Aviation Investigation Final Report

Location:	SOUTH BEND, Indiana	**Incident Number:**	CHI99IA350
Date & Time:	August 27, 1999, 11:10 Local	**Registration:**	N460CE
Aircraft:	British Aerospace JETSTREAM 3101	**Aircraft Damage:**	None
Defining Event:		**Injuries:**	20 None
Flight Conducted Under:	Part 121: Air carrier - Scheduled		

Analysis

The airplane sustained an in-flight failure of the right engine. The captain performed the checklist to shut down the engine and performed the single engine landing. No injuries were reported. A review of the engine history revealed that this was the third "in-flight shutdown" for this engine. The engine's time since new was 21,101.8 hours, its time since overhaul was 2,414.3 hour, and its time installed on the airplane since its last maintenance was 76.4 hours. The reason for the last maintenance was an "in-flight shutdown." The accessory section was examined at the NTSB Materials Laboratory. The report stated that the spur gear appeared undamaged. The spur gearshaft had portions of teeth missing. The housing had markings and impressions consistent with splined spur gear contact. The splined spur gear was found fractured and deformed into an oval shape, resulting in a gap between the mating fracture faces. The outer surfaces parallel to the circumferential plane of the splined spur gear appeared rubbed, and portions had a blue-purple tint consistent with frictional heating. Areas of the fracture surfaces also had a similar blue-purple tint. Portions of five external gear teeth were missing. All of the internal spline's teeth peaks were missing and the teeth were deformed. One radial fracture face had smooth flat features, consistent with fatigue and crack arrest lines were found. The fatigue had multiple origins. Inner diameter origins were located in the root of a spline. The contact surface of the spline tooth adjacent to the fracture origin was deformed consistent with rotational contact with spline crowns. Hardness of the splined spur gear was measured to be 38 HRC, which was within its specified range.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this incident to be: the right engine accessory section's splined gear spur gear failure during cruise flight.

Findings

Occurrence #1: LOSS OF ENGINE POWER
Phase of Operation: CRUISE

Findings
1. (C) ACCESSORY DRIVE ASSY,DRIVE GEAR - FAILURE

Occurrence #2: FORCED LANDING
Phase of Operation: DESCENT - EMERGENCY

Findings
2. EMERGENCY PROCEDURE - PERFORMED - FLIGHTCREW

Factual Information

On August 27, 1999, at 1110 central daylight time, a British Aerospace Jetstream 3010, N460CE, operated as Chicago Express flight #3294, piloted by an airline transport pilot rated captain and commercial rated first officer, sustained an in-flight right engine failure and engine shutdown. The flight diverted for an emergency landing at Michiana Regional Transportation Center Airport, near South Bend, Indiana. Visual meteorological conditions prevailed during the 14 CFR Part 121 flight. The 2 flightcrew and 18 passengers on board reported no injuries. The scheduled domestic passenger flight originated at 1025, from Chicago Midway Airport, Chicago, Illinois, and was en route to Kent County International Airport, near Grand Rapids, Michigan, at the time of the incident.

The first officer said, "We leveled off at 9,000 MSL [mean sea level] and had been handed over to South Bend Approach. We had just been given direct Grand Rapids when the right engine abruptly quit. I was flying at the time." He said that he continued to fly as the captain "...ran the appropriate memory items and checklist to shut down and secure the engine." He stated, "We then declared an emergency and briefed the passengers. We requested to land at South Bend, it being the closest airport, and Grand Rapids approx 70 miles away. South Bend vectored us on to final." The first officer said that the captain assumed control and performed a single engine landing.

A Federal Aviation Administration (FAA) inspector examined the accessory section from the right engine, a Garrett TPE 331-10UGR-513H, serial number P63082. The engine history was reviewed. The review revealed that this occurrence was the third "in-flight shutdown" for this engine. The engine's time since new was 21,101.8 hours, its time since overhaul was 2,414.3 hour, and its time installed on the airplane since its last maintenance was 76.4 hours. The reason for the last maintenance was an "in-flight shutdown." The FAA inspector forwarded the accessory section for a detailed examination at the National Transportation Safety Board Materials Laboratory.

The Materials Laboratory Factual Report number 01-071 stated that the spur gearshaft and the spur gear were joined together and rotated freely within the first stage idler housing and that the splined spur gear was received separated from the other components. As assembled in the engine, the splined spur gear is located within the housing and meshes with the spur gearshaft. The report stated, "The spur gear appeared undamaged. Portions of 16 teeth were missing from the spur gearshaft, with not more than four adjacent teeth damaged. Markings and impressions were observed on the interior surface of the housing, consistent with sliding contact with teeth of the splined spur gear." The splined spur gear was found fractured and deformed into an oval shape, resulting in a gap between the mating fracture faces. The report stated, "No pieces appeared to be missing from between the fracture surfaces. The outer surfaces parallel to the circumferential plane of the splined spur gear appeared rubbed, and

portions had a blue-purple tint consistent with frictional heating. Areas of the fracture surfaces also had a similar blue-purple tint. Portions of five of the external gear teeth adjacent one of the fracture surfaces were missing. The peaks on all of the internal spline teeth were missing, and the teeth were deformed circumferentially." One face of the radial fracture had smooth flat features, consistent with fatigue, across most of its surface. The report stated, "Crack arrest lines were visible, and at higher magnification using scanning electron microscopy, striations were observed." The fatigue features were reported to have emanated from multiple origins at the splined inner edge. The fracture origins at the inner diameter were located in the root of a spline adjacent to a spline tooth base. The report stated, "The contact surface of the spline tooth adjacent to the fracture origin was deformed consistent with rotational contact with spline crowns on an externally splined shaft (not received by the materials laboratory). According to the engineering drawings for the splined spur gear, the internal splines were flat root, side fit, involute splines. A view of the profile of several of the deformed splines is shown in figure 5 on a cross section through the gear. The root of one of the splines is shown at higher magnification in the center photograph. Cracks were observed in several of the spline roots, including the magnified root shown in figure 5. The cracks were located at both of the root corners adjacent to the bases of the spline teeth. Some of the cracks had secondary cracks, such as the one shown in figure 5. The surface roughness measured from the profile at 80 times magnification was approximately 125 microinches in the root, as specified in the engineering drawings. No fillet was observed at the base of the tooth where it intersected the root, and none was specified in the engineering drawings. According to Machinery's Handbook, 22nd Edition, 'the fillet which joins the sides to the bottom of the tooth space, if generated, has a varying radius of curvature. Specification of this fillet is usually not required. It is controlled by the form diameter which is the diameter at the deepest point of the desired true involute form.'" Hardness of the splined spur gear was measured to be 38 HRC, which was within its specified range. (See appended report.)

Pilot Information

Certificate:	Airline transport	**Age:**	Male
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):		**Toxicology Performed:**	No
Medical Certification:	Class 1 Valid Medical--w/ waivers/lim	**Last FAA Medical Exam:**	April 20, 1999
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	
Flight Time:	2602 hours (Total, all aircraft), 2133 hours (Pilot In Command, all aircraft), 234 hours (Last 90 days, all aircraft), 89 hours (Last 30 days, all aircraft), 8 hours (Last 24 hours, all aircraft)		

Aircraft and Owner/Operator Information

Aircraft Make:	British Aerospace	**Registration:**	N460CE
Model/Series:	JETSTREAM 3101 JETSTREAM	**Aircraft Category:**	Airplane
Year of Manufacture:		**Amateur Built:**	
Airworthiness Certificate:	Transport	**Serial Number:**	680
Landing Gear Type:	Retractable - Tricycle	**Seats:**	21
Date/Type of Last Inspection:	August 5, 1999 Continuous airworthiness	**Certified Max Gross Wt.:**	15212 lbs
Time Since Last Inspection:	128 Hrs	**Engines:**	2 Turbo prop
Airframe Total Time:	21604 Hrs	**Engine Manufacturer:**	Garrett
ELT:		**Engine Model/Series:**	TPE-331-10UGR
Registered Owner:	CHICAGO EXPRESS AIRLINES INC.	**Rated Power:**	940 Horsepower
Operator:		**Operating Certificate(s) Held:**	Commuter air carrier (135)
Operator Does Business As:		**Operator Designator Code:**	CX7A

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Day
Observation Facility, Elevation:	SBN ,799 ft msl	**Distance from Accident Site:**	
Observation Time:	11:01 Local	**Direction from Accident Site:**	
Lowest Cloud Condition:	Unknown	**Visibility**	9 miles
Lowest Ceiling:	Broken / 1600 ft AGL	**Visibility (RVR):**	
Wind Speed/Gusts:	/	**Turbulence Type Forecast/Actual:**	/
Wind Direction:	0°	**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:	30 inches Hg	**Temperature/Dew Point:**	75°C / 66°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	CHICAGO , IL (MDW)	**Type of Flight Plan Filed:**	IFR
Destination:	GRAND RAPIDS , MI (GRR)	**Type of Clearance:**	IFR
Departure Time:	10:25 Local	**Type of Airspace:**	

Airport Information

Airport:	MICHIANA REGIONAL SBN	**Runway Surface Type:**	Asphalt
Airport Elevation:	799 ft msl	**Runway Surface Condition:**	
Runway Used:	9	**IFR Approach:**	
Runway Length/Width:	7099 ft / 150 ft	**VFR Approach/Landing:**	Full stop

Wreckage and Impact Information

Crew Injuries:	2 None	**Aircraft Damage:**	None
Passenger Injuries:	18 None	**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	20 None	**Latitude, Longitude:**	41.670349,-86.260871(est)

Administrative Information

Investigator In Charge (IIC):	Malinowski, Edward
Additional Participating Persons:	THOMAS F DUELLMAN; WEST CHICAGO , IL
Original Publish Date:	July 26, 2001
Last Revision Date:	
Investigation Class:	Class
Note:	
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=47473