



Aviation Investigation Final Report

Location:	Traverse City, Michigan	Incident Number:	CEN14IA172
Date & Time:	March 26, 2014, 15:21 Local	Registration:	N580QS
Aircraft:	Cessna 560XL	Aircraft Damage:	None
Defining Event:	Flight control sys malf/fail	Injuries:	4 None
Flight Conducted Under:	Part 91 subpart k: Fractional		

Analysis

The flight was conducted at flight level 400, and the entire flight was 3 hours 17 minutes long. During the landing at the destination airport, the flying pilot noted that the rudder pedals were hard or frozen; however, he was able to make an uneventful landing. The nonflying pilot then took the flight controls and confirmed the rudder pedal situation. Once slowed to a safe speed, the flight crew was able to break the rudder pedals free and to taxi the airplane to the ramp. After the airplane was parked and shut down, the rudder still felt stiff and required more input than normal to operate.

Postaccident examinations confirmed compliance with an alert service letter and service bulletin related to control cable icing. Examinations also revealed witness mark consistent with a water line in the fuselage area, and a liquid consistent with pooled deice fluid, staining, and moisture was found in the tailcone compartment. Water was also found where the galley drain exits the pressure vessel and enters the fairing area. Water was observed draining from the black foam wrap around the drain tube's heating element, and the black foam exhibited deformation consistent with the expansion of frozen water. Removal of the foam revealed an opening in the drain tube. Testing of the galley drain heating element revealed that it was inoperative. Black foam deposits were observed on a rudder cable, but no rudder system anomalies were detected.

Laboratory tests revealed that an opening in the drain tube caused the rudder cables to freeze to the drain mast, and some additional force above a baseline was needed to break the simulated rudder pedals free from a static position. At the time of the incident, the airplane's approved inspection program did not specify that the galley drain tube or heater should be inspected. Additionally, the failure of the galley drain heater is not annunciated to the flight crew nor to maintenance personnel.

It is likely that the undetected failure of the galley drain tube heater allowed the water within the galley drain tube to freeze, which led to the tube's failure. Once the tube failed, water was allowed to drain

from the tube onto the rudder cables; this water also froze due to the inoperative heater and caused the rudder to bind during landing.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this incident to be:

The inoperative galley drain tube heater, which allowed water within the tube to freeze and led to its failure; the tube's failure allowed water to drain onto the rudder cables and freeze and resulted in the rudder binding during landing.

Findings

Aircraft	Water/waste sys wiring - Failure
Aircraft	Rudder control system - Inoperative

Factual Information

History of Flight

Landing-landing roll	Flight control sys malf/fail (Defining event)
Landing-landing roll	Loss of control on ground

On March 26, 2014, about 1521 eastern daylight time, a Cessna 560XL airplane, N580QS, lost rudder authority when the airplane's rudder was bound during landing at the Cherry Capital Airport (TVC), near Traverse City, Michigan. The airplane was landed without further incident and was undamaged. The two pilots and two passengers were not injured. The airplane was registered to and fractionally operated by Netjets Sales Inc. under the provisions of 14 Code of Federal Regulations Part 91K as a business flight. Day visual flight rules conditions prevailed for the flight, which operated on an instrument flight rules flight plan. The flight originated from the Sarasota/Bradenton International Airport (SRQ), near Sarasota, Florida, about 1210, and was destined for TVC.

According to the operator, the incident crew picked up the airplane March 25, 2014, at the Dulles International Airport (IAD), near Washington, DC. The crew was assigned to a revenue flight from IAD to the Mobile Regional Airport (MOB), near Mobile, Alabama. Prior to departing IAD, the airplane was de-iced with 34 gallons of Type I and 26 gallons of Type 4 deicing fluid. The flight from IAD to MOB was conducted at flight level (FL) 400 and lasted 2 hours and 35 minutes. That flight was uneventful and no rudder anomalies were noted. While the airplane was on the ground at MOB, weather reports indicated clear skies and no precipitation.

The crew repositioned the airplane from MOB to SRQ. The flight from MOB to SRQ was conducted at FL 330 and lasted 1 hour and 11 minutes. The flight was uneventful and no rudder anomalies were noted. The airplane remained overnight at SRQ. While the airplane was on the ground in SRQ, weather reports indicated clear skies and no precipitation.

The next day, the crew initiated the incident flight from SRQ to TVC. The flight was conducted at FL 400 and lasted 3 hours and 17 minutes. The flight to TVC was uneventful until landing. The auto-pilot and yaw damper were turned off on final approach and the flying pilot (right seat pilot) noted the rudder pedals were hard or frozen during the landing. He was able to make an uneventful landing. Once safely on the runway, the flight controls were passed to the non-flying pilot (left seat pilot) to confirm the rudder pedal situation. The non-flying pilot confirmed the hard or frozen pedals. Once slowed to a safe speed, the rudder pedals were freed enough for the crew to be able to taxi to the ramp without further issues or assistance. After parking, the rudder still felt stiff and required more input than normal to operate. Once the airplane was powered down, the rudders pedals still had the same stiffness that was noted during the taxi.

Pilot Information

Certificate:	Airline transport; Commercial	Age:	42
Airplane Rating(s):	Single-engine land; Single-engine sea; Multi-engine land	Seat Occupied:	Left
Other Aircraft Rating(s):	None	Restraint Used:	3-point
Instrument Rating(s):	Airplane	Second Pilot Present:	Yes
Instructor Rating(s):	Airplane multi-engine; Airplane single-engine; Instrument airplane	Toxicology Performed:	No
Medical Certification:	Class 1 Without waivers/limitations	Last FAA Medical Exam:	November 13, 2013
Occupational Pilot:	Yes	Last Flight Review or Equivalent:	
Flight Time:	(Estimated) 4658 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):	None	Restraint Used:	3-point
Instrument Rating(s):	Airplane	Second Pilot Present:	Yes
Instructor Rating(s):	None	Toxicology Performed:	No
Medical Certification:	Class 1 With waivers/limitations	Last FAA Medical Exam:	April 3, 2013
Occupational Pilot:	Yes	Last Flight Review or Equivalent:	November 8, 2013
Flight Time:	(Estimated) 2796 hours (Total, this make and model)		

Left Seat Pilot Information

He held a Federal Aviation Administration (FAA) airline transport pilot certificate with an airplane multiengine land rating, which included commercial privileges for single-engine land and sea airplanes. He held a flight instructor certificate with single and multiengine and instrument airplane ratings. The left seat pilot held CE-500, BE-300, and CE-560XL type ratings. He also held a FAA first-class airmen medical certificate with no limitations. According to the operator's report, the left seat pilot had accumulated 4,658 hours of total flight time in the accident make and model and 4,574 hours of total flight time as pilot in command (PIC) in the accident make and model. The left seat pilot had logged 118 hours in the previous 90 days to the incident, 50 hours in the previous 30 days, and 7 flight hours in the previous 24 hours, which were all in the accident make and model.

Right Seat Pilot Information

He held an FAA airline transport pilot certificate with an airplane multiengine land rating, which included commercial privileges for single-engine land airplanes. He had held a flight instructor certificate with single and multiengine and instrument airplane ratings. The right seat pilot held A-320, CL-65, and CE-560XL type ratings. He also held a FAA first-class airmen medical certificate with a limitation for near vision corrective lenses. According to the operator's report, the right seat pilot had accumulated 2,796 hours of total flight time in the accident make. The right seat pilot had logged 74

hours in the previous 90 days to the incident, 34 hours in the previous 30 days, and 7 flight hours in the previous 24 hours, which were all in the accident make and model.

Aircraft and Owner/Operator Information

Aircraft Make:	Cessna	Registration:	N580QS
Model/Series:	560XL	Aircraft Category:	Airplane
Year of Manufacture:	2007	Amateur Built:	
Airworthiness Certificate:	Transport	Serial Number:	560-5741
Landing Gear Type:	Tricycle	Seats:	9
Date/Type of Last Inspection:	March 1, 2014 AAIP	Certified Max Gross Wt.:	20400 lbs
Time Since Last Inspection:		Engines:	2 Turbo fan
Airframe Total Time:	5183 Hrs as of last inspection	Engine Manufacturer:	P&W CANADA
ELT:	Installed, not activated	Engine Model/Series:	PW545B
Registered Owner:	NETJETS SALES INC	Rated Power:	4119 Lbs thrust
Operator:	NETJETS SALES INC	Operating Certificate(s) Held:	Fractional ownership

N580QS was registered as a 2007 Cessna 560XL twin engine, transport category, turbojet airplane, with serial number 560-5741. The airplane was equipped with two Pratt & Whitney Canada PW545B turbofan engines. Each engine was rated to produce 3,400 pounds of thrust. According to the operator's report, the airplane was configured to seat two flight crewmembers and seven passengers. It also indicated that the airplane's maximum takeoff weight was 20,400 pounds and its weight at the time of the incident was 15,487 pounds. The incident airplane was maintained on an approved aircraft inspection program. The last inspection was completed on March 1, 2014. The airframe had a total time of 5,183 hours at the time of that inspection.

Dual flight controls are provided consisting of control wheel columns, adjustable rudder pedals, brakes, and mechanical nose wheel steering. Pushrod, bellcrank, sector, and cable systems are used to actuate the rudder, elevator, and ailerons. Corrosion resistant stainless steel cables are used in all primary and secondary systems. An integral control lock is provided for the ailerons, elevators, rudder and throttles. Trim wheels installed on the pedestal control mechanical trim tabs on the left aileron, the elevators, and a servo/trim tab on the rudder. The nose gear uses a single wheel, chined tire assembly and an oil over air strut. The nose gear is mechanically steered by the rudder pedals to 20 degrees either side of center.

The rudder control passes through the fuselage skin at fuselage station (FS) 153.00 and left buttocks line (LBL) 6.580 as a torque tube and then transitions to a dual cable sector system, with an inboard and outboard set of cables. The inboard upper cable run forward and aft at approximately LBL 3.72. The inboard lower cable runs forward and aft at approximately LBL 3.77. The outboard upper cable runs forward and aft at approximately LBL 9.62. The lower cable runs forward and aft at approximately LBL 9.67. The cables run aft to approximately FS 379.0 where they split. The upper cables turn and run up to the upper section of the aft fuselage and then aft to the rudder. The lower cables continue aft to the

rudder.

The overboard drain tube for the forward refreshment center passes through the fuselage skin at FS 176.5 and LBL 8.98. The drain tube is equipped with a valve and a heating element with a foam insulation covering. The drain tube heating element is connected to the pitot heat system. The refreshment drain tube valve is designed to be closed in-flight.

According to the manufacturer, a layout of the cable run and the drain tube revealed that the clearance between the tube and the upper cable is .389 inches and the lower cable and the tube is .441 inches. The drain tube insulation, part number S2958-7, has a wall thickness of .50 inches, which would indicate interference between the cable and the insulation, however the insulation is held in place with two S2357-1 clamps which compresses the insulation to provide clearance.

The airplane's maintenance manual prescribed a 96 calendar month inspection interval of the drain tube area. However, the maintenance manual does not specify that the drain tube nor its heater be inspected.

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	Condition of Light:	Day
Observation Facility, Elevation:	KTVC,630 ft msl	Distance from Accident Site:	0 Nautical Miles
Observation Time:	14:53 Local	Direction from Accident Site:	87°
Lowest Cloud Condition:	Few / 4200 ft AGL	Visibility	10 miles
Lowest Ceiling:	None	Visibility (RVR):	
Wind Speed/Gusts:	5 knots /	Turbulence Type Forecast/Actual:	/
Wind Direction:	210°	Turbulence Severity Forecast/Actual:	/
Altimeter Setting:	30.15 inches Hg	Temperature/Dew Point:	-2°C / -13°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	SARASOTA/BRADENTON, FL (SRQ)	Type of Flight Plan Filed:	IFR
Destination:	Traverse City, MI (TVC)	Type of Clearance:	IFR
Departure Time:	12:10 Local	Type of Airspace:	

At 1453, the recorded weather at TVC was: Wind 210 degrees at 5 knots; visibility 10 statute miles; sky condition few clouds at 4,200 feet, scattered clouds at 20,000 feet; temperature -2 degrees C; dew point -13 degrees C; altimeter 30.16 inches of mercury.

Airport Information

Airport:	CHERRY CAPITAL TVC	Runway Surface Type:	Asphalt
Airport Elevation:	624 ft msl	Runway Surface Condition:	Dry;Snow
Runway Used:	28	IFR Approach:	Visual
Runway Length/Width:	6901 ft / 150 ft	VFR Approach/Landing:	Full stop

TVC was located approximately two miles south of Traverse City, Michigan, and was owned and operated by the Grand Traverse and Leelanau County Northwestern Regional Airport Commission. TVC was a certificated airport under 14 CFR Part 139. TVC's field elevation was surveyed as 623.7 feet above mean sea level. The airport listed 124.2 megahertz as its common traffic advisory frequency and reported that it meets the fire and rescue requirements of aircraft rescue and firefighting index B. TVC had two runways: Runway 10/28 - 6,901 feet by 150 feet, asphalt and runway 18/36 - 5,378 feet by 150 feet, asphalt. Runway 28 was marked as a precision approach runway and had high intensity runway edge lights. A four-light, three-degree, precision approach path indicator serviced runway 28. Runway 28 obstruction remarks listed a 440 foot lighted tower, located 16,670 feet from the runway and 2,350 feet left of centerline, which indicated a 37:1 slope to clear that obstruction.

Wreckage and Impact Information

Crew Injuries:	2 None	Aircraft Damage:	None
Passenger Injuries:	2 None	Aircraft Fire:	None
Ground Injuries:	N/A	Aircraft Explosion:	None
Total Injuries:	4 None	Latitude, Longitude:	44.740833,-85.587501(est)

Tests and Research

On March 27, 2014, representatives from the FAA, the operator, and a fixed base operator examined the incident airplane and confirmed compliance with Alert Service Letter 53-08 and Service Bulletin 53-16. Beginning aft on the airplane and moving forward, they inspected for signs of moisture, frozen pulleys, and debris that might be blocking drain paths. All pulleys rotated freely. In the aft canted bulkhead, visible stains were observed on both bottom pulleys and cables, along with surrounding moisture and liquid consistent with deicing fluid. The airplane was last deiced on March 25, 2014 and the airplane accumulated 78.2 hours of flight time since the last bilge cleaning inspection conducted on March 1, 2014. A gap in the stinger seal was observed and the seal was deflected downward on one edge. At

fuselage station 528.5 looking forward, a witness mark consistent with a water line was observed. The view looking rearward, at fuselage station 544.5, appeared clean. In the tailcone compartment, at fuselage station 479.5, looking forward, a liquid consistent with pooled deice fluid, moisture, and staining was observed to the left of the centerline. Removal of belly panel 313DC revealed it was holding water. Belly panel 313BC was removed and water was observed.

On March 28, 2014, panels on the incident airplane were removed to inspect cable runs forward of the wing to the rudder pedals. No significant moisture or debris was noted. Observations did not reveal if the rudder cables rested on the bottom of the over wing passage tubes. The left-hand back rudder tube was slipped forward, out of its adel clamp. Manually running the autopilot revealed no resistance in cable movement. There was no moisture found near the rudder bias lines by their drain point and actuator. Observations of the galley drain revealed the presence of water where the galley drain exits the pressure vessel and enters the fairing area. Water was exiting from the black foam wrap around the drain tube's heating element and the black foam exhibited deformation consistent with expansion of retained, frozen water. Water poured into the galley drain exited from the black foam into the fairing area. Removal of the foam revealed an opening in the drain tube. With the foam removed, the rudder cables were about 1/4 inch from the galley drain tube. Deposits, consistent with the black foam, were observed on a rudder cable. Testing of the galley drain heating element revealed it was inoperative and its drain tube valve was found in the open position. The tension of the rudder bias cable, rudder servo cable, and rudder cables were tested and found to be within limits. The nose wheel was moved, full travel, without resistance from the nose wheel bearing. A test of the rudder bellcrank bearing was conducted by packing three pounds of dry ice around the bellcrank area and left to cold soak for one hour. After one hour, there was no noticeable difference in rudder pedal stiffness following that cold soak of the rudder bellcrank area. The rudder pedals were stiff when the control lock was engaged. The rudder pedals were stiff when the rudder was physically held in streamlined position.

The right and left-hand lower rudder bias pulleys, a section of the forward galley drain tube insulation foam, part number S2958-7, and a sample of pooled fluid found in the tail cone forward of station 479.5 and left of centerline, were removed from the incident airplane and shipped to an FAA airplane certification office representative for an examination at Cessna. A NetJets representative was not able to attend the follow-on examination at Cessna, which was conducted under FAA supervision.

According to the Cessna engineering report, a limited laboratory test was developed to attempt to simulate the incident conditions to determine if an opening in the drain tube could cause the rudder cables to freeze to the drain mast under various scenarios.

A sample section of the incident drain tube insulation material was dimensioned and then submerged in water for 24 hours. The sample was then re-measured and no dimensional changes were found. No water was expelled when the sample was compressed. The insulation material was abraded and the test was repeated. No retained water or dimensional changes were found.

A rudder cable icing test fixture was configured with a closed cable loop between two pulleys. A production galley drain tube with its drain insulation was mounted to the fixture adjacent to the cable in the approximate airplane orientation. The cable loop was constructed so that a spring scale could measure the pull force required to move the cable.

The testing was conducted with the drain insulation in contact with cable resulting in an approximate .030 inch deflection of the insulation. The test article was cold soaked to -65 degrees F. External water was then introduced via spray bottle and simulated water drain line to determine the possible effects.

After cold soak, a mist of water was introduced via spray bottle until drips were noted and allowed to soak for an additional 30 minutes, and then repeated, followed by another cold soak of approximately 1.5 hours. This test showed ice bridging between the cable and the drain tube insulation. The cable was then manually pulled and an increase in breakout force from the baseline force was observed. The breakout force is consistent with a 3.3 pound force increase at the rudder pedals.

After another cold soak, a stream of water was introduced to the cable and drain tube contact interface by an external water line and by pouring water directly onto the cable. The application of water was then continued using a spray bottle, coating the setup until drips were noted for four more cycles. This test showed a greater ice build-up on the cable, with greater bridging between the cable and the drain tube insulation, as well as bridging between the cable and the test article structure. An increase in breakout force was observed, which would result in a 14.4 pound increase in force at the rudder pedals over the baseline force. The drain tube insulation was observed to tear before the ice yielded.

Another test was repeated with the test setup reoriented so that the water would drain away from the structure before freezing the cable to the fixture. This test was conducted by spraying the cable contact interface with water after cold soak every five minutes for a total of nine applications. Observations revealed a greater ice build-up on the cable and a greater bridging between cable and insulation than during prior tests. An increase in breakout force was observed, which would result in 16.6 pound increase at rudder pedals over baseline. The drain insulation was torn before the ice yielded.

The amount of water that exited through the opening in the failed drain tube during the incident flight could not be determined. The testing could not duplicate the exact incident icing scenario. All the icing testing, done at Cessna, recorded breakaway force only. Once the cables broke free, the force dropped back to nominal. The testing did show an increase in required rudder pedal force over the baseline force during all conducted scenarios to break the pedals free.

Additional Information

The operator subsequently checked their fleet of Cessna 560XL airplanes during the two weeks following this event. Three more 560XL airplane, N654QS, N698QS, and N577QS, had deformed galley drain tube insulation.

The operator reviewed their usage rate in reference to the drain tube and its heater. The operator reported that in 2012 the drain tube heater, part number 105881, was replaced 12 times, in 2013 it was replaced 13 times, and in 2014 it was replaced 41 times. In 2012, the left hand weld assembly(drain tube), part number 6619292-7, was replaced 12 times, in 2013 it was replaced 8 times, and in 2014 it was replaced 18 times.

The failure of the galley drain heater is not annunciated to the crew nor to maintenance personnel.

The Cessna safety representative had some follow-up questions. The Cessna representative asked if the valve is opened as part of a standard practice to drain the water from the ice bucket after completion of the flight and the pilot's safety representative indicated that it was not a standard practice in the fleet. The representative added that the crews sometimes have to manipulate the hose to get the ice drawer to drain properly.

The Cessna representative asked if the manual valve for the ice bucket left open during the flight and the pilot's representative indicated that the reported typical normal practice is that the ice bucket drain is left open. Some crew will close it if the drain starts to "whistle" but then they will reopen it when on the ground and water collects in the bucket.

The Cessna representative asked if the valve was opened, was there a whistling noise during the flight to TVC and the pilot's representative replied that neither pilot remembers hearing any whistling.

The Cessna representative asked if the push button valve for the drip tray ever activated during the flight and the pilot's representative replied that it doesn't stay open when used, it is spring loaded or electronically unloaded shut.

The Cessna representative advised that if the valves associated with the galley drain were not opened or activated during the flight, the split in the galley drain would not have introduced water in this cable area to form ice and bridge from the drain tube to the rudder cables.

The operator listed a safety recommendation in a communication to the investigator in charge. The recommendation, in part, stated:

As indicated in your report, failure of the heating element is not annunciated. We are concerned with the effects undetected water and ice introduced into the galley drain area may have. As such, we believe the manufacturer should modify the aircraft inspection program to include an appropriate inspection/test of the galley drain heater and mast at a reasonable interval to ensure that they function as designed. The inspection/test may require addition of an indicator to notify crews or maintenance of heater failure.

According to a Cessna representative, the manufacturer is designing an amendment to their maintenance manual which will include steps to engage and disengage the galley drain heater during maintenance and will include an operational test in the inspection requirements. The amendment is scheduled to be implemented in July 2015.

Administrative Information

Investigator In Charge (IIC):	Malinowski, Edward
Additional Participating Persons:	Robert D Holdridge; Federal Aviation Administration; Grand Rapids, MI Andrew L Hall; Textron Aviation; Wichita, KS John W Greier; NetJets Aviation; Columbus, OH Courtney C Ohl; NetJets Aviation; Columbus, OH Suzy Danielson; NJASAP; Columbus, OH
Original Publish Date:	May 13, 2015
Last Revision Date:	
Investigation Class:	Class
Note:	The NTSB did not travel to the scene of this incident.
Investigation Docket:	https://data.nts.gov/Docket?ProjectID=88979

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