Aviation Investigation Final Report

Location:	Minneapolis, Minnesota	**Incident Number:**	ENG11IA016
Date & Time:	February 9, 2011, 06:30 Local	**Registration:**	N704X
Aircraft:	Boeing 757-2Q8	**Aircraft Damage:**	Minor
Defining Event:	Fire/smoke (non-impact)	**Injuries:**	2 None
Flight Conducted Under:	Part 121: Air carrier - Scheduled		

Analysis

A Delta Air Lines Boeing 757-2Q8 airplane, N704X, experienced a tailpipe fire in the No.2 (right) engine, a Pratt & Whitney (P&W) PW2037, during engine start at the Minneapolis-St. Paul International Airport, Minneapolis, Minnesota. The main and aft inboard flaps and inboard flap track fairing on the right wing were blistered, charred, and delaminated, and the right main landing gear fairing was blistered. During engine start, the pilots stated that the No. 2 engine lit off immediately. The pilots stated that immediately after the engine lit off, they were distracted by a yellow glow on the right side of the airplane that grew in intensity; the captain initially thought it was an airport vehicle approaching the airplane. The pilots then heard a low frequency rumbling sound; and also heard people talking on the ground control frequency about an airplane on fire. The captain stated that when he looked back at the engine indications, the No. 2 engine fuel flow was 8,300 pounds per hour (pph); the normal is 1,000 pph. The captain then called for the engine to be shut down. The interrogation of the engine indicating and crew alerting system electronic propulsion control system page revealed several fault codes indicating that the fuel control unit (FCU) fuel metering valve (FMV) did not move to the position commanded by the electronic engine control. The disassembly of the FCU revealed corrosion on the FMV sleeve and slide. According to the FCU manufacturer, when the PW2037 engine is shut down, the FCU FMV is in the full open position. The airplane had been parked outside on the ramp in subzero temperatures for about 36 hours before the incident occurred. Naturally present water in the fuel nucleated on the corrosion on the FMV sleeve and slide, freezing it in position, which prevented it from during before engine start. The manufacturer also stated that at the time of the event, when the high pressure rotor speed was about 40 percent, the fuel flow with the FCU FMV in the full open position would be in the 8,000 pph range.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this incident to be: the failure of the right engine's fuel control unit to operate correctly when the fuel metering valve became frozen in the full open position because of corrosion on the fuel metering valve slide and sleeve, which caused the engine to be overfueled during engine start and resulted in a tailpipe fire.

Findings

Aircraft	Fuel control electronic - Malfunction

Factual Information

History of Flight

Standing-engine(s) start-up	Fire/smoke (non-impact) (Defining event)

History of Flight

On February 9, 2011, about 0630 central standard time, a Boeing 757-2Q8, N704X, operated by Delta Air Lines as flight 9931, experienced a tailpipe fire in the No. 2 (right) engine as it was being started in preparation for departure from the Minneapolis-St. Paul International Airport (MSP), Minneapolis, Minnesota. The flight was the first since the No. 2 engine had been installed on the airplane. The airplane had been pushed back from the gate and the No. 1 (left) engine was started. The pilots stated that they had cleared the ground crew to disconnect the tow bar and they proceeded to start the No. 2 engine that lit off immediately. The pilots stated that immediately after the No. 2 engine lit off, they observed an orange glow on the right side of the airplane and heard a low frequency rumble as well as hearing people talking on the ground control frequency about an airplane being on fire. The pilots stated that when they looked back at the engine instruments, they saw the No. 2 engine's fuel flow was 8,300 pounds per hour(pph)and immediately shut down the engine. The pilots stated that after they shut down the No. 2 engine, they continued to motor it on the starter for at least 30 seconds. Airport fire department equipment and personnel responded to the airplane, but the fire was out by the time they arrived. The fire department personnel reported that there was a puddle of fuel in the No. 2 engine's tailpipe. The airplane taxied back into the gate under its own power and the two pilots, the only occupants on board, deplaned normally. The airplane was operating on an instrument flight rules flight plan under the provisions of 14 Code of Federal Regulations Part 121 as a repositioning flight from MSP to John F. Kennedy International Airport, Jamaica, New York.

Injuries to Persons

The two pilots were the only occupants on the airplane and were not injured.

Damage to Airplane

The left side of the airplane fuselage, the right side of the airplane fuselage forward of the wing and aft of the right main landing gear fairing, the left wing, and the empennage were not damaged. The right wing aft of the No. 2 engine and the wing root fairing had thermal distress and soot.

Other Damage

There was no other reported damage.

Personnel Information

The captain, age 54, holds an airline transport license and reported having 10,935 hours of flying time with 7,104 hours being in the 757/767 airplane. The captain reported flying 223 hours in the Boeing

757/767 airplane in the previous 90 days. The captain's last line check was on August 4, 2010. The captain is type rated in the Airbus A320, 757/767, and Boeing (formerly McDonnell Douglas) DC10 airplanes.

The first officer (FO), age 50, holds an airline transport pilot license and reported having 6,951 hours of flying time with 2,134 being in the 757/767 airplane. The FO reported flying 208 hours in the last 90 days and 1 hour in the previous 24 hours in the 757/767 airplane. The FO's last line check was on May 25, 2010. The FO is type rated in the 757/767, DC9, and DC10 airplanes.

Airplane and Engine Information

The airplane was a Boeing 757-2Q8, serial number (SN) 28163, with a maximum takeoff weight of 255,000 pounds. The airplane's weight at the time of the incident was 153,865 pounds. The airplane was carrying approximately 18,000 pounds of fuel. According to Delta Air Lines maintenance records, at the time of the incident, the airplane had accumulated 47,209 hours and 14,839 cycles since new.

The engines on the airplane were Pratt & Whitney (P&W) PW2037 turbofans. The No. 2 engine was SN 728843. According to Delta Air Lines maintenance records, at the time of the incident, the right engine had accumulated 24,778 hours and 7,758 cycles since new. The engine had just been overhauled at Delta's Technical Operations Center (TOC), Atlanta Georgia, and had 0 hours and cycles since it had been overhauled and installed on the airplane at MSP on February 6, 2011. The engine had been removed from service on August 14, 2010, because of a hung start and a high exhaust gas temperature (EGT) of 615 to 621 degrees F for 3 seconds.

Meteorological Information

At the 0553 observation, the MSP weather was clear skies, visibility 10 miles, wind 270 degrees at 8 knots, altimeter setting 30.24 inches of mercury, temperature -20 degrees C, and dew point -25 degrees C.

Communications

Just prior to pushback, it was discovered that the intercom cannon plug on the nose landing gear used to communicate between the cockpit and the ground personnel was broken. Maintenance personnel entered an item into the airplane's logbook to defer the broken intercom cannon plug. The ground personnel then coordinated with the Captain to communicate via radio for the push back. There were no reported radio communications issues between the pilots and the ground personnel during the push back, with MSP ground control, or with the fire department personnel.

Flight Recorders

The airplane was equipped with a cockpit voice recorder (CVR) and a flight data recorder (FDR). Both the CVR and FDR were removed from the airplane and sent to the NTSB Flight Recorder Laboratory for playback and readout, respectively.

The playback of the CVR revealed audio sounds that were consistent with the incident having been overwritten.

The readout of the FDR revealed that the starting incident was captured. According to Delta Air Lines maintenance personnel, the airplane underwent a preflight engine test on February 7, 2011, because the No. 2 engine had just been installed. During the interview of the aviation maintenance technician (AMT) who occupied the left seat and conducted the test, he stated he does not pull the FDR circuit breaker, he did not remember pulling the FDR circuit breaker, and he thought the FDR circuit breaker was depressed. However, the readout of the FDR did not show any ground operation of the airplane prior to the incident engine start. The last recorded operation of the airplane prior to the incident engine start involved an actual flight.

For the incident engine start, the FDR data shows that the No. 1 engine was started first followed by the No. 2 engine about 1 minute 40 seconds later. The FDR data shows that when the No. 1 engine was started, the N2 rpm began to increase that was followed by the N1 rpm beginning to increase. The N2 rpm increased from zero to about 26 percent over a 34 second period, stabilized momentarily, and then after the indication for the fuel switch showed it changing from OFF to RUN, the N2 rpm began to further increase slowly as the N1 rpm also continued to increase. After about one minute, the No. 1 engine's N2 and N1 rpm indications stabilized at about 57 percent and 20 percent, respectively. The No. 1 engine's fuel flow indication, which is recorded once every 72 seconds, indicated about 1,000 pph and the EGT indicated about 300 degrees C. When the No. 2 engine was started, the N2 rpm indication began to increase from zero that was followed by the N1 rpm beginning to increase. About 20 seconds later when the N2 rpm indication was about 25 percent, the fuel switch indication changed from OFF to RUN. The No. 2 engine's N2 rpm indication continued to increase until it stabilized at about 40 percent without any intermediate stabilization or even slowing down. The No. 2 engine's N1 rpm indication increased very slowly getting up to a maximum of about 10 percent before decreasing slowly. The No. 2 engine's fuel flow indication, which was recorded about a minute after the N2 rpm indication began to increase from zero, was about 8,000 pph. The FDR data shows that after the high fuel flow was recorded for the No. 2 engine, the No. 2 engine's fuel switch was moved from RUN to OFF and the N2 rpm indication decreased to about 30 percent where it remained for about a minute before further decreasing to zero.

Fire

The No. 2 engine had a tailpipe fire that occurred during the engine start that damaged portions of the right wing aft and to the left, as viewed from the rear, of the No. 2 engine. The lower surface of the main and aft inboard flaps inboard of the inboard flap track fairing were blistered, charred, and delaminated. The lower surface of the main and aft inboard flaps outboard of the inboard flap track fairing were blistered. The lower fixed trailing edge panels on either side of the inboard flap track fairing were blistered, charred, and delaminated. There was no indication of internal damage to the inboard flaps or the fixed trailing edge panels. Grease on the inside of the panels was not melted. The exterior of the aft two-thirds of the inboard flap track fairing was charred, blistered, and delaminated. Grease located on the inside of the fairing was not melted. The right main landing gear fairing had a small area of blistered paint on the exterior surface. The No. 2 engine strut aft fairing had a small area of charred paint on the inboard side adjacent to the wing at the aft end.

Tests and Research

During the on-scene portion of the investigation, the Engine Indicating and Crew Alerting System (EICAS) was interrogated that revealed several fault codes on the Electronic Propulsion Control System

(EPCS) page. According to the Boeing 757 Fault Isolation Manual, the fault codes displayed on the EICAS EPCS page referred to the fuel control unit (FCU) fuel metering valve (FMV) position and that the FCU FMV failed to move to the electronic engine control (EEC) commanded position.

The No. 2 engine was removed from the airplane and shipped to Delta's TOC for disassembly. The disassembly revealed there were no mechanical issues with the engine that could have caused the fire. The examination of the engine did reveal that all of the high pressure and low pressure turbine as well as exhaust gas path components were heavily sooted.

The EEC underwent several tests that included the acceptance test procedure, thermal cycle test, and a vibration test, at the manufacturer's facility. The EEC passed all of the tests.

During the disassembly of the engine at Delta's TOC, the FCU was removed from the engine and sent to the TOC fuel control shop for testing. When the AMT removed the channel A wire harness to the FCU, he stated that it was only hand tight. However, the AMT also stated that the red indicator band was covered and that he still had to make a number of turns on the connector to disconnect it from the FCU. The AMT also stated that the channel B wire harness connector to FCU was tight. The FCU was tested in the TOC fuel control shop. The FCU passed all of the electrical tests at room temperature. However, when the FCU was retested after being cold soaked overnight to -10 degrees F, the channel A and B FMV resolver angles were 2.4 and 7.55 degrees, respectively over the high limit. The FCU FMV resolver rotor resistance was 1.4 and 1.1 ohms, respectively, below the lower limit. And the FMV channel A and B torque motor resistance was 4.2 and 3.9 ohms, respectively, below the lower limit. When the test stand was started, the FMV made a smooth translation from fully open position when the unit is shutdown to the idle power position, although the channel A and B resolver angles for the idle power position were 2.02 and 6.58 degrees, respectively, over the high limit. The FCU was run through the flow test and all points met the flow requirements except that the overspeed trip flow was 375 pph below the minimum required.

The FCU was shipped to the manufacturer for disassembly and examination. The disassembly revealed the FMV slide and sleeve had surface corrosion. There were axial scratches visible in the surface corrosion.

After the engine had been installed, it reportedly underwent a satisfactory preflight test. The airplane was then parked outside on the ramp for about 36 hours in subzero temperatures.

Pilot Information

Certificate:	Airline transport	**Age:**	54
Airplane Rating(s):	Single-engine land; Multi-engine land	**Seat Occupied:**	Left
Other Aircraft Rating(s):	None	**Restraint Used:**	
Instrument Rating(s):	Airplane	**Second Pilot Present:**	Yes
Instructor Rating(s):	None	**Toxicology Performed:**	No
Medical Certification:	Class 1 Without waivers/limitations	**Last FAA Medical Exam:**	December 6, 2010
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	August 4, 2010
Flight Time:	10935 hours (Total, all aircraft), 7104 hours (Total, this make and model)		

Co-pilot Information

Certificate:	Airline transport	**Age:**	50
Airplane Rating(s):	Single-engine land; Multi-engine land	**Seat Occupied:**	Right
Other Aircraft Rating(s):		**Restraint Used:**	
Instrument Rating(s):	Airplane	**Second Pilot Present:**	Yes
Instructor Rating(s):	None	**Toxicology Performed:**	No
Medical Certification:	Class 1 Without waivers/limitations	**Last FAA Medical Exam:**	January 20, 2011
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	May 25, 2010
Flight Time:	6951 hours (Total, all aircraft), 2134 hours (Total, this make and model)		

Aircraft and Owner/Operator Information

Aircraft Make:	Boeing	**Registration:**	N704X
Model/Series:	757-2Q8	**Aircraft Category:**	Airplane
Year of Manufacture:		**Amateur Built:**	
Airworthiness Certificate:	Transport	**Serial Number:**	28163
Landing Gear Type:	Retractable - Tricycle	**Seats:**	178
Date/Type of Last Inspection:		**Certified Max Gross Wt.:**	
Time Since Last Inspection:		**Engines:**	2 Turbo fan
Airframe Total Time:		**Engine Manufacturer:**	P & W
ELT:		**Engine Model/Series:**	PW2037
Registered Owner:	INTERNATIONAL LEASE FINANCE CORP	**Rated Power:**	37530 Lbs thrust
Operator:	DELTA AIR LINES INC	**Operating Certificate(s) Held:**	Flag carrier (121)
Operator Does Business As:	Delta Air Lines	**Operator Designator Code:**	DALA

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Night
Observation Facility, Elevation:		**Distance from Accident Site:**	
Observation Time:		**Direction from Accident Site:**	
Lowest Cloud Condition:		**Visibility**	
Lowest Ceiling:		**Visibility (RVR):**	
Wind Speed/Gusts:	/	**Turbulence Type Forecast/Actual:**	/
Wind Direction:		**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:		**Temperature/Dew Point:**	
Precipitation and Obscuration:			
Departure Point:	Minneapolis, MN (KMSP)	**Type of Flight Plan Filed:**	IFR
Destination:	Jamaica, NY (KJFK)	**Type of Clearance:**	None
Departure Time:		**Type of Airspace:**	

Airport Information

Airport:	Minneapolis-St.Paul Internatio KMSP	**Runway Surface Type:**	
Airport Elevation:	842 ft msl	**Runway Surface Condition:**	
Runway Used:		**IFR Approach:**	None
Runway Length/Width:		**VFR Approach/Landing:**	None

Wreckage and Impact Information

Crew Injuries:	2 None	**Aircraft Damage:**	Minor
Passenger Injuries:		**Aircraft Fire:**	On-ground
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	2 None	**Latitude, Longitude:**	44.52,-93.120002(est)

Administrative Information

Investigator In Charge (IIC):	Hookey, Gordon
Additional Participating Persons:	Eric West; FAA; Washington, DC Jason Ragogna; Delta Air Lines; Atlanta, GA Paul Terjak; Boeing; Seattle, WA Chris Demers; Pratt & Whitney; East Hartford, CT Michael Gotaski; Hamilton Sundstrand; Windsor Locks, CT
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