25(d), 26(e), and 27(f).

Table 17. B747 Test Results: P/N 65B80832-4 Aileron Actuator Link

Airplane Origin	Inspection Phase	Visual Inspection Findings
N000A3	1	Impact damage 0.866″ x 0.039″ x 0.00125″ deep. Possibly the result of excess play from a worn bearing described below.
	2	1. Worn bearing with approx 5/8 of bearing surface effected to a depth of 0.088″ . 2. Corrosion/fretting to a depth of 0.014″ deep.
	3	No defects noted.

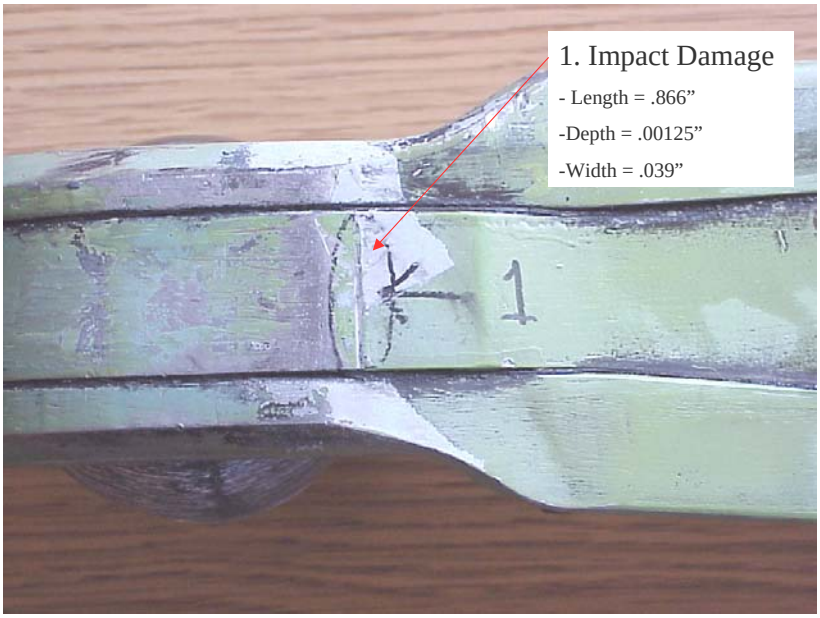
Table 17. B747 Test Results: P/N 65B80832-4 Aileron Actuator Link (Continued)

Airplane Origin	Inspection Phase	Visual Inspection Findings
N000C1	1	Minor surface corrosion on fastener, which holds the inner and outer links together.
	2	1. Worn bearing with approximately 3/8 of bearing surface effected to a depth of 0.004″. 2. Impact damage to a depth of 0.0122″ on the outer link near the bushing. 3. Rotational metal to metal wear possibly due to worn bearing.
	3	No defects noted.
KG-DDD	1	1. Corrosion on two fasteners heads that hold the inner and outer links together. 2. Impact damage 1.38″ x 0.118″ wide x 0.118″ deep. 3. Surface scratches found near the bearing end of the link.
	2	1. Corrosion and rust found on the outer link near the bushing. 2. Worn bearing with approximately 1/4 of bearing surface worn.
	3	No defects noted.

B747 LINK ACTUATOR INSTALLED P/N 65B80832-4
(PICTURE 02 "A1")

Photo courtesy of Evergreen Aircraft Sales and Leasing

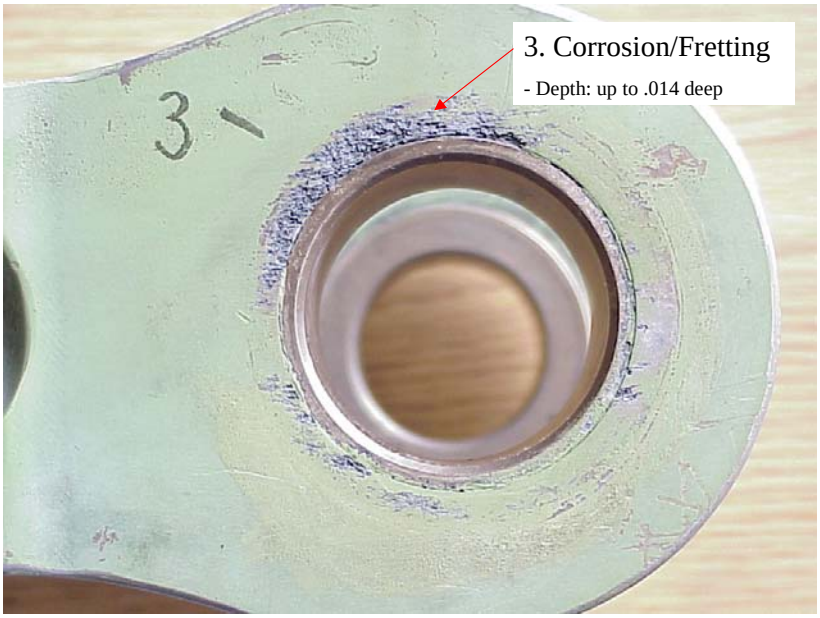
Figure 24. B747 P/N 65B80832-4 Aileron Actuator Link Installation



(a) Inspection Phase 1: Visual inspection prior to cleaning with accessibility issues considered, airplane: N000A3.

(b) Inspection Phase 2: Postcleaning with part removed from aircraft and cleaned, airplane: N000A3.

Figure 25. B747 P/N 65B80832-4 Aileron Actuator Link, N000A3



(c) Inspection Phase 2: Postcleaning with part removed from aircraft and cleaned, airplane: N000A3.

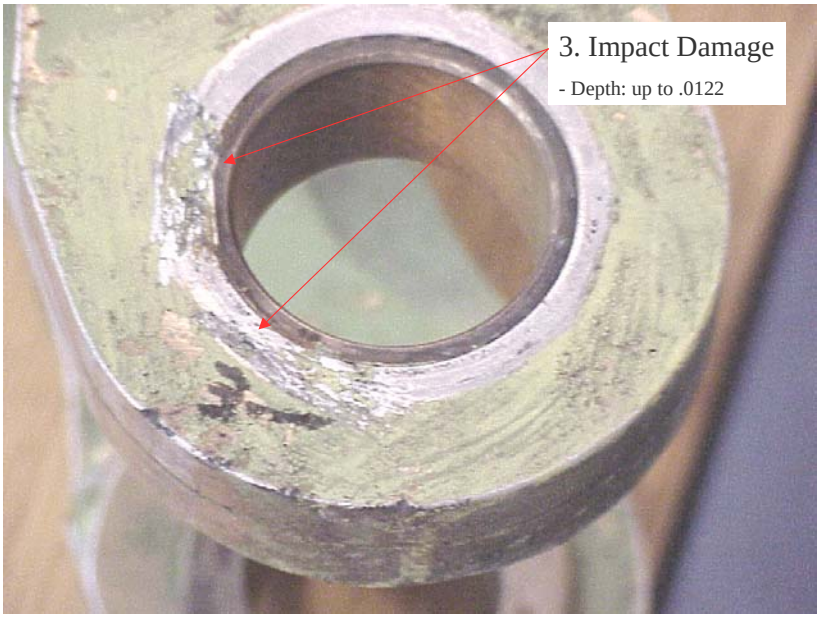
(d) Inspection Phase 3: Disassembly with all attachments removed, airplane: N000A3.

Figure 25. B747 P/N 65B80832-4 Aileron Actuator Link, N000A3 (Continued)

(a) Inspection Phase 1: Visual inspection prior to cleaning with accessibility issues considered, airplane: N000C1.

(b) Inspection Phase 2: Postcleaning with part removed from aircraft and cleaned, airplane: N000C1.

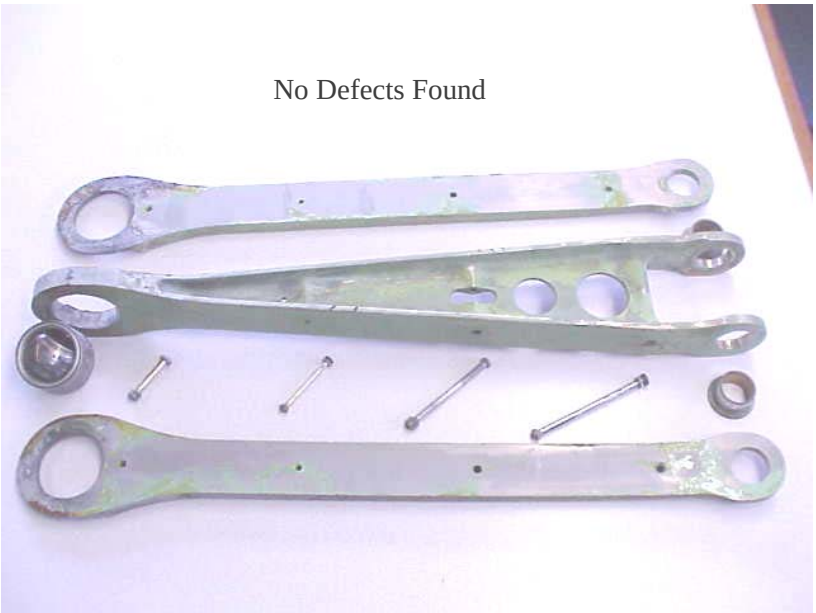
Figure 26. B747 P/N 65B80832-4 Aileron Actuator Link, N000C1



(c) Inspection Phase 2: Postcleaning with part removed from aircraft and cleaned, airplane: N000C1.

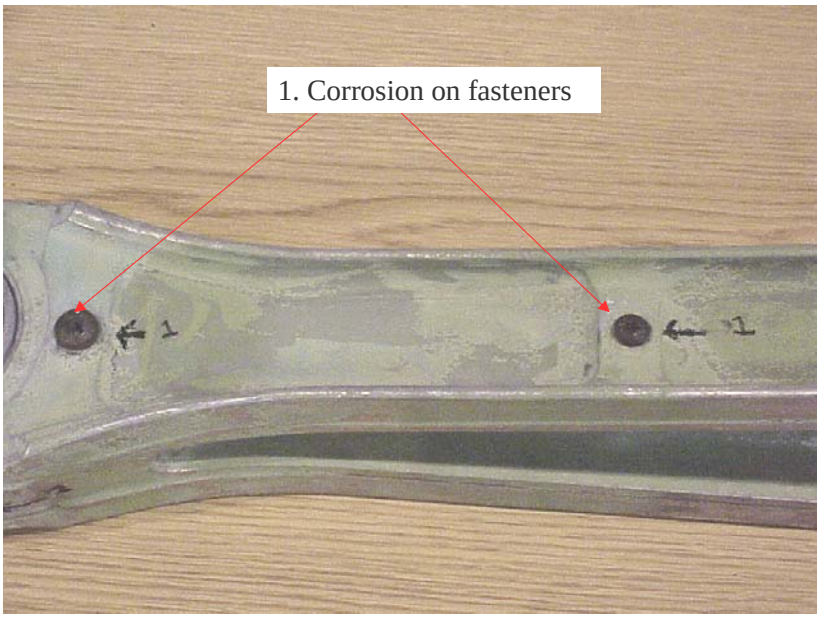
(d) Inspection Phase 2: Postcleaning with part removed from aircraft and cleaned, airplane: N000C1.

Figure 26. B747 P/N 65B80832-4 Aileron Actuator Link, N000C1 (Continued)



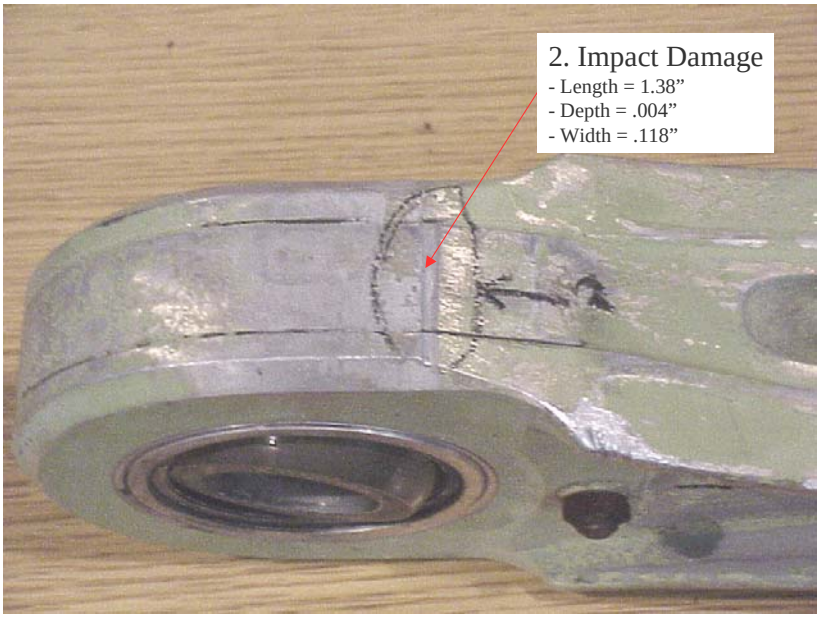
(e) Inspection Phase 3: Disassembly with all attachments removed, airplane: N000C1.

Figure 26. B747 P/N 65B80832-4 Aileron Actuator Link, N000C1 (Continued)

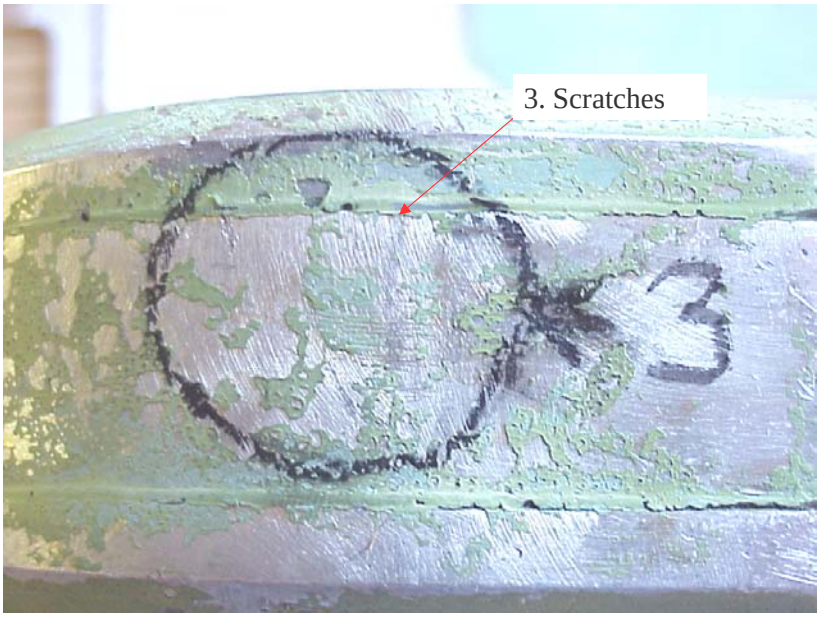


(a) Inspection Phase 1: Visual inspection prior to cleaning with accessibility issues considered, airplane: KG-DDD.

Figure 27. B747 P/N 65B80832-4 Aileron Actuator Link, KG-DDD



(b) Inspection Phase 1: Visual inspection prior to cleaning with accessibility issues considered, airplane: KG-DDD.



(c) Inspection Phase 1: Visual inspection prior to cleaning with accessibility issues considered, airplane: KG-DDD.

Figure 27. B747 P/N 65B80832-4 Aileron Actuator Link, KG-DDD (Continued)

(d) Inspection Phase 2: Postcleaning with part removed from aircraft and cleaned, airplane: KG-DDD.

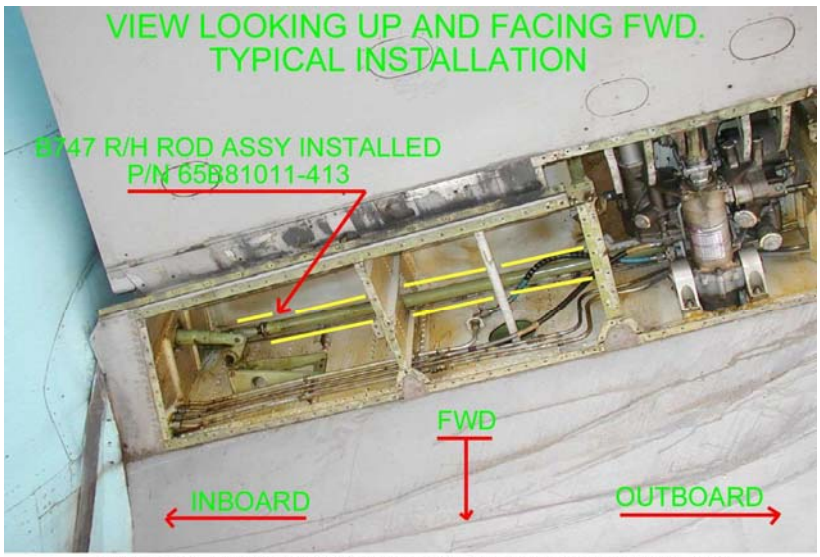
(e) Inspection Phase 2: Postcleaning with part removed from aircraft and cleaned, airplane: KG-DDD.

Figure 27. B747 P/N 65B80832-4 Aileron Actuator Link, KG-DDD (Continued)

(f) Inspection Phase 3: Disassembly with all attachments removed, airplane: KG-DDD.

Figure 27. B747 P/N 65B80832-4 Aileron Actuator Link, KG-DDD (Continued)

Figure 28 shows the 65B81011-413 tube assembly installed on the B747 aircraft. This figure demonstrates that a majority of the external surface of the outer tube is accessible to an inspector during a C-check visual inspection.



B747 ROD ASSY LINKAGE R/H INSTALLED P/N 65B81011-413
(PICTURE 04 "A1")

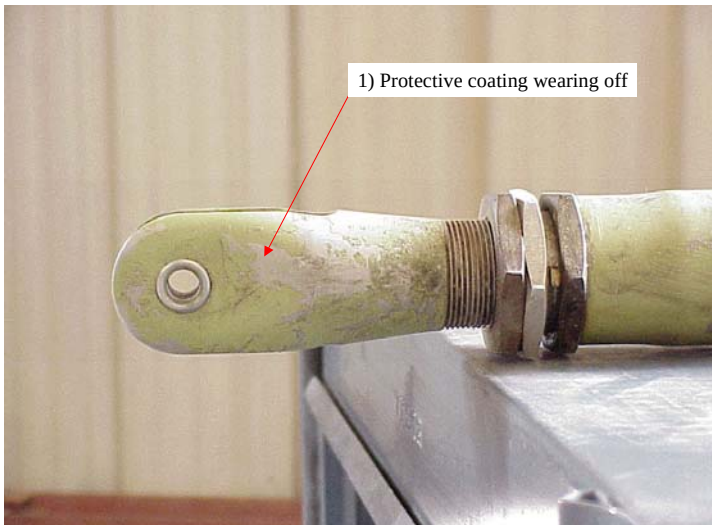
Photo courtesy of Evergreen Aircraft Sales and Leasing

Figure 28. B747 P/N 65B81011-413 Tube Assembly Installation

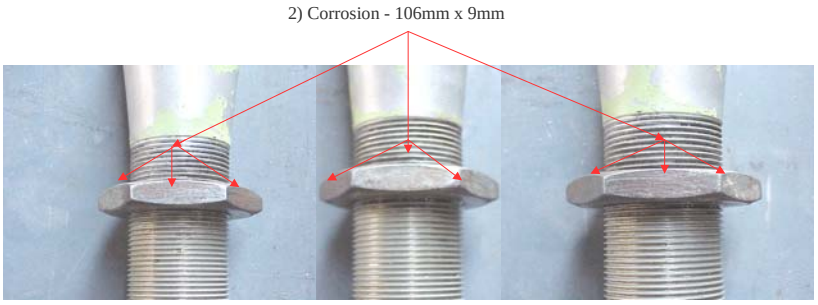
Significant visual inspection findings of the 65B81011-413 and -414 tube assemblies are highlighted in table 18 and are illustrated in figures 29(a)-29(d). Overall, the findings were minor; in general, there was protective coating wear and slight corrosion. The inner and outer tubes could not be disassembled. Consequently, the outer portion of the inner tube cannot be visually inspected nor the inner portion of the outer tube. Therefore, further NDI is required to interrogate the external surface of the inner tube as well as the internal surface of the outer tube interface to ensure no flaws exist in these areas.

Table 18. B747 Test Results: P/Ns 65B81011-413 and -414 Tube Assy

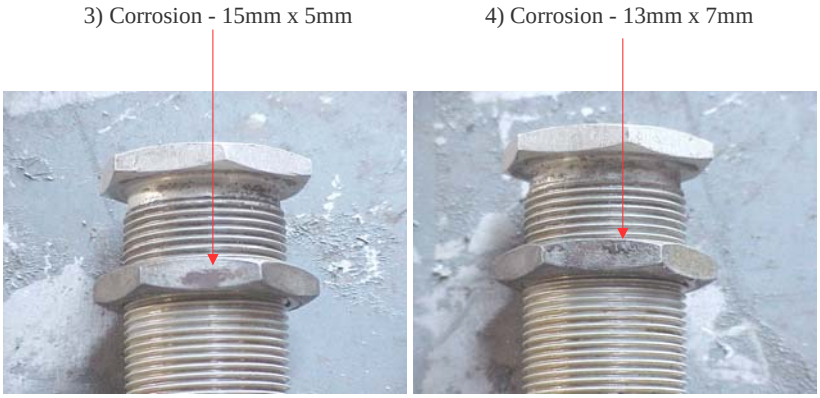
Airplane Origin	Inspection Phase	Visual Inspection Findings
N000A3 414	1	Protective coating wear.
	2	No defects noted.
	3	No defects noted.
	4	No defects noted.
N000A3 413	1	No defects noted.
	2	No defects noted.
	3	1. Corrosion on entire circumference of inner bolt. 2. Corrosion inside inner bolt.
	4	Corrosion found on inner bolt.
N000C1 414	1	No defects noted.
	2	Impact damage in three places with largest area being 5 x 15 mm.
	3	No defects noted.
	4	Corrosion found on inner bolt.
N000C1 413	1	No defects noted.
	2	No defects noted.
	3	No defects noted.
	4	Corrosion found on inner bolt.
KG-DDD 413	1	No defects noted.
	2	1. Protective coating wear on both ends of tube near attach points. 2. Three scratches on outer rod 20, 7, and 25 mm long.
	3	1. Corrosion on exterior of lock nut 40 x 7 mm. 2. Corrosion on exterior of nut in two places 13 x 7 mm and 15 x 7 mm.
	4	No defects noted.
KG-DDD 413	1	Protective coating wear.
	2	No defects noted.
	3	1. Corrosion on exterior of nut 15 x 5 mm. 2. Corrosion on exterior of nut 13 x 7 mm. 3. Corrosion on exterior of lock nut 106 x 9 mm. 4. Corrosion covering circumference of bolt that connects the tube halves together.
	4	No defects noted.



(a) Inspection Phase 1: Visual inspection prior to cleaning with accessibility issues considered, airplane: KG-DDD.

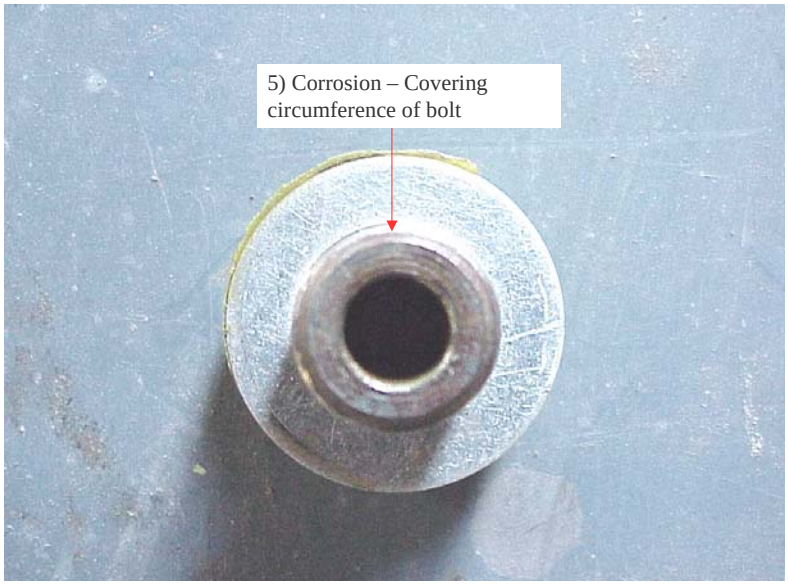


(b) Inspection Phase 3: Disassembly with all attachments removed, airplane: KG-DDD



(c) Inspection Phase 3: Disassembly with all attachments removed, airplane: KG-DDD

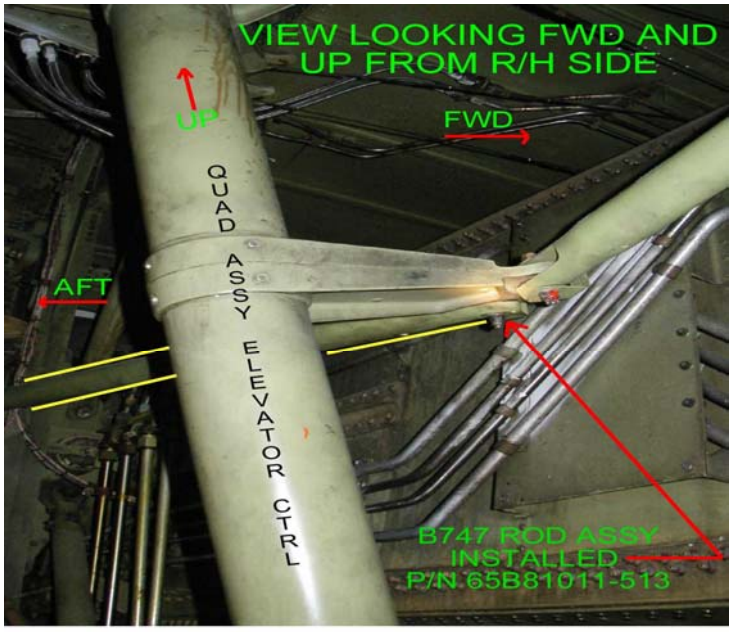
Figure 29. B747 P/N 65B81011-413 Tube Assembly



(d) Inspection Phase 3: Disassembly with all attachments removed, airplane: KG-DDD

Figure 29. B747 P/N 65B81F011-413 Tube Assembly (Continued)

Figure 30 shows the 65B81011-513 tube assembly installed on the B747 aircraft. This figure demonstrates that a majority of the external surface of the outer tube is accessible to an inspector during a C-check visual inspection.



B747 ROD ASSY L/H INSTALLED P/N 65B81011-513
(PICTURE 07 "A1")

Photo courtesy of Evergreen Aircraft Sales and Leasing

Figure 30. B747 P/N 65B81011-513 Tube Assembly Installation

The visual inspection findings of the 65B81011-504 and -513 tube assemblies can be found in table 19. Several longitudinal fatigue cracks (figures 31(b), (e), and (f)) were detected with visual inspection in the outer tube and the largest was 21 mm long. Eddy-current testing showed several other small cracks that have not yet been quantified. The development of an eddy-current standard (currently no standard exists) for the tube assemblies would be helpful in validating the results. In addition to cracks, the tube also exhibited some protective coating wear (figure 32) and some scratches (figure 31(c) and (d)). One common flaw, a small dent on the 69B82722-1 air dam tube appeared on three of the six tube assemblies tested, as shown in figures 33, 31(a), and 34(a). The Boeing design drawings for the tube assemblies require that the 69B82722-1 air dam tube be installed using a synthetic, rubber-based, corrosion-resistant sealant, known as BMS5-95. Only the tube assemblies originating from the KG-DDD aircraft used the sealant (see figure 34(b)). Tube assemblies from the N000A3 and N000C1 contained no sealant between the air dam tube and the outer tube (see figure 35) and therefore do not meet the design drawing requirements.

Much like the 65B81011-413 and -414 tube assemblies, the inner and outer tubes could not be disassembled. Consequently, neither the outer portion of the inner tube nor the inner portion of the outer tube could be visually inspected. Therefore, further NDI is required to interrogate the inner and outer tube interface to ensure no flaws exist in these areas.

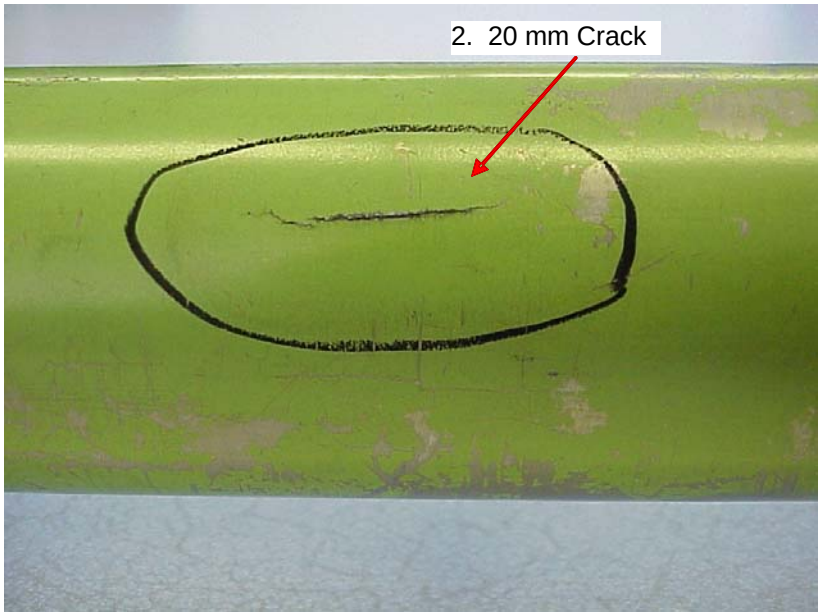
Table 19. B747 Test Results: P/Ns 65B81011-504 and -513 Tube Assy

Airplane Origin	Inspection Phase	Visual Inspection Findings
N000A3 513	1	No defects noted.
	2	Diamond-shaped dent 5 x 5 mm at the top of the diamond perimeter and 10 x 10 mm at the bottom of the diamond perimeter on 69B82722-1 air dam (depth could not be determined).
	3	Air dam tube 69B82722-1 not installed per Boeing design specifications. The BMS5-95 sealant was omitted between air dam tube and outer tube.
	4	NDI test specimen. Selected for eddy current.
	5	Test specimen for eddy current (tube sectioned vertically).
N000A3 509	1	Protective coating wear, at three different locations, along outer surface of tube.
	2	Gouges 40 x 40 mm in largest area on outer tube surface was found after cleaning.
	3	Air dam tube 69B82722-1 not installed per Boeing design specifications. The BMS5-95 sealant was omitted between air dam tube and outer tube.
	4	NDI test specimen. Selected for eddy current.
	5	Test specimen for eddy current (tube sectioned horizontally).

Table 19. B747 Test Results: P/Ns 65B81011-504 and -513 Tube Assy (Continued)

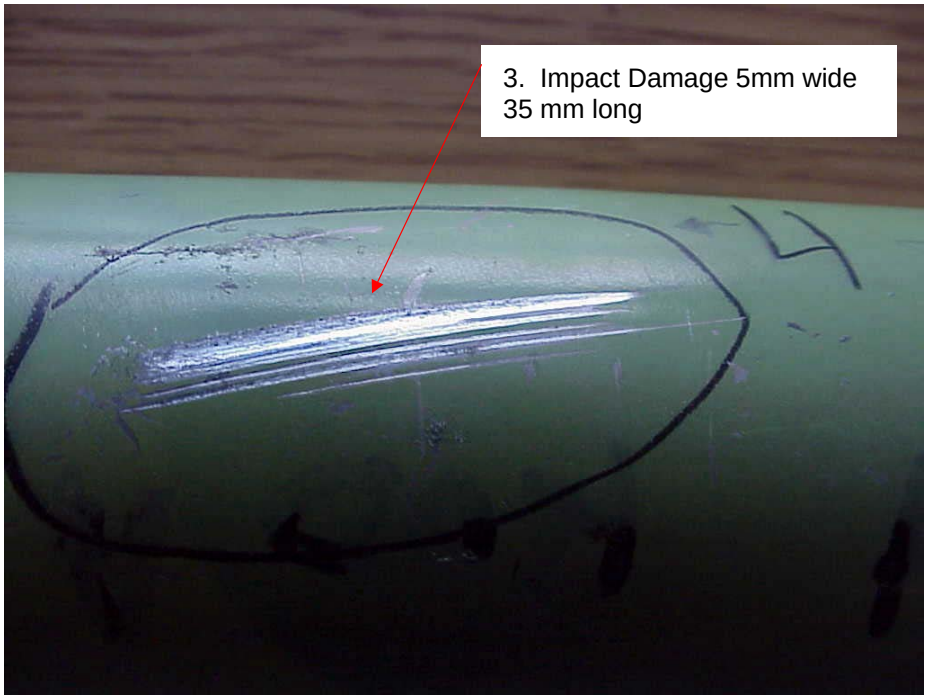
Airplane Origin	Inspection Phase	Visual Inspection Findings
N000C1 513	1	Protective coating wear along outer surface of tube.
	2	Impact damage/nick found after cleaning (item 69 of parts catalog).
	3	Air dam tube 69B82722-1 not installed per Boeing design specifications. The BMS5-95 sealant was omitted between air dam tube and outer tube.
	4	No defects noted.
N000C1 510	1	Protective coating wear.
	2	1. Dent with area of 10 mm diameter on 69B82722-1 air dam. 2. Crack 20 mm long. 3. Impact damage 35 mm long x 5 mm wide. 4. Minor impact scratches. 5. Crack 20 mm long. 6. Crack 15 mm long. 7. Crack 21 mm long.
	3	Air dam tube 69B8722-1 not installed per Boeing design specifications. The BMS5-95 sealant was omitted between air dam tube and outer tube.
	4	No defects noted.
KG-DDD 518	1	No defects noted.
	2	No defects noted.
	3	Destructive disassembly required.
	4	Dislodged stop. No other defects noted.
	5	Air dam tube correctly installed per Boeing design specifications. BMS5-95 sealant was found in KG-DDD tubes only.
KG-DDD 523	1	No defects noted.
	2	1. Dent 15 mm in diameter in 69B82722-1 air dam. 2. Dent 3 mm in diameter in 69B82722-1 air dam.
	3	Destructive disassembly required.
	4	No defects noted.
	5	Air dam tube correctly installed per Boeing design specifications. BMS5-95 sealant was found in KG-DDD tubes only.

(a) Inspection Phase 1: Visual inspection prior to cleaning with accessibility issues considered, airplane: N000C1.

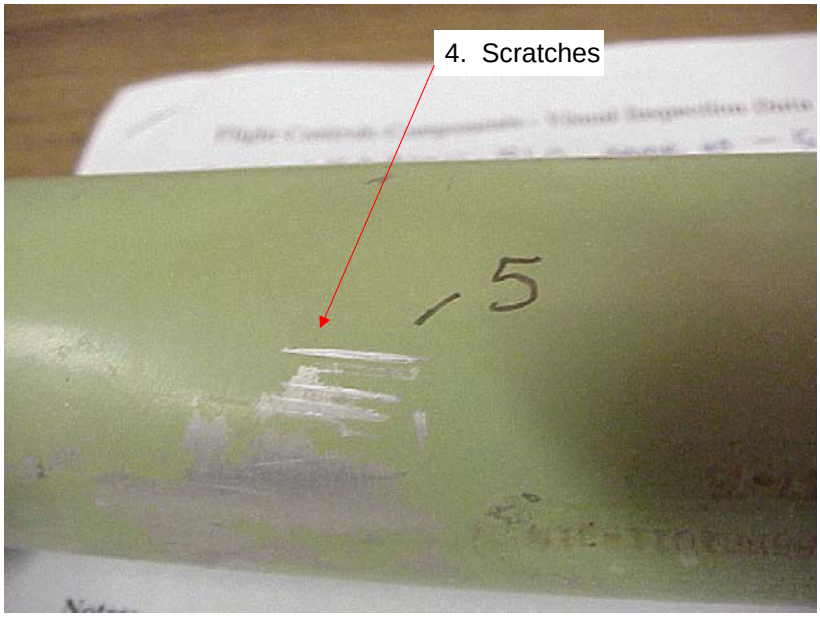


(b) Inspection Phase 2: Postcleaning with part removed and cleaned, airplane: N000C1.

Figure 31. B747 P/N 65B81011-513 Tube Assembly, Phases 1 and 2, N000C1

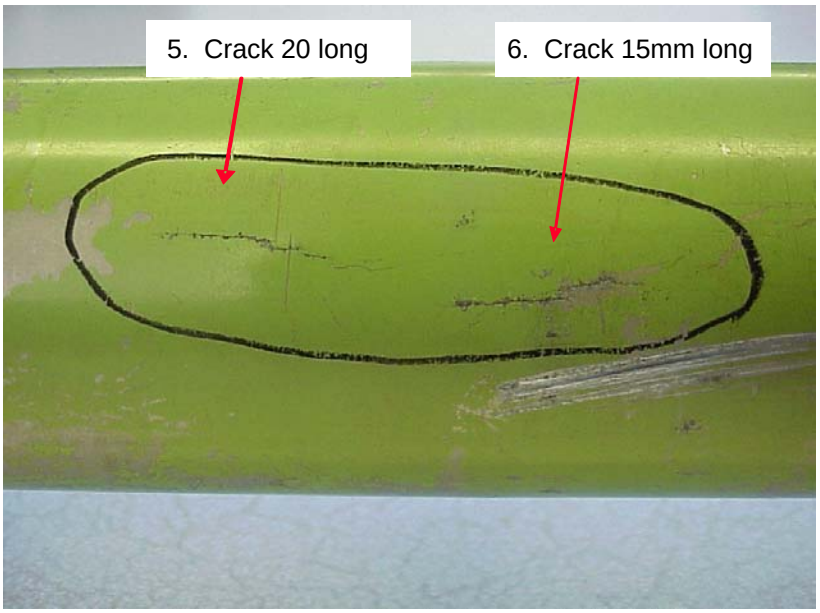


(c) Inspection Phase 2: Postcleaning with part removed and cleaned, airplane: N000C1.

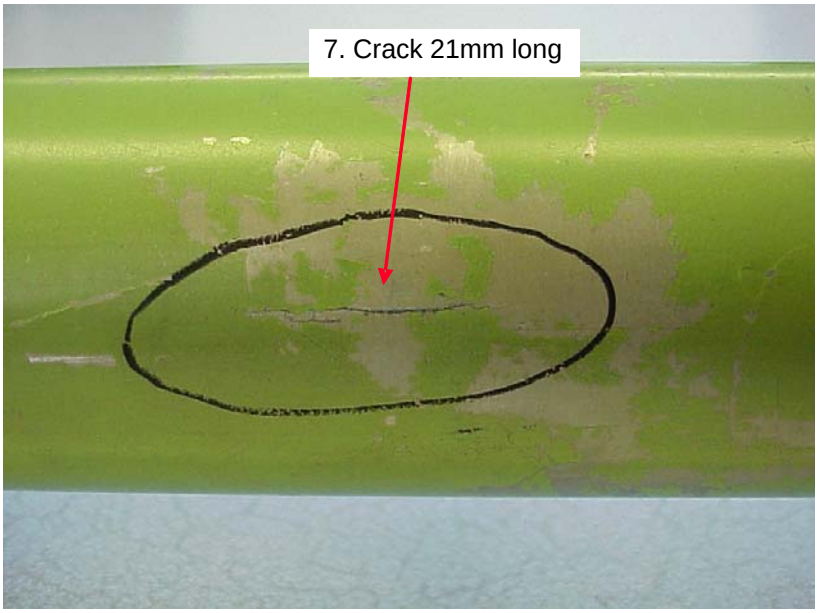


(d) Inspection Phase 2: Postcleaning with part removed and cleaned, airplane: N000C1.

Figure 31. B747 P/N 65B81011-513 Tube Assembly, Phases 1 and 2, N000C1 (Continued)



(e) Inspection Phase 2: Postcleaning with part removed and cleaned, airplane: N000C1.



(f) Inspection Phase 2: Postcleaning with part removed and cleaned, airplane: N000C1.

Figure 31. B747 P/N 65B81011-513 Tube Assembly, Phases 1 and 2, N000C1 (Continued)

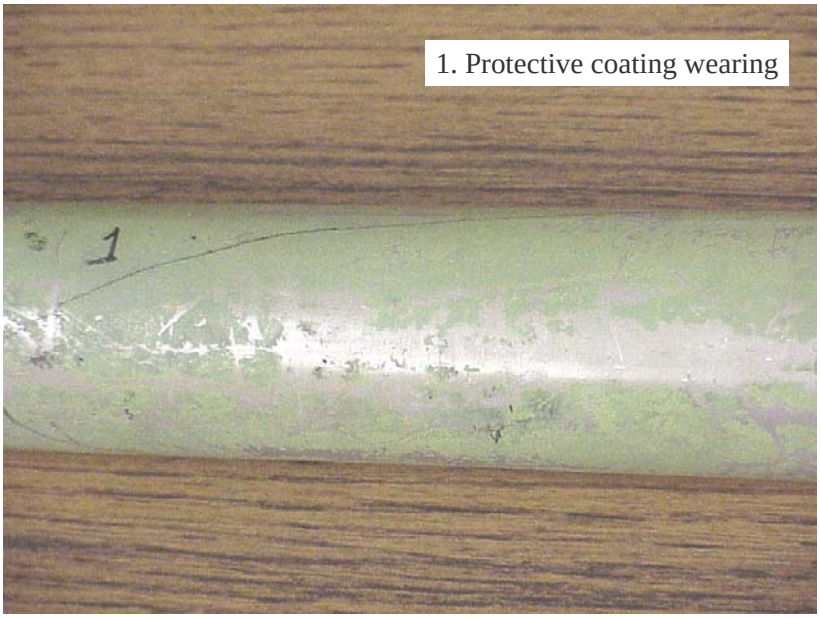


Figure 32. B747 P/N 65B81011-513 Tube Assembly, Phase 1, N000C1
(Inspection Phase 1: Visual inspection prior to cleaning with accessibility issues considered, airplane: N000C1.)

Figure 33. B747 P/N 65B81011-513 Tube Assembly, N000A3
(Inspection Phase 2: Postcleaning with part removed and cleaned, airplane: N000A3.)

(a) Inspection Phase 2: Postcleaning with part removed and cleaned, airplane: KG-DDD-523.

(b) Inspection Phase 2: Postcleaning with part removed and cleaned, airplane: KG-DDD-518.

Figure 34. B747 P/N 65B81011-523 Tube Assembly

Figure 35. B747 P/N 65B81011-513 Tube Assembly
(Inspection Phase 1: Visual inspection prior to cleaning with accessibility issues considered, airplane: N000C1.)

The visual inspection findings of the 69B82658-1 link actuator bolt assemblies are listed in table 20. The majority of the findings were minor. The most significant findings are highlighted in table 20 and shown in figures 36-38(b).

Table 20. B747 Test Results: P/N 69B82658-1 Link Actuator Bolt Assy

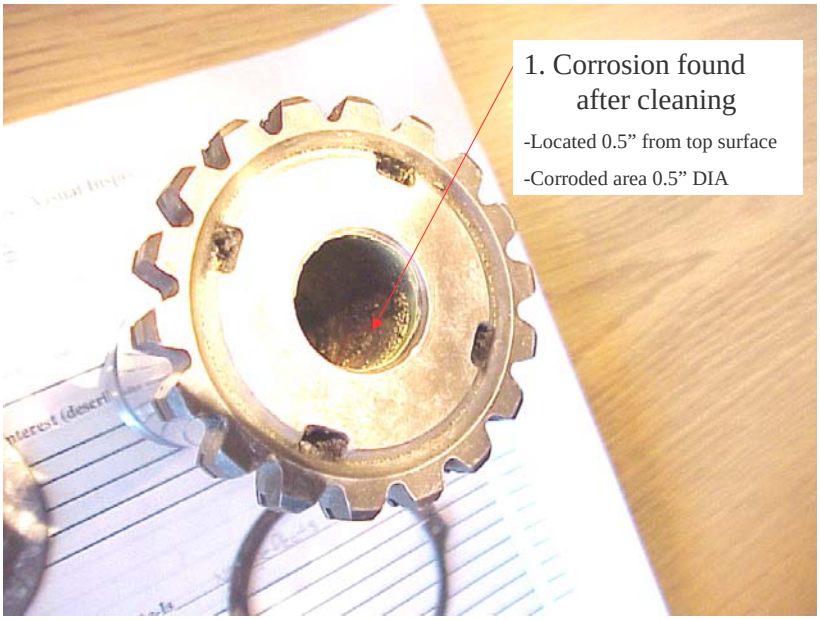
Airplane Origin	Inspection Phase	Visual Inspection Findings
N000A3	1	No defects noted.
	2	1. Corrosion in inner bolt 0.5″ from bolt head and area of 0.5″ diameter. 2. Gouges in large washer.
	3	No defects noted.
N000C1	1	No defects noted (bolt appears fairly new).
	2	No defects noted.
	3	Unable to disassemble further. NDI required.
KG-DDD	1	No defects noted.
	2	1. Galling on out bolt surface near head, covers 1/2 diameter of both with a width of 0.669″. 2. Corrosion on bolt end, washer & nut.
	3	Unable to disassemble further. NDI required.

Figure 36 shows that the 69B82658-1 bolt assembly mounted on the B747 aircraft is obstructed. It may be possible to get a glimpse of it from the side. Even if that were possible, only the bolt head would be visible.

B747 BOLT ASSY INSTALLED P/N 69B82658-1
(PICTURE 11 "A1")

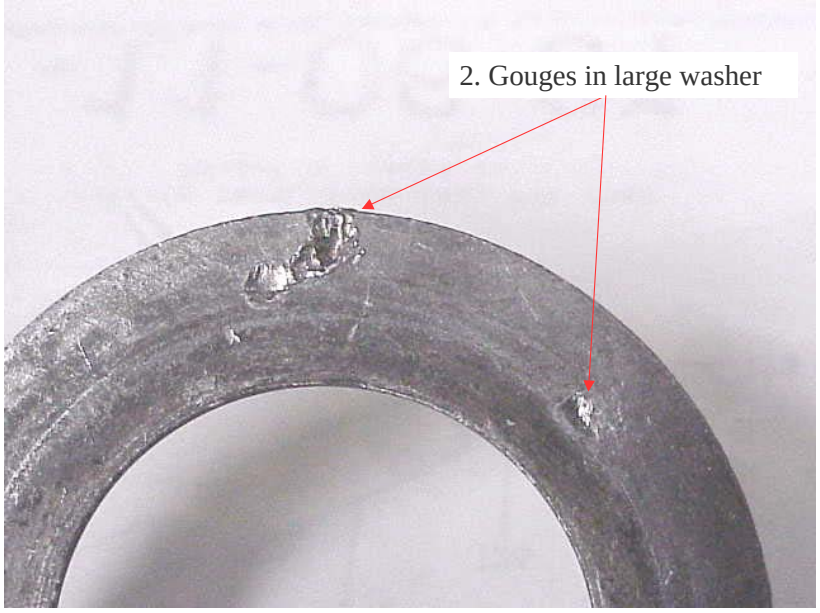
Photo courtesy of Evergreen Aircraft Sales and Leasing

Figure 36. B747 P/N 69B82658-1 Link Actuator Bolt Assy Installation



(a) Inspection Phase 2: Postcleaning with part removed from aircraft and cleaned, airplane: N000A3.

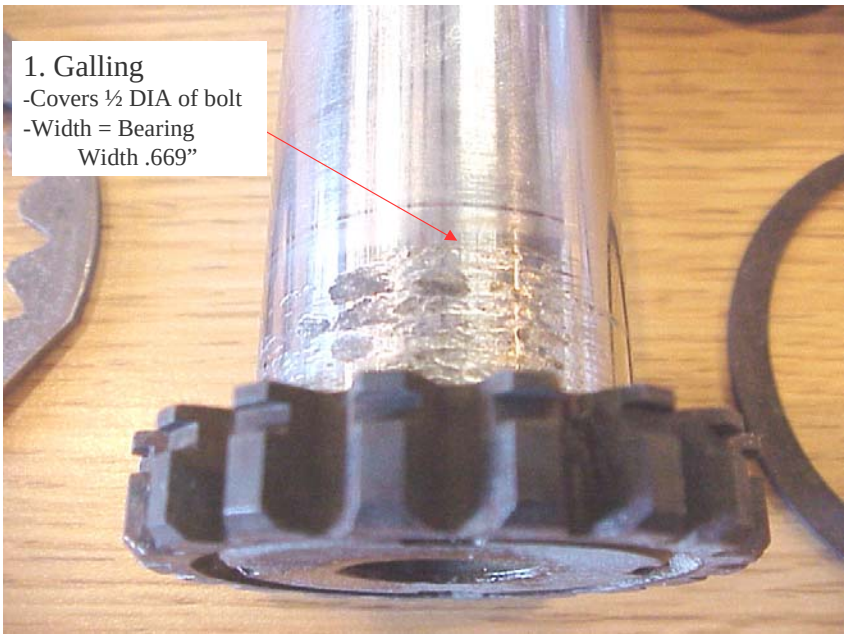
Figure 37. B747 P/N 69B82658-1 Link Actuator Bolt Assy, N000A3



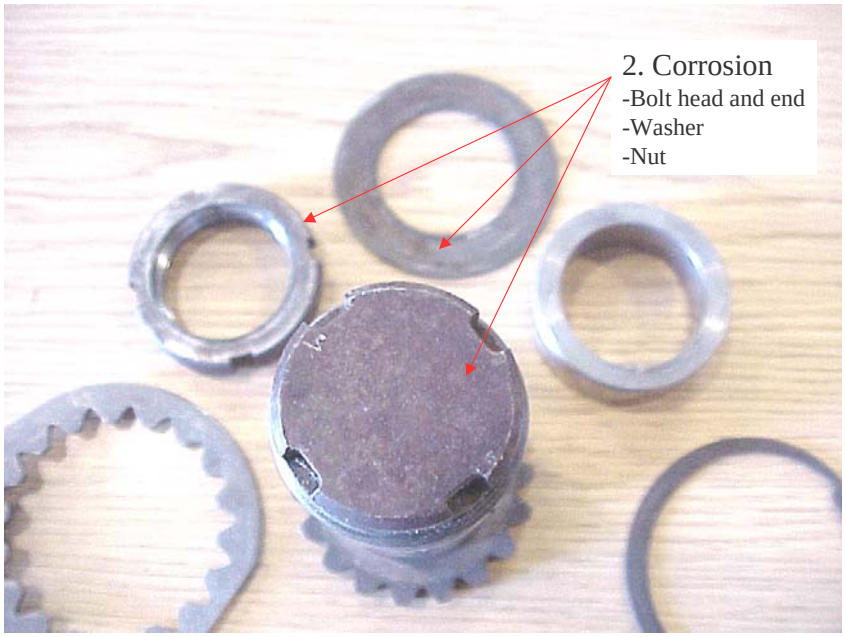
(b) Inspection Phase 2: Postcleaning with part removed from aircraft and cleaned, airplane: N000A3.

(c) Inspection Phase 3: Disassembly with all attachments removed, airplane: N000A3.

Figure 37. B747 P/N 69B82658-1 Link Actuator Bolt Assy, N000A3 (Continued)



(a) Inspection Phase 2: Postcleaning with part removed from aircraft and cleaned, airplane: KG-DDD.



(b) Inspection Phase 2: Postcleaning with part removed from aircraft and cleaned, airplane: KG-DDD.

Figure 38. B747 P/N 69B82658-1 Link Actuator Bolt Assy, KG-DDD

The visual inspection findings of the 93677 rod assembly input are shown in table 21. The most significant findings are highlighted in table 21 and shown in figures 36-38(b).

Table 21. B747 Test Results: P/N 93677 Rod Assy Input

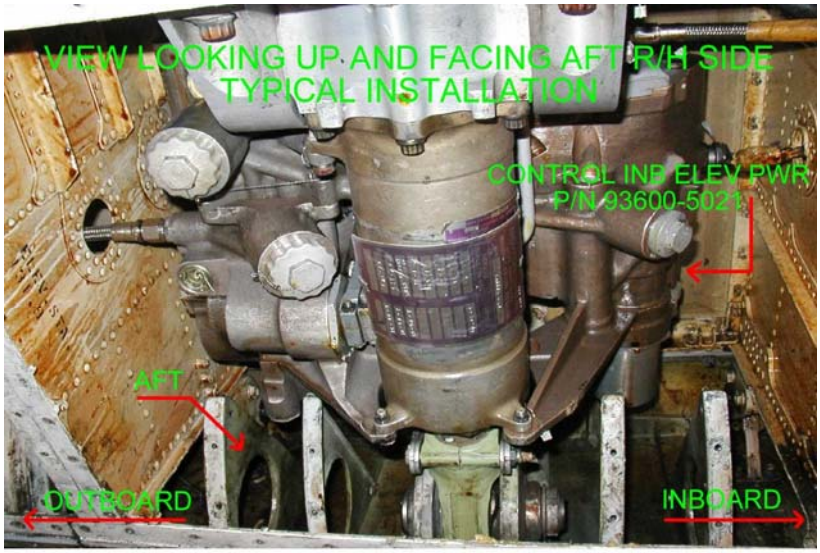
Airplane Origin	Inspection Phase	Visual Inspection Findings
N000A3	1	No defects detected as a result of the obstruction.
	2	(Note: No protective coating) 1. Crack 1″ long and approximately 0.0525″ deep, crack verified with eddy current. 2. Scratch and wear, scratch 0.125″ long. 3. Gouge 0.375″ long and 0.0625″ wide, inspected with eddy-current and found cracks in that general area.
	3	No other defects noted (bushings need to be removed for complete disassembly).
	4	Unidentified fiberscope indication on inner tube located below crack found in figure 40(a).
N000C1	1	No defects detected as a result of obstruction.
	2	Protective coating wear.
	3	No defects noted (bushings need to be removed for complete disassembly).
	4	No defects noted.
KG-DDD	1	No defects detected as a result of the obstruction.
	2	1. Circumferential gouge 0.032″ wide, depth could not be determined. 2. Nick near end of rod.
	3	No defects noted (bushings need to be removed for complete disassembly).
	4	No defects noted.

The 93677 rod assembly input was visually obstructed, while installed on the aircraft, making a thorough inspection very difficult. This rod assembly was installed on the 93600-5021 control assembly inboard elevator power assembly. Figure 39 shows the location of the 93677 rod assembly in relation to the 93600. Figure 40 shows how the 93677 rod assembly is visually obstructed while installed on the aircraft. Therefore, it was concluded that no flaws could be detected during inspection phase 1 unless the entire assembly was removed from the aircraft. Figure 41(a) reveals a longitudinal crack that was detected on the outer load path of the 93677 rod assembly that was removed from the N000A3 aircraft. A gouge and scratch were also detected and are shown in figure 41(b).

B747 CONTROL PACKAGE INBD ELEVATOR PWR REMOVED P/N 93600-5021
(PICTURE 12 "B1")

Photo courtesy of Evergreen Aircraft Sales and Leasing

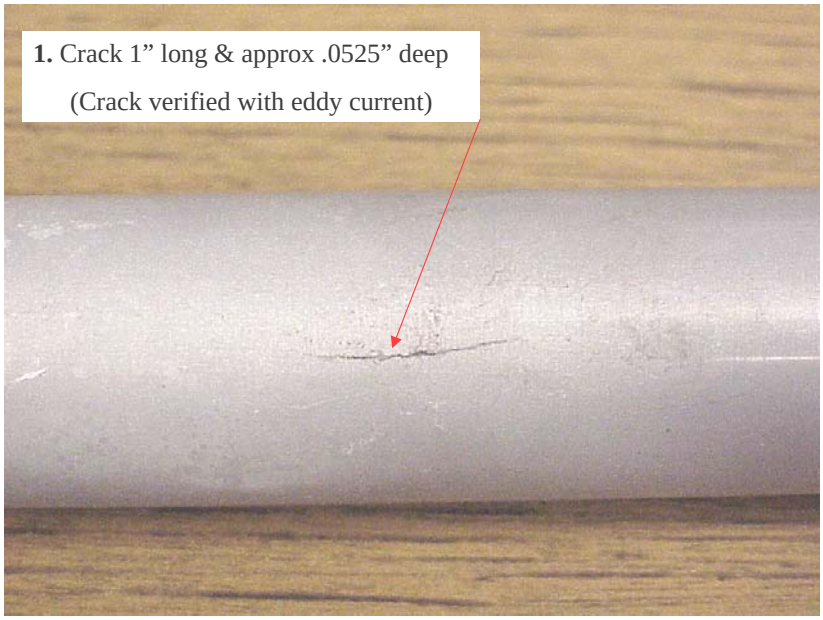
Figure 39. B747 P/N 93600-5021 Control Assy Inbd Elev PWR



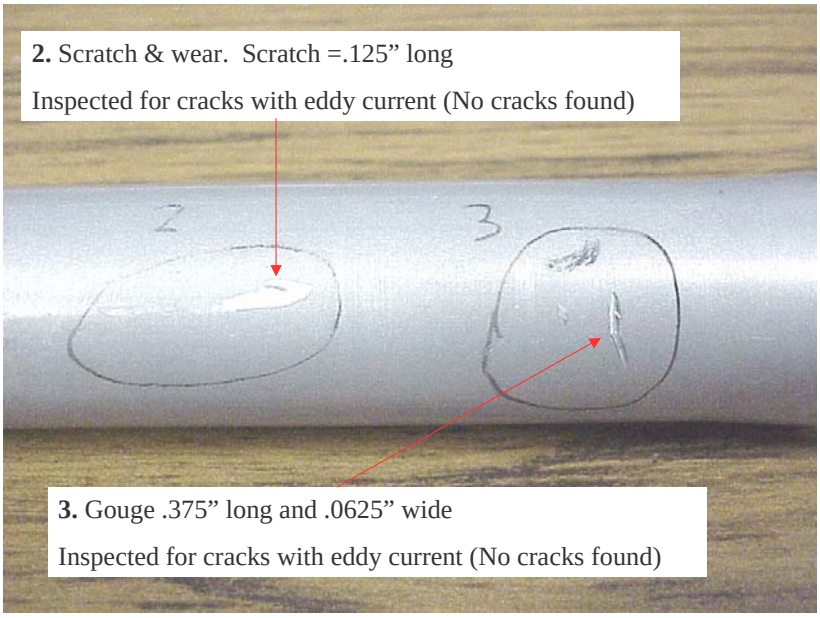
B747 CONTROL PACKAGE INBD ELEVATOR PWR INSTALLED P/N 93600-5021
(PICTURE 12 "A1")

Photo courtesy of Evergreen Aircraft Sales and Leasing

Figure 40. B747 P/N 93677 Rod Assy Input Installation

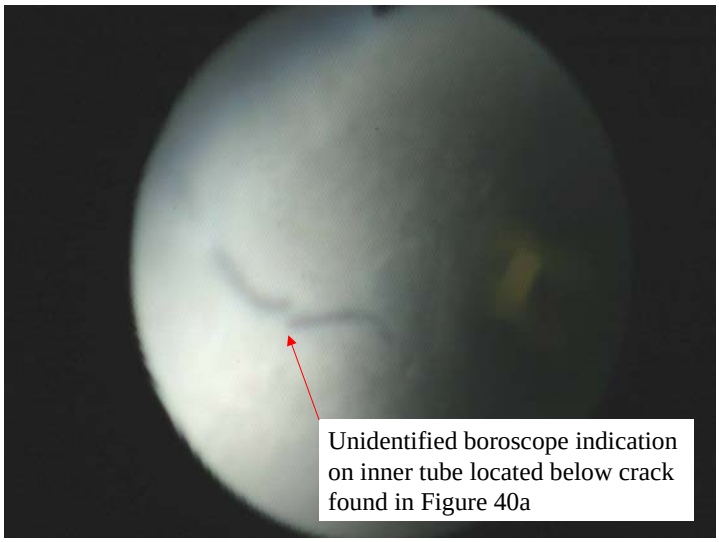


(a) Inspection Phase 2: Postcleaning with part removed from aircraft and cleaned, airplane: N000A3.



(b) Inspection Phase 2: Postcleaning with part removed from aircraft and cleaned, airplane: N000A3.

Figure 41. B747 P/N 93677 Rod Assy Input

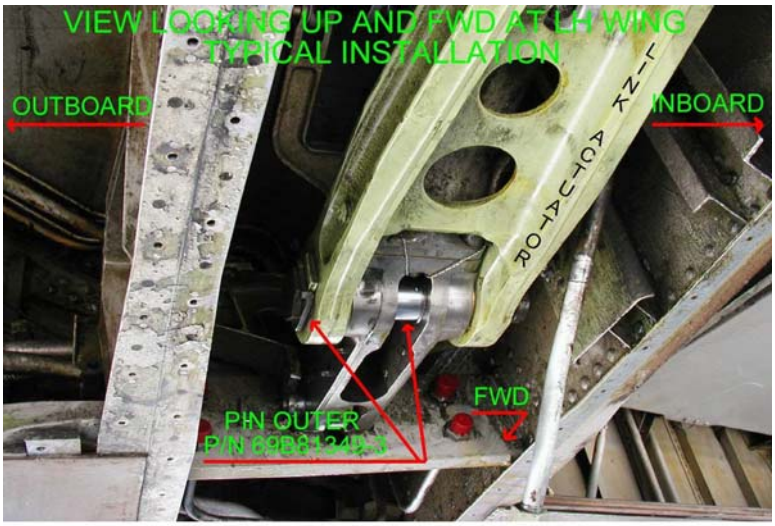


(c) Inspection Phase 4: Fiberscope, airplane: N000A3.

Figure 41. B747 P/N 93677 Rod Assy Input (Continued)

4. ADVANCED NDI STUDY.

In addition to a visual inspection, a side study was conducted to demonstrate the capabilities of various NDI techniques that could be performed on dual-load path components similar to the components in this report. The development and validation of various NDI techniques was applied to pin assembly 69B81622-5 where no defects were found per a visual inspection. This pin assembly retains one end of the 65B80832-4 aileron actuator link. Note a visual inspection was performed on the aileron actuator link and those results can be found in table 17. Figure 42 identifies the outer pin of the assembly, as installed on the B747 aircraft.



B747 PIN OUTER P/N INSTALLED 69B81349-3
(PICTURE 09 "A1")

Photo courtesy of Evergreen Aircraft Sales and Leasing

Figure 42. B747 P/N 69B81349-3 Pin Assembly

A series of test specimens and NDI standards that included realistic, but properly controlled, engineered flaws were created using aileron bolts recovered from the field. Numerous NDI techniques were applied to the problem of crack detection in the inner cylindrical component and the outer tubular sleeve component of the retention bolt. The following techniques were used: ultrasonics, eddy current, liquid penetrant, magnetic particle, and radiography. The specific ultrasonic, eddy-current, and liquid penetrant methods were successful in detecting cracks in various areas on the bolt. The results are summarized in table 22. Inspection of the inner cylinder can be completed without removing the part from its aileron link installation[2]. However, the bolt must be removed for an adequate inspection of the outer sleeve. It is not necessary to disassemble the bolt to complete the inspections and achieve the level of crack detection sensitivity noted here.

Table 22. Summary of NDI Techniques Evaluated and Their Performance on Pin Assembly 69B81622-5 Test Specimens

Inspection Technique	Crack Detection Performance by Smallest Length Detectable		
	Outer Sleeve Inside Surface Cracks	Outer Sleeve Outer Surface Cracks*	Inner Cylinder Cracks**
Shear-Wave Pulse-Echo Ultrasonics	0.040″	0.060″	-
Longitudinal-Wave Pulse-Echo Ultrasonics	-	-	0.040″
High-Frequency Eddy Current	-	< 0.040″	-
Liquid Penetrant	-	0.040″ – 0.060″	-
Radiography	-	-	-
Magnetic Particle	-	-	-

* Access to outside surface assumed (requires removal of pin assembly).
** No access to outside surface assumed; inspection performed from ends.

5. SUMMARY.

Visual inspections were conducted to assess the condition of aging flight control linkages particularly, single-element, safety-critical, dual-load path components. Four different components listed in tables 1 and 2 were found to have degradation worth noting and investigating further to better understand their effect on the aircraft and determine if in-service components have similar damage. The degradation seen might affect the components' ability to perform their intended functions indefinitely, assuming the components remained or were returned to service. Table 23 lists the four components.

[2] Roach, Dennis and Jacob, Z., "Inspection Results of Boeing 747 Dual-load Path Bolts Used in Inboard Aileron Link," Sandia National Laboratories, CA, August 6, 2003.

Table 23. Degradation of Interest

Component	Part Number	Model	Inspection Results
Mach Trim Actuator	2590653-901	B737	Failed acceptance test
Aileron Actuator Link	65B80832-4	B747	Excessive bearing wear
Tube Assembly	65B81011-504/-513	B747	Fatigue cracks on outer tube
Rod Assembly Input	93677	B747	Fatigue crack on outer rod Crack indication on inner rod

Visual inspection results revealed that four different components were found to have minor degradation of interest. There is not a significant reduction in the strength of these components as tested, particularly relative to the loads they actually experience in service. However, it is also worth mentioning that each component listed in table 24 revealed a specific minor flaw that appeared to be a trend for that particular part number.

Table 24. Minor Degradation of Interest

Component	Part Number	Model	Reason
Rod Assembly Vernier	69-37290-13	B737	Impact damage to outer rods
Bolt Assembly	69-43956-1	B737	Permanent deformation (bent)
Rod Assembly	69-44427-3	B737	Corrosion inner bolt and sleeve
Tube Assembly	65B81011-504/-513	B747	Dents on air dam/absent sealant

6. CONCLUSIONS AND RECOMMENDATIONS.

The small size of the sample set and source of the samples (retired, nonairworthy aircraft) make it inappropriate to draw any definitive conclusion concerning the condition of parts in current service. While one cannot draw any definitive conclusions from a relatively small sample set, based upon the frequency of damage found in this sample set and the fact that the sampled airplanes were stored in an area with a benign climate, a reasonable hypothesis would be that similar degradation exists on in-service aircraft.

6.1 KEY FINDINGS.

6.1.1 Mach Trim Actuator.

Two actuators were acquired and tested, one from airplane N000A1 and the other from airplane N000A2, both operated by airline A. Since both airplanes were recently taken out of service, one would assume that the actuators should be airworthy, meaning the component met its type design, either as-produced or properly altered and is in a condition for safe operation as defined by the Federal Aviation Administration (FAA). Both mach trim actuator units were returned to the original manufacturer Sperry Rand Corporation, now Honeywell, to perform an integrated test, which is conducted to the specifications of Sperry Overhaul Manual 22-20-51. Mach trim actuators that pass the test are issued an FAA 8130-3 airworthy form/tag.

Both actuators failed the test, thus neither met the required performance specifications and were deemed nonairworthy. The results conclude that one actuator had a sluggish and rough motor, while the other was considered sluggish. In both cases, the motor required complete replacement in order to establish airworthiness.

Honeywell has considered, but not validated, that the lack of performance could be attributed to the motors in both actuators being worn and the bearings dry as a result of age. The 2590653-901 mach trim actuator was replaced by part number 2A7-200A on newer airplanes, coincidental with the introduction of the B737-600, -700, and -800 airplane models. Note one 2A7-200A mach trim actuator was tested for this study and was found to be airworthy.

It is recommended to obtain quantified test data from Honeywell to determine the degree of roughness/sluggishness and determine if the actuators could travel the full length of movement. Each unit should be disassembled and each actuator arm should be destructively sectioned to expose visually inaccessible areas caused by the permanent bonding of the load paths. Additional 2590653-901 mach trim actuators should be sampled to determine if a trend exists.

6.1.2 Aileron Actuator Link.

Three aileron actuator links were acquired from three different aircraft operated by three different airline carriers. All three aileron actuator links were found to have excessive bearing wear, which is defined for this study as removal of bearing material as the result of contact. No damage was found on the inner link/load path. Under normal design loads the component in theory should support the load since the inner load path is intact.

It is important to note that since the actuator link is installed for visual inspections, the bearing area (area with excessive bearing wear found in this study) is visually concealed because the fixed 69B82658-1 bolt assembly, which goes through the bearing, limits its movement and accessibility. As a result, bearing wear is likely to remain undetected unless the actuator link is removed from the aircraft or alternative inspection criteria is implemented, such as a check for excessive control surface movement with the actuator link fixed.

It is recommended to measure the bearing free play of each bearing and compare with original equipment manufacturer (OEM) specifications. Additional aileron actuator links should be sampled and the rate of bearing wear should be determined.

6.1.3 Tube Assembly.

Six 65B81011-504/-513 tube assemblies were acquired from three different airline carriers and were visually inspected. One of the six had four visually detectable fatigue cracks 21, 20, 20, and 15 mm long, respectively, in the outer tube/load path. Preliminary eddy-current results show that many other smaller cracks were present on the outer surface in addition to the four found visually. The inner tube is permanently bonded to the outer tube so access to the inner tube was unattainable. However, the inner diameter surface of the tube was inspected using a fiberscope and no visual cracks were detected. The outer diameter surface of the inner tube is still in question. Eddy-current testing was attempted to investigate this area but with some difficulty. Air gaps between the bond of the inner and outer tube negatively affected the eddy-current

readings. In addition, no eddy-current standard or procedure exists to validate and ensure proper testing.

It is recommended that an eddy-current standard and a simple procedure be developed to test all six 65B81011-504/-513 inner tubes for flaws. It is suggested that a standard and procedure be created for the 65B81011-413 and -414 concurrently, since they have similar characteristics. Should creating a standard and procedure not be feasible, structural testing of these components would be a suitable option. This would require the magnitude and orientation of flight loads (or limit loads), which could then be applied to the aged component to determine if the aged component can meet the original design loads. Should structural testing not become feasible, destructive sectioning is recommended. Other aged 65B81011-504 and -513 and 65B81011-413 and -414 tube assemblies should also be visually inspected.

6.1.4 Rod Assembly Input.

Three rod assemblies were visually inspected from three different airline carriers. One of the three contained a 25-mm-inch-long crack on the outer rod or load path. The inner rod is permanently bonded to the outer rod so access to the inner rod was unattainable. However, the internal surface of the inner rod was inspected using a fiberscope, and an unidentified indication was detected in an area below the crack found in the outer rod. The fiberscope indication as well as the external surface of the inner rod and the internal surface of the outer rod is still in question. Currently no eddy-current standard or procedure exists to validate and ensure proper testing.

It is recommended to develop an eddy-current standard and procedure that can be used to test all three 93677 inner rods. Should creating a standard and procedure not become feasible, structural testing of this component is suggested. This would require the magnitude and orientation of flight loads (or limit loads) to determine if the aged component can meet its original design loads. Should structural testing not be feasible, destructive sectioning is recommended. Additional rod assemblies should be sampled to determine if a trend exists.

6.2 MINOR FINDINGS.

6.2.1 Rod Assembly Vernier.

Several rod assemblies contained extensive impact damage on the outer rod surface. Yet, one specific type of impact damage, nicks near the rod end, was found 11 different times.

What is not understood is what caused the impact damage to occur. These areas of reduced material can potentially become a stress concentration depending on the magnitude and location of stress fields relative to the damaged area. Fatigue cracks can then initiate at the stress concentration should this area no longer withstand the amount of stress present. Note, no fatigue cracks were observed on the external surface of the outer rods. In addition, no fatigue cracks were observed on the internal surface of all inner rods when inspected using a fiberscope.

The precise cause of the rod assembly impact damage (nicks) should be determined. The rod assemblies should be destructively sectioned to expose visually inaccessible areas caused by the

permanent bonding of the load paths. Additional rod assemblies should be sampled to determine if a trend exists.

6.2.2 Bolt Assembly.

Four bolt assemblies were visually inspected, and it was discovered during the phase 3 inspection (disassembly with all attachments removed) that two of the four bolt assemblies could not be disassembled. The bolt assembly was slightly bent thus preventing the separation of the outer bolt from the inner bolt.

It is recommended that more bolt assemblies be sampled to determine if a trend exists. An aircraft C-check inspection prior to the removal of additional bolt assembly specimens could provide insight as to whether the bolt deformation occurs as a result of in-service use or by the removal process.

6.2.3 Rod Assembly.

Six rod assemblies were visually inspected, and two of the six contained an internal corrosive reaction, which is most evident by the surface condition along the shank of the internal bolt. Slight corrosion was also found on the inner rod in an area beneath the inner rod sleeve. Both components exhibiting the corrosion were acquired from different airplanes operated by different airline carriers (N000A2 and N000B1).

It is recommended to investigate the type and cause of the corrosive reactions. Remaining rod assemblies should be destructively sectioned to expose visually inaccessible areas caused by the permanent bonding of the load paths. If needed, a material change or corrosion-resistant coating may mitigate corrosion in the field. Additional rod assemblies should be sampled to determine if a trend exists.

6.2.4 Tube Assembly.

Six tube assemblies were visually inspected and three of the six exhibited dents on the 69B82722-1, air dam tube. The air dam tube had damages that ranged from 10-15 mm in diameter. In addition, the Boeing design drawing for the tube assemblies direct the bonding installation of the 69B82722-1 air dam tube to use a synthetic rubber-based, corrosion-resistant sealant known as BMS5-95. Only the tube assemblies originating from the KG-DDD aircraft used the sealant. Consequently, four of the six tubes inspected were manufactured without sealant between the air dam tube and the outer tube, and therefore, these four do not meet the drawing and design requirements for this component.

It is recommended to

- Investigate the cause of the impact damage.
- An aircraft C-check inspection prior to the removal of additional tube assembly specimens could provide insight as to whether the tube deformation occurs as a result of in-service use or by the removal process.

- Investigate the omission of BMS5-95 sealant at the OEM.
- If needed, improved quality control measures could be implemented.

7. FUTURE WORK.

As it is unknown whether these findings are the result of a trend or an anomaly, additional aged dual-load path inspection specimens will be acquired. This first phase of testing has identified subjects for further study. Since the inner and outer load paths of several components investigated in this study are permanently bonded together, a visual inspection was limited in that it cannot access all areas. Therefore, it is recommended that these components undergo additional testing, such as advanced nondestructive testing (radiography, eddy-current, ultrasonics, etc.), structural testing, and destructive sectioning. For example, many B737 bolt assemblies that have remaining adhesive visually conceal the mating load path surfaces, which prohibit a visual inspection of these areas. Therefore, it is currently unknown if flaws exist in this specific area.

This study tested many, yet not all, of the dual-load path components from primary flight control systems on the B737 and B747 aircraft. This study could be expanded to include other safety-critical dual-load path components that may further enhance the operational safety of these aircraft. Future efforts can be made to diversify and investigate other commercial aircraft manufacturers and models.

APPENDIX A—VISUAL INSPECTION RESULTS

The visual inspection results from table 6 are shown in figures A-1 through A-24.

Figure A-1. B737 P/N: 69-27229-20, N000B1, A
Inspection Phase 1: No Defects Noted

Figure A-2. B737 P/N: 69-27229-20, N000B1, A
Inspection Phase 2: No Defects Noted

Figure A-3. B737 P/N: 69-27229-20, N000B1, A
Inspection Phase 3: Adhesive Coating
Hinders Visual Inspection

Figure A-4. B737 P/N: 69-27229-20, N000B1, B
Inspection Phase 1: No Defects Noted

Figure A-5. B737 P/N: 69-27229-20, N000B1, B
Inspection Phase 2: No Defects Noted

Figure A-6. B737 P/N: 69-27229-20, N000B1, B
Inspection Phase 3: Adhesive Coating
Hinders Visual Inspection

Figure A-7. B737 P/N: 69-27229-20, N000B1, C
Inspection Phase 1: No Defects Noted

Figure A-8. B737 P/N: 69-27229-20, N000B1, C
Inspection Phase 2: No Defects Noted

Figure A-9. B737 P/N: 69-27229-20, N000B1, C
Inspection Phase 3: Adhesive Coating
Hinders Visual Inspection

Figure A-10. B737 P/N: 69-27229-20, N000B1, D
Inspection Phase 1: No Defects Noted

Figure A-11. B737 P/N: 69-27229-20, N000B1, D
Inspection Phase 2: No Defects Noted

Figure A-12. B737 P/N: 69-27229-20, N000B1, D
Inspection Phase 3: Adhesive Coating
Hinders Visual Inspection

Figure A-13. B737 P/N: 69-27229-20, N000A1
Inspection Phase 1: No Defects Noted

Figure A-14. B737 P/N: 69-27229-20, N000A1
Inspection Phase 2: No Defects Noted

Figure A-15. B737 P/N: 69-27229-20, N000A1
Inspection Phase 3: Adhesive Coating
Hinders Visual Inspection

Figure A-16. B737 P/N: 69-27229-20, N000A2, A
Inspection Phase 1: No Defects Noted

Figure A-17. B737 P/N: 69-27229-20, N000A2, A
Inspection Phase 2: No Defects Noted

Figure A-18. B737 P/N: 69-27229-20, N000A2, A
Inspection Phase 3: Adhesive Coating
Hinders Visual Inspection

Figure A-19. B737 P/N: 69-27229-20, N000A2, B
Inspection Phase 1: No Defects Noted

Figure A-20. B737 P/N: 69-27229-20, N000A2, B
Inspection Phase 2: No Defects Noted

Figure A-21. B737 P/N: 69-27229-20, N000A2, B
Inspection Phase 3: Adhesive Coating
Hinders Visual Inspection

Figure A-22. B737 P/N: 69-27229-20, N000A2, C
Inspection Phase 1: No Defects Noted

Figure A-23. B737 P/N: 69-27229-20, N000A2, C
Inspection Phase 2: No Defects Noted

Figure A-24. B737 P/N: 69-27229-20, N000A2, C
Inspection Phase 3: Adhesive Coating
Hinders Visual Inspection

The visual inspection results from table 7 are shown in figures A-25 through A-61.

Figure A-25. B737 P/N: 69-37290-13, N000B1
Inspection Phase 1: Impact Damage 2 x 2 mm

Figure A-26. B737 P/N: 69-37290-13, N000B1, A
Inspection Phase 2: No Defects Noted

Figure A-27. B737 P/N: 69-37290-13, N000B1
Inspection Phase 3: No Defects Noted

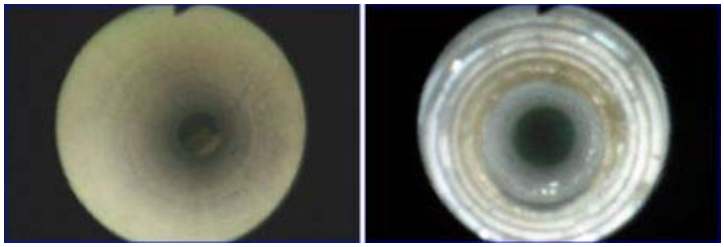


Figure A-28. B737 P/N: 69-37290-13, N000B1, A
Inspection Phase 4: No Defects Noted

Figure A-29. B737 P/N: 69-37290-13, N000B1
Inspection Phase 1: No Defects Noted

Figure A-30. B737 P/N: 69-37290-13, N000B1, B
Inspection Phase 2: No Defects Noted

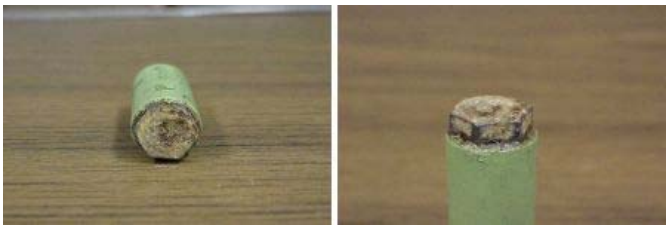


Figure A-31. B737 P/N: 69-37290-13, N000B1
Inspection Phase 3: Unidentied
Material On Bolt Assy 69-40727-2

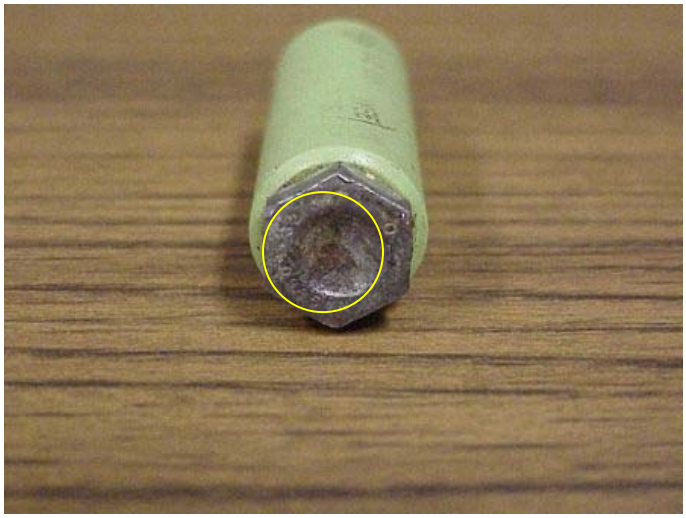


Figure A-32. B737 P/N: 69-37290-13, N000B1
Inspection Phase 3: Corrosion Found
on Bolt Head 9 x 2 mm

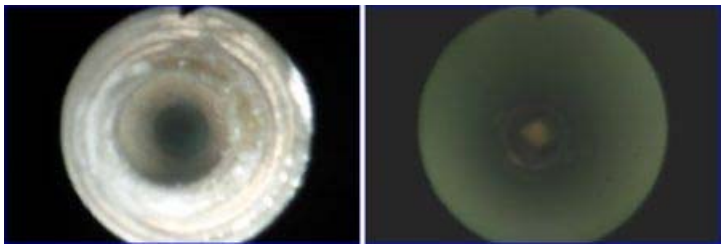


Figure A-33. B737 P/N: 69-37290-13, N000B1, B
Inspection Phase 4: No Defects Noted

Figure A-34. B737 P/N: 69-37290-13, N000A1
Inspection Phase 1: No Defects Noted

Figure A-35. B737 P/N: 69-37290-13, N000A1
Inspection Phase 2: No Defects Noted

Figure A-36. B737 P/N: 69-37290-13, N000A1, A
Inspection Phase 3: No Defects Noted

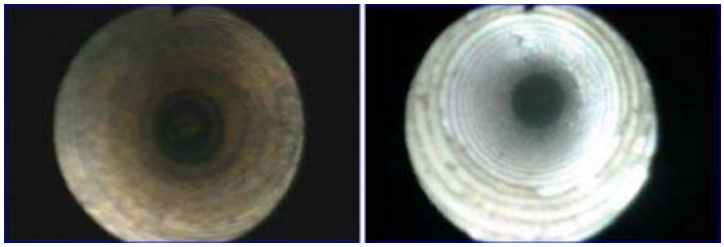


Figure A-37. B737 P/N: 69-37290-13, N000A1, A
Inspection Phase 4: No Defects Noted

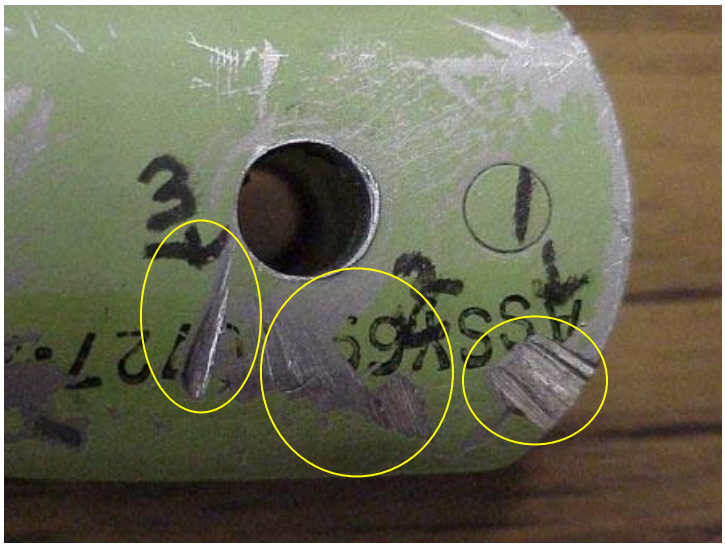


Figure A-38. B737 P/N: 69-37290-13, N000A1
Inspection Phase 1: (1) Gouge 13 x 2 mm
(2) Gouge 12 x 10 mm and (3) Gouge 5 mm x 5 mm x 0.012″ deep

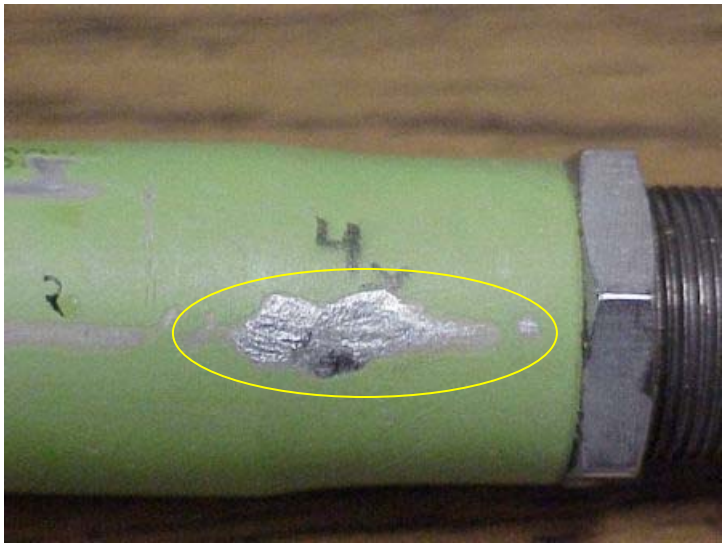


Figure A-39. B737 P/N: 69-37290-13, N000A1
Inspection Phase 1: (4) Gouge 18 x 7 mm

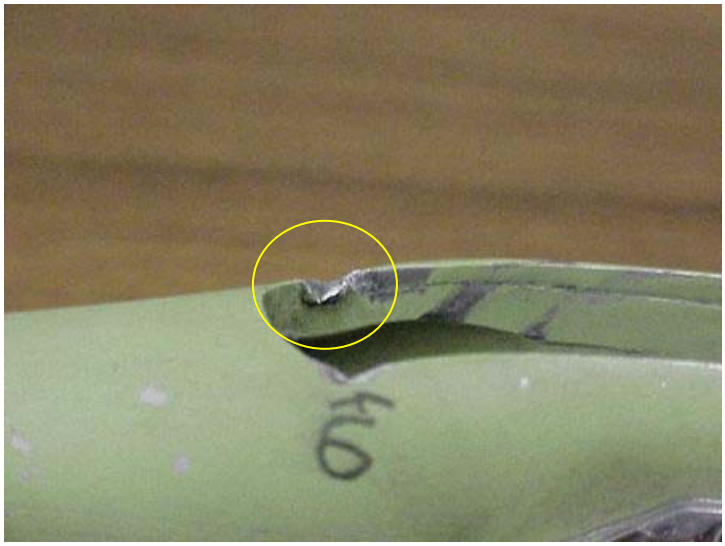


Figure A-40. B737 P/N: 69-37290-13, N000A1
Inspection Phase 1: (5) Impact Damage 4 x 2 mm

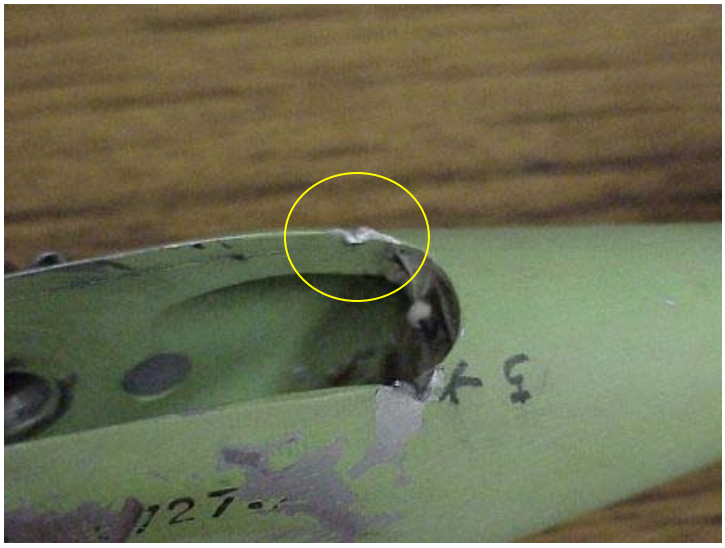


Figure A-41. B737 P/N: 69-37290-13, N000A1
Inspection Phase 1: (6) Impact Damage 4 x 2 mm

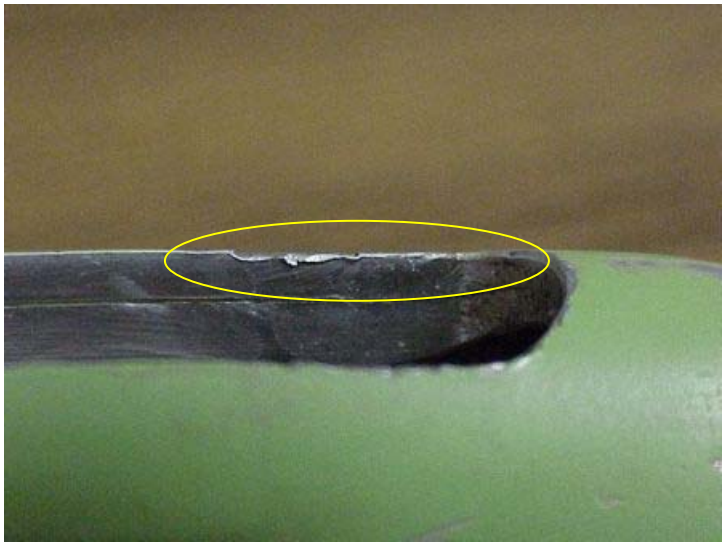


Figure A-42. B737 P/N: 69-37290-13, N000A1
Inspection Phase 1: (7) Impact Damage 10 x 1 mm

Figure A-43. B737 P/N: 69-37290-13, N000A1
Inspection Phase 2: (8) Protective Coating Wear

Figure A-44. B737 P/N: 69-37290-13, N000A1, B
Inspection Phase 3: No Defects Noted

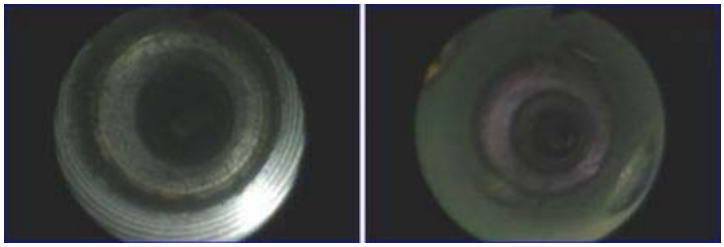


Figure A-45. B737 P/N: 69-37290-13, N000A1, B
Inspection Phase 4: No Defects Noted

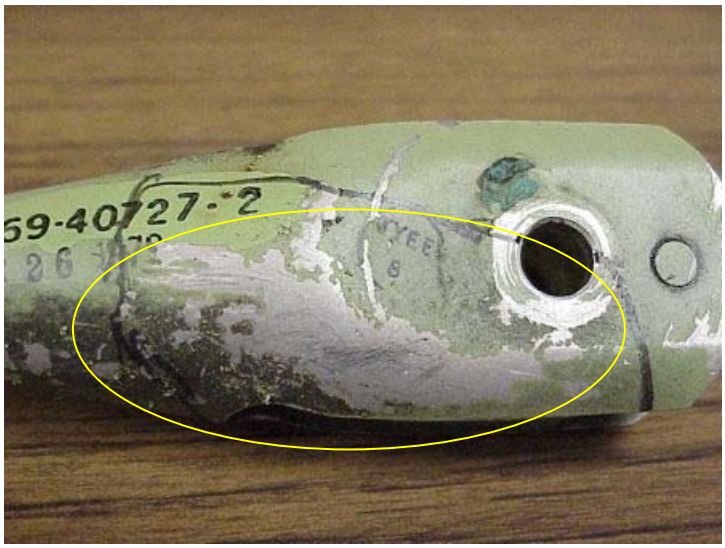


Figure A-46. B737 P/N: 69-37290-13, N000A2, A
Inspection Phase 1: (1) Protective Coating Wear

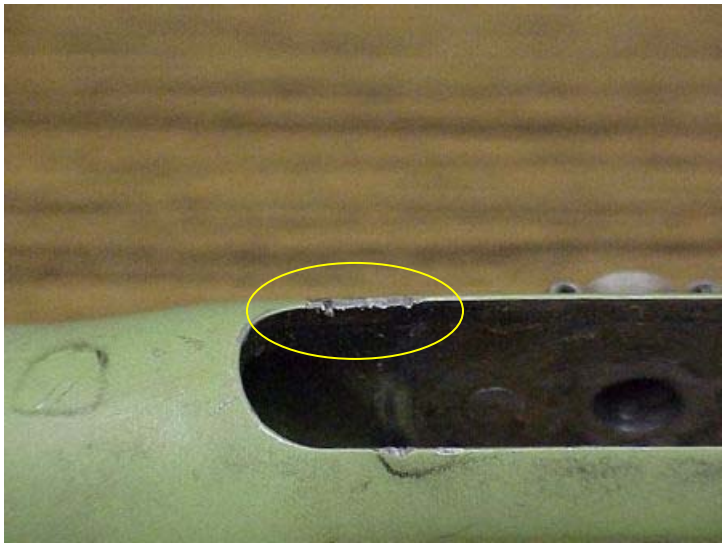


Figure A-47. B737 P/N: 69-37290-13, N000A2
Inspection Phase 1: (2) Impact Damage 9 x 1 mm

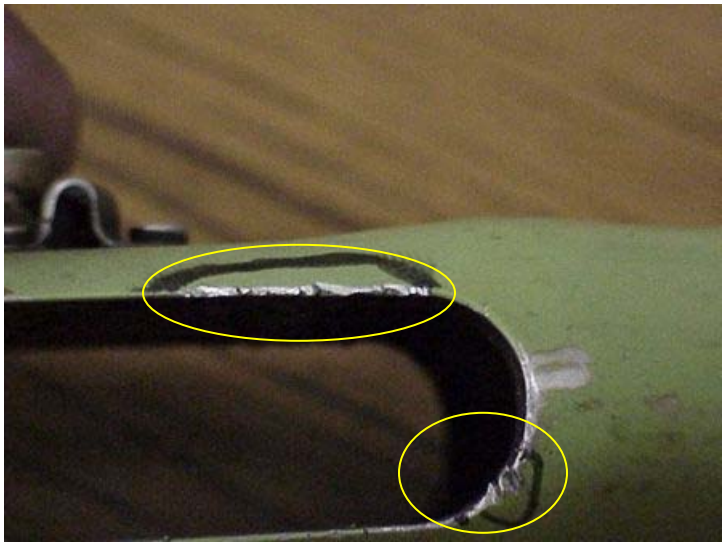


Figure A-48. B737 P/N: 69-37290-13, N000A2
Inspection Phase 1: (3) Impact Damage 16 x 1 mm
(4) Impact Damage 3 x 3 mm

Figure A-49. B737 P/N: 69-37290-13, N000A2
Inspection Phase 2: (5) Impact Damage 3 x 2 mm

Figure A-50. B737 P/N: 69-37290-13, N000A2, A
Inspection Phase 3: No Defects Noted

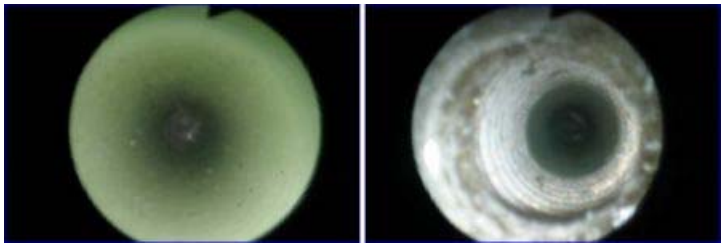


Figure A-51. B737 P/N: 69-37290-13, N000A2, A (View 2)
Inspection Phase 3: No Defects Noted

Figure A-52. B737 P/N: 69-37290-13, N000A2, B
Inspection Phase 1: (1) Protective Coating Wear

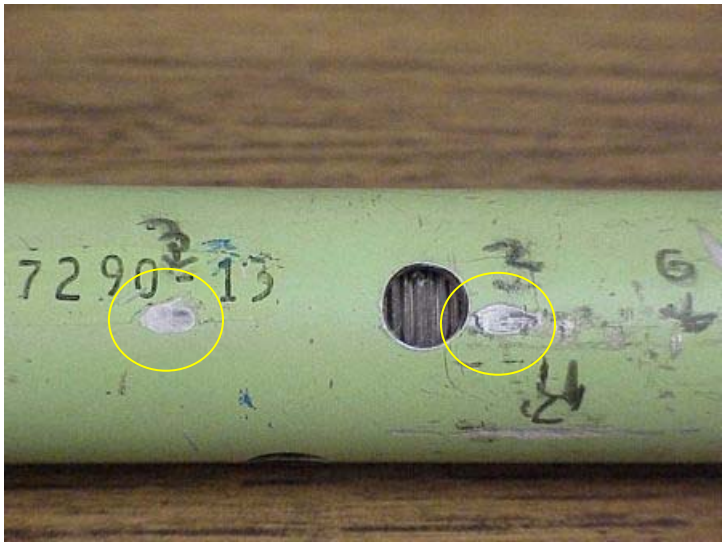


Figure A-53. B737 P/N: 69-37290-13, N000A2
Inspection Phase 1: (2) Gouge 6 mm x 3 mm x 0.002″ deep
(3) Gouge 6 mm x 3 mm x 0.002″ deep

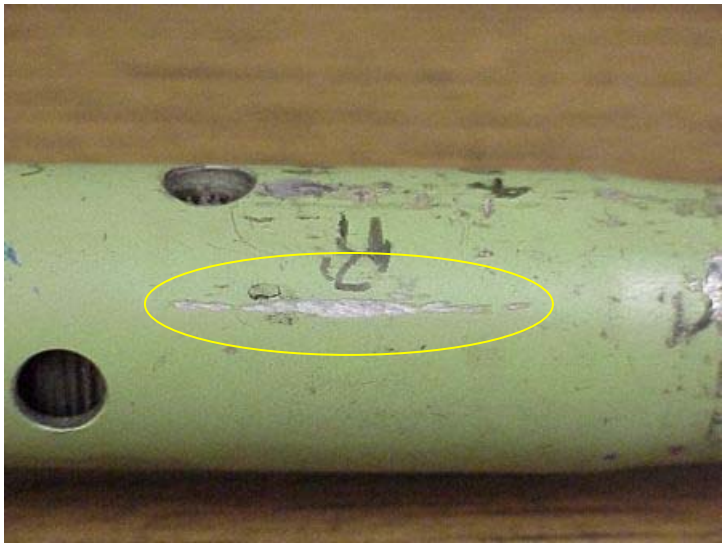


Figure A-54. B737 P/N: 69-37290-13, N000A2
Inspection Phase 1: (4) Gouge 28 x 2 mm

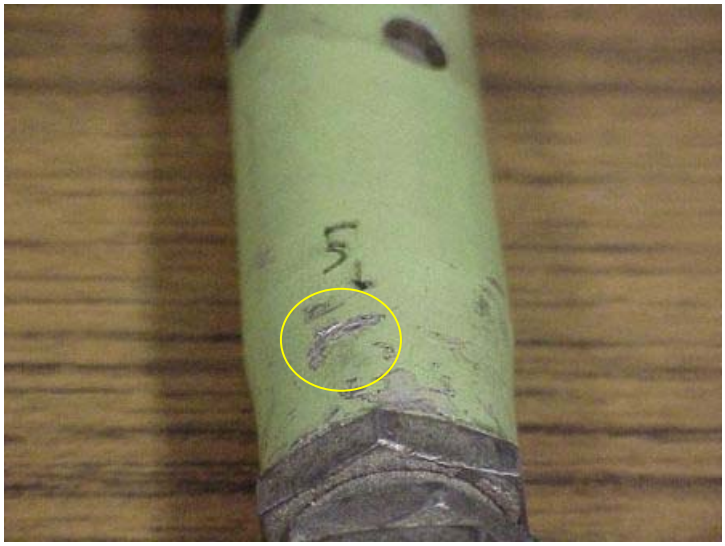


Figure A-55. B737 P/N: 69-37290-13, N000A2
Inspection Phase 1: (5) Gouge 8 mm x 1.5 mm x 0.0025″ deep

Figure A-56. B737 P/N: 69-37290-13, N000A2
Inspection Phase 1: (6) Impact Damage 3 mm x 1 mm x 0.0025″ deep

Figure A-57. B737 P/N: 69-37290-13, N000A2
Inspection Phase 1: (7) Impact Damage 6 x 5 mm

Figure A-58. B737 P/N: 69-37290-13, N000A2
Inspection Phase 1: (8) Impact Damage 2 x 0.5 mm

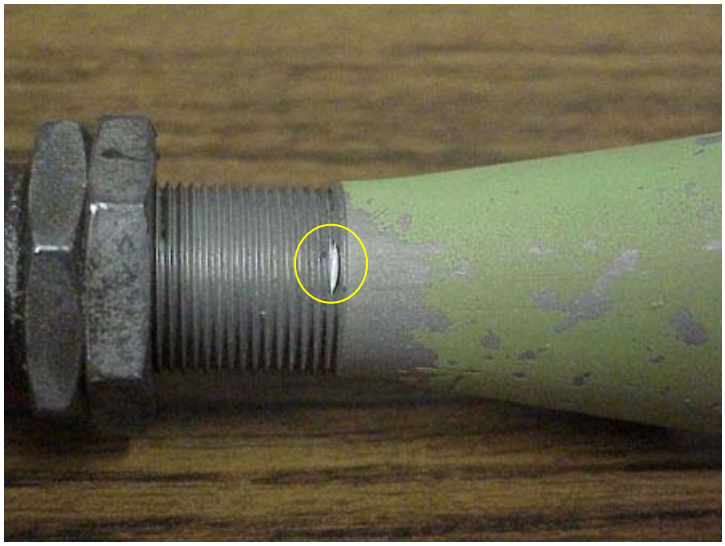


Figure A-59. B737 P/N: 69-37290-13, N000A2
Inspection Phase 2: (9) Thread Damage

Figure A-60. B737 P/N: 69-37290-13, N000A2, B
Inspection Phase 3: No Defects Noted

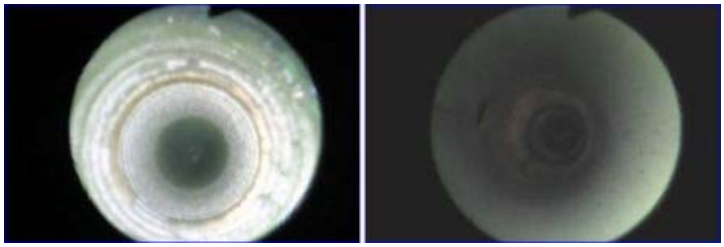


Figure A-61. B737 P/N: 69-37290-13, N000A2
Inspection Phase 4: No Defects Noted

The visual inspection results from table 8 are shown in figures A-62 through A-78.

Figure A-62. B737 P/N: 69-37290-13, N000A2
Inspection Phase 1: (1) Protective Coating Wear

Figure A-63. B737 P/N: 69-37290-13, N000A2
Inspection Phase 2: No Defects Noted

Figure A-64. B737 P/N: 69-37290-13, N000A2
Inspection Phase 3: No Defects Noted

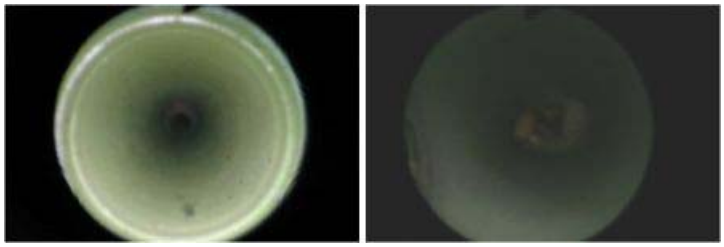


Figure A-65. B737 P/N: 69-37290-13, N000A2, Table 8
Inspection Phase 4: No Defects Noted

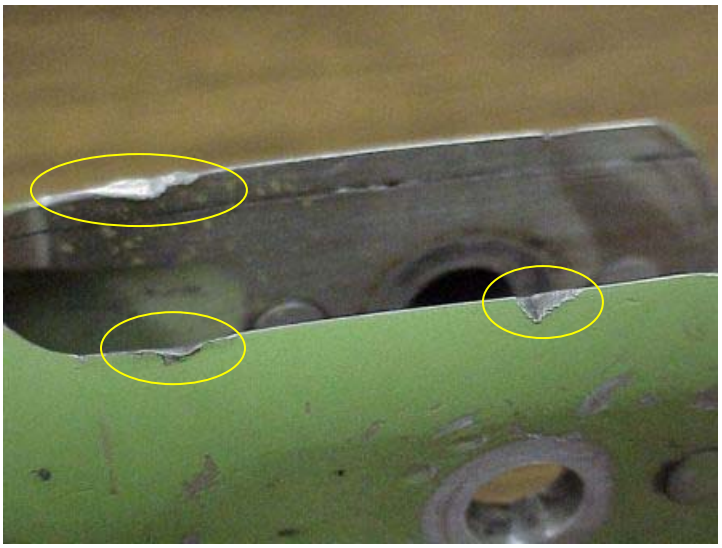


Figure A-66. B737 P/N: 69-37290-13, N000A1
Inspection Phase 1: (1) Impact Damage

Figure A-67. B737 P/N: 69-37290-13, N000A1
Inspection Phase 2: (2) Impact Damage

Figure A-68. B737 P/N: 69-37290-13, N000A1, Table 8, A
Inspection Phase 3: No Defects Noted

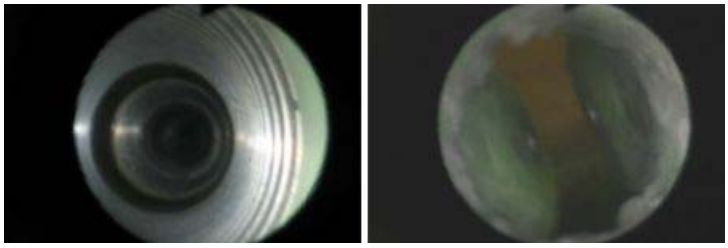


Figure A-69. B737 P/N: 69-37290-13, N000A1, Table 8, A
Inspection Phase 4: No Defects Noted

Figure A-70. B737 P/N: 69-37290-13, N000A1, Table 8
Inspection Phase 1: No Defects Noted

Figure A-71. B737 P/N: 69-37290-13, N000A1
Inspection Phase 2: (1) Impact Damage

Figure A-72. B737 P/N: 69-37290-13, N000A1, Table 8, B
Inspection Phase 3: No Defects Noted

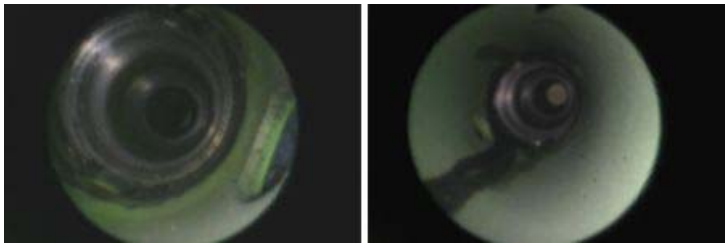


Figure A-73. B737 P/N: 69-37290-13, N000A1, Table 8, B
Inspection Phase 4: No Defects Noted

Figure A-74. B737 P/N: 69-37290-13, N000B1
Inspection Phase 1: (1) Circular Abrasion

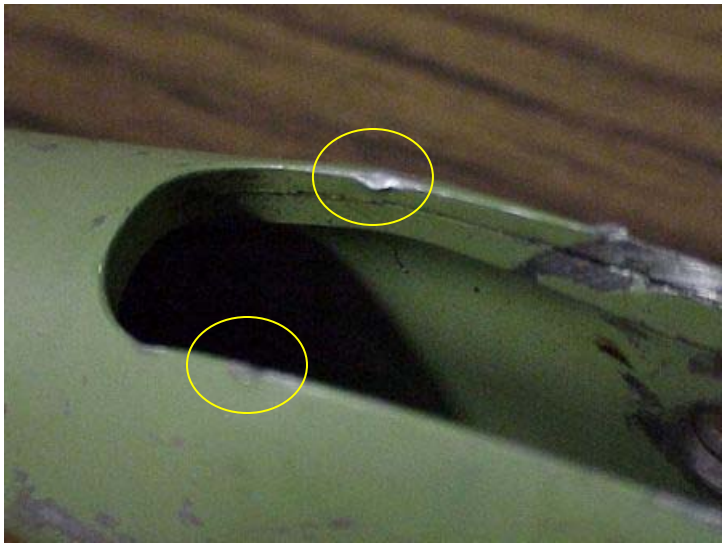


Figure A-75. B737 P/N: 69-37290-13, N000B1
Inspection Phase 1: (2) Impact Damage

Figure A-76. B737 P/N: 69-37290-13, N000B1
Inspection Phase 2: No Defects Noted

Figure A-77. B737 P/N: 69-37290-13, N000B1, Table 8
Inspection Phase 3: No Defects Noted

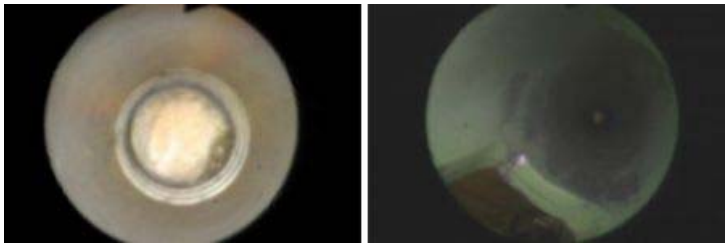


Figure A-78. B737 P/N: 69-37290-13, N000B1
Inspection Phase 4: No Defects Noted

The visual inspection results from table 9 are shown in figures A-79 through A-83.

Figure A-79. B737 P/N: 69-37290-15, N000A1
Inspection Phase 1: (1) Protective Coating Wear

Figure A-80. B737 P/N: 69-37290-15, N000A1
Inspection Phase 1: (2) Corrosion

Figure A-81. B737 P/N: 69-37290-15, N000A1
Inspection Phase 2: No Defects Noted

Figure A-82. B737 P/N: 69-37290-15, N000A1
Inspection Phase 3: (3) Sand Found

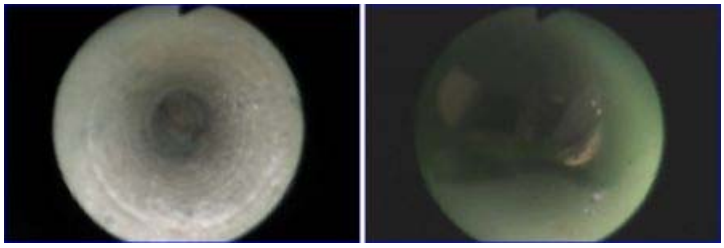


Figure A-83. B737 P/N: 69-37290-15, N000A1
Inspection Phase 4: No Defects Noted

The visual inspection results from table 10 are shown in figures A-84 through A-101.

Figure A-84. B737 P/N: 69-40718-8, N000A1, A
Inspection Phase 1: No Defects Noted

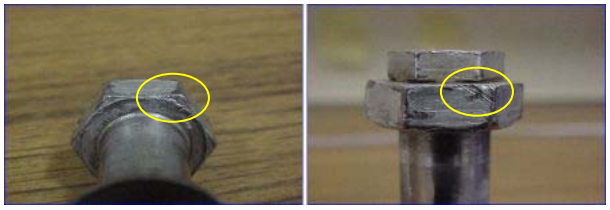


Figure A-85. B737 P/N: 69-40718-8, N000A1
Inspection Phase 2: (1) Various Minor Dents
and Scratches on Larger Bolt Head

Figure A-86. B737 P/N: 69-40718-8, N000A1
Inspection Phase 3: (1) Slight Wear Marks
Adhesive Coating Hinders Visual Inspection

Figure A-87. B737 P/N: 69-40718-8, N000A1, B
Inspection Phase 1: No Defects Noted

Figure A-88. B737 P/N: 69-40718-8, N000A1
Inspection Phase 2: No Defects Noted

Figure A-89. B737 P/N: 69-40718-8, N000A1
Inspection Phase 3: Adhesive Coating
Hinders Visual Inspection

Figure A-90. B737 P/N: 69-40718-8, N000A2, A
Inspection Phase 1: No Defects Noted

Figure A-91. B737 P/N: 69-40718-8, N000A2, A
Inspection Phase 2: No Defects Noted

Figure A-92. B737 P/N: 69-40718-8, N000A2
Inspection Phase 1: (1) Discoloration of Inner Bolt
Shank/Possible Corrosive Reaction

Figure A-93. B737 P/N: 69-40718-8, N000A2, B
Inspection Phase 1: No Defects Noted

Figure A-94. B737 P/N: 69-40718-8, N000A2, B
Inspection Phase 2: No Defects Noted

Figure A-95. B737 P/N: 69-40718-8, N000A2
Inspection Phase 3: Adhesive Coating
Hinders Visual Inspection

Figure A-96. B737 P/N: 69-40718-8, N000B1, A
Inspection Phase 1: No Defects Noted

Figure A-97. B737 P/N: 69-40718-8, N000B1, A
Inspection Phase 2: No Defects Noted

Figure A-98. B737 P/N: 69-40718-8, N000B1, A
Inspection Phase 3: Adhesive Coating
Hinders Visual Inspection

Figure A-99. B737 P/N: 69-40718-8, N000B1, B
Inspection Phase 1: No Defects Noted

Figure A-100. B737 P/N: 69-40718-8, N000B1, B
Inspection Phase 2: No Defects Noted

Figure A-101. B737 P/N: 69-40718-8, N000B1, B
Inspection Phase 3: Adhesive Coating
Hinders Visual Inspection

The visual inspection results from table 11 are shown in figures A-102 through A-118.

Figure A-102. B737 P/N: 69-43282-1, N000A2
Inspection Phase 1: No Defects Noted

Figure A-103. B737 P/N: 69-43282-1, N000A2
Inspection Phase 2: (1) Scratches Possible
From Removal (2) Gouge Possible From Removal

Figure A-104. B737 P/N: 69-43282-1, N000A2, A
Inspection Phase 3: Unable To Press Out Inner Bolt

Figure A-105. B737 P/N: 69-43282-1, N000A2
Inspection Phase 1: No Defects Noted

Figure A-106. B737 P/N: 69-43282-1, N000A2
Inspection Phase 2: (1) Gouge

Figure A-107. B737 P/N: 69-43282-1, N000A2
Inspection Phase 2: (2) Gouge/Wear Mark

Figure A-108. B737 P/N: 69-43282-1, N000A2
Inspection Phase 2: (3) Scratch Possible From Removal

Figure A-109. B737 P/N: 69-43282-1, N000A2, B
Inspection Phase 3: Unable To Press Out Inner Bolt

Figure A-110. B737 P/N: 69-43282-1, N000A1, A
Inspection Phase 1: No Defects Noted

Figure A-111. B737 P/N: 69-43282-1, N000A1, A
Inspection Phase 2: No Defects Noted

Figure A-112. B737 P/N: 69-43282-1, N000A1, A
Inspection Phase 3: Unable to Press out Inner Bolt

Figure A-113. B737 P/N: 69-43282-1, N000A1, B
Inspection Phase 1: No Defects Noted

Figure A-114. B737 P/N: 69-43282-1, N000A1
Inspection Phase 2: Thread Damage

Figure A-115. B737 P/N: 69-43282-1, N000A1, B
Inspection Phase 3: Unable to Press out Inner Bolt

Figure A-116. B737 P/N: 69-43282-1, N000B1
Inspection Phase 1: No Defects Noted

Figure A-117. B737 P/N: 69-43282-1, N000B1
Inspection Phase 2: No Defects Noted

Figure A-118. B737 P/N: 69-43282-1, N000B1
Inspection Phase 3: Unable to Press out Inner Bolt

The visual inspection results from table 12 are shown in figures A-119 through A-130.

Figure A-119. B737 P/N: 69-43956-1, N000A1, A
Inspection Phase 1: No Defects Noted

Figure A-120. B737 P/N: 69-43956-1, N000A1
Inspection Phase 2: (1) Thread Damage on
Outer and Inner Bolt

Figure A-121. B737 P/N: 69-43956-1, N000A1
Inspection Phase 3: (2) Bolt is Slightly Bent
Which Prohibits Inner Bolt Disassembly

Figure A-122. B737 P/N: 69-43956-1, N000A1, B
Inspection Phase 1: No Defects Noted

Figure A-123. B737 P/N: 69-43956-1, N000A1
Inspection Phase 2: (1) Bolt is Slightly Bent

Figure A-124. B737 P/N: 69-43956-1, N000A1
Inspection Phase 3: Disassembly
Prohibited by Bolt Being Bent

Figure A-125. B737 P/N: 69-43956-1, N000A2, A
Inspection Phase 1: No Defect Noted

Figure A-126. B737 P/N: 69-43956-1, N000A2, A
Inspection Phase 2: No Defect Noted

Figure A-127. B737 P/N: 69-43956-1, N000A2, A
Inspection Phase 3: No Defect Noted

Figure A-128. B737 P/N: 69-43956-1, N000A2, B
Inspection Phase 1: No Defect Noted

Figure A-129. B737 P/N: 69-43956-1, N000A2, B
Inspection Phase 2: No Defect Noted

Figure A-130. B737 P/N: 69-43956-1, N000A2, B
Inspection Phase 3: No Defect Noted

The visual inspection results from table 13 are shown in figures A-131 through A-156.

Figure A-131. B737 P/N: 69-44427-3, N000A1
Inspection Phase 1: (1) Protective Coating Wear

Figure A-132. B737 P/N: 69-44427-3, N000A1, A
Inspection Phase 2: No Defects Noted
(Note: Cleaning removed remainder of protective coating.)

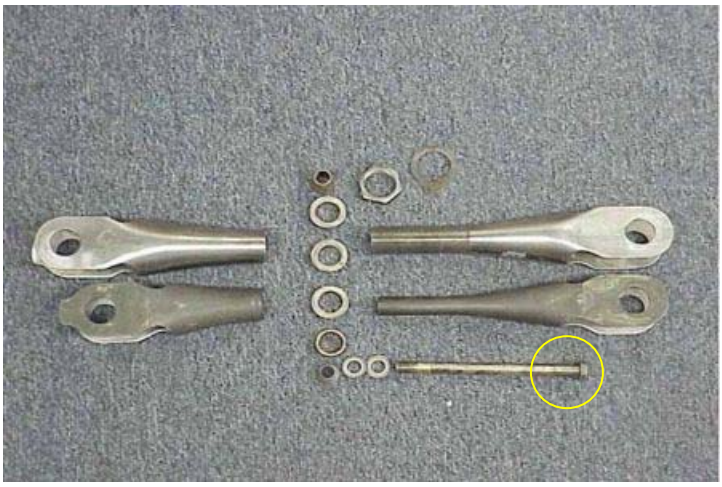


Figure A-133. B737 P/N: 69-44427-3, N000A1
Inspection Phase 3: Boeing Confirms that Hex Head
Bolt does not meet boeing design spec (Incorrect bolt used)

Figure A-134. B737 P/N: 69-44427-3, N000A1, A
Inspection Phase 4: No Defects Noted

Figure A-135. B737 P/N: 69-44427-3, N000A1
Inspection Phase 1: Protective Coating Wear

Figure A-136. B737 P/N: 69-44427-3, N000A1, B
Inspection Phase 2: No Defects Noted
(Note: Cleaning removed remainder of protective coating.)

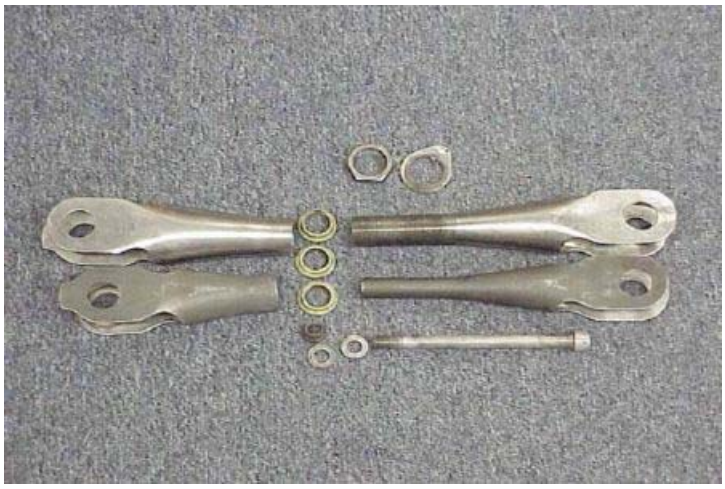


Figure A-137. B737 P/N: 69-44427-3, N000A1
Inspection Phase 3: No Defects Noted

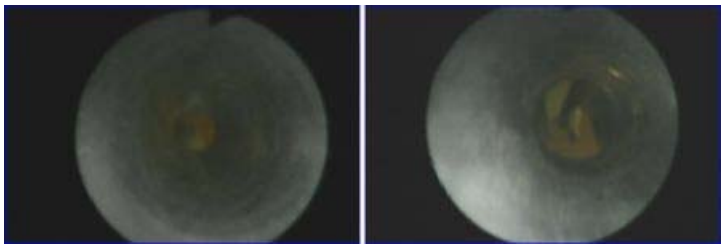


Figure A-138. B737 P/N: 69-44427-3, N000A1, B
Inspection Phase 4: No Defects Noted

Figure A-139. B737 P/N: 69-44427-3, N000A2
Inspection Phase 1: No Defects Noted

Figure A-140. B737 P/N: 69-44427-3, N000A2
Inspection Phase 2: No Defects Noted
(Note: Cleaning removed remainder of protective coating.)

Figure A-141. B737 P/N: 69-44427-3, N000A2
Inspection Phase 3: No Defects Noted

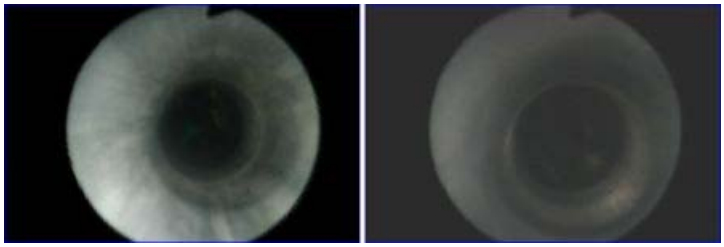


Figure A-142. B737 P/N: 69-44427-3, N000A2
Inspection Phase 4: No Defects Noted

Figure A-143. B737 P/N: 69-44427-3, N000A2
Inspection Phase 1: Protective Coating Wear

Figure A-144. B737 P/N: 69-44427-3, N000A2
Inspection Phase 2: No Defects Noted

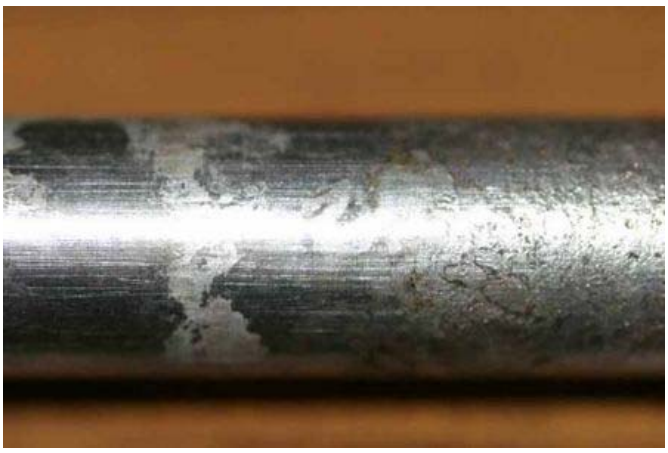


Figure A-145. B737 P/N: 69-44427-3, N000A2
Inspection Phase 3: (1) Corrosion Along Bolt Shank

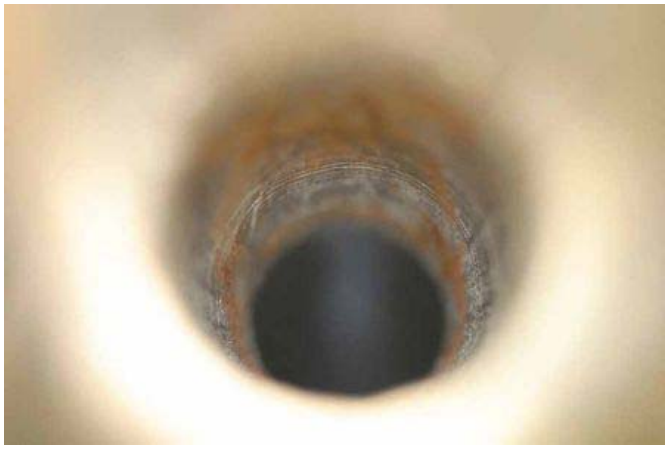


Figure A-146. B737 P/N: 69-44427-3, N000A2
Inspection Phase 3: (2) Corrosion Inside of Rod

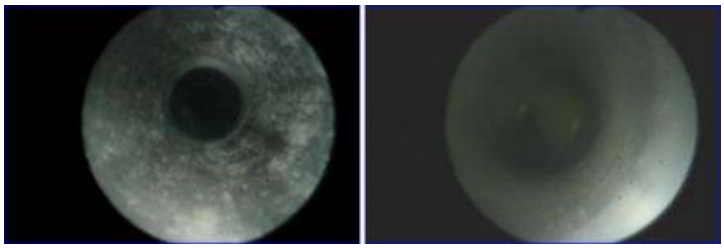


Figure A-147. B737 P/N: 69-44427-3, N000A2, Table 13
Inspection Phase 4: No Defects Noted

Figure A-148. B737 P/N: 69-44427-3, N000B1, A
Inspection Phase 1: No Defects Noted

Figure A-149. B737 P/N: 69-44427-3, N000B1, A
Inspection Phase 2: No Defects Noted

Figure A-150. B737 P/N: 69-44427-3, N000B1
Inspection Phase 3: (1) Corrosion Along Shank of Bolt

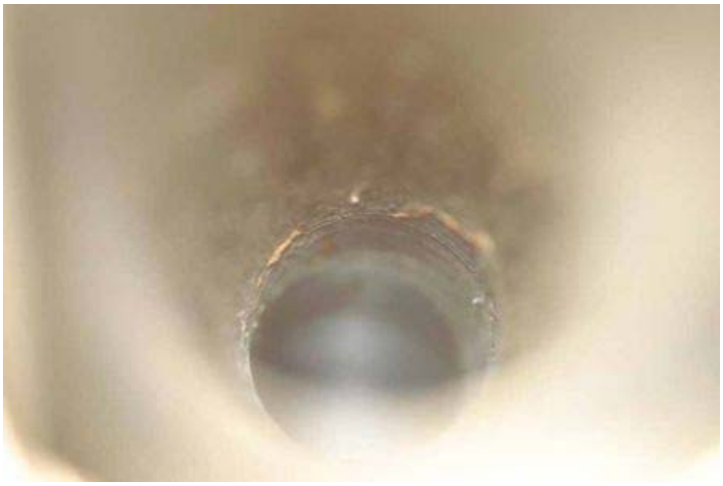


Figure A-151. B737 P/N: 69-44427-3, N000B1
Inspection Phase 3: (2) Corrosion Inside of Rod

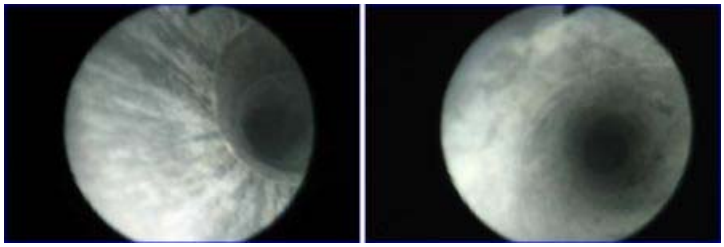


Figure A-152. B737 P/N: 69-44427-3, N000B1, A
Inspection Phase 4: No Defects Noted

Figure A-153. B737 P/N: 69-44427-3, N000B1, B
Inspection Phase 1: No Defects Noted

Figure A-154. B737 P/N: 69-44427-3, N000B1, B
Inspection Phase 2: No Defects Noted

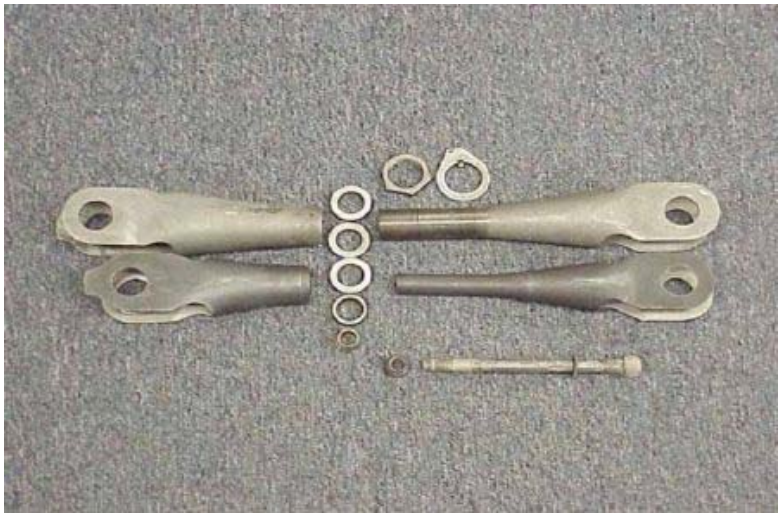


Figure A-155. B737 P/N: 69-44427-3, N000B1
Inspection Phase 3: No Defects Noted

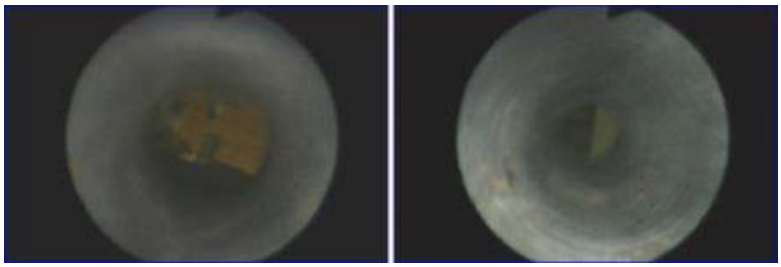


Figure A-156. B737 P/N: 69-44427-3, N000B1, B
Inspection Phase 4: No Defects Noted

The visual inspection results from table 14 are shown in figures A-157 through A-168.

Figure A-157. B737 P/N: 69-44683-2, N000A1, A
Inspection Phase 1: No Defects Noted

Figure A-158. B737 P/N: 69-44683-2, N000A1, A
Inspection Phase 2: No Defects Noted

Figure A-159. B737 P/N: 69-44683-2, N000A1, A
Inspection Phase 3: Adhesive Coating
Hinders Visual Inspection

Figure A-160. B737 P/N: 69-44683-2, N000A1, B
Inspection Phase 1: No Defects Noted

Figure A-161. B737 P/N: 69-44683-2, N000A1, B
Inspection Phase 2: No Defects Noted

Figure A-162. B737 P/N: 69-44683-2, N000A1, B
Inspection Phase 3: Adhesive Coating
Hinders Visual Inspection

Figure A-163. B737 P/N: 69-44683-2, N000A2, A
Inspection Phase 1: No Defects Noted

Figure A-164. B737 P/N: 69-44683-2, N000A2, A
Inspection Phase 2: No Defects Noted

Figure A-165. B737 P/N: 69-44683-2, N000A2, A
Inspection Phase 3: Adhesive Coating
Hinders Visual Inspection

Figure A-166. B737 P/N: 69-44683-2, N000A2, B
Inspection Phase 1: No Defects Noted

Figure A-167. B737 P/N: 69-44683-2, N000A2, B
Inspection Phase 2: No Defects Noted

Figure A-168. B737 P/N: 69-44683-2, N000A2, B
Inspection Phase 3: Adhesive Coating
Hinders Visual Inspection

The visual inspection results from table 15 are shown in figures A-169 through A-171.

Figure A-169. B737 P/N: 2A7-200A, N000B1
Operates and Passes all Performance Requirements

Figure A-170. B737 P/N: 2590653-901, N000A1
Failed Integrated Test (Unit Deemed Not Airworthy)

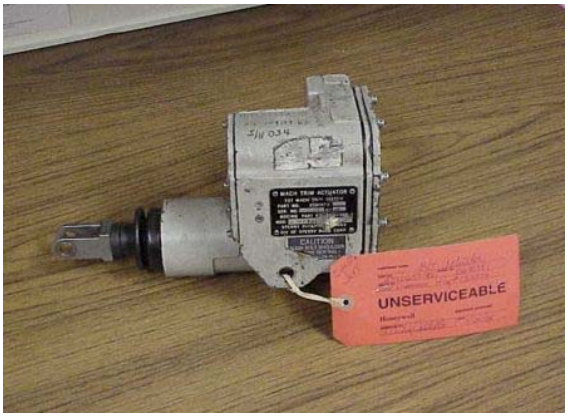


Figure A-171. B737 P/N: 2590653-901, N000A2
Failed Integrated Test (Unit Deemed Not Airworthy)

The visual inspection results from table 16 are shown in figures A-172 through A-185.

Figure A-172. B747 P/N: 65B80481-1, N000A3
Inspection Phase 1: No Defects Noted

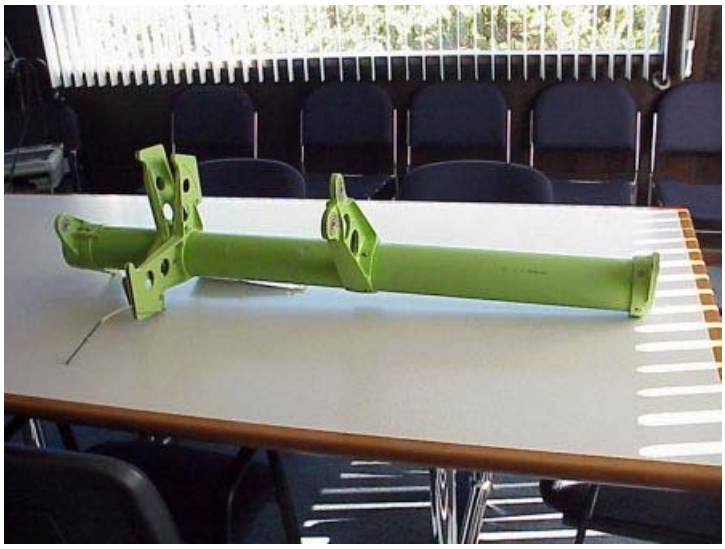


Figure A-173. B747 P/N: 65B80481-1, N000A3
Inspection Phase 2: No Defects Noted

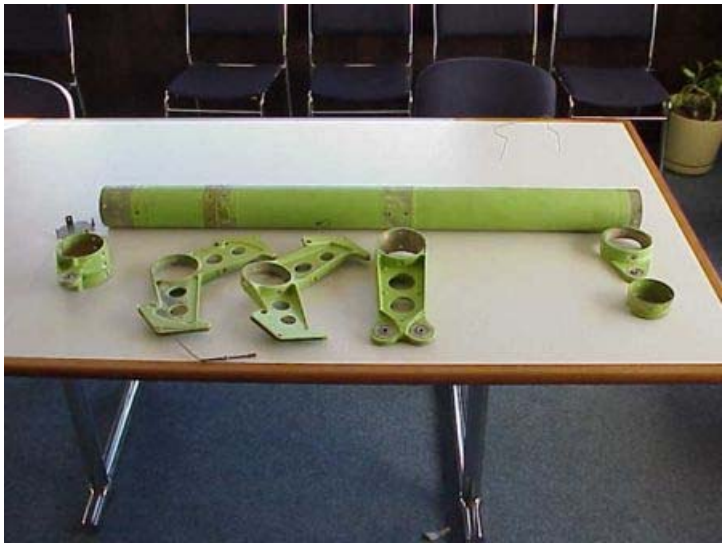


Figure A-174. B747 P/N: 65B80481-1, N000A3
Inspection Phase 3: No Defects Noted

Figure A-175. B747 P/N: 65B80481-1, N000C1
Inspection Phase 1: (1) Surface Corrosion on Fasteners
(2) Protective Coating Removed Possibly From Hydraulic Fluid

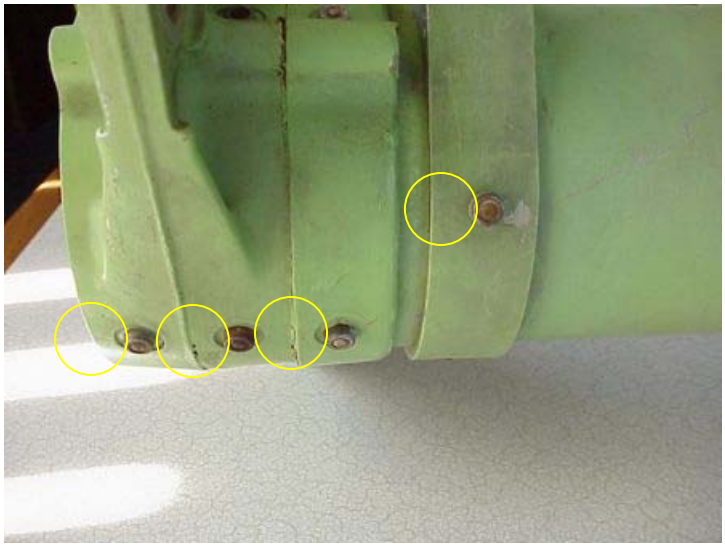


Figure A-176. B747 P/N: 65B80481-1, N000C1
Inspection Phase 1: (3) Surface Corrosion
on Fasteners From Opposite Side of Tube

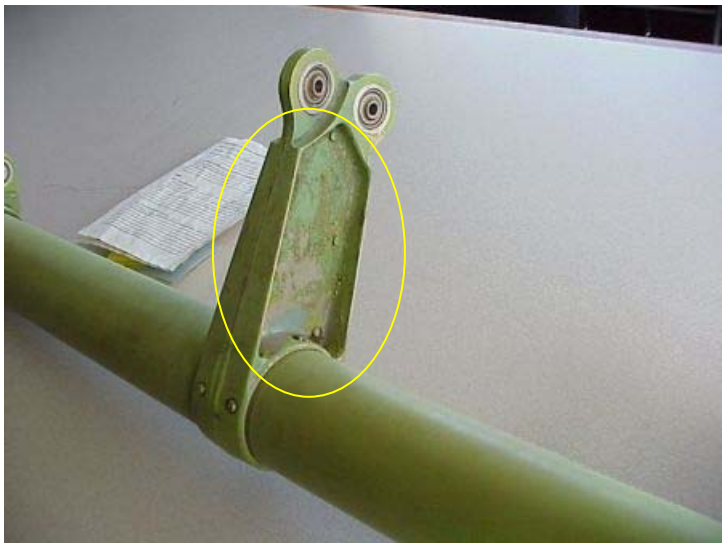


Figure A-177. B747 P/N: 65B80481-1, N000C1
Inspection Phase 1: (4) Paint Removed
Possibly From Hydraulic Fluid

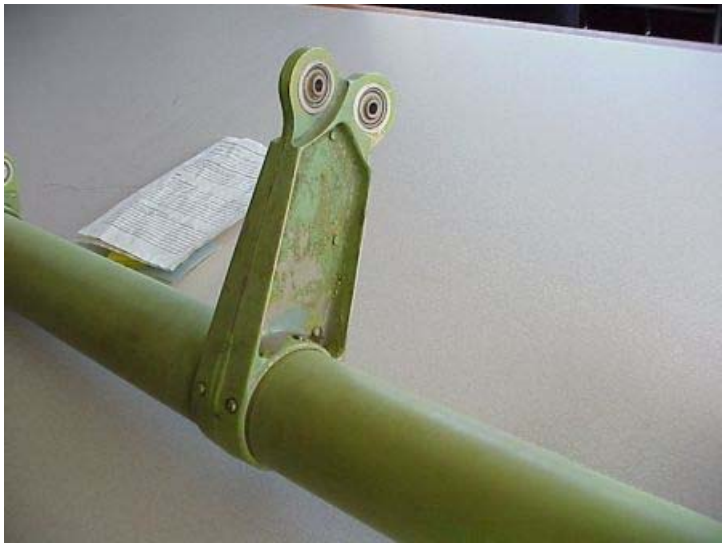


Figure A-178. B747 P/N: 65B80481-1, N000C1
Inspection Phase 2: No Defects Noted

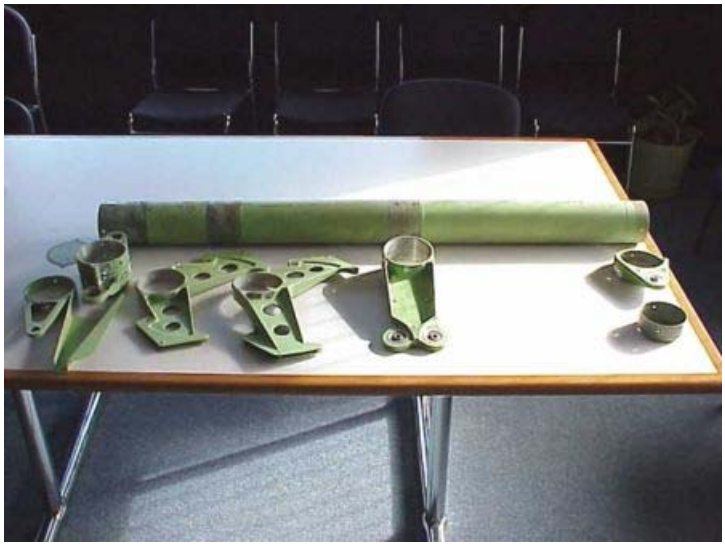


Figure A-179. B747 P/N: 65B80481-1, N000C1
Inspection Phase 3: No Defects Noted

Figure A-180. B747 P/N: 65B80481-1, KG-DDD
Inspection Phase 1: No Defects Noted

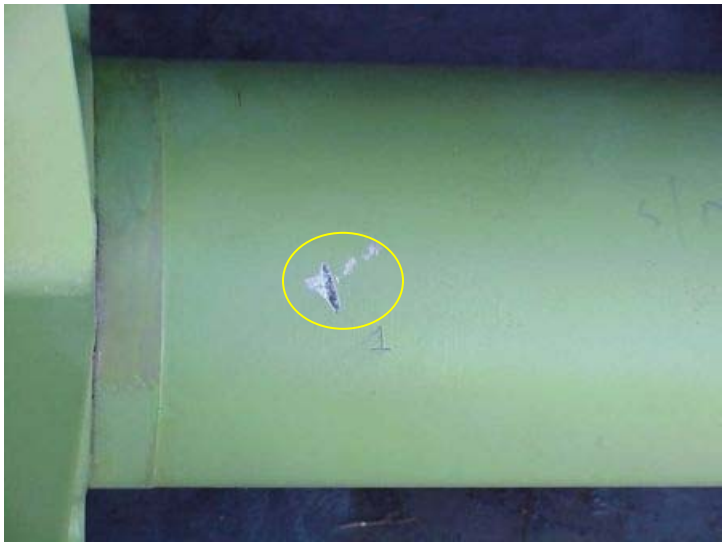


Figure A-181. B747 P/N: 65B80481-1, KG-DDD
Inspection Phase 2: (1) Impact Damage
10 mm x 2 mm x 0.0030″ deep

Figure A-182. B747 P/N: 65B80481-1, KG-DDD
Inspection Phase 3: No Defects Noted

Figure A-183. B747 P/N: 65B80481-1, Extra
Inspection Phase 1: No Defects Noted

Figure A-184. B747 P/N: 65B80481-1, Extra Inspection Phase 2: No Defects Noted

Figure A-185. B747 P/N: 65B80481-1, Extra Inspection Phase 3: No Defects Noted

The visual inspection results from table 17 are shown in figures A-186 through A-200.

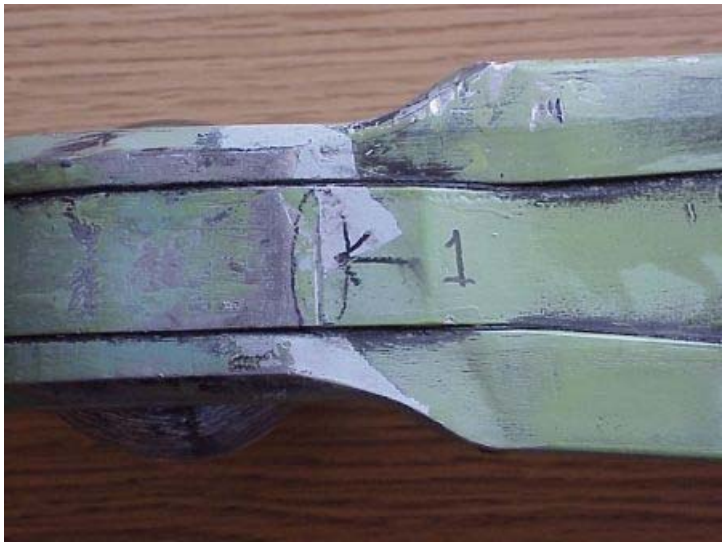


Figure A-186. B747 P/N: 65B80832-4, N000A3
Inspection Phase 1: (1) Impact Damage
22 mm x 1 mm x 0.00125″ deep

Figure A-187. B747 P/N: 65B80832-4, N000A3
Inspection Phase 2: (2) Approx. 60% of Bearing
Surface Worn (Depth up to 0.088″)

Figure A-188. B747 P/N: 65B80832-4, N000A3
Inspection Phase 2: (3) Corrosion Around
Bushing up to 0.014″ deep

Figure A-189. B747 P/N: 65B80832-4, N000A3
Inspection Phase 3: No Defects Noted

Figure A-190. B747 P/N: 65B80832-4, N000C1
Inspection Phase 1: (1) Minor Corrosion
on Fastener

Figure A-191. B747 P/N: 65B80832-4, N000C1
Inspection Phase 2: (2) Approx. 40% of Bearing
Surface Worn (Depth up to 0.004″)

Figure A-192. B747 P/N: 65B80832-4, N000C1
Inspection Phase 2: (3) Impact Damage
Around Bushing (Depth up to 0.0122″ deep)

Figure A-193. B747 P/N: 65B80832-4, N000C1
Inspection Phase 2: (4) Rotational Wear
Possibly Due to Worn Bearing

Figure A-194. B747 P/N: 65B80832-4, N000C1
Inspection Phase 3: No Defects Noted

Figure A-195. B747 P/N: 65B80832-4, KG-DDD
Inspection Phase 1: (1) Corrosion on Fasteners

Figure A-196. B747 P/N: 65B80832-4, KG-DDD
Inspection Phase 2: Impact Damage
35 mm x 3 mm x 0.118″ deep

Figure A-197. B747 P/N: 65B80832-4, KG-DDD
Inspection Phase 2: (3) Scratches

Figure A-198. B747 P/N: 65B80832-4, KG-DDD
Inspection Phase 2: (4) Corrosion Around Bushing

Figure A-199. B747 P/N: 65B80832-4, KG-DDD
Inspection Phase 2: (5) Approx. 25% of
Bearing Surface Worn

Figure A-200. B747 P/N: 65B80832-4, KG-DDD
Inspection Phase 3: No Defects Noted

The visual inspection results from table 18 are shown in figures A-201 through A-228.

Figure A-201. B747 P/N: 65B81011-414, N000A3
Inspection Phase 1: (1) Protective Coating Wear

Figure A-202. B747 P/N: 65B81011-414, N000A3
Inspection Phase 2: No Defects Noted

Figure A-203. B747 P/N: 65B81011-414, N000A3
Inspection Phase 3: No Defects Noted

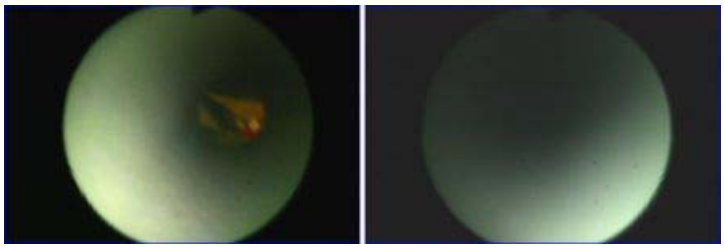


Figure A-204. B747 P/N: 65B81011-414, N000A3
Inspection Phase 4: No Defects Noted

Figure A-205. B747 P/N: 65B81011-413, N000A3
Inspection Phase 1: No Defects Noted

Figure A-206. B747 P/N: 65B81011-413, N000A3
Inspection Phase 2: No Defects Noted

Figure A-207. B747 P/N: 65B81011-413, N000A3
Inspection Phase 3: (1) Corrosion on Bolt Face
(2) Corrosion in Inside Inner Bolt

Figure A-208. B747 P/N: 65B81011-413, N000A3
Inspection Phase 4: (2) Corrosion Inside Inner Bolt

Figure A-209. B747 P/N: 65B81011-414, N000C1
Inspection Phase 1: No Defects Noted

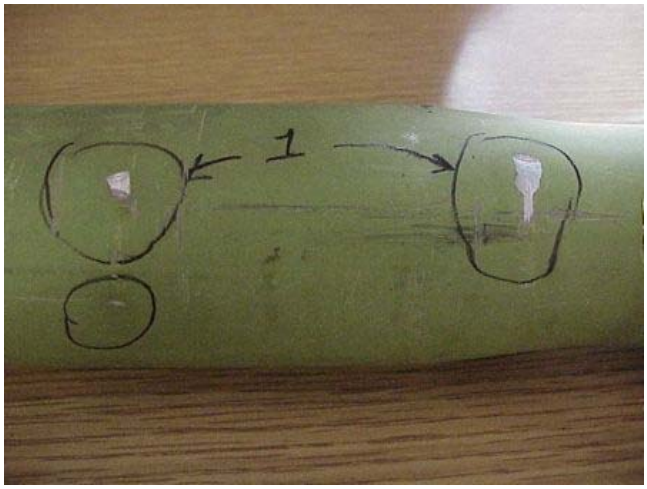


Figure A-210. B747 P/N: 65B81011-414, N000C1
Inspection Phase 2: (1) Impact Damage in
Three Places Largest 15 x 5 mm

Figure A-211. B747 P/N: 65B81011-414, N000C1
Inspection Phase 3: (2) Corrosion on Inside of Bolt
(See figure A-212)

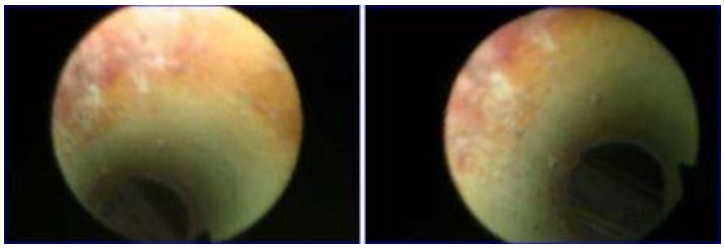


Figure A-212. B747 P/N: 65B81011-414, N000C1
Inspection Phase 4: (2) Corrosion on Inside of Bolt

Figure A-213. B747 P/N: 65B81011-413, N000C1
Inspection Phase 1: No Defects Noted

Figure A-214. B747 P/N: 65B81011-413, N000C1
Inspection Phase 2: No Defects Noted

Figure A-215. B747 P/N: 65B81011-413, N000C1
Inspection Phase 3: (1) Corrosion On Inner
Bolt (See figure A-216)

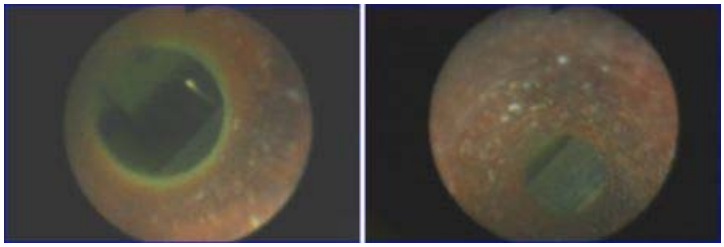


Figure A-216. B747 P/N: 65B81011-413, N000C1
Inspection Phase 4: (1) Corrosion on Inner Bolt

Figure A-217. B747 P/N: 65B81011-413, KG-DDD
Inspection Phase 1: No Defects Noted

Figure A-218. B747 P/N: 65B81011-413, KG-DDD
Inspection Phase 2: (1) Protective Coating Wear

Figure A-219. B747 P/N: 65B81011-413, KG-DDD
Inspection Phase 2: (2) Protective Coating Wear

Figure A-220. B747 P/N: 65B81011-413, KG-DDD
Inspection Phase 2: (3) Three Scratches
25, 20, and 7 mm long

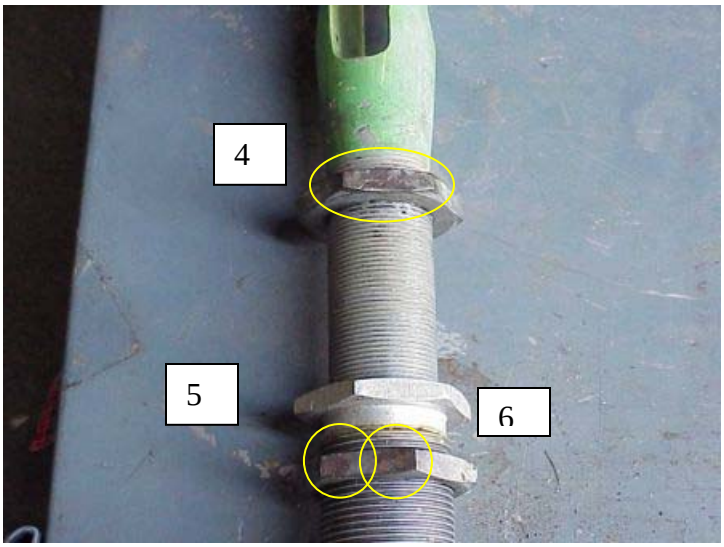


Figure A-221. B747 P/N: 65B81011-413, KG-DDD
Inspection Phase 3: (4) Corrosion 40 x 7 mm,
(5) Corrosion 13 x 7 mm, and (6) Corrosion 15 x 7 mm

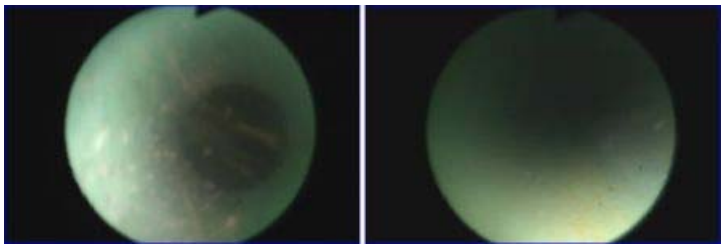


Figure A-222. B747 P/N: 65B81011-413, KG-DDD
Inspection Phase 4: No Defects Noted

Figure A-223. B747 P/N: 65B81011-413, KG-DDD
Inspection Phase 1: (1) Protective Coating Wear

Figure A-224. B747 P/N: 65B81011-413, KG-DDD
Inspection Phase 2: No Defects Noted

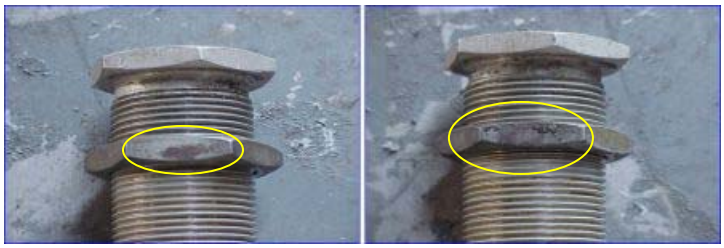


Figure A-225. B747 P/N: 65B81011-413, KG-DDD
Inspection Phase 3: (2) Corrosion 15 x 5 mm,
and (3) Corrosion 13 x 7 mm

Figure A-226. B747 P/N: 65B81011-413, KG-DDD
Inspection Phase 3: (4) Corrosion on Nut

Figure A-227. B747 P/N: 65B81011-413, KG-DDD
Inspection Phase 3: (5) Corrosion on Bolt Face

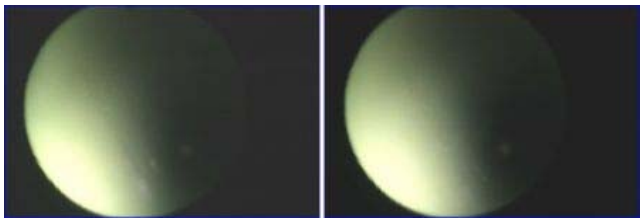


Figure A-228. B747 P/N: 65B81011-413, KG-DDD
Inspection Phase 3: No Defects Noted

The visual inspection results from table 19 are shown in figures A-229 through A-262.

Figure A-229. B747 P/N: 65B81011-513, N000A3
Inspection Phase 1: No Defects Noted

Figure A-230. B747 P/N: 65B81011-513, N000A3
Inspection Phase 2: (1) Diamond-Shaped Dent
Diamond Perimeter top 5 x 5 mm and bottom
10 x 10 mm

Figure A-231. B747 P/N: 65B81011-513, N000A3
Inspection Phase 3: (2) BMS-95 Sealant Omitted
Between Air Dam Tube and Outer Tube

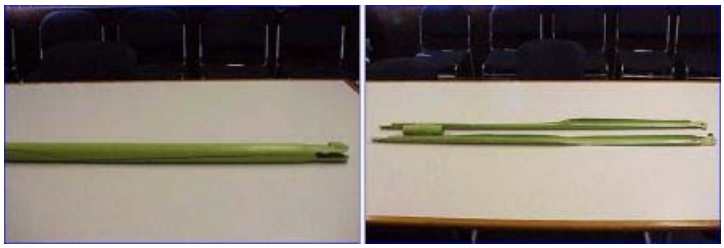


Figure A-232. B747 P/N: 65B81011-513, N000A3
Inspection Phases 4 and 5: Tube Sectioned Horizontally
and Used as an NDI (Eddy-Current) Test Specimen

Figure A-233. B747 P/N: 65B81011-509, N000A3
Inspection Phase 1: (1) Protective Coating Wear

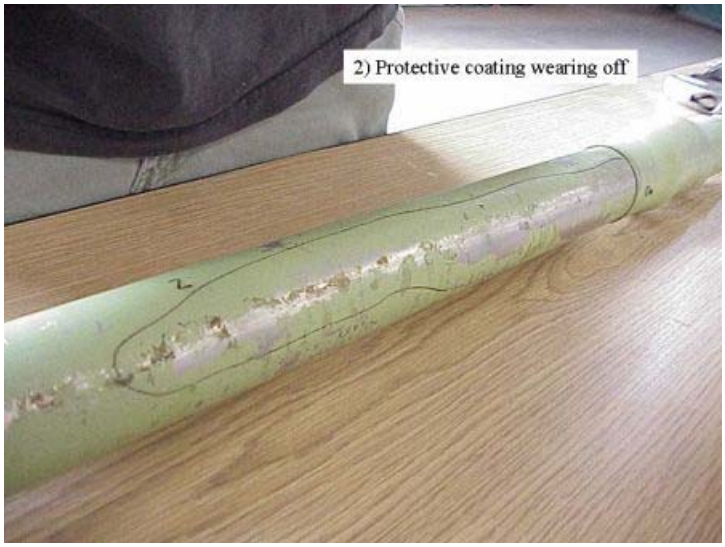


Figure A-234. B747 P/N: 65B81011-509, N000A3
Inspection Phase 1: (2) Protective Coating Wear

Figure A-235. B747 P/N: 65B81011-509, N000A3
Inspection Phase 1: (3) Protective Coating Wear

Figure A-236. B747 P/N: 65B81011-509, N000A3
Inspection Phase 2: (4) Gouge

Figure A-237. B747 P/N: 65B81011-509, N000A3
Inspection Phase 3: (5) BMS-95 Sealant Omitted
Between Air Dam Tube and Outer Tube

Figure A-238. B747 P/N: 65B81011-509, N000A3
Inspection Phases 4 and 5: Tube Sectioned Horizontally
and Used as an NDI (Eddy-Current) Test Specimen

Figure A-239. B747 P/N: 65B81011-513, N000C1
Inspection Phase 1: (1) Protective Coating Wear

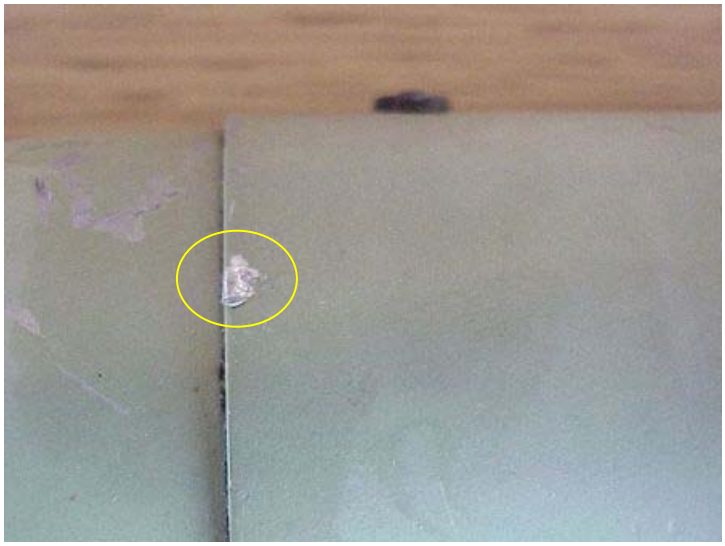


Figure A-240. B747 P/N: 65B81011-513, N000C1
Inspection Phase 2: (2) Impact Damage

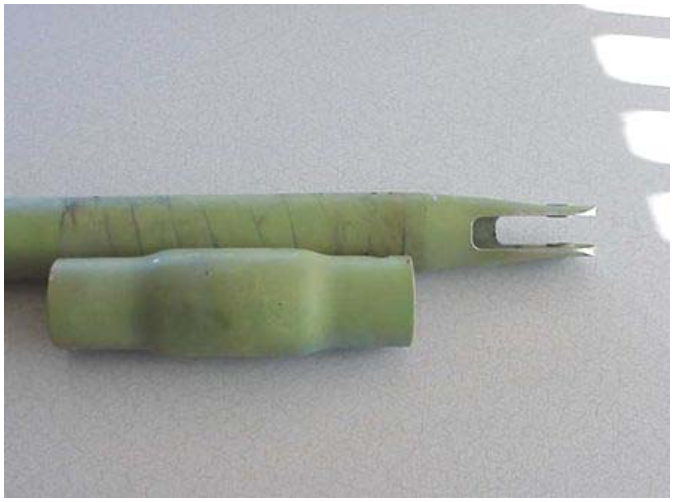


Figure A-241. B747 P/N: 65B81011-513, N000C1
Inspection Phase 3: (2) BMS-95 Sealant Omitted
Between Air Dam Tube and Outer Tube

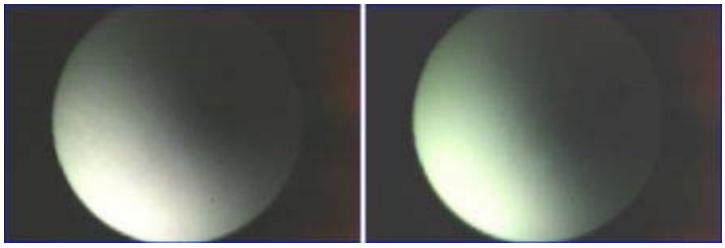


Figure A-242. B747 P/N: 65B81011-513, N000C1
Inspection Phase 4: No Defects Noted

Figure A-243. B747 P/N: 65B81011-510, N000C1
Inspection Phase 1: (1) Protective Coating Wear

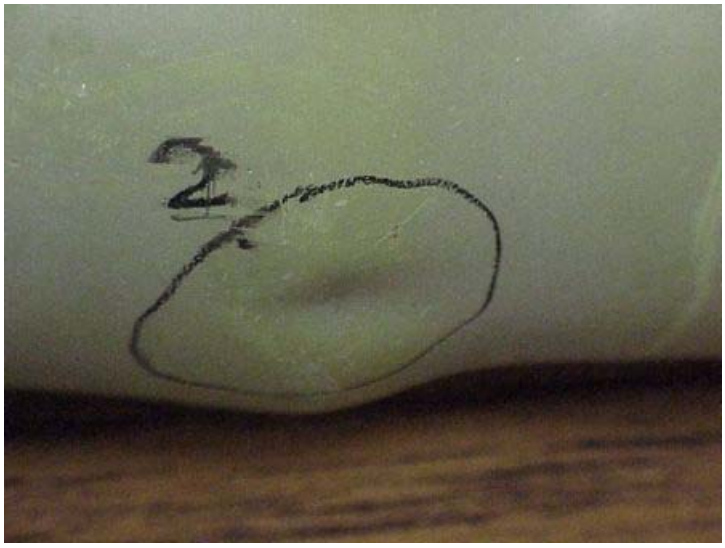


Figure A-244. B747 P/N: 65B81011-510, N000C1
Inspection Phase 2: (2) Dent 10 mm in diameter

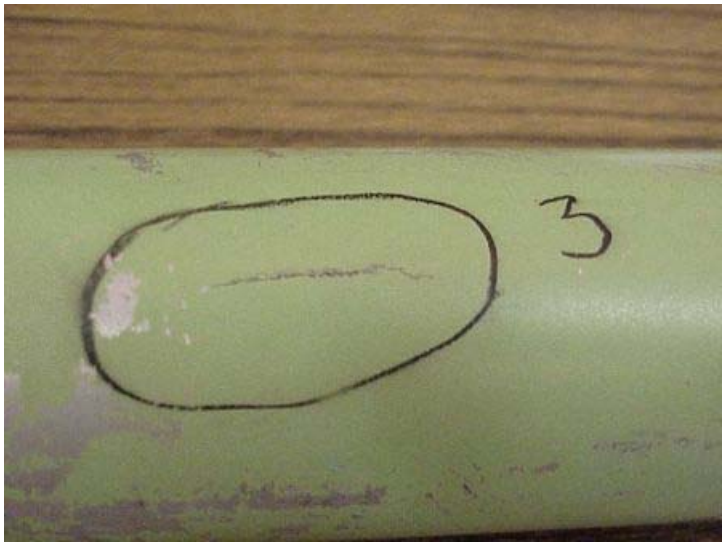


Figure A-245. B747 P/N: 65B81011-510, N000C1
Inspection Phase 2: (3) Crack 20 mm long

Figure A-246. B747 P/N: 65B81011-510, N000C1
Inspection Phase 2: (4) Gouge 35 x 5 mm

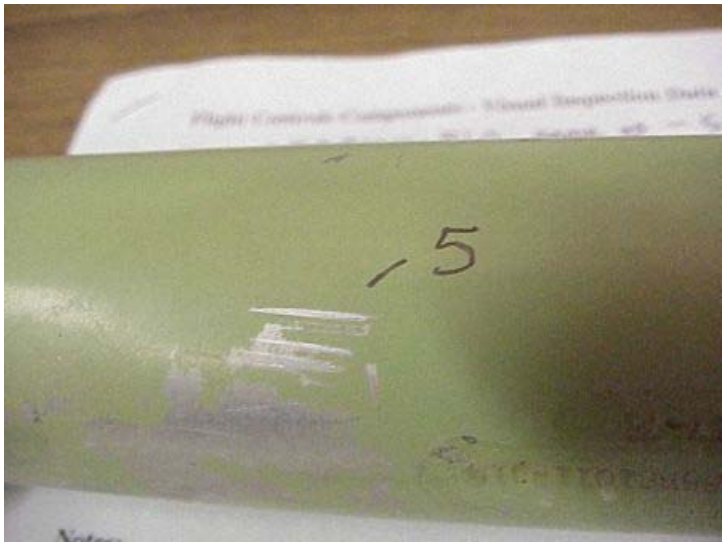


Figure A-247. B747 P/N: 65B81011-510, N000C1
Inspection Phase 2: (5) Scratches

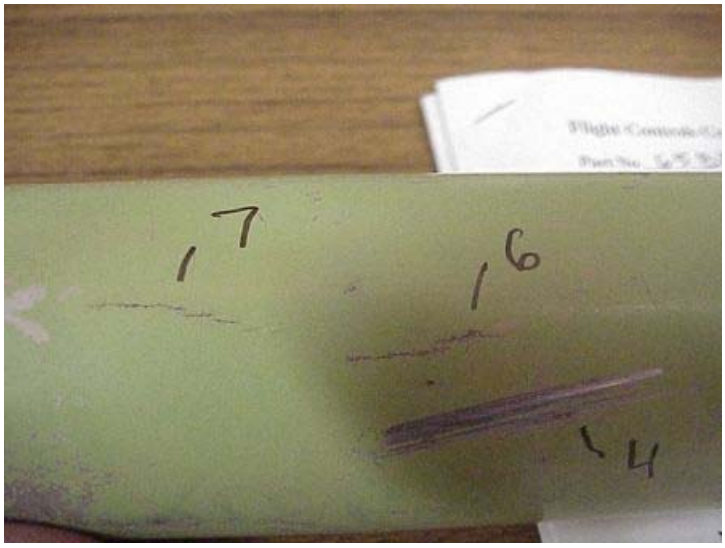


Figure A-248. B747 P/N: 65B81011-510, N000C1
Inspection Phase 2: (6) Crack 15 mm long
and (7) Crack 20 mm long

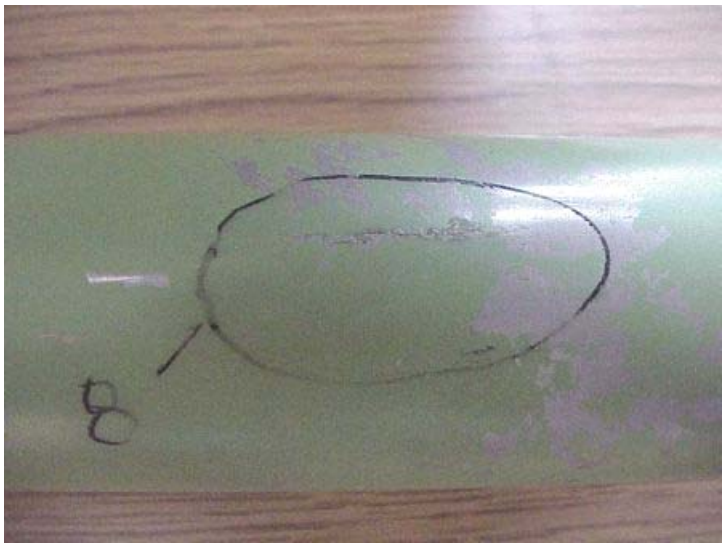


Figure A-249. B747 P/N: 65B81011-510, N000C1
Inspection Phase 2: (8) Crack 21 mm long

Figure A-250. B747 P/N: 65B81011-510, N000C1
Inspection Phase 3: (9) BMS-95 Sealant Omitted
Between Air Dam Tube and Outer Tube

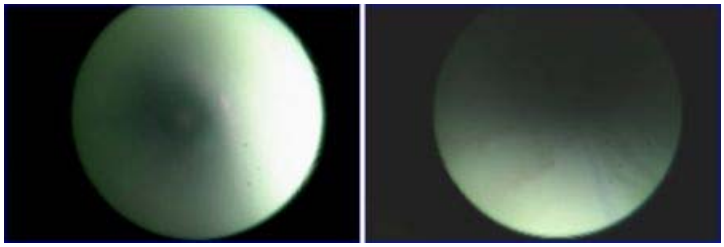


Figure A-251. B747 P/N: 65B81011-510, N000C1
Inspection Phase 4: No Defects Noted

Figure A-252. B747 P/N: 65B81011-518, KG-DDD
Inspection Phase 1: No Defects Noted

Figure A-253. B747 P/N: 65B81011-518, KG-DDD
Inspection Phase 2: No Defects Noted

Figure A-254. B747 P/N: 65B81011-518, KG-DDD
Inspection Phase 3: Distructive Assembly
Required for Further Inspection

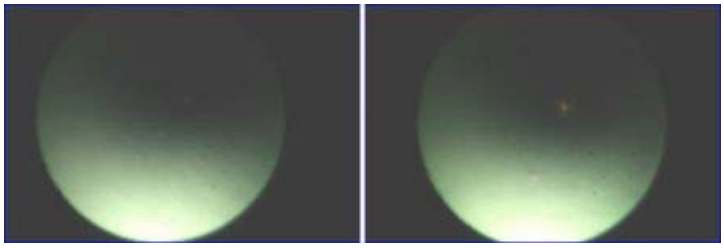


Figure A-255. B747 P/N: 65B81011-518, KG-DDD
Inspection Phase 4: No Defects Noted

Figure A-256. B747 P/N: 65B81011-518, KG-DDD
Inspection Phase 5: Air Dam Tube Correctly
Installed per Boeing Design Specifications
(BMS-95 Sealant found in KG-DDD tubes only)

Figure A-257. B747 P/N: 65B81011-523, KG-DDD
Inspection Phase 1: No Defects Noted

Figure A-258. B747 P/N: 65B81011-523, KG-DDD
Inspection Phase 2: (1) Dent in Air Dam Tube
15 mm in diameter

Figure A-259. B747 P/N: 65B81011-523, KG-DDD
Inspection Phase 2: (2) Dent in Air Dam Tube
3 mm in diameter

Figure A-260. B747 P/N: 65B81011-523, KG-DDD
Inspection Phase 3: Distructive Disassembly
Required for Further Inspection

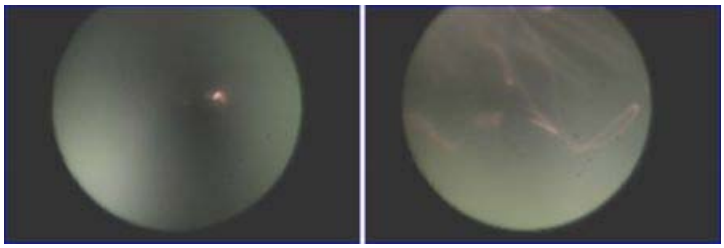


Figure A-261. B747 P/N: 65B81011-523, KG-DDD
Inspection Phase 4: No Defects Noted

Figure A-262. B747 P/N: 65B81011-523, KG-DDD
Inspection Phase 5: Air Dam Tube Correctly
Installed per Boeing Design Specifications
(BMS-95 Sealant found in KG-DDD tubes only)

The visual inspection results from table 20 are shown in figures A-263 through A-273.

Figure A-263. B747 P/N: 69B82658-1, N000A3
Inspection Phase 1: No Defects Noted

Figure A-264. B747 P/N: 69B82658-1, N000A3
Inspection Phase 2: (1) Corrosion 13 mm in diameter

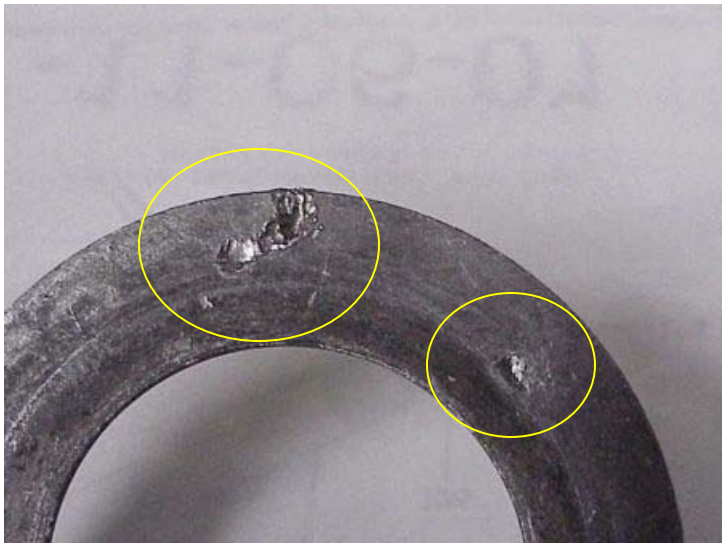


Figure A-265. B747 P/N: 69B82658-1, N000A3
Inspection Phase 2: (2) Gouges in Washer

Figure A-266. B747 P/N: 69B82658-1, N000A3
Inspection Phase 3: No Defects Noted

Figure A-267. B747 P/N: 69B82658-1, N000C1
Inspection Phase 1: No Defects Noted
Note: Appears fairly new

Figure A-268. B747 P/N: 69B82658-1, N000C1
Inspection Phase 2: No Defects Noted

Figure A-269. B747 P/N: 69B82658-1, N000C1
Inspection Phase 3: Unable to Disassemble Further

Figure A-270. B747 P/N: 69B82658-1, KG-DDD
Inspection Phase 1: No Defects Noted

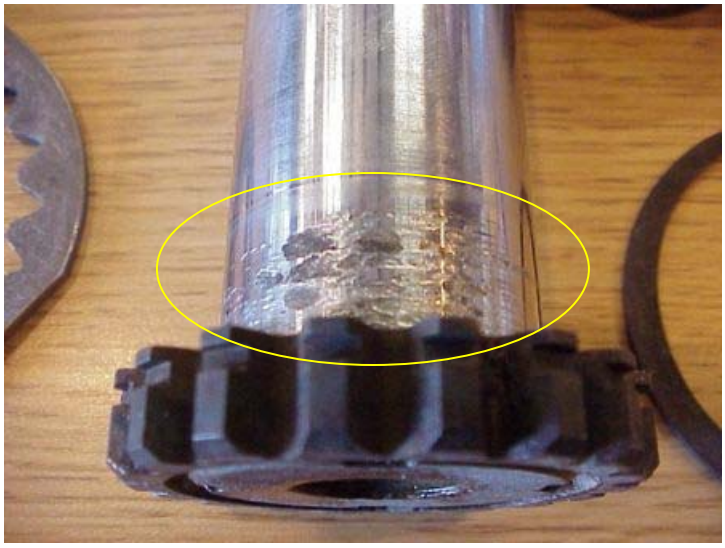


Figure A-271. B747 P/N: 69B82658-1, KG-DDD
Inspection Phase 2: (1) Galling on
Outer Bolt Shank

Figure A-272. B747 P/N: 69B82658-1, KG-DDD
Inspection Phase 2: (2) Corrosion
on Bolt End, Washer, and Nut

Figure A-273. B747 P/N: 69B82658-1, KG-DDD
Inspection Phase 3: Unable to Disassemble Further

The visual inspection results from table 21 are shown in figures A-274 through A-287.

Figure A-274. B747 P/N: 93677, N000A3
Inspection Phase 1: No Defects Noted

Figure A-275. B747 P/N: 93677, N000A3
Inspection Phase 2: (1) Crack 25 mm long
(Note: No protective coating.)

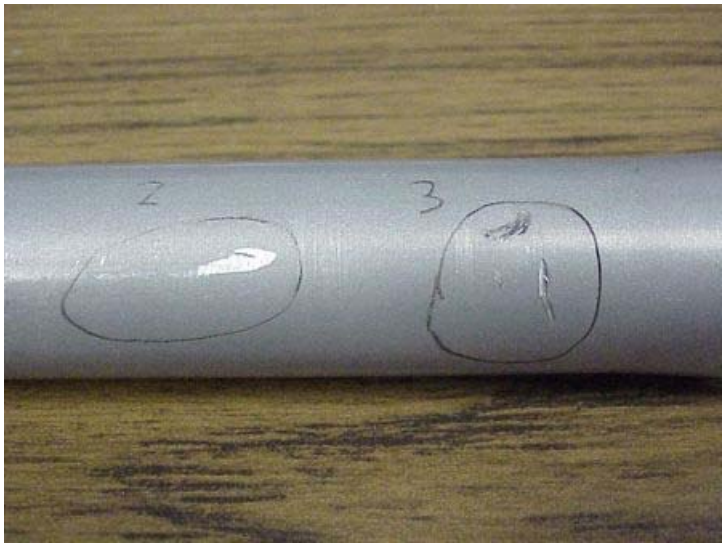


Figure A-276. B747 P/N: 93677, N000A3
Inspection Phase 2: (2) Scratch 3 mm long
and Wear (3) Gouge 10 x 2 mm

Figure A-277. B747 P/N: 93677, N000A3
Inspection Phase 3: No Defects Noted

Figure A-278. B747 P/N: 93677, N000A3
Inspection Phase 4: (4) Unidentified Fiberscope Indication
Note: No protective coating on inside of rod

Figure A-279. B747 P/N: 93677, N000C1
Inspection Phase 1: No Defects Noted

Figure A-280. B747 P/N: 93677, N000C1
Inspection Phase 2: Protective Coating Wear

Figure A-281. B747 P/N: 93677, N000C1
Inspection Phase 3: No Defects Noted

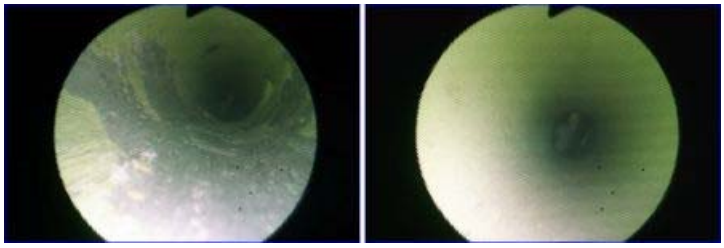


Figure A-282. B747 P/N: 93677, N000C1
Inspection Phase 4: Note Protective Coating Wear

Figure A-283. B747 P/N: 93677, KG-DDD
Inspection Phase 1: No Defects Noted

Figure A-284. B747 P/N: 93677, KG-DDD
Inspection Phase 2: (1) Gouge 1 mm wide
(Note: No protective coating.)

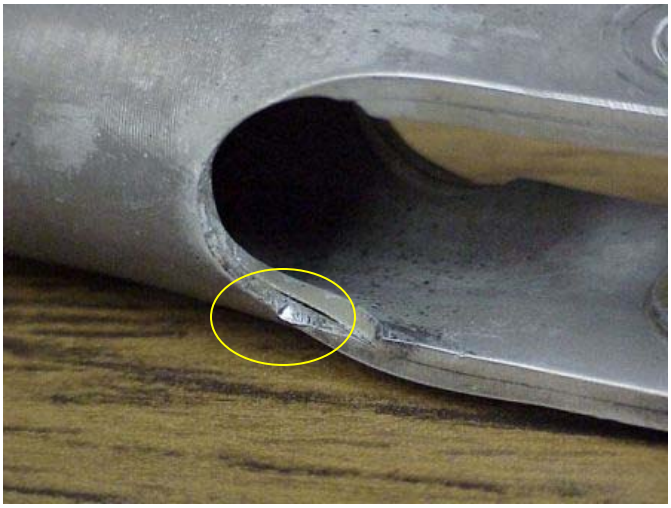


Figure A-285. B747 P/N: 93677, KG-DDD
Inspection Phase 2: (2) Nick

Figure A-286. B747 P/N: 93677, KG-DDD
Inspection Phase 3: No Defects Noted

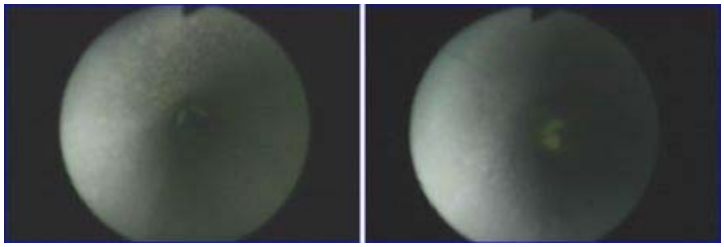


Figure A-287. B747 P/N: 93677, KG-DDD
Inspection Phase 4: Note No Protective
Coating on Inside of Rod