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NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.

GE PRODUCT SUPPORT REVIEW OF THE DELTA ATLANTA TOC ENGINE COMPONENT FPI AND CLEANING PROCESS

(13 PAGES)

GE Aircraft Engines
Flight Safety Office

Subject: NTSB Document Request

***Paul R. Mingler**, Principal Engineer*
General Electric Company
One Neumann Way, Mail Drop J-60
Cincinnati, OH 45215-1988

[redacted]

March 7, 1997

Tom Conroy, Investigator In Charge
Major Investigations Division
National Transportation safety Board

The attached material is in response to your request, dated 6 March 1997, for the use of documentation in support of the Safety Board's public hearing with regard to the Delta Airlines Flight 1288 accident in Pensacola, Florida on July 6, 1996. Attached is a copy of the subject document, the document cover letter, two pages covering corrective actions, and a copy of a Delta Fax concurring with this transmittal.

GE Aircraft Engines coordinated with Delta Airlines to insure that we were not violating proprietary information per our contractual agreements since some of the information was generated by Delta. Delta provided their support and permission for GEAE to forward this package to the NTSB. GEAE is also in concurrence that the material may be used for its requested purpose per the NTSB's normal practices and procedures

Note that the two pages pertaining to the shop review debrief, dated 9 March 1990, reflect the meeting actions and corrective actions "C/A" that were added by Delta Quality Control/Process Engineering at a later date. These pages are located just before the last page which is the Delta Fax dated 3/7/97.

I hope that this package satisfies your request. Please call me if you have any questions.

[redacted]

Paul R. Mingler, Principal Engineer
Accident/Incident Investigations

cc: Jack Drake, NTSB
Jim Anderson*, Delta
Terry Kessler*, GEAE

* - No Attachments

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March 26, 1990

Mr. Harold Joiner
Assistant Vice President Quality
Delta Airlines
Department 510
Hartsfield International Airport
Atlanta, Georgia 30320

Subject: FPI and Cleaning Processes Review

Dear Harold:

Recently our Product Support Engineering group conducted a review of your FPI and cleaning processes in Atlanta. The results of that review confirm that Delta has sufficient capability to perform critical FPI inspections.

A detailed report on the observations of our engineers are attached.

Again, thank you and Delta for allowing us the opportunity to conduct this review. If you have further questions or comments regarding this subject or the report, please do not hesitate to contact either Moody Shields or me.

Best regards,

[redacted]

J.P. Linz
Customer Support Manager

cc: M. Bauer
J. Crawford (DL)
[redacted]
J. Reed
M. Shields
L. Stokley

mb:3654P/96

GE Aircraft Engines

Subject:

GE Product Support Review of the Delta Atlanta TOC Engine Component FPI and Cleaning Processes

Commercial Product Support Department
General Electric Company
111 Merchant Street, Cincinnati, OH 45246 USA
Room No.
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R. Kesler, Delta
T. Kessler, GE
Jane Reed, GE
E. M. Shields, GE
J. Hein, GE

March 19, 1990

Jerry Linz
Delta Airlines
Customer Support Manager

CONCLUSIONS:

- Delta has adequate equipment and inspection capability to conduct the necessary FPI inspections required for GE Engine components. There were some anomolies observed which should be reviewed and corrected. Explanation of these anomolies will follow in subsequent FPI discussion.

- As no GE rotating hardware was scheduled for cleaning, the cleaning, stripping, and etching processes were not reviewed at this time. A general tour and facility study was performed. All observations will be discussed under the cleaning discussion section.

FPI PROCESSING:

Delta uses an in-line roller conveyor/dip tank system to handle large rotating parts. Parts are fixtured on carriers to allow for immersion processing. Larger static components are processed in an adjoining spray booth. No parts were observed in the spray booth.

After observation of this week's parts processing, the following comments can be made:

- Part Emulsification: The processing operators are quite conservative in the emulsification immersion time. A thirty second dip with the associated transfer times insured contact times under sixty seconds.

  This does not present a problem except that, with the initial as cleaned condition and surface condition of the parts observed, this strict adherence to minimum emulsifier times can lead to an excessive background fluorescence problem. Background fluorescence was observed on several of the parts processed, which made the subsequent inspections more difficult.

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- It is recommended that Delta review the emulsifier sequence with the process operators. They should be focused on the need to review the parts at the post emulsifier rinse station for background fluorescence conditions. Efforts to reduce background at this point in the process will make the inspection shorter, easier, and more predictable.

o Parts Drying: A concern was noted with the temperature setpoint on the line dryer. The dryer is set to 225°F. The GE Standard Practice requires a dryer temperature of 140°F to 160°F.

- GE recommends that Delta decrease the oven temperature to this lower range. The historical concern is that drying at this higher temperature has been shown to reduce the brilliance of a fluorescent penetrant in an indication.

o Dry Powder Application: Delta uses a pressure pot to apply dry powder mechanically to the surface of the parts. From the parts observed, it is the GE opinion that insufficient dry powder is being applied. A very low flow of powder was observed coming from the pressure pot tube. This, coupled with the observance of the process operator routine, did not allow for full part coverage on several occasions (i.e. CRF). It is usual to apply enough powder where the excess is removed by blowing with light air pressure (as in a storm cabinet), or by implementation of electrostatic powder application.

- As a minimum, Delta should review powder application with the process operators to reduce this variability and also look at increasing the amount of powder coming out of the pressure pot. Switching to a different type of powder delivery system (i.e. nozzle) should be evaluated. It is understood that Delta has attempted to increase dry developer flow by increasing the air pressure in the pressure pots.

o Non Aqueous Wet Developer (NAWD) Application: It is a general observation that there are no defined guidelines established to direct the use of NAWD on any of the components, or to direct the operators where to spray the NAWD on any of the individual piece parts. The HPTR disk shaft did not have NAWD applied to it as part of the initial processing; only after the inspector was having trouble in reviewing some of the indications.

- This type of situation should be corrected and adherence to GE Manual requirements should be incorporated into Delta's system with respect to NAWD application.

o Parts Handling: In general, parts handling and fixturing allow for good presentation of the components for inspection. One fixturing problem was observed, which should be corrected immediately—the inability to inspect the disk bore area on the -80 stage 1 HPT disk/shaft.

- The HPTR disk/shaft fixturing should be corrected immediately as the bore area is considered to be a critical area and must be included in the inspection sequence. As a result of this situation, a hoist has been added in the inspection booth to temporarily facilitate bore inspection.

- It was observed that the rollers on the fixtures were smearing residual penetrant across the contacting surfaces of the parts. To reduce this background problem, particular care should be taken in the washing process, and affected areas should be inspected prior to rotating the component in the fixture.

FPI INSPECTION:

In general, inspectors were knowledgeable of the techniques required for sufficient inspection. There were two observations made which Delta should address. These observations are not unique to Delta and have been addressed in other shop reviews.

o The first observation concerns the bleed back procedure used to evaluate indications. It was determined that the bleed back procedures were not being followed according to GE Standard Practice recommendations. After the use of solvent to clear an indication for further review (i.e. bleed back), if the indication does not reappear, the indication area should be redeveloped with powder or NAHD (whichever is applicable to the inspection in progress). This is particularly important for tight cracks as bleed back may not occur without the aid of additional developer. A demonstration to enforce this point was conducted with the available inspectors on a sample fan disk post.

  - Delta should revise the standard procedure and training sequence to stress proper bleed back/redevelopment techniques.

o A second critical observation was made during the HPT disk shaft inspection. During this inspection, it was observed that the operator missed multiple indications on the embossment faces. During the inspection sequence, these indications were not evaluated by any bleed back/redevelopment technique. After the inspector was finished, another review was conducted on these embossment areas by the GE representative. During this process, it was determined that the disk had multiple relevant indications which should have been flagged for further evaluation.

  This situation is of concern due to the critical part involved, plus the need for the inspector's understanding of the fundamental procedures needed for critical inspections. It must be made clear how to determine what is to be evaluated and how an indication is to be determined relevant.

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- It is recommended that Delta should reinforce the training program for inspectors to prevent this type of situation from recurring.

- It is recommended that Delta review the internal mechanism for insuring that NAND is applied to all critical areas as specified by the GE Engine Manuals.

TRAINING:

Training is accomplished by on-the-job training with supplemental reinforcement by attending one of the commercially available training schools. This procedure is commonly used by several operators. It is noted that this training should be reinforced by more specific training into techniques required for engine hardware. This needs to be accomplished by additional supplements to the in-house training or by a different out-of-house training sequence. As trends develop in these FPI reviews, it should be noted that GE is concerned about the commercially available training and its lack of focus to specific engine hardware problems. Until such time as a source for good specific training can be found external to Delta, attention should be focused on in-house training needs. In general, it is recognized that external courses serve as a good basic introduction, and that training on engine component inspection requirements should be reinforced in-house.

PARTS PROCESSED:

o GE sample LCF blocks. Blocks were processed by two independent sets of process operator/inspector teams with a thirty second emulsifier time (total contact of approximately one minute). In general, the results show that the process sensitivity is adequate and that both operators were equivalent in indication determination in focused inspections. There was a problem with one of the blocks in the first run (block 64). It had not been properly rinsed during processing and subsequently was not readable. This reinforces the idea that more attention should be paid to the parts in process at the post emulsifier water rinse station.

  - It is recommended that Delta focus on the emulsification/wash process to reduce background FPI.

o TAM Panels. Daily process panels were observed during a run. These panels receive a fifteen second emulsification time. All indications were visible, but there was notable background also present. As these panels were processed in accordance with the CFM Standard Practice recommendations, all were acceptable. It is noted, however, that this fifteen second limit will be reevaluated at GE. Logically, the test panels should see the same conditions as the processed parts.

  - It is recommended that the TAM panels receive the same processing sequence that the parts are exposed to.

- HPT Disk Segment. Processed and evaluated in correct manner. The LCF cracks at the embossment did not show up adequately due to less than ideal NAMD application. After NAMD was reapplied by the GE representative, the embossment cracks were clearly visible.

  This exercise, coupled with the fan disk post evaluation, led to a good discussion about NAMD with the operators and foreman. It was explained why NAMD is different, how it works, and why it must be applied properly.

  - It is recommended that Delta include a NAMD procedure in the standard process, and train the operators accordingly.

- Fan Disk Post Segment. The indications were properly found by the inspectors. This piece was used to show how excessive solvent used during bleed back could wash out penetrant from shallow cracks. It was also used to show why redevelopment is crucial in the indication evaluation procedure.

- Fan Disk P/N 9319M28P02, S/N MPOH 4573. Processed and evaluated in general correct fashion. Critical observations on the application of NAMD and lack of review of the heavy background fluorescent areas in the bore areas were discussed with the operator and foreman. As the bore is a critical area, all surfaces should be properly evaluated. Heavy fluorescent background areas should be cleaned for proper inspection.

- HPT Disk Shaft P/N 9367M45G04, S/N MPOH 1245. Part was not processed according to GE requirements. NAMD was not initially applied as required. The bore was not inspected. The indications apparent on the aft embossment faces were not evaluated and marked. After the operator discussion, this piece was used as a tool to guide the operator through the proper evaluation procedure. It was also used as a tool to discuss indication locations with the foreman.

  It must be stressed that indications may appear anywhere on a part, not just in predetermined areas. Focused inspections look for indications in known problem areas, but it must be crystal clear that inspectors should not limit their inspections to these areas.

  Subsequent review of the indications seen on this disk shaft with the local GE Representative and the Cincinnati-based responsible Product Support Engineer, identified this component as one of a family that had received attention for indications on the embossment side faces due to a manufacturing problem in ECM known as "Barking". Disks that exhibited these indications in the past were usually sent back to GE for review and rework, or possibly blended at the overhaul facility if -80A 72-53-02 Repair 002 substantiation had been previously earned.

This disk should have had these embossment side face indications flagged. If this disk is to be ultimately scrapped for thread damage, as currently expected, it is strongly recommended that it be kept as a good training aid to help in future inspection training. Examples of real hardware conditions like this are hard to find.

- CRF P/N 9283M77G16, S/N VOL 02262. Delta has a good setup for processing the CRF through the dip tank line. The piece was hand pump sprayed with GE Class D penetrant and saw a 30-second immersion in emulsifier (total contact time 60 seconds). The process operators also sprayed additional emulsifier on the CRF during the water post rinse in an attempt to cut down the background fluorescence. Suds were visible on the part when it entered the dryer. Powder application was very clean compared to preferred conditions.

  The inspector was very thorough in his evaluation of the frame, with all areas inspected and several indications reviewed and marked. As there were a lot of background fluorescence on the part, his inspection was difficult, and he handled it very well. A debrief with the inspector and the foreman highlighted the concern over the excess background and experience with the CF6-6/-50 frames compared to the -80A frames.

  Recommendations are to focus efforts on the reduction of background fluorescence by increasing immersion times in the emulsition up to 60 to 70 seconds, and total contact time to 90 seconds, as this casting (like all castings)is a difficult part to inspect.

  Effort must also be made to insure proper dry powder coverage.

FPI PROCESS CONTROL:

All penetrants were recently changed over due to new formulations. Penetrant checks consist of daily process runs with the TAM panels, and quarterly TAM panel checks of line penetrant versus master.

Emulsifier is checked quarterly--line tank versus master. No refractometer readings are done. Additions are always done at twenty percent. Reviewed concept of concentration check with the foreman. Explained need to do so because of water loss. As Delta does not air agitate the emulsifier bath, this is not a major concern. Although, some control check should be implemented to monitor emulsifier concentration.

D. DeHays, the TURCO representative, was contacted to help establish this check by coordinating a refractometer or titration reading program. It is understood at this time that a titration procedure will be developed and implemented.

The drying oven is checked, by Maintenance, on a regular basis. It is recommended that a temperature indicator be considered.

Dry powder is not normally checked, as fresh powder is loaded into the pot when needed.

CLEANING PROCESSES:

As no parts were available for observation, the review was limited to a brief tour/question and answer session with Billy Jacobs, Production Control and Acting Foreman of the cleaning area.

In general, Delta operates a cold line (Ti Safe) and hot line (hot section parts) process. The cold line uses T4181 at 7 to 9 ounces per gallon. The T5948R is tanked on the cold line, and Billy reports they are quite happy with its performance.

The hot line resembles GE Method 10 cleaning, but it is not complete. Delta uses T4008 alkaline solution as a substitute for T4931 acid descaler. The normal run is T4181, T4008, T4338, and T4181 with the customary dip/spray rinses. Typical part exposure time in each non-agitated tank is thirty minutes.

Process solution control is done on a weekly basis at Delta laboratories and at TURCO. Temperatures are monitored every other day. New temperature controls have been procured and are scheduled for introduction.

Delta complements these lines with varsol cleaning, steam/emulsion cleaning, dry blasting, and U/S cleaning with manual scrub. The dry blast areas use a variety of medias. Alumina from 120 to 500 grit, glass bead, organic blast, and plastic media (automated/manual) are on station. HPT disk blasting is said to be done with 500 grit at 20 to 30 PSI. Fan disk molydag removal is accomplished by organic/glass bead blast. A fan disk was observed coming out of the stripping area with only partial stripping. It was headed back to cleaning for more blasting.

General recommendations to the cleaning area are as follows:

- Consider the implementation of GE SPM Method 10 or Method 20 cleaning by adding an acid descaler (T4931) and/or phosphoric acid (T4409). GEAE considers these methods to be the best available chemical methods to clean hot section components. It is currently required on -50 turbine disks. CF6-80 requirements are under evaluation.

- Introduce agitation in the hot and cold line chemical tanks by introduction of mechanical stirrers.

- Dedicate a dry blast cabinet to Method GE 70-21-04C process (low pressure 500 grit). The blaster, at the time of the visit, was operating larger grit at higher pressure. It is preferred that a cabinet be dedicated to 500 grit.

- Consider PMB for removal of dry film lube (DFL) material on fan and compressor blades in lieu of T6453.

- Consider use of T6453 for use on fan disk DFL when Cu-Ni-In coating is scheduled for removal. Also consider alternate chromic acid strip for DFL on fan disk. DFL and Cu-Ni-In strip could then be accomplished in plating area with a minimum of part movement.

MISCELLANEOUS:

- A brief tour of the old and new blade and vane FPI line was arranged. These systems are similar to the main FPI line in setup operating on dip tank carrier philosophy. The compressor blade focus center is currently in a start-up mode.

SUMMARY:

Delta has sufficient capability to perform critical FPI inspections. Anomolies observed show that focused attention must be paid to operator/inspector "calibration" to prevent processing variability.

A big thank you to all of those involved in the review. Everyone was helpful in all aspects.

[redacted]

Louis C. Stokley
Materials and Processes Engineer
Product Support Engineering
Commercial Product Support Dept.
GE Aircraft Engines

Attachments: 1) LCF Block Data, Delta
2) LCF Block Data, GE
3) Delta Chemical Report
4) TURCO Chemical Report

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DL 3/6-3/7/97 LCF BLOCKS B

BLOCK S/N	RUN NO.	1	CRACK LENGTH (INCHES) 2	3	4	5	6
0786-64	1*	.015	.015	.015	<.010	—	—
	2	.030	.015	.020	.015	(.015 MISS)	.020
	3						
0983-74	1						
	2	.030	.020	.030	.050	.040	.050
	3	.030	.020	.015	.050	.040	.040
0983-75	1	.020	.030	.040	.040	.030	.040
	2	.030	.040	.030	.060	.050	.050
	3						
0983-76	1	.030	.020	.030	.040	.020	.015
	2	.040	.030	.050	.050	.030	.040
	3						
0983-78	1	.020	.020	.050	.020	.060	.040
	2	.030	.020	.090	.030	.060	.040
	3						
0983-79	1	.030	.030	.030	.040	.030	.060
	2	.040	.030	.020	.060	.040	.060
	3						
			PP = <.005"				
			- = NO INDICATION				

NOTES: Run #1, Block #64 Block too DIRTY TO READ.
Results shown are values After Bleedback Procedure.
Run #2, Block #62, crack 5 misread - No crack visible

System: PG0H(M), E41, DD2, Sherchek Nonaqueous Dev.
Emulsification Times: 30 to 60 Seconds.

BLOCK S/N	RUN NO.	1.X	CRACK LENGTH (INCHES OR MM) 2X	3X	4X	5X	6X
0786-64	1	.030	.020	.030	.024	—	.015
	2 FPI	.022	.008	.016	.009	.005	.008
	3 VISUAL	.027	.011	.018	.017	.007	.014
0983-77	1	.030	.020	.020	.040	.040	.040
	2 FPI	.014	.014	.011	.026	.013	.019
	3 VISUAL	.016	.015	.015	.029	.017	.022
0983-75	1	.015	.020	.025	.045	.030	.030
	2 FPI	.007	.013	.017	.024	.019	.017
	3 VISUAL	.010	.016	.017	.022	.019	.023
0983-96	1	.015	.015	.030	.041	.020	.025
	2 FPI	.011	.009	.024	.021	.008	.009
	3 VISUAL	.016	.015	.023	.024	.014	.015
0983-78	1	.020	.020	.030	.026	.050	.030
	2 FPI	.012	.008	.035	.010	.044	.020
	3 VISUAL	.015	.012	.041	.022	.040	.022
0983-79	1	.020	.020	.015	.030	.020	.025
	2 FPI	.011	.013	.009	.018	.010	.030
	3 VISUAL	.017	.019	.013	.022	.019	.023
			PP = <.005"				
			- = NO INDICATION				

(1) C. Lout GG 1/15/90 RC77/ER531/TURBO NAVD

(2) Metcut FPI (ORIG. NAL) ZL35A/ZR10B/D499C

(3) Metcut Visual STICKS/MEASURE AT 100X MAG.

TANK	SPECS	SAMPLE SIZE-ML	TIME	PH	FACTOR	TITRATION AMOUNT	ADDITIONS OR REMARKS
3 4009	Boil Ph 250°F ± 5°F					250°	NONE
	Alkalinity 23.0 Sec	5	11.4			20.8	None
1	32.4 g/L	10.0	11.4	.988	39.8	35.3	NONE
4181 6	"	10.0	11.4	.668	50.6	449.	NONE
8	6.9 oz/gal	10.0	11.4	.888	7.4	6.6	NONE
4338	ALKALINITY 2.0 lbs/gal	5.0	7.0	.135	17.6	2.4	NONE — STD 10
	Permanganate 4-6 oz/gal	2.0		2.11	235	5.1	NONE
5351	SP. Grav 1.160					1.160	NONE
3 5948	20.26 %	100	8.0	2.0	12.2	24.4	NONE
6448	SP. Grav 1.160					1.170	NONE.
6453	ALKALINITY T1	5.0	5.0				NO SAMPLE
	T2	50.0	8.0				
	SP. Grav 1.33-1.38						NO SAMPLE
Versene	400 g/L minim.	5.0		T:tn x .05 x 452.2 ÷ 2	11.7	529	NONE
3							