National Transportation Safety Board
Aviation Accident Final Report

Location:	Charleston, WV	**Accident Number:**	DCA09FA065
Date & Time:	07/13/2009, 1745 EDT	**Registration:**	N387SW
Aircraft:	BOEING 737	**Aircraft Damage:**	Substantial
Defining Event:	Aircraft structural failure	**Injuries:**	131 None
Flight Conducted Under:	Part 121: Air Carrier - Scheduled		

Analysis

Flight data recorder data revealed that the airplane took off and climbed for about 25 minutes to an altitude of approximately 35,000 feet, at which point the cabin altitude warning activated, and the captain disengaged the autopilot. Postincident examination of the airplane revealed fatigue cracking of the fuselage skin near the leading edge of the vertical stabilizer adjacent to the rupture. The fatigue cracking penetrated the fuselage skin and created an approximate 18-inch by 12-inch flap in the skin that depressurized the airplane.

The fuselage skin assembly near the leading edge of the vertical stabilizer was manufactured by bonding two full aluminum sheets together, then selectively chemically milling away pockets (bays) of the inner sheet. Continuous fatigue cracks initiated from multiple origins on the inner surface of the skin adjacent to the step formed at the edge of the chemically milled area and propagated outward.

Following the Southwest Airlines (SWA) flight 2294 event, on September 3, 2009, Boeing issued Service Bulletin (SB) 737-53A1301, calling for repetitive external inspections to detect cracks in the fuselage skin along the chemically milled step at stringers S-1 and S-2 right and between BS 827 and BS 847. (The hole from the SWA event was within those boundaries.) If cracks are detected, operators are to contact Boeing for repair instructions. On January 12, 2010, the Federal Aviation Administration issued Airworthiness Directive 2010-01-09, which mandated the inspection requirements in SB 737-53A1301.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be: Fuselage skin failure due to preexisting fatigue at a chemically milled step.

Findings

Aircraft	Plates/skins (aux fuselage) - Fatigue/wear/corrosion (Cause)
	Plates/skins (aux fuselage) - Failure (Cause)

Factual Information

History of Flight

On July 13, 2009, about 1745 eastern daylight time, Southwest Airlines (SWA) flight 2294, a Boeing 737-3H4 (737), N387SW, experienced rapid decompression while in cruise flight at approximately 35,000 feet when the fuselage crown skin ruptured just forward of the vertical stabilizer. Passenger oxygen masks deployed automatically. The flight crew declared an emergency, and the flight landed uneventfully at Yeager Airport (CRW), Charleston, West Virginia. The flight, which was on an instrument flight rules flight plan, had departed Nashville International Airport, Nashville, Tennessee, and was scheduled to fly to Baltimore-Washington International Airport, Baltimore, Maryland.

Flight data recorder data revealed that the airplane took off and climbed for about 25 minutes to an altitude of approximately 35,000 feet. At that point, the cabin altitude warning activated, and the captain disengaged the autopilot and began a descent. The altitude warning ceased as the airplane descended through approximately 9,000 feet. Cockpit voice recorder data and postincident interviews revealed that the flight and cabin crewmembers followed appropriate cockpit procedures following the rapid decompression and during the emergency descent and landing at CRW.

Injuries to Persons

No injuries occurred during the event.

Damage to Aircraft

A three-sided hole (flap) was located in skin assembly part number 65C35792-3 in the fuselage crown skin near the leading edge of the vertical stabilizer and measured about 17.4 inches longitudinally and between 11.5 and 8.6 inches circumferentially.

Personnel Information

The captain had accumulated 22,500 total flight hours, 19,300 hours of which were in the 737. He held an airline transport pilot (ATP) certificate and a class one medical certificate with a limitation/waiver for corrective lenses.

The first officer had accumulated 10,100 total flight hours, 2,240 hours of which were in the 737. He held an ATP certificate and a class two medical certificate with no limitations/waivers.

Aircraft Information

The airplane, serial number 26602, was delivered to SWA in June 1994. At the time of the SWA event, the airplane had accumulated approximately 42,500 cycles and 50,500 hours.

Tests and Research

Skin assembly parts are made of an outer sheet of skin, which covers the entire assembly, and a waffle-pattern doubler sheet hot bonded to the inner surface of the part. Both pieces were 0.036-inch-thick, 2024–T3 clad aluminum sheets. Boeing indicated that the skin assembly was manufactured by forming and bonding two full sheets together, then selectively masking and chemically milling away pockets (bays) of the inner doubler sheet to create a waffle pattern. The bay immediately adjacent to the rupture is not chemically milled to provide for possible installation of an emergency locator transponder (ELT) antenna.

Magnified inspections of the fracture surface of the skin assembly part revealed bright faceted surfaces indicative of fatigue progress along the longitudinal section of the flap, which followed the chemically milled edge of the adjacent doubler. The circumferential crack regions displayed matte grey slant fracture surfaces and bulk deformation patterns indicative of overstress tearing away from the longitudinal portion of the crack.

The longitudinal fatigue crack was 13.7 inches long from approximately BS 831 to BS 844. Highly magnified inspections of the longitudinal crack revealed continuous fatigue thumbnail cracks propagating outward (through-thickness) from multiple origins at the inner surface of the skin. The visual depth of the fatigue regions varied along the crack length. Near the middle of the longitudinal crack, the fatigue crack appeared to completely penetrate the skin thickness for a distance of approximately 3 inches. Scanning electron microscope examinations clearly showed microscopic features typical of fatigue progression, including areas of striations, in the longitudinal crack region.

Additional Information

The specific area of rupture and skin cracking (adjacent to the non-chemically milled skin to allow for a potential rear ELT antenna installation) associated with the SWA event was not subject to any inspection airworthiness directives (AD) or service bulletins (SB). However, Boeing finite element modeling suggests stress levels are higher in the skin at the edges of chemically milled steps adjacent to non-chemically milled bays due to the difference in stiffness.

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History of Flight

Enroute-cruise	Emergency descent initiated
	Aircraft structural failure (Defining event)

Pilot Information

Certificate:	Airline Transport; Commercial; Private	**Age:**	53, Male
Airplane Rating(s):	Multi-engine Land; Single-engine Land	**Seat Occupied:**	Left
Other Aircraft Rating(s):	None	**Restraint Used:**	Seatbelt, Shoulder harness
Instrument Rating(s):	Airplane	**Second Pilot Present:**	Yes
Instructor Rating(s):	None	**Toxicology Performed:**	No
Medical Certification:	Class 1 With Waivers/Limitations	**Last Medical Exam:**	02/23/2009
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	06/14/2009
Flight Time:	22500 hours (Total, all aircraft), 19300 hours (Total, this make and model), 17500 hours (Pilot In Command, all aircraft), 225 hours (Last 90 days, all aircraft), 75 hours (Last 30 days, all aircraft)		

Co-Pilot Information

Certificate:	Airline Transport; Flight Instructor; Commercial	**Age:**	41, Male
Airplane Rating(s):	Multi-engine Land; Single-engine Land	**Seat Occupied:**	Right
Other Aircraft Rating(s):	Glider	**Restraint Used:**	Seatbelt, Shoulder harness
Instrument Rating(s):	Airplane	**Second Pilot Present:**	Yes
Instructor Rating(s):	Airplane Single-engine	**Toxicology Performed:**	No
Medical Certification:	Class 2 Without Waivers/Limitations	**Last Medical Exam:**	09/08/2008
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	08/05/2008
Flight Time:	10100 hours (Total, all aircraft), 2240 hours (Total, this make and model), 6300 hours (Pilot In Command, all aircraft), 167 hours (Last 90 days, all aircraft), 67 hours (Last 30 days, all aircraft)		

Aircraft and Owner/Operator Information

Aircraft Manufacturer:	BOEING	**Registration:**	N387SW
Model/Series:	737 3H4	**Aircraft Category:**	Airplane
Year of Manufacture:		**Amateur Built:**	No
Airworthiness Certificate:	Transport	**Serial Number:**	26602
Landing Gear Type:	Retractable - Tricycle	**Seats:**	
Date/Type of Last Inspection:	06/15/2009, Continuous Airworthiness	**Certified Max Gross Wt.:**	
Time Since Last Inspection:		**Engines:**	2
Airframe Total Time:	50888 Hours	**Engine Manufacturer:**	
ELT:	Not installed	**Engine Model/Series:**	
Registered Owner:	US Bank NA Trustee	**Rated Power:**	
Operator:	SOUTHWEST AIRLINES CO	**Air Carrier Operating Certificate:**	Flag carrier (121)
Operator Does Business As:		**Operator Designator Code:**	SWAA

Meteorological Information and Flight Plan

Conditions at Accident Site:		**Condition of Light:**	
Observation Facility, Elevation:		**Observation Time:**	
Distance from Accident Site:		**Direction from Accident Site:**	
Lowest Cloud Condition:		**Temperature/Dew Point:**	
Lowest Ceiling:		**Visibility**	
Wind Speed/Gusts, Direction:		**Visibility (RVR):**	
Altimeter Setting:		**Visibility (RVV):**	
Precipitation and Obscuration:			
Departure Point:	Nashville, TN (BNA)	**Type of Flight Plan Filed:**	Unknown
Destination:	Baltimore, MD (BWI)	**Type of Clearance:**	IFR
Departure Time:	CDT	**Type of Airspace:**	

Airport Information

Airport:	Yeager Airport, Charleston, WV (CRW)	**Runway Surface Type:**	
Airport Elevation:		**Runway Surface Condition:**	
Runway Used:	N/A	**IFR Approach:**	None
Runway Length/Width:		**VFR Approach/Landing:**	

Wreckage and Impact Information

Crew Injuries:	5 None	**Aircraft Damage:**	Substantial
Passenger Injuries:	126 None	**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	131 None	**Latitude, Longitude:**	38.373056, -81.593056 (est)

Administrative Information

Investigator In Charge (IIC):	Robert P Benzon	**Adopted Date:**	08/18/2010
Additional Participating Persons:	David Keenan; FAA AAI-100; Washington, DC		
Publish Date:	08/18/2010		
Investigation Docket:	http://dms.ntsb.gov/pubdms/search/dockList.cfm?mKey=74266		