NATIONAL TRANSPORTATION SAFETY BOARD

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

August 15, 2000

MATERIALS GROUP FACTUAL REPORT Report No. 00-074

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

During the week of May 15, 2000, the Materials group conducted additional tests and measurements on the accident jackscrew and on seven other jackscrew assemblies received as part of the investigation. These tests and measurements were intended to both validate and augment the measurements previously performed at Trig Aerospace and reported in Materials

Group Report 00-068. In additions, similar tests and measurements were performed on five separate Acme nut assemblies. These nuts were received from Trig Aerospace as the result of overhauls performed on other jackscrew assemblies from Alaska Airlines. The overhaul nuts were from jackscrew assemblies (5910962-71), DCA-2264, DCA-1935, DCA-2272, DCA-2192 and the nut from N955AS (serial number unknown).

Measurements performed by the Materials Group to validate Trig measurements included; Thread Straightness, Major Diameter, Minor Diameter, Surface Finish, Thread Pitch and Thread Crest Width. In addition, the surface hardness of the screws was measured. Many of these measurements employed similar techniques to those at Trig but with different machines and operators. The general areas of measurement were the same at Trig and the NTSB Materials Lab but the specific locations may have varied. Other measurements utilized alternate techniques than those at Trig, such as video based measurements. Additional casts of the thread forms were also made on the overhaul nuts.

Measurement techniques are discussed below with differences in techniques noted. Summarized findings are also discussed below. Numerical data are presented in the following tables with comparative data from Trig (reported in 00-068) also presented.

Thread Straightness

Straightness was measured as at Trig with the screw rotated on Vee blocks and the movement measured in the center with a dial indicator.

The accident screw and three others exceeded the limits for straightness during measurements at both Trig and the NTSB lab. Numerical data in Table A.

Major Diameter

The major diameters were measured at the top, middle and bottom of the screw with a set of outside micrometers. The accuracy of the micrometer was checked before and after the measurements.

The accident screw and four others exceeded engineering drawing limits in some locations when measured at Trig and / or by the Materials Group. Numerical data are in Table A.

Minor Diameter

Because of the thread lead, normal blade micrometers could not be used. Instead the minor diameters were measured using a calibrated computerized video based measurement system (SmartScope). All screws were measured near the top of the threads at two locations oriented 90° apart. In addition, the accident screw along with the ones from N981AS (Alaska Airlines) and N941AS (TWA) were measured near the middle and bottom.

All screw measurements met the minor diameter requirement. Numerical data are in Table A.

Surface Finish

Surface finish was measured with a Mitutoyo SurfTest 402 electronic profilometer with a small hole stylist. The measurements were made in a generally radial direction on the upper tooth flank (the wear flank). Measurements were made on two unworn threads near the top (2nd, 3rd or 5th) and on one in the worn area near the middle (40th from top) of the screw. The stylist was stroked across the surface several times until about 4 consecutive readings were consistent (within 5 to10 µin). At Trig the profilometer was stroked tangentially across the thread flank until about two consistent readings were obtained.

In addition to the electronic measurements, the roughness levels of three screws were visually estimated by comparing the major and minor surfaces to a roughness chart.

The accident screw met the surface roughness requirements of the engineering drawing. Four other screws did not. The average electronic and visual surface roughness measurements are contained in Table B below. In some cases, the lab data also indicated large differences between nearly adjacent locations (see AirTran, Alaska N982AS and TWA). The data showed a general correlation between the Trig measurements and the lab measurements.

Thread Pitch

The thread pitch was measured at 0° and 90° orientations (also 180° and 270° for the accident screw) between randomly selected threads at the top, middle and bottom locations on all screws. The pitch was determined on an optical comparator using a similar technique to that of Trig. The 0°, 90°, 180° and 270° measurements are listed in Table C below. Additionally, the pitch of every thread was measured along one side of the accident screw and the TWA screw. The raw measurements are contained in Table D and are graphically presented in Figure 1. The changes in pitch length between successive threads are also calculated and shown in Table D.

There are no direct specifications for pitch on the drawing or referenced standards. The drawing specification is for a 1 ¾– 0.25 pitch – 0.500 lead NA-5C Acme Special thread per design handbook H-28. This describes a thread form with two individual thread starts, each with a nominal lead of 0.500-inch. The thread as a whole would then have an effective pitch of 4 threads per inch (0.25 inch). For a single start screw, pitch and lead are the same but for a two-start screw, lead is the distance between every other thread form (0.500). Lead values are calculated and presented in Table D along with lead changes between successive threads.

The average, minimum, and maximum for pitch, pitch change, lead and lead changes are presented at the bottom of the table.

Thread Crest Width

Casts of the thread forms on the overhauled nuts were prepared and measured as previously reported in 00-068. The individual tooth measurements are presented in Table E along with data previously reported in 00-068. In addition, on nut DCA-2264 that had been previously cut longitudinally, the thread crest widths along the entire length of the nut were measured using a SmartScope.

Figure 2 graphically depicts the measurements in relation to their position in the nut. As can be seen, the thread crests had a strong tendency to be more reduced (smaller) toward the bottom of the nut.

Hardness

Superficial surface hardness tests (HR15N) were performed on all jackscrews except the MD-90 screw from Delta. Six hardness impressions were made on the major diameter on the threads after the surfaces had been smoothed with 400 grit abrasive. For all nitrided DC-9 / MD-80 jackscrews (-503, 505, -507), the engineering drawing requires a minimum surface hardness of 85 HR15N. All screws met this requirement. Individual results are presented in Table F.

MD-90 screws (-509) are through hardened to an ultimate strength of 260 to 280 kpsi and do not have a surface hardness requirement. Rockwell C hardness (HRC) measurements at the upper end of the screw ranged from 48.6 to 49.6 HRC. This hardness range approximately corresponds to 233 to 240 kpsi ultimate tensile strength.

Hardness tests were not performed on the screws at Trig.

Hardness tests (Rockwell B scale) were also performed on the five overhauled gimbal nuts and the accident nut. The engineering drawing requires a minimum 93 HRB for the nuts. All nuts met this requirement. The average nut hardness data are presented in Table G. The previously measured hardness of the accident nut (Trig) is presented for reference.

Joe Epperson
Senior Metallurgist

Table A Straightness, Major Minor Diameters

Airline		AirTran		Alaska		Alaska		Alaska	
Assembly SN		DCA-459		DCA-2064		DCA-3008		DCA-3000	
N No.				N963AS		N981AS		N982AS	
Location		Trig	Lab	Trig	Lab	Trig	Lab	Trig	Lab
Screw									
Thread Straightness 0.005 max		**0.0070**	**0.0060**		**0.0080**	0.0015	0.0020	0.0025	0.0020
Major Diameter	Top	1.7150	1.7162	**1.7170, 1.7175**	**1.7185**	1.7155	1.7160	1.7160	1.7155
1.7149-1.7169	Mid	1.7150	1.7154	1.7160, 1.7168	1.7165	1.7155	1.7155	1.7155	1.7155
	Bot	1.7160	1.7164	1.7160, 1.7165	1.7 165	**1.7145**	1.7150	**1.7145**	1.7160
Minor Diameter	Top	1.4240	1.4205, 1.4260	1.4275, 1.4325	1.4258, 1.4206	1.4295	1.4308, 1.4317	1.4300	1.4308, 1.4312
1.4192-1.4353	Mid	1.4210		1.4185, 1.4280	1.4196, 1.4250	1.4300	1.4301, 1.4322	1.4300	
	Bot	1.4255		1.4235, 1.4275	1.4243, 1.4278	1.4295	1.4320, 1.4315	1.4305	

Airline		Delta		NWA		Reliant		TWA	
Assembly SN		DCA-0009		00060		92-2290		DCA-1798	
N No.		N907DA		N925US				N941AS	
Location		Trig	Lab	Trig	Lab	Trig	Lab	Trig	Lab
Screw									
Thread Straightness 0.005 max		0.0030	0.0015	**0.0055**	**0.0070**	**0.0070**	**0.0060**	0.0015	0.0025
Major Diameter	Top	1.7165	**1.7170**	1.7155	1.7168	**1.7190**	**1.7200**	1.7165	1.7168
1.7149-1.7169	Mid	1.7165	1.7165	1.7155	1.7154	1.7165	1.7160	1.7160	1.7162
	Bot	1.7165	1.7165	1.7155	1.7160	**1.7175**	1.7168	1.7165	1.7168
Minor Diameter	Top	1.4325	1.4308, 1.4332	1.4255	1.4199, 1.4223	1.4220	1.4209, 1.4180	1.4280	1.4296, 1.4279
1.4192-1.4353	Mid	1.4325		1.4250		1.4230		1.4270	1.4288, 1.4281
	Bot	1.4320		1.4240		1.4230		1.4275	1.4295, 1.4283

Table B Surface Finish

Airline		AirTran		Alaska		Alaska		Alaska	
Assembly SN		DCA-459		DCA-2064		DCA-3008		DCA-3000	
N No.				N963AS		N981AS		N982AS	
Location		Trig	Lab	Trig	Lab	Trig	Lab	Trig	Lab
Screw									
Average Surface	Top 3rd	30	**54.17**		11.00	**33**	**38.50**	**75**	**85.67**
Finish	Top 5th		23.40		25.00		**36.20**		**41.86**
RMS (µin)	Mid	**43**	**37.00**		19.71	31	17.86	28-30	27.71
32 max	Bot	28-**36**				27		**55**	
Visual	Major Dia				64				125
	Minor Dia				32				64

Airline		Delta		NWA		Reliant		TWA	
Assembly SN		DCA-0009		00060		92-2290		DCA-1798	
N No.		N907DA		N925US				N941AS	
Location		Trig	Lab	Trig	Lab	Trig	Lab	Trig	Lab
Screw									
Average Surface	Top 3rd	30	25.40	**48**	**42.29**	**57**	**54.75**	**54**	**34.60**
Finish	Top 5th		27.80		**37.33**		**54.60**		**54.60**
RMS (µin)	Mid	**35**	30.17	**74 step**	**47.25**	**68**	**57.88**	21	25.50
32 max	Bot	28		32		**67**		20	
Visual	Major Dia								64
	Minor Dia								32

Table C		**Thread Pitch**							
Airline		AirTran		Alaska		Alaska		Alaska	
Assembly SN		DCA-459		DCA-2064		DCA-3008		DCA-3000	
N No.				N963AS		N981AS		N982AS	
Location		Trig	Lab	Trig	Lab	Trig	Lab	Trig	Lab
Screw									
Lead 0°	Top	0.2489	0.2484	0.2503	0.2492	0.2485	0.2487	0.2496	0.2496
	Mid	0.2484	0.2498	0.2471	0.2488	0.2476	0.2488	0.2480	0.2508
	Bot	0.2490	0.2490	0.2495	0.2519	0.2475	0.2485	0.2496	0.2499
Lead 90°	Top	0.2481	0.2498	0.2497	0.2500	0.2490	0.2496	0.2475	0.2498
	Mid	0.2496	0.2467	0.2496	0.2494	0.2489	0.2492	0.2491	0.2491
	Bot	0.2485	0.2486	0.2472	0.2481	0.2483	0.2500	0.2489	0.2495
Pitch 180°	Top			0.2501	0.2492				
	Mid			0.2491	0.2485				
	Bot			0.2478	0.2490				
Pitch 270°	Top			0.2483	0.2527				
	Mid			0.2494	0.2493				
	Bot			0.2506	0.2483				

Airline		Delta		NWA		Reliant		TWA	
Assembly SN		DCA-0009		00060		92-2290		DCA-1798	
N No.		N907DA		N925US				N941AS	
Location		Trig	Lab	Trig	Lab	Trig	Lab	Trig	Lab
Screw									
Pitch 0°	Top	0.2497	0.2490	0.2487	0.2503	0.2494	0.2501	0.2487	0.2495
	Mid	0.2497	0.2492	0.2494	0.2493	0.2475	0.2487	0.2492	0.2497
	Bot	0.2492	0.2504	0.2514	0.2500	0.2495	0.2504	0.2492	0.2485
Pitch 90°	Top	0.2478	0.2506	0.2488	0.2489	0.2479	0.2496	0.2498	0.2500
	Mid	0.2480	0.2478	0.2492	0.2492	0.2480	0.2499	0.2499	0.2501
	Bot	0.2485	0.2485	0.2491	0.2496	0.2476	0.2501	0.2490	0.2501

Table D Pitch End to End For Alaska N963AS and TWA N941AS									
Airline	Alaska					TWA			
Assembly SN	DCA-2064					DCA-1798			
N No.	N963AS					N941AS			
Thread	Pitch!	Pitch Chg#	Lead$	Lead Chg&		Pitch	Pitch Chg	Lead	Lead Chg
	(inch)	Calculated	Calculated	Calculated			Calculated	Calculated	Calculated
Bottom	0.2503					0.2498			
2	0.2481	0.0022	0.4984			0.2494	0.0004	0.4992	
3	0.2502	-0.0021	0.4983			0.2498	-0.0004	0.4992	
4	0.2487	0.0015	0.4989	-0.0005		0.2494	0.0004	0.4992	0.0000
5	0.2508	-0.0021	0.4995	-0.0012		0.2501	-0.0007	0.4995	-0.0003
6	0.2478	0.0030	0.4986	0.0003		0.2498	0.0003	0.4999	-0.0007
7	0.2520	-0.0042	0.4998	-0.0003		0.2490	0.0008	0.4988	0.0007
8	0.2486	0.0034	0.5006	-0.0020		0.2493	-0.0003	0.4983	0.0016
9	0.2501	-0.0015	0.4987	0.0011		0.2493	0.0000	0.4986	0.0002
10	0.2488	0.0013	0.4989	0.0017		0.2492	0.0001	0.4985	-0.0002
11	0.2501	-0.0013	0.4989	-0.0002		0.2498	-0.0006	0.4990	-0.0004
12	0.2486	0.0015	0.4987	0.0002		0.2498	0.0000	0.4996	-0.0011
13	0.2495	-0.0009	0.4981	0.0008		0.2494	0.0004	0.4992	-0.0002
14	0.2490	0.0005	0.4985	0.0002		0.2505	-0.0011	0.4999	-0.0003
15	0.2500	-0.0010	0.4990	-0.0009		0.2505	0.0000	0.5010	-0.0018
16	0.2529	-0.0029	0.5029	-0.0044		0.2489	0.0016	0.4994	0.0005
17	0.2490	0.0039	0.5019	-0.0029		0.2500	-0.0011	0.4989	0.0021
18	0.2490	0.0000	0.4980	0.0049		0.2490	0.0010	0.4990	0.0004
19	0.2508	-0.0018	0.4998	0.0021		0.2494	-0.0004	0.4984	0.0005
20	0.2485	0.0023	0.4993	-0.0013		0.2491	0.0003	0.4985	0.0005
21	0.2474	0.0011	0.4959	0.0039		0.2497	-0.0006	0.4988	-0.0004
22	0.2510	-0.0036	0.4984	0.0009		0.2505	-0.0008	0.5002	-0.0017
23	0.2506	0.0004	0.5016	-0.0057		0.2489	0.0016	0.4994	-0.0006
24	0.2474	0.0032	0.4980	0.0004		0.2499	-0.0010	0.4988	0.0014
25	0.2482	-0.0008	0.4956	0.0060		0.2493	0.0006	0.4992	0.0002
26	0.2499	-0.0017	0.4981	-0.0001		0.2493	0.0000	0.4986	0.0002
27	0.2497	0.0002	0.4996	-0.0040		0.2490	0.0003	0.4983	0.0009
28	0.2497	0.0000	0.4994	-0.0013		0.2493	-0.0003	0.4983	0.0003
29	0.2486	0.0011	0.4983	0.0013		0.2501	-0.0008	0.4994	-0.0011
30	0.2502	-0.0016	0.4988	0.0006		0.2482	0.0019	0.4983	0.0000
31	0.2467	0.0035	0.4969	0.0014		0.2496	-0.0014	0.4978	0.0016
32	0.2510	-0.0043	0.4977	0.0011		0.2496	0.0000	0.4992	-0.0009
33	0.2504	0.0006	0.5014	-0.0045		0.2500	-0.0004	0.4996	-0.0018
34	0.2471	0.0033	0.4975	0.0002		0.2490	0.0010	0.4990	0.0002
35	0.2501	-0.0030	0.4972	0.0042		0.2501	-0.0011	0.4991	0.0005
36	0.2493	0.0008	0.4994	-0.0019		0.2496	0.0005	0.4997	-0.0007
37	0.2492	0.0001	0.4985	-0.0013		0.2495	0.0001	0.4991	0.0000

38	0.2492	0.0000	0.4984	0.0010		0.2492	0.0003	0.4987	0.0010
39	0.2483	0.0009	0.4975	0.0010		0.2501	-0.0009	0.4993	-0.0002
40	0.2509	-0.0026	0.4992	-0.0008		0.2496	0.0005	0.4997	-0.0010
41	0.2493	0.0016	0.5002	-0.0027		0.2484	0.0012	0.4980	0.0013
42	0.2490	0.0003	0.4983	0.0009		0.2491	-0.0007	0.4975	0.0022
43	0.2487	0.0003	0.4977	0.0025		0.2495	-0.0004	0.4986	-0.0006
44	0.2494	-0.0007	0.4981	0.0002		0.2487	0.0008	0.4982	-0.0007
45	0.2499	-0.0005	0.4993	-0.0016		0.2496	-0.0009	0.4983	0.0003
46	0.2486	0.0013	0.4985	-0.0004		0.2495	0.0001	0.4991	-0.0009
47	0.2498	-0.0012	0.4984	0.0009		0.2486	0.0009	0.4981	0.0002
48	0.2493	0.0005	0.4991	-0.0006		0.2494	-0.0008	0.4980	0.0011
49	0.2494	-0.0001	0.4987	-0.0003		0.2493	0.0001	0.4987	-0.0006
50	0.2495	-0.0001	0.4989	0.0002		0.2496	-0.0003	0.4989	-0.0009
51	0.2489	0.0006	0.4984	0.0003		0.2507	-0.0011	0.5003	-0.0016
52	0.2498	-0.0009	0.4987	0.0002		0.2487	0.0020	0.4994	-0.0005
53	0.2480	0.0018	0.4978	0.0006		0.2484	0.0003	0.4971	0.0032
54	0.2491	-0.0011	0.4971	0.0016		0.2498	-0.0014	0.4982	0.0012
55	0.2514	-0.0023	0.5005	-0.0027		0.2496	0.0002	0.4994	-0.0023
56	0.2483	0.0031	0.4997	-0.0026		0.2494	0.0002	0.4990	-0.0008
57	0.2489	-0.0006	0.4972	0.0033		0.2498	-0.0004	0.4992	0.0002
58	0.2493	-0.0004	0.4982	0.0015		0.2490	0.0008	0.4988	0.0002
59	0.2496	-0.0003	0.4989	-0.0017		0.2501	-0.0011	0.4991	0.0001
60	0.2495	0.0001	0.4991	-0.0009		0.2494	0.0007	0.4995	-0.0007
61	0.2498	-0.0003	0.4993	-0.0004		0.2503	-0.0009	0.4997	-0.0006
62	0.2494	0.0004	0.4992	-0.0001		0.2492	0.0011	0.4995	0.0000
63	0.2499	-0.0005	0.4993	0.0000		0.2497	-0.0005	0.4989	0.0008
64	0.2498	0.0001	0.4997	-0.0005		0.2490	0.0007	0.4987	0.0008
65	0.2495	0.0003	0.4993	0.0000		0.2501	-0.0011	0.4991	-0.0002
66	0.2514	-0.0019	0.5009	-0.0012		0.2493	0.0008	0.4994	-0.0007
67	0.2478	0.0036	0.4992	0.0001		0.2494	-0.0001	0.4987	0.0004
68	0.2507	-0.0029	0.4985	0.0024		0.2494	0.0000	0.4988	0.0006
69	0.2496	0.0011	0.5003	-0.0011		0.2489	0.0005	0.4983	0.0004
70	0.2487	0.0009	0.4983	0.0002		0.2487	0.0002	0.4976	0.0012
71	0.2480	0.0007	0.4967	0.0036		0.2495	-0.0008	0.4982	0.0001
72	0.2494	-0.0014	0.4974	0.0009		0.2494	0.0001	0.4989	-0.0013
73	0.2518	-0.0024	0.5012	-0.0045		0.2492	0.0002	0.4986	-0.0004
74	0.2499	0.0019	0.5017	-0.0043		0.2497	-0.0005	0.4989	0.0000
75						0.2495	0.0002	0.4992	-0.0006
76						0.2501	-0.0006	0.4996	-0.0007
77						0.2491	0.0010	0.4992	0.0000
Average	0.2494	0.0000	0.4989	-0.0001		0.2495	0.0000	0.4989	0.0000
Min	0.2467	-0.0043	0.4956	-0.0057		0.2482	-0.0014	0.4971	-0.0023
Max	0.2529	0.0039	0.5029	0.0060		0.2507	0.0020	0.5010	0.0032
Spread	0.0062	0.0082	0.0073	0.0117		0.0025	0.0034	0.0039	0.0055

! Pitch—distance between similar geometric points on successive thread forms

Pitch Chg—difference (subtractive) in pitch measurements between successive threads

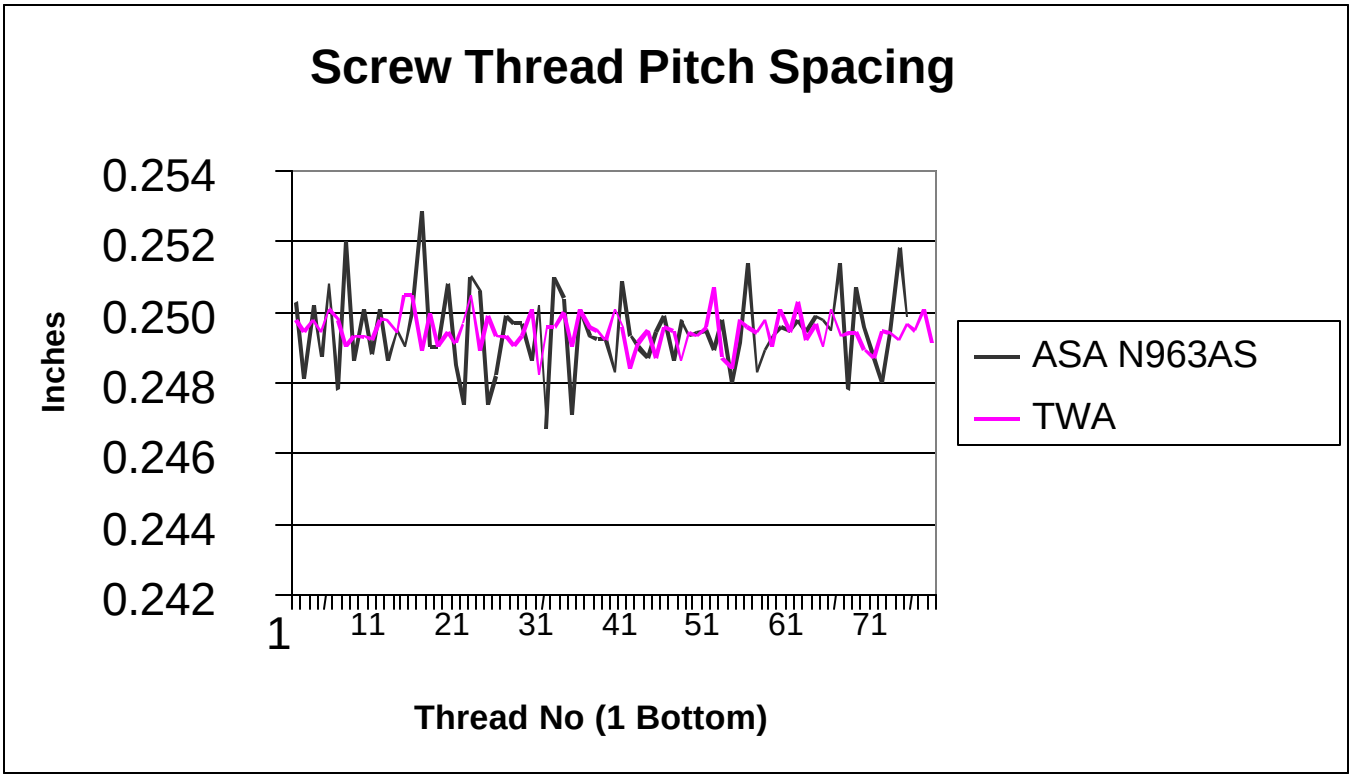

Figure 1. Raw screw pitch measurements for the accident screw and the TWA screw. The number 1 screw thread is at the bottom of the screw (left in graph).

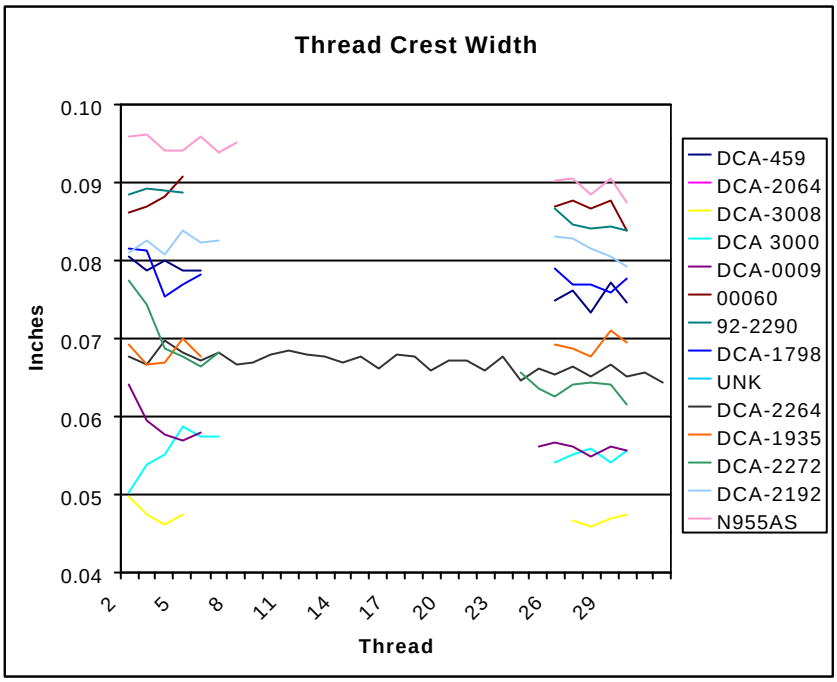

Figure 2. Graphs of thread crest widths vs thread position. No 1 thread is at the top of the nut (left in graph).

Table E		Thread Crown Measurements											
Airline		Airtran	Alaska	Alaska	Delta	NWA	Reliant	TWA	Alaska	Alaska	Alaska	Alaska	Alaska
Assembly SN		DCA-459	DCA-3008	DCA 3000	DCA-0009	00060	92-2290	DCA-1798	DCA-2264	DCA-1935	DCA-2272	DCA-2192	
N No.			N981AS	N982AS	N907DA	N925US		N941AS					N955AS
	Top								0.06783				
Thread	2	0.08060	0.04960	0.05030	0.06395	0.08605	0.08840	0.08160	0.06670	0.06915	0.07745	0.08100	0.09590
Crown	3	0.07855	0.04750	0.05380	0.05935	0.08690	0.08910	0.08120	0.06976	0.06660	0.07430	0.08250	0.09620
Width	4	0.07990	0.04615	0.05505	0.05770	0.08810	0.08900	0.07540	0.06815	0.06705	0.06880	0.08080	0.09410
	5	0.07880	0.04750	0.05880	0.05685	0.09080	0.08860	0.07700	0.06723	0.07010	0.06780	0.08375	0.09410
	6	0.07880		0.05745	0.05810			0.07810	0.06820	0.06755	0.06650	0.08235	0.09570
	7			0.05735					0.06653		0.06820	0.08260	0.09380
nominal	8								0.06700				0.09505
.3707p	9								0.06807				
0.0927	10								0.06832				
	11								0.06787				
	12								0.06760				
	13								0.06689				
	14								0.06775				
	15								0.06625				
	16								0.06800				
	17								0.06758				
	18								0.06584				
	19								0.06710				
	20								0.06719				
	21								0.06602				
	22								0.06762				
	23								0.06461				
	24								0.06615		0.06570		
	25				0.05600				0.06545		0.06360		
	26	0.07475		0.05405	0.05655	0.08680	0.08655	0.07895	0.06647	0.06920	0.06265	0.08320	0.09025
	27	0.07620	0.04675	0.05525	0.05620	0.08750	0.08465	0.07705	0.06506	0.06865	0.06405	0.08270	0.09030
	28	0.07340	0.04585	0.05590	0.05480	0.08670	0.08400	0.07680	0.06671	0.06760	0.06445	0.08150	0.08840
	29	0.07710	0.04690	0.05410	0.05630	0.08780	0.08440	0.07590	0.06499	0.07105	0.06405	0.08065	0.09040
	30	0.07465	0.04745	0.05555	0.05555	0.08390	0.08375	0.07760	0.06563	0.06960	0.06160	0.07930	0.08745
	31								0.06439				
Avg		**0.07106**	**0.04262**	**0.05116**	**0.05320**	**0.07950**	**0.07886**	**0.07173**	**0.06687**	**0.06866**	**0.06686**	**0.08185**	**0.09264**
Avg Wear		0.02164	0.05008	0.04154	0.03950	0.01320	0.01384	0.02097	0.02583	0.02405	0.02584	0.01085	0.00006

Table F Screw, Superficial Hardness Measurements.

Airline		Airtran	Alaska	Alaska	Alaska	Delta	NWA	Reliant	TWA
Assembly SN		DCA-459	DCA-2064	DCA-3008	DCA 3000	DCA-0009	00060	92-2290	DCA-1798
N No.			N963AS	N981AS	N982AS	N907DA	N925US		N941AS
Screw Surface Hardness									
85 min 15n	1	90.50	86.50	89.10	87.00	88.00	91.60	90.00	88.90
	2	90.50	87.90	88.00	87.00	87.00	92.10	91.20	90.20
	3	90.20	88.50	88.10	86.20	86.20	92.00	91.50	90.00
	4	91.10	87.00	87.00	86.00	87.90	91.70	90.00	90.00
	5	91.10	87.50	87.90	87.20	88.00	91.50	91.90	90.20
	6	91.50	87.00	88.00	87.00	87.50	91.00	91.00	90.20
	AVG	**90.82**	**87.40**	**88.02**	**86.73**	**87.43**	**91.65**	**90.93**	**89.92**
	STDEV	0.49	0.72	0.67	0.50	0.72	0.39	0.78	0.51

Table G Nut, Hardness Measurements.

Airline	Alaska	Alaska	Alaska	Alaska	Alaska	Alaska
Assembly SN	DCA-2064	DCA-1935	DCA-2272	DCA-2192	N955AS	DCA-2264
N No.	N963AS					
Average Nut Hardness						
93 HRB min	98.8	97.0	96.5	95.6	96.2	94.7
Trig	103					