NATIONAL TRANSPORTATION SAFETY BOARD

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

May 31, 2000

MATERIALS GROUP FACTUAL REPORT Report No. 00-068

A. ACCIDENT

Place	:	Near Port Hueneme, California
Date	:	January 31, 2000
Vehicle	:	Boeing MD-83, N963AS
Operator	:	Alaska Airlines, Flight 261
NTSB No.	:	DCA00-M-A023

B. Accident Summary

On January 31, 2000, at about 1621 PST, Alaska Airlines flight 261 a Boeing MD-83, N963AS, crashed approximately 2.69 miles north of Anacapa Island, California into the Pacific Ocean. The flight, from Puerto Vallarta, Mexico to Seattle Washington with an intermediate stop in San Francisco, was operating under title 14 CFR part 121. All 83 passengers and 5 crewmembers were fatally injured and the aircraft was destroyed. Visual meteorological conditions prevailed at the time of the accident.

C. GROUP MEMBERS

The following members of the Materials Group participated in examinations and measurements of various jackscrews and gimbal nuts at Trig Aerospace, Santa Ana, California. Joe Epperson (NTSB, Chairman), Dan Ho (Alaska Airlines), Terry Khaled (FAA) Joe Bracken (ALPA), Jim Dart (AMFA Alaska Airlines), and Tom Posten (Boeing, Long Beach).

D. COMPONENTS EXAMINED

Horizontal stabilizer jackscrew and gimbal (Acme) nut from the accident airplane, various jackscrews and gimbal nuts from other airplanes.

E. DETAILS OF THE EXAMINATION

On March 22 and 23, 2000, the jackscrew and a portion of the Acme nut from the accident aircraft and seven (7) others listed in Table A below (Acme nut and screw) were transported to Trig Aerospace (Trig), Santa Ana, CA for specific measurements and inspections. The Acme screw assemblies (with attached Acme nuts) from the non-accident

airplanes had been disassembled from the torque tube and gearbox support assemblies in the NTSB materials laboratory. The Acme nuts however had not been removed from the screw until receipt at Trig where they were separated and steam cleaned to remove grease and dirt. In addition, another screw and nut assembly (P-1988) from Alaska Airlines that was awaiting overhaul at Trig was included in the measurements. Information on the P-1988 components was limited.

Table A List of Jackscrews and Nuts Measured

Operator	AC N No.	Screw and Support Assy p/n	Screw and Support Assy s/n	Screw p/n	Screw s/n	Nut p/n	Nut s/n
		5910962		5914168		5914169	
AirTran		-5	DCA-459	-503L	?-?096	N.V.	?-1096
Alaska	N963AS	-71	DCA-2064	-505M	N.V.	-507H	P-2663
Alaska	N981AS	-71AZ17	DCA-3008	-505S	D-3141	-507L	D-3142
Alaska	N982AS	-71AZ17	DCA-3000	-505S	N.V.	-507L	D-3145
Alaska*	UNK		UNK		P-1988		P-1988
Delta	N907DA	-3	DCA-0009	-509R	D-3026	-511K	D-3026
Northwest	N925US	N.V.	00060!	-501P	P-2645	-503H	?-2645
Reliant		-62	92-2290#	N.V.	P-????	N.V.	P-1186
TWA+	N941AS	-71AP4	DCA-1798	-505M	P-2355	-507H	P-2355

? Denotes unreadable character
N.V. Not visible or readable
* Awaiting overhaul at Trig, not in NTSB custody
! Stamped into gearbox support
Camco Assembly Tag S/N reference number
+ Leased from Alaska Airlines
Blank Data not available

The measurements listed in Table B were performed on all sets of components. A short description of the measurement and the measurement methodology is included in the table along with the applicable limits. The table also references figures that depict typical setups for many of the measurements. Trig quality control personnel under the direct supervision of the Materials Group performed the inspections. For the measurements, certified and calibrated production tooling was employed and, where practical, production methodology was used. Other than hardness and thread profile casts, no measurements were performed on the accident nut.

Table B	**Measurement Types, Methods and Limits**		
Measurement	Description	Specifications	Figure
Screw			
Thread Straightness (referenced as concentricity)	Measurement of screw straightness or bow. Screw placed horizontal in Vee blocks set at each end of the threads. Dial indicator set at center of threads. Screw is rotated to maximum and minimum dial reading. Difference is straightness or TIR (total indicator runout)	Maximum TIR 0.004 inch (overhaul), 0.005 inch per Blueprint (BP)	Fig. 1
Counterbore Runout	Same as above. Indicator at large end counterbore diameter.	Maximum TIR 0.004 inch (overhaul) 0.005 inch per BP	Fig. 2
Major Diameter	Major diameter is the outer diameter at the thread crests. Measured with anvil outside micrometers.	1.7149-1.7169 inch per BP	NA
Pitch Diameter (PD)	Diameter at the pitch line of the threads. Diameter measured over 3 thread wires of calculated size and spacer block. Measurement minus wire and spacer sizes equal PD.	1.5591-1.5629 inch per BP	Fig. 3
Minor Diameter	Diameter at root of threads. Direct measurement with blade micrometer.	1.4192-1.4353 inch per BP	Fig. 4
Surface Finish	Surface roughness. Measured by an electronic profilometer mounted on a surface height gage.	32 RA max on flanks and crowns of threads per BP	Fig. 5
Pitch	Distance between the same locations on successive teeth. Measured on a horizontal optical comparator.	No specification 4 Threads per inch Nominal 0.250 inch	Fig. 6
Nut			
Hardness	Rockwell B scale (HRB). Direct indentation into surface of nut.	HRB 93 minimum Per BP	NA
GO gage functional	Checks functional dimensions of threads. Threaded into nut.	Must Pass completely through nut without binding	Fig. 7
NO-GO Pitch Dia	Measures Pitch Diameter of nut. Attempt to thread into both ends of nut.	Must not Pass into nut thread.	Fig. 7

Table B	**Measurement Types, Methods and Limits**		
Measurement	Description	Specifications	Figure
N0-GO Major Dia	Measures Major Diameter of nut. Attempt to thread into both ends of nut.	Must not Pass into nut thread.	Fig. 7
Thread Crown Width	Width of thread crown at minor diameter. Optical comparator measurements of crowns replicated by plastic molds of several teeth near nut ends.	No Specification Nominal new thread 0.0927 inch.	Fig. 8
Assembly			
Endplay	Measures axial play between nut and screw. Nut is assembled onto screw and forced axially down, top surface mounted dial indicator is zeroed. Nut forced up with hand pressure and indicator is read.	New production 0.003 - 0.010 inch In service 0.040 inch max	

The measurements and inspection results are listed in Table C below. Dimensions and features specific to the screw thread were measured and are listed in the table for three locations on each screw. The locations were 1) near the large end (top), 2) in the middle, and 3) near the small end (bottom) of the screw thread. The top and bottom locations were in areas outside the normal operational range of the nut and are not normally contacted. The middle locations were all in worn areas that were contacted by the nut during normal operation of the jackscrew. Thread pitch was measured along two longitudinal lines approximately 90° apart, labeled Pitch 0° and Pitch 90°. Except that the accident screw was measured in each 90° quadrant, labeled 0°, 90°, 180° and 270°. Major and minor diameters on the accident screw were also measured at two 90° locations. Out-of-limit dimensions are shown in bold text. Unusual physical features that may have affected the measurements are also listed in the table.

The thread crown width measurements were performed on plastic casts of the thread forms at the upper and lower ends of the nut. From 4 to 6 threads were measured at each end. Some casts were made at Trig but others were made at a later date in the NTSB Materials Lab to make up a complete set. All casts were measured in the Materials Lab using an optical comparator. The data presented in Table C averages the thread crown widths from the upper and lower casts and also shows a cumulative average of all threads for each nut.

The production process for screws and nuts was observed, and step by step notes were made from the present production workcards. The production steps are contained in Appendix I “Processing Steps for Screws and Nuts”.

Joe Epperson
Senior Metallurgist

Table C Measurement Results

		AirTran	Alaska	Alaska	Alaska	Alaska	Delta	Northwest	Reliant	TWA
		DCA-459	DCA-2064	DCA-3008	DCA-3000	UNK	DCA-0009	00060	92-2290	DCA-1798
Measurement			N963AS	N981AS	N982AS	UNK	N907DA	N925US		N941AS
Screw			0°, 90°							
Thread Straightness 0.005 max		**0.0070**		0.0015	0.0025	0.0045	0.0030	**0.0055**	**0.0070**	0.0015
Counterbore Runout 0.005 max		**0.0080**	Visible Bend	0.0030	0.0030	0.003	0.0020	**0.0075**	**0.0100**	0.0025
Major Diameter	Top	1.7150	1.7170, 1.7175	1.7155	1.7160	1.7165	1.7165	1.7155	**1.7190**	1.7165
1.7149-1.7169	Mid	1.7150	1.7160, 1.7168	1.7155	1.7155	1.7165	1.7165	1.7155	1.7165	1.7160
	Bot	1.7160	1.7160, 1.7165	**1.7145**	**1.7145**	1.7165	1.7165	1.7155	**1.7175**	1.7165
Pitch Diameter	Top	1.5624	1.5716	**1.5646**	**1.5630**	1.5631	1.5596	1.5606	1.5626	**1.5640**
1.5591-1.5629	Mid	**.012 below* Steped sides**	**0.005-.008 below**	1.5616	1.5621	1.5606	1.5611	**.005 below**	**.011 below**	**1.5586**
	Bot	**1.5631**	**0.0015 below**	**1.5636**	**1.5630**	1.5626	**1.5636**	1.5601	1.5621	1.5621
Minor Diameter	Top	1.4240	1.4275, 1.4325	1.4295	1.4300	1.4245	1.4325	1.4255	1.4220	1.4280
1.4192-1.4353	Mid	1.4210	1.4185, 1.4280	1.4300	1.4300	1.4270	1.4325	1.4250	1.4230	1.4270
	Bot	1.4255	1.4235, 1.4275	1.4295	1.4305	1.4245	1.4320	1.4240	1.4230	1.4275
Surface Finish	Top	30		**33**	**75**	28	30	**48**	**57**	**54**
32 RA max	Mid	**43**		31	28-30	14/23	**35**	**74 step**	**68**	21
	Bot	**28-36**		27	**55**	28	28	32	**67**	20
Pitch 0°	Top	0.2489	0.2503	0.2485	0.2496	0.2497	0.2487	0.2494		0.2487
4 tpi 0.250 nom	Mid	0.2484	0.2471	0.2476	0.2480	0.2497	0.2494	0.2475		0.2492
	Bot	0.2490	0.2495	0.2475	0.2496	0.2492	0.2514	0.2495		0.2492
Pitch 90°	Top	0.2481	0.2497	0.2490	0.2475	0.2478	0.2488	0.2479		0.2498

Table C Measurement Results

		AirTran	Alaska	Alaska	Alaska	Alaska	Delta	Northwest	Reliant	TWA
		DCA-459	DCA-2064	DCA-3008	DCA-3000	UNK	DCA-0009	00060	92-2290	DCA-1798
Measurement			N963AS	N981AS	N982AS	UNK	N907DA	N925US		N941AS
4 tpi 0.250 nom	Mid	0.2496	0.2496	0.2489	0.2491	0.2480	0.2492	0.2480		0.2499
	Bot	0.2485	0.2472	0.2483	0.2489	0.2485	0.2491	0.2476		0.2490
Pitch 180°	Top		0.2501							
4 tpi 0.250 nom	Mid		0.2491							
	Bot		0.2478							
Pitch 270°	Top		0.2483							
4 tpi 0.250 nom	Mid		0.2494							
	Bot		0.2506							
Nut										
Hardness 93 HRB min		101	103	99	103	102	101	102		100
GO Gage Functional Pass	Pass	Pass	NA	Pass	Pass	Pass	Pass	Pass	Pass	Pass
No-Go Pitch Dia No Pass	**Fail**	**Fail**	NA	**Fail**	**Fail**	**Fail**	**Fail**	**Fail**	**Fail**	**Fail**
No-Go Major Dia No Pass	Pass	Pass	NA	Pass		Pass	Pass	Pass	Pass	Pass
Thread Crown Width	Upper	0.07933		0.04769	0.05546		0.05919	0.08796	0.08878	0.07866
0.0927 Nom	Lower	0.07522		0.04674	0.05497		0.05588	0.08654	0.08467	0.07726
	Overall	0.07728		0.04721	0.05524		0.05740	0.08717	0.08649	0.07796
Assembly										
Endplay 0.040 max		**0.0350**		**0.0550**	**0.0480**	**0.0400**	0.031	0.0160	NA damage	0.0200

* On several screws the wires used to measure the pitch diameter did not extend past the major diameter and the PD could not be measured. In these instances the listed measurement is the distance from the top of the wire to the major diameter of the adjacent thread.

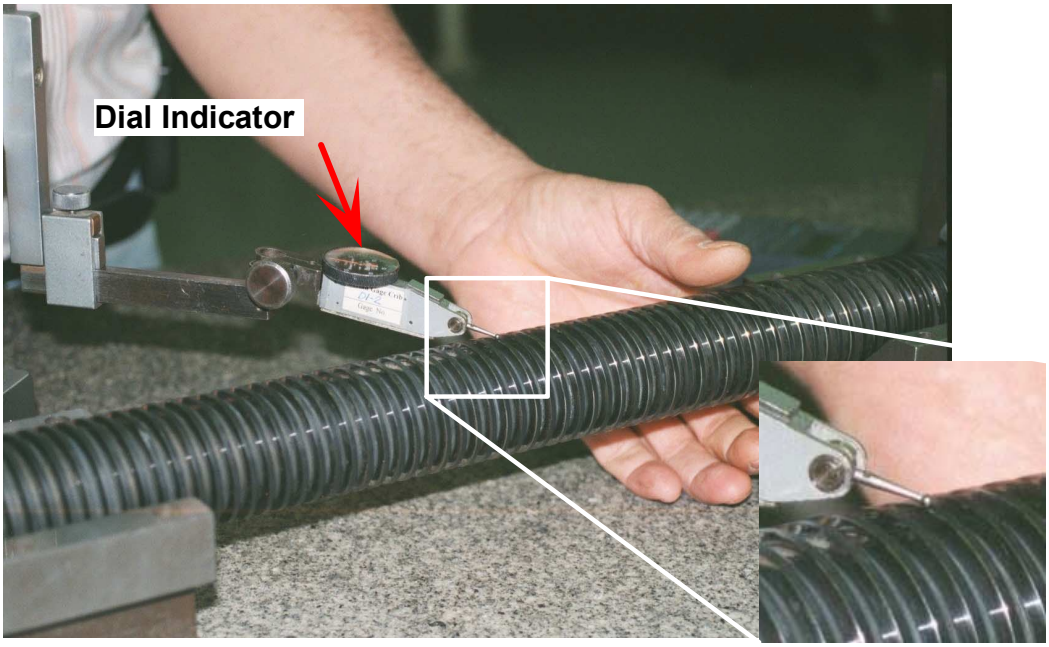

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Figure 1. Measurement of thread straightness. Also refered to as concentricity.

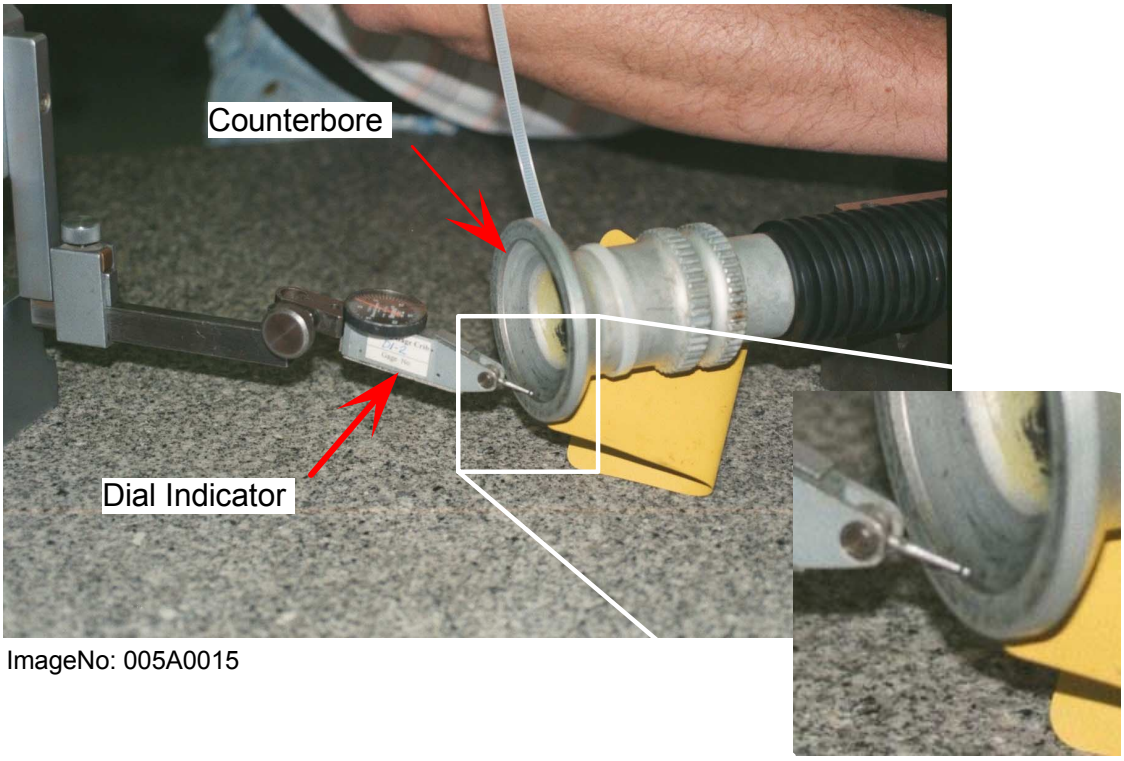

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Figure 2. Measurement of counterbore concentricity (runout).

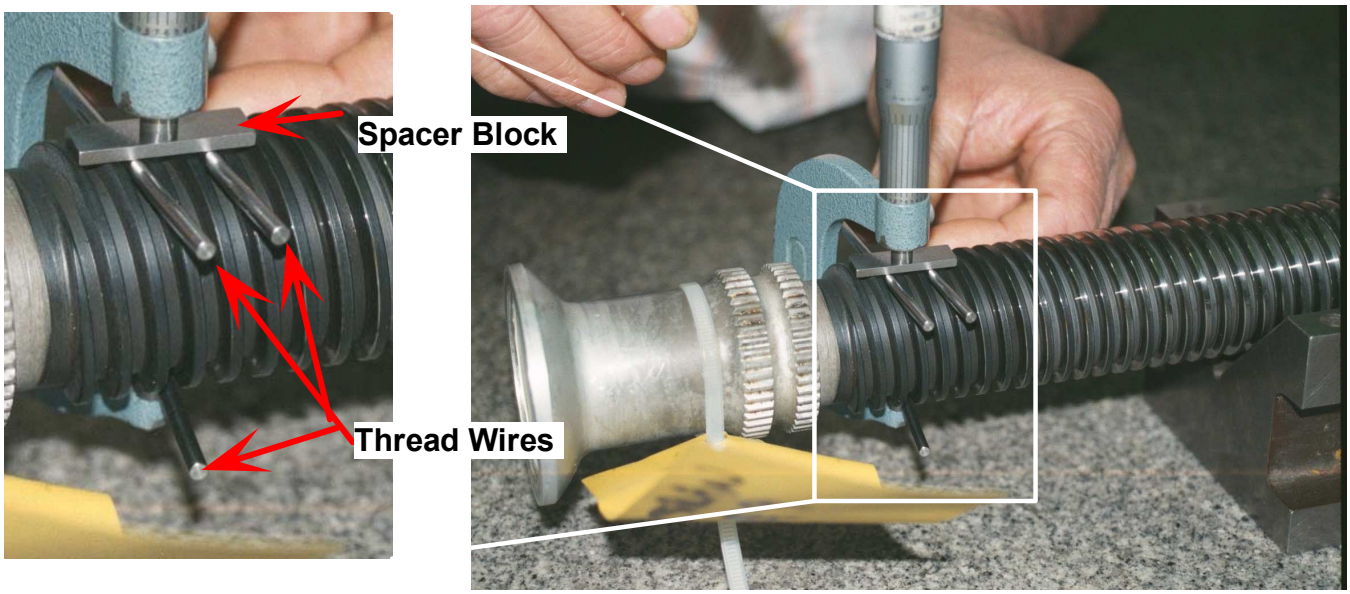

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Figure 3. Measurement of thread pitch diameter using three thread wires of known size and a spacer block.

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Figure 4. Measurement of minor diameter with an offset blade micrometer.

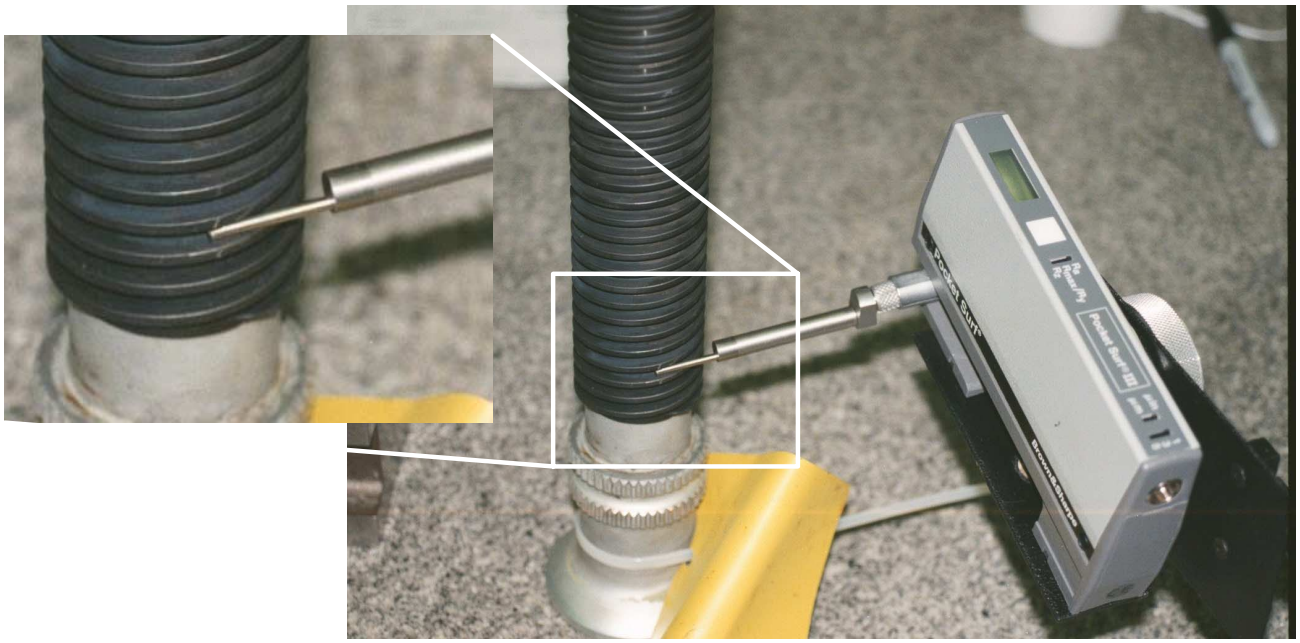

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Figure 5. Measurement of surface roughness with an electronic profilometer.

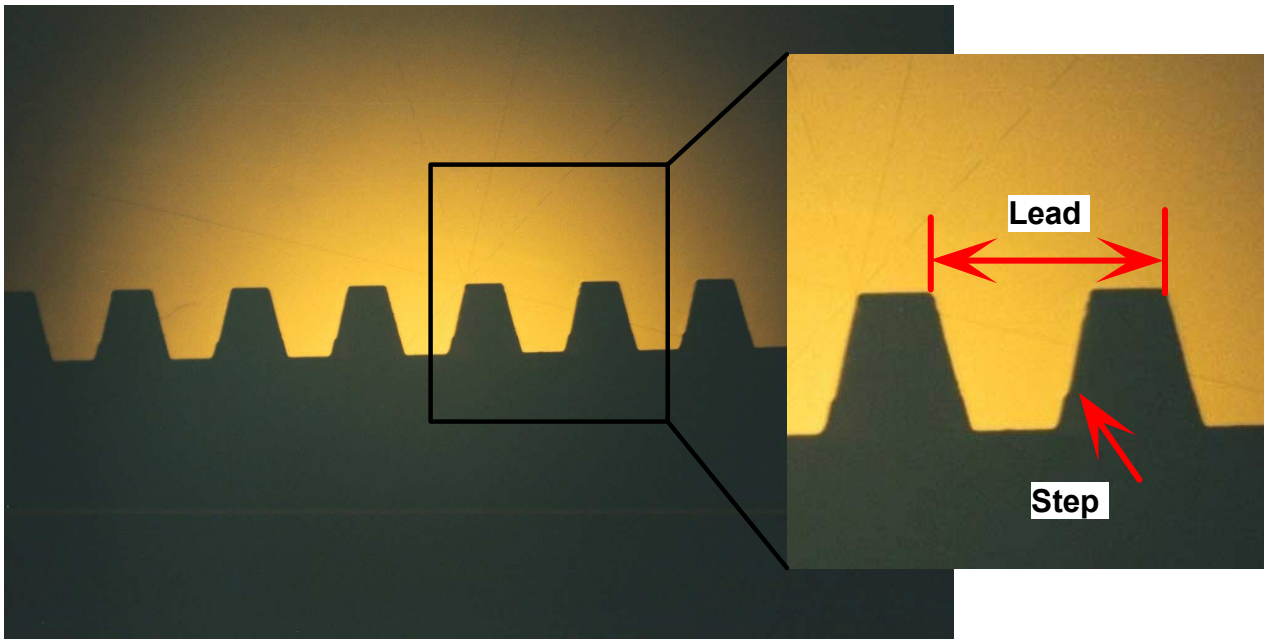

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Figure 6. Measurement of thread profile and lead with an optical comparator. Note the step in the flank profile.

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Figure 7. Performing a functional check on the nut with Go No-Go gaging.

ImageNo: 005A0029

ImageNo:

Figure 8. Casts (green material) made of the nut thread profiles to allow measurements of the crown thickness.

Apendix I Processing Steps for Manufacture of Screws and Nuts.

For 5914168-505 Screw Acme, as of 2-16-2000

Step	Operation No.	Operation Name	Per Spec
	Description		
1	0	Operations Control	
	Next Assy 5914169-507 Final Assy 5910962-71 –57 –53		
2	10	Issue Material	
	Material 5914168-3, forging, AISI 4140		MIL-S-5626 D1 DMS 1800
3	30	Inspection	
	Verify Material and heat treatment certifications		AQL 1.5 (QCP 010)
4	40	Heat Treat (outside processing)	
	Boeing Approved Source Normalize		HRC 32 max
5	45	Saw	
	Cut to length		
6	50	Hey face and center	
	Face large end Center drill small end		
7	60	Cinturn CNC	
	Rough turn to oversized diameter		
8	80	HES Lathe	
	Turn large diameter		
9	90	Bench Inspect	
	Through operation 80		AQL 1.5 (QCP 010)
10	100	Drillmation	

Step	Operation No.	Operation Name	Per Spec
	Description		
	Drill centerline hole 1.137		
11	105	Drillmation	
	Drill hole 0.038		
12	106	Sunnen Horiz Hone	
	Hone 1.137 dia hole		125 RA
13	120	HES Lathe	
	Turn large diameter		
14	122	Engine Lathe	
	Turn 1.790 diameter		
15	124	Hydraulic Press	
	Straighten		
16	126	Inspection	
	Visual inspect drill and honed surface for tear outs Concentricity 100%		AQL 1.5 (QCP 010)
17	130	Cinturn CNC	
	Bore 1.0 hole Finish profile OD thread Diameter Form grooves 0.156 radius Check for bow		
18	140	SL-75 CNC	
	Rough turn threads Check concentricity		No tears
19	180	HES Lathe	
	Face to 25.964 Turn large diameter Break edges		
20	210	Bench Inspection	

Step	Operation No.	Operation Name	Per Spec
	Description		
	Inspect operations 130 thru 180 ID concentric 100%		AQL 1.5 (QCP 010)
21	250	Heat Treat (outside processing)	
	Boeing Approved Source A. Straighten B. Stress Relieve C. Copper plate D. Heat treat 16-180 ksi with coupons (3/25) E. Straighten F. Strip Copper		 5.00-1 9.05 9.69 5.00-1 9.69
22	255	Receiving Inspection	
	Verify certs, coupons returned Visual inspect for cu plate and damage Hardness 100% and record		 1.05-2,-4
23	260	Magnetic Inspect	
	Boeing Approved Source		4.704
24	262	Hydraulic press	
	Straighten		
25	264	Landis Grinder 545	
	Rough grind OD 1.727		
26	266	Thread Grinder	
	Rough grind threads Hold PD oversize and minor dia to high side		
27	268	Hydraulic Press	
	Check OD runout of threads Straighten if necessary		
28	270	#3 KT Horizontal Mill	
	Mill detail		
29	280	#3 KT Horizontal Mill	

Step	Operation No.	Operation Name	Per Spec
	Description		
	Mill detail		
30	290	Bench Inspect	
	Inspect from operation 264 ID/OD runout on threads OD .004 ID .008		AQL 1.5 (QCP 010)
31	300	Gear Cut (outside source)	
	Boeing Approved Source A. cut 24/48 ID splines B. cut 32/64 OD spline C. cut 24/48 OD spline GO, NO-GO gaging with parts		GO, NO-GO
32	315	Receiving Inspection	
	Inspect ID / OD splines with gages Check all teeth wit NO-GO gage Check orientation Visual 100% for burrs DAC Source Inspection for splines		
33	320	Excello Center Lap	
	Lap centers		
34	330	Landis Grinder 545	
	Finish grind thread major diameter 1st Article to verify ID runout		32 RA max 16 RA desired
35	360	Thread Grinder	
	Finish grind threads complete Hold PD to high side		12RA root / flank 1st Article Inspect
36	365	Thread Grinder	
	Back off thread starts on end		
37	370	Thread Grinder	
	Back off thread starts opposite end		
38	374	Thread Grinder	

Step	Operation No.	Operation Name	Per Spec
	Description		
	Chamfer threads		
39	375	Hydraulic Press	
	Check OD runout Straighten if necessary		
40	376	Bench Inspect	
	Check from operation 330 Check ID/OD concentricity		AQL 1.5 (QCP 010) B/P
41	380	Cinci Avenger 250T	
	Stop off spline shoulders		
42	440	General Deburr	
	Burr and file chamfer 1st thread		
43	450	Mag Part Inspect	
	Boeing Approved Source		4.704
44	460	Inspect	
	Check operations 380 & 440		B/P AQL 1.5 (QCP 010)
45	470	Customer Source Inspect	
	Customer Source Inspection if required		
46	480	Stress Relieve (outside source)	
	Boeing Approved Source Stress relieve 700 F 3 hr		5.00-1 Table 4.8
47	490	Receiving Inspect	
	Verify certs Inspect ID/OD concentricity 100% Coupon sent with parts		100% per B/P
48	500	Glass Bead (outside source)	

Step	Operation No.	Operation Name	Per Spec
	Description		
	Glass bead clean thread area		B/P note14 9.05 32 RA max
49	510	Malcomize (nitride) (outside source)	
	Boeing Approved Source With coupons Malcomize .003/.010 from EO "W"		BP Note 20 5.00-3
50	520	Receiving Inspect	
	Verify certs for glass bead and Malcomize Verify hardness 100% and record Verify finish on OD, roots, flanks and record		BP Notes 14, 20 15N-85 min 1.05-2,-4 32RA
51	530	Black Oxide and Cad (outside	
	Boeing Approved Source Black oxide threads, no blasting Mask threads and cad plate Embrittlement Relief 5 hrs at 275°F		 9.27 9.74 Type 1 5.00-1 Table 4.9, Grp 7
52	540	Receiving inspection	
	Verify certs black oxide and cad plate Visual inspect 100% for coverage/ pits/ blisters/ damage Verify surface finish on threads		BP 15 & 16 AQL 1.5 (QCP 010) 32 RA max
53	550	Mag Inspect (outside source)	
	Boeing Approved Source Magno-Glow		 4.704
54	560	Paint	
	Primer ID		4.50-36
55	570	Final Inspect / Identify	
	Inspect paint Verify complete operations Final Rockwell 100% and record Identify part (Ink Stamp) Complete 1st article report		AQL 1.5 (QCP 010) 1.05-2, -4 3.02, 3.27-1
56	580	Source Inspect	

Step	Operation No.	Operation Name	Per Spec
	Description		
	DAC source if required by PO		
57	590	Finish Stores	
	Protect and store		

Nut, Acme 5914405-501 as of 2/11/00

Step	Operation No.	Operation Name	Per Spec
	Operation Description		
1	0	Operation Control	
	Next Assy 2919145-511 (5914169-500 Derlan sub) Final Assy 5940560-3 5910962-69, -71, -75, -77, -79, -81, & -83		
2	10	Issue Material	
	5914405-3 Casting, Alum Bronze Note ASTM B 271 supercedes QQ-B-671		ASTM B 271 HT
3	20	Verify Material	
	Verify Quantity, Material, Heat Lot per certs		
4	30	OKK MCU-630	
	A. Mill B. Drill and bore 1.453 hole C. Drill and bore tool holes		
5	40	PCU 620	
	A. Mill all over B. Rough C. Rough Pockets D. Mill chamfer		
6	50	OKK VMC-630	
	Mill		
7	80	General Deburr	
	Remove burrs and sharp edges .005 / .015 R Note Use extreme caution		
8	85	Inspect	
	Complete inspect thru 80 start First Article Report		AQL 1.5 (QCP 010)
9	90	X-ray (outside processing)	

Step	Operation No.	Operation Name	Per Spec
	Operation Description		
	Approved Source		4.706 Class 1B, grade C
10	100	Receiving Inspection	
	Verify Certs Rockwell 100%, Record Note Reference Material Brinell 200 HRB 93		 1.05-2 1.05-5 alloy 955 HT
11	120	OKK VMC-500	
	Mill ends to 8 inch		
12	180	OKK VMC-500	
	Mill details		
13	245	General Deburr	
	Remove burrs and sharp edges .005 / .015 R		
14	250	Turret Lathe	
	A. Bore ID 1.470 B. Thread 1 ¾ x.250-.500 L-NA-5C Pitch Dia 1.6026-1,5919		
15	251	Walker-Turner	
	A. Drill .250 B. Drill #3		
16	252	Walker-Turner	
	Spot Face		
17	253	Walker-Turner	
	Tap ¼-28tpi		
18	254	Walker-Turner	

Step	Operation No.	Operation Name	Per Spec
	Operation Description		
	Countersink		
19	260	Conventional Mill	
	Relieve threads at 30 degree		
20	280	General Debur	
	Deburr Threads Centerpunch end of thread Radius .250 slot		
21	285	Bench Inspect	
	Inspect Complete from oper 120		AQL 1.5 (QCP 010)
22	287	DAC Source Inspect	
	DAC inspect prior to Cad plate		
23	290	Outside Processing	
	Approves Source Pre etch Penetrant Inspect Cad plate		 9.014 4.707 9.74 Type I
24	320	Identify	
	Verify Certs Penetrant and Cad Plate Visual inspect for Pits, Blisters, Damage, 100% Inspect Threads Identify Complete First Article		 3.02 and 3.27-1
25	330	Finish Stores	
	Protect and store for next assy		