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MAINTENANCE GROUP CHAIRMAN'S FACTUAL REPORT

(11 PAGES)

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NATIONAL TRANSPORTATION SAFETY BOARD
NORTH CENTRAL REGIONAL OFFICE
WEST CHICAGO, ILLINOIS

February **4**, 1997

MAINTENANCE GROUP CHAIRMAN'S FACTUAL REPORT OF INVESTIGATION

DCA-96-M-A068

A. ACCIDENT

Location:	Pensacola, FL
Date:	July 6, 1996
Time:	1438 CDT
Airplane:	Delta Air Lines, Inc., McDonnell-Douglas MD-88, N927DA

B. MAINTENANCE GROUP MEMBERS

Group Chairman:	Frank S. Gattolin NTSB, West Chicago, IL
Group Member:	Mario Giordano FAA, Pittsburgh, PA
Group Member:	Evan Byrne NTSB, Washington, DC
Group Member:	Roger Browning Delta Air Lines, Inc., Atlanta, GA
Group Member:	Terry Thompson ALPA/Delta, Atlanta, **GA**

C. SYNOPSIS

On July 6, 1996, at 1438 central daylight time, a McDonnell-Douglas MD-88, N927DA, operating as Delta Air Lines (Delta) Flight 1288, experienced an uncontained failure of the left engine (serial number 726984) during the beginning of its takeoff roll at the Pensacola Regional Airport, Pensacola, Florida. Two passengers were fatally injured. One passenger sustained serious injuries and two other passengers received minor injuries.. An engine fire followed: however, it self-extinguished within moments.

The airplane was equipped with Pratt and Whitney (P&W) JT8D-219 engines. The on-scene investigation revealed the

left engine's front compressor hub had fractured. Sections of the hub and its 34 fan blades penetrated the airplane's fuselage. Hub pieces also exited the fuselage. One piece of the hub was found about 2,400 feet west of the runway used for the aborted takeoff.

At the time of the accident, according to maintenance records at Delta, N927DA had a total time of 22,031 hours and 18,826 cycles on its airframe. The hub, serial number R32971, had a total time of 16,542.0 hours and 13,835 cycles on it at the time of the accident. The left engine had a total time of 7,371 hours and 5,905 cycles since new.

Delta was the original/initial operator of the engine, S/N 726984. This engine was removed from a fleet airplane on December 21, 1995, due to *Smoke in cabin." The problem was described as an oil leak in the compressor section. A carbon seal, P/N 758309 was replaced. Records showed a continued time set (serviceable) of fan blades were installed on the front compressor hub, S/N R32971 (P&W P/N 5000501-01). The engine was then installed on the accident airplane on January 1, 1996. At the time of installation the hub had 12,693 cycles on it. The hub failed at 13,835 cycles on July 6, 1996. The hub had 1,142 cycles since its last fluorescent penetrant inspection (FPI) and visual inspection at Delta on October 27, 1995.

D. DETAILS OF THE INVESTIGATION

Manufacturing History of the Hub:

According to a July 10, 1996, letter from P&W, hub S/N R32971 was manufactured from "...a heat of PWA 1215 titanium alloy (Heat No. T8825Z3) melted by TIMET on 11/29/87." The heat was cut into 4 billets. Mults from the 4 billets were foraed into 32 fan hub forgings by Ladish Company, in Milwaukee, Wisconsin. The Ladish-assigned heat code and suffix number for the fractured hub was LCCU-4019. The fractured hub was forged from billet "M2," which was the 3rd billet from the top of the heat (i.e., the 2nd billet from the bottom). The titanium alloy was triple vacuum melted. No oxidizers were used in its manufacturing process.

The hub was machined, finished, and inspected for P&W by Volvo in Trollhattan, Sweden, according to P&W records. A letter from P&W, dated July 19, 1996, said that "Volvo... performs various dimensional and nondestructive test conformity inspections to ensure [the]... hubs, meet P&W design specifications prior to delivery of a final product. Volvo and P&W require dimensional inspection for both hole size and hole location. P&W Visual 'Inspection Standard 454 applies to holes, including the bolt hole... providing

acceptance criteria for surface imperfections on major rotating parts."

P&W provided a copy of their Quality Standard 454 as well as the paperwork associated with hub S/N R32971. According to Standard 454, bolt holes are allowed to have "burnish marks" up to .125 of an inch around the hole's opening on the hub surface. The marks are described as "A shiny area resulting from rubbing against a hard smooth surface; may contain scratches of no apparent depth." The Standard does not describe how to determine a "...scratch of no apparent depth." The Standard does not describe acceptable damage to the hole's interior walls.

A P&W Supplier's Report of Nonconformance, dated May 26, 1989, showed hub S/N R32971 had 2 reports of nonconformance related to the hub's diameter. Volvo's December 7, 1987, hub inspection paperwork showed "Two holes at 12.117 are +0.035 and one hole at 13.095 is 0.08, some chatter marks in two holes applies to serial number R32971." The report continues, "Visual inspection... R32971 machining marks in hole noted on traveler at 13.145 loc.(ation) 180 degrees from serial number with address to the marking... inspection department 473." Following a determination by Volvo that the hub met P&W's manufacturing criteria, the hub was sent to P&W for subsequent installation on a new engine. S/N 725528.

According to a representative from P&W's Safety Department, the company does not perform a detailed inspection of hubs received from Volvo. He described P&W's receiving inspection is described as a general inspection of the hub. The P&W representative stated that the receiving inspection involves a general review of the hub for shipping damage and serial number/part number verification. He said the company did not do nondestructive testing of the hub when received from Volvo.

According to a July 19, 1996, P&W letter, P&W "...brought [Volvo] on board as a vendor of these hubs in 1984, at which time they became a partner with P&W in the JT8D Program... ." The letter continues, "The Quality Assurance Core Group conducts a full systems audit on the average of every four years. The vendor's quality system, manufacturing and process, gage calibration, processing of nonconforming material, nondestructive testing, product, etc. is audited. Volvo was audited in 1992 and 1996. In both audits, no significant items were found."

Operational History of The First Stage Hub:

On November 2, 1989, engine S/N 725528 was the first

engine to have the accident fan hub, S/N R32971, installed on it at the P&W factory. The engine was installed on the left side of a McDonnell-Douglas MD-88, N956DA, and the airplane was received by Delta on April 27, 1990. The engine operated in revenue service until January 14, 1992. The engine and hub were removed from N956DA at Delta on January 14, 1992, because of foreign object damage (FOD) to the fan blades at 4,456 cycles. The FOD was a mechanic's file that was left in the engine inlet after the fan blades had been dressed. Consequently, the hub underwent a shop visit inspection that called for a visual inspection after the fan blades were removed.

The visual inspection of the hub was reportedly done according to the P&W inspection procedure used by Delta. This inspection is entitled, "Front Compressor Front Hub (Stage One)- Inspection-01.'' Its manual reference number is 72-33-31, dated May 1, 1994. The manual instructions direct the inspector to pay particular attention to "...all holes..." in the hub. The instructions relating to the tierod and/or counterweight hole inspection requires the hole bore to be clean. The instructions tell the inspector to "Mount hub on tilted, rotating holding fixture and illuminate opposite end of hole from viewing end." The instructions also state, "NOTE: EACH HOLE MUST BE INSPECTED FROM BOTH SIDES." The subtask section detailing the surface inspection states that a white fluorescent light and a 3 power magnifying glass are used to identify surface damage "...suchas nicks, dents, scratches and corrosion pits." According to the Delta maintenance group representative (Delta representative), the visual inspection of the hub is also called a "shop visit." There was no reworking of part. This was confirmed by the fact that there was no shop routing of the hub.

The hub assembly was installed on engine S/N 725627 on March 6, 1992. It was removed from this engine when it had a total of 12,693 cycles on September 24, 1995. Delta's representative said the engine and hub were removed because the engine had restricted parts in the T-2 section. He added, the hub's blades had reached Delta's soft time limit of 4,000 cycles. The maintenance conducted on the hub assembly was considered restoration maintenance, or "heavy maintenance" according to the Delta Air Lines JT8D-219 Enqine Maintenance Management Plan (EMMP). Non destructive testing, blade slot dimensional inspection, and shotpeening the blade slots were accomplished during this process. According to the Delta representative, all work performed on the hub was done by the mechanics at Delta.

'The first stage Ian assembly was 'balanced and installed on engine S/N 726984 on December 29, 1995. The engine was

operated in a test cell on December 30, 1995. The engine test log data showed all vibration parameters were within the manufacturer's acceptable limits. The engine was ultimately installed on the left side of airplane N927DA on January 1, 1996, and operated until July 6, 1996, with no reported anomalies.

N927DA's engine performance logbook was reviewed. The logbook review covered the period between May 9, 1996, and July 5, 1996. The records do not reveal any engine operating anomalies. It should be noted that there were no engine vibration data observed by the Delta flight crews because the engines and airplane are not instrumented with vibration equipment.

N927DA's aircraft logbook was reviewed. The logbook covers a period between January 1, 1996, and July 5, 1996. There were no pilot reported engine discrepancies that could be associated with the fan blades or fan hub. No reports of any airframe vibration events were observed. Between June 6, 1996, and July 5, 1996, the port engine consumed 54 pints of oil. The right engine used 97 pints of oil during this period. The oil added to the left engine was well within the manufacturer's oil consumption rate of the P&W JT8D-219 operating limits, according to a P&W representative.

FAA Accident/Incident records between 1990 and July 6, 1996, related to the JT8D-200 series engines showed 69 records. The FAA Service Difficulty Reports (SDR) system showed 355 records for the same period. Accident/incident data showed no hub related events. However, one report stated: "NR1 engine failed on takeoff roll. Aborted and returned to gate. Changed engine." Date: July 13, 1992, N931DL, Syracuse, NY. No other data on this event is presently available. There was 1 hub related SDR. It stated: "Engine S/N 716760 was removed ....to investigate cause of high titanium content in oil sample, found that the C-1 hub had a groove approx. .25 inch deep by .75 inch wide, worn seal ring journal caused by C-1 hub shaft rotating inside of seal ring.'' The FAA Directorate and Delta were not aware of any hub defects in their experience other than those in the SDR system.

Hub Inspection Personnel, Traininu and Qualifications:

According to Delta's employee training records, at the time the hub was inspected, the quality assurance inspectors who did the NDT inspection on the hub had received training to perform their specific task. These individuals were trained according to the Air Transport Association of America (ATA) Guidelines €or Training and Qualifying

Personnel in Nondestructive Testing Methods, ATA Specification 105.

Each inspector is given an eye examination by Delta's first aid department. They are tested for near vision in both eyes. They must be able to read, with at least one eye, the Jaeger 2 size letters at a distance of not less than 12 inches. The inspectors were also checked for color blindness. According to Delta's nondestructive testing (NDT) operations manual, the inspectors must be able to distinguish "...contrast between colors using the Ishirara color plates, or another method which gives equivalent results." The NDT shop foreman said an inspector who fails the company vision test is sent to an optometrist for examination and recommendations. Each vision test is administered on a periodic basis, not to exceed 2 years, by a qualified nurse or person of greater qualifications. According to the operations manual, "Personnel deficient in visualizing certain colors shall only be restricted from performing examinations that require distinguishing between colors he or she is deficient in.

The NDT shop foreman was asked to define the training involved to obtain Level II FPI certification. He explained that an individual qualifying for Level II FPI certification receives 20 hours of classroom instruction and 480 hours of on-the-job training.

The inspectors who conducted the FPI and Visual inspections were interviewed. The FPI inspector said that he worked the afternoon shift on October 21, 1995, and acknowledged that he had done many FPI's including an FPI on the subject hub. However, he was unable to recall the number of hubs he had done. He said he undergoes FPI recurrent training every 9 to 12 months. The inspector said he has been doing FPI's about 18 months. The inspector said he is also eddy current qualified. This was confirmed by the NDT shop foreman.

The inspector said he followed the maintenance manual areas of emphasis during the -219 hub's inspection. He said each FPI inspector does the inspection using his own process. Though the inspection may be started at a different point on the hub by each inspector he said they follow the manufacturer's critical area's inspection procedures. According to this inspector, the -219 hub inspections take about 40 to 60 minutes each to complete.

The inspector said the inspection process can become very monotonous. He said he takes frequent stress breaks. The breaks are taken after he has completed working on a particular part. At times he will find somethinq he

believes may be a crack, but is not sure. He will ask another inspector to examine the part in his presence. The two will confer on what had been observed, according to this inspector. The inspector said he had never found a -219 hub with any cracks in it during his inspection career. He also related that he has never rejected a -219 hub for any reason.

The inspector said that finding cracks in the bolt and balance weight holes is not really possible. He said it was his opinion that an FPI wasn't meant for that type inspection, and secondly, the UV light being used by him would not project very far into the hole. The inspector said, in his opinion, that the only correct method to check the tierod bolt holes for cracks was with an eddy current inspection.

The second inspector interviewed was the individual who conducted the accident hub's visual inspection. He said he always conducted the visual inspection with the white fluorescent light and a magnifying glass that had 3 different magnification capabilities: 3-X, 4-X, and 7-X. The inspector said hubs would receive the FPI first and then came to him for a visual inspection. When he completed the visual inspection, the hub would go through a shotpeening and anti-galling process. Once these processes were completed, the hub would be returned for a second visual inspection. He said the hub may have gone through a third visual inspection by the personnel who were going to install it on the engine. However, he wasn't sure what that inspection involved.

Note: Delta's process standard stated the following: "The use of visual aids (mirrors, boreoscope or other suitable equipment) is required to examine areas not readily visible due to geometric configuration." P&W's overhaul standard practices manual directs the inspector to "Use visual aids (such as, dental mirrors and borescopes) during inspections of surfaces that are difficult to see by direct vision."

During the visual inspection, the inspector said it was very difficult to see into the holes on the hub. It was his opinion that an eddy current inspection of the bolt holes may not work due to the hub's thickness. Although a borescope inspection of the holes was not an approved procedure he was asked if the holes could be examined with a borescope. He replied that he never thought of using a borescope.

Observations Resulting From Inspection of Delta's Maintenance Facility:

Delta's management gave the maintenance group members a tour of the hub's "restoration maintenance" process. The process begins with vat cleaning of the hub. That is, once the hub is removed it is moved to the FPI shops's aqueous cleaning area. The hub is placed onto a wheeled "float" that is equipped with a rubber mesh mat while awaiting its cleaning process.

The hub is placed into a vat containing Turco 5948 for about 30 minutes. The Turco solution is replaced depending on the quality at an average time of 12 to 15 months. The hub is placed into a vat of circulating city tap water which is called a cold rinse. It is then placed into another vat with a 20 to 25 percent blue soap mixture. The hub remains in this vat for about 10 minutes and is removed for cold water rinsing. The hub is again placed into a vat with circulating city tap water. This rinse is called a hot flash rinse.

The hub's last vat visit involves a 1 to 4 hour soaking in Turco 6453 graphite stripper. According to Delta, "The hub is hot water rinsed and then it is placed on its float and proceeds to the plastic bead blasting area. After this is accomplished the hub proceeds to FPI to be emersed into the dye penetrant." It is usually on the float for about 1 to 2 hours before being emersed into the penetrant dye. No specific drying of the hub was observed after it was removed from the last vat in the cleaning process.

Note: Delta's process standard, 900-1-1 No. 21, states, "Dry plastic media abrasive can be used for removal of heat scale, carbon deposits, corrosion, and rust and for stripping paint in preparation for repainting on steel or titanium parts." The standard instructs the technician to "Use nozzle air pressure of 40 PSI for pressure-type machine, and 80 PSI for suction-type machine. Nozzle distance from part surface should be 6-8 inches."

The NDT foreman said that the P&W and Delta manuals allow the use of plastic bead blasting before emersion into the dye. According to P&W's JT8D Engine Manual, "Subtask 72-33-31-12-009 Hub, 1st Stage (Titanium) SPOP 19," the hub can be plastic bead blasted. SPOP 19 states, "there must be a 3 - 4 inch nozzle-to-part distance at a 45 - 60 degree angle to the work surface." It continues by stating, "Blow clean with air. If necessary, clean... and pressure rinse with hot water to remove any remaining plastic media." During the demonstration of the bead blasting the fore-going was not stated or demonstrated to the maintenance group.

The bead blasting procedure does not address at which point in the cleaning/inspection process this should occur.

The P&W representative stated that the plastic bead blasting is done before the hub is emersed into the dye. He said the bead blasting will eliminate any anti-galling compound, RTV, oil, etc. that was left on the hub after its final wash.

The NDT shop foreman walked members of the group through the hub's dye penetrant application process. The hub is placed in a vat containing the penetrating dye for 30 minutes. He said the dye's quality was checked on a daily basis. The supervisor added that it is rare for the dye too lose its quality level. After the hub is removed from the dye vat it is spray-rinsed with city tap water at a 30 PSI pressure level. He said it takes about 1 to 2 minutes for the rinse.

The hub is then placed into an emulsifier for 30 to 90 seconds. After removal from the emulsifier it is placed into a vat of water for 60 seconds. Upon removal from the vat it is spray-rinsed with city tap water at 34 PSI pressure with a temperature of about 40 degrees Centigrade. The rinsing takes 90 to 120 seconds. The technician doing the rinsing procedure physically moves the hub from a vertical position to a reclined position. This is done in order to get the rinse water into the inside of the hub. The hub is then placed into a drying oven for 5 to 10 minutes at 140 to 160 degrees Fahrenheit.

After the hub is removed from the drying oven developer dust is applied. The dust is applied with a hose nozzle that has about 20 PSI pressure moving the developer. It is sprayed on the exterior and interior visible surfaces by sweeping the hose nozzle in various directions over the hub. The hub's base is covered with the developer in the same way as the conically shaped section. Although the developer is applied to both sides and the edge of the hub base it is not directly applied to the tierod bolt or SR holes. Whatever gets into the holes and adheres to their surfaces is, essentially peripheral.

Delta's FPI process standard states the parts must be inspected within 2-hours of its developer application. Defects identified by the FPI process, which are more than 1 hour old, should be interpreted as suspect. These defects may be false positives. In the event the 2-hour time frame is not adhered to, the hub is returned for cleaning, dye emersion, drying, and developer process. There was no formal logging procedure observed that would show the inspector when the part undergoing the FPI was ready. The inspectors said they generally have a "group knowledge" of how long the part has been ready for inspection.

A hub inspection demonstration was observed on two separate occasions. The first observation was accomplished with a regular shop FPI inspector performing the task. The second was done by the individual who gave the accident hub its last FPI. The FPI's observed by the group members were, essentially the same except for individual inspector techniques.

The inspection darkroom is referred to as a tent by the inspectors. The inspection area has 4 heavy canvas-like fabric walls and a ceiling of similar material. The hub is on a set of plastic rollers that allow it to be moved relatively easy once in the "tent." A round shaped work area having the same type rollers is the inspector's work area. Black paper is positioned beneath the roller work area. This paper was about 70 percent covered with various sized developed dye specks. The group did not observe any lifting aids in the tent area. All items, according to the inspectors, must be moved about by hand. According to Delta's Director of Quality Assurance, the tent is provided with an overhead hoist and strap.

The inspector may wear gloves and special glasses to protect their eyes from the UV rays of the inspection lamp. The tent's ceiling has an overhead white light that is referred to as a tent light, according to Delta's Director of Quality Assurance. The inspector used this light to do a cursory inspection of the hub before starting the UV-light's inspection. There is also an overhead UV light that augments the inspector's hand held unit. The hand held unit is a flood light mounted in a metal shroud with a handle attached to it. The inspectors use an oblong-shaped incandescent bulb fixture for detail visual verification inspection of a suspected flaw.

The number of times the inspectors switch back and forth between the two types of lighting varies. The UV flood light appeared not to illuminate the hub's tierod bolt and S holes. It appeared as though the hole's interiors did not have developer applied to it. Occasionally, residual specks of developer, going about 1/4 to 1/2 inch into the holes, were illuminated by the UV light.

During the use of the hand-held UV light the inspector had to get the lamp to broadcast its light into the hole while he had to position his head and eyes to see into the hole. The head blocked part of the lamp's light rays. If the lamp is aligned with the hole, the size of the unit prevents the inspector from being able to see into the hole.

Both inspectors used a magnifying glass to look at suspect areas picked out by the UV or incandescent light

illumination. One inspector used a small magnifying glass (about 3/4 inch in diameter), the other used one that was about 2 inches in diameter. The first was a 10-X power and the second had 2 lenses of 3-X and 4-X. The 2 lenses could be combined to make a 7-X magnifying glass. The inspectors also used inspection mirrors during the **FPI** process.

The following is a description of the -219 hub **FPI** process as observed by the maintenance group representatives.

"It was observed that the UV spotlight does not effectively penetrate into the tierod bolt holes when viewed from the top of the hub. The geometric design of the -219 [hub], especially the conical front, and the size of the [floodlight] prevents the positioning of the spotlight in such a way that both (1) the light penetrates deeply into the [tierod bolt holes] and **(2)** the interior of the hole can be seen by the inspector [if any developer was in the hole]. On the bottom of the hub, the task is easier however, proper alignment can only be done if the inspector rotates the hub under a particular frame of reference. Instead, the inspector was observed to rotate the hub in an approximate 120 degree increments and then physically move his body to and light along an arc to inspect the holes.

As the method was demonstrated, the light does not effectively penetrate into the hole beyond .5 inches; and examination of the entire 360 degrees of interior surface requires substantial re-positioning of the inspector, the light, and the part; this was not observed. To inspect other hard to reach areas, the inspectors **use** [an inspection] mirror having a metal edge. No formal marking of the part occurs unless a suspect indication is identified."

Submitted on February 4, 1997, Frank S. Gattolin, NCR-A

Signed: [redacted]