Aviation Investigation Final Report

Location:	Anchorage, Alaska	**Accident Number:**	ANC20LA059
Date & Time:	June 8, 2020, 09:45 Local	**Registration:**	N3188M
Aircraft:	Piper PA 12	**Aircraft Damage:**	Substantial
Defining Event:	Aircraft structural failure	**Injuries:**	2 None
Flight Conducted Under:	Part 91: General aviation - Instructional		

Analysis

The flight instructor reported that after conducting a landing and departure at a remote lake in the float-equipped airplane, they climbed to about 500 ft above ground level (agl) before turning to a left crosswind traffic pattern leg. While on the left crosswind leg, the airplane yawed abruptly to the right and the pilot receiving instruction indicated that the controls felt strange. The flight instructor assumed control of the airplane and noticed drastically diminished control about the vertical axis. In addition, significant downward elevator pressure (forward control yoke) was required. The flight instructor decided to return to their destination airport, where emergency services were available, and conducted an uneventful landing.

An examination of the rudder revealed that the vertical rudder post fractured above the upper hinge point and the top portion of the rudder folded over the horizontal stabilizer tail brace wires. As part of the NTSB's investigation, examination of four other similarly fractured rudder posts revealed that they had all fractured above the upper hinge. Each of the rudder posts exhibited evidence of a progressive fracture mechanism. Although the fracture surfaces of the accident rudder post were obliterated by post-fracture contact, fatigue fracture features were observed on three of the other rudder posts.

Analysis of the material composition of all of the posts found it to be consistent with Piper part number 40622 posts made of American Iron and Steel Institute (AISI) 1025 carbon steel. According to engineering drawings, rudder posts were originally manufactured from AISI 1025 carbon steel. A Piper engineering change order specified a change to AISI 4130 low-alloy steel that was incorporated into the part number 40622 engineering drawing in June 1974. According to Advisory Circular 23-27, Parts and Materials Substitution for Vintage Aircraft, AISI 4130 low-alloy steel generally has more desirable material properties, such as higher tensile ultimate strength, yield strength, and fatigue strength.

A structural load analysis of three of the rudders found that, with no scatter factor applied, the bending stress from certification gust and maneuver loads is significantly closer to the endurance limit of AISI 1025 carbon steel than to the endurance limit of AISI 4130 low-alloy steel. These results indicate rudder posts constructed of AISI 1025 steel are more susceptible to fatigue failure during normal service than those constructed of AISI 4130 steel.

In addition, corrosion, scratches, or surface roughness features were observed on each of the rudder posts examined. These types of surface anomalies can occur over time during normal operations and can weaken metal material where they occur. Because AISI 1025 carbon steel has lower overall and fatigue strength than AISI 4130 low-alloy steel, the surface anomalies likely made the affected rudder posts more susceptible to fatigue failure during normal service conditions than they would have been if manufactured with 4130 low-alloy steel.

Thus, the rudder failure on the accident airplane was due to the fatigue fracture of the AISI 1025 carbon steel rudder post. Contributing to the fatigue failure was the post's susceptibility to fatigue cracking under normal service conditions.

Probable Cause and Findings

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

The fatigue fracture of the American Iron and Steel Institute (AISI) 1025 carbon steel rudder post, which resulted in structural failure of the rudder. Contributing to the fatigue failure was the post's susceptibility to fatigue cracking under normal service conditions.

Findings

Aircraft	Rudder - Failure
Aircraft	Rudder - Fatigue/wear/corrosion

Factual Information

History of Flight

Initial climb	Aircraft structural failure (Defining event)

On June 8, 2020, about 0945 Alaska daylight time, a Piper PA-12, N3188M, was substantially damaged when it was involved in an accident near Anchorage, Alaska. The flight instructor and pilot receiving instruction were not injured. The airplane was operated as a Title 14 *Code of Federal Regulations* Part 91 instructional flight.

According to the flight instructor, they departed Lake Hood Airport (PALH) and proceeded to Twin Island Lake (about 8 nm northwest of PALH), where, upon arrival, they conducted a normal landing. After departing, they climbed to about 500 ft above ground level (agl) before turning to a left crosswind traffic pattern leg. While on the left crosswind leg, the airplane yawed abruptly to the right and the pilot indicated that the controls felt strange. The flight instructor assumed control of the airplane and noticed drastically diminished control about the vertical axis. In addition, a significant downward elevator pressure (forward control yoke) was required. In an effort to aid in directional control the water rudders were deployed. Uncertain that he could make a 180° and return to Twin Island Lake due to the poor directional control, he elected to return to PALH where emergency services were available and conducted an uneventful landing.

An examination of the rudder revealed that the vertical rudder post fractured above the upper hinge point and the top portion of the rudder folded over the horizontal stabilizer tail brace wires (see figure).

Figure - Photo of the damaged rudder. Photo provided by FAA.

A review of the National Transportation Safety Board (NTSB) accident database found two additional accidents that involved an in-flight structural failure of the rudder on single engine Piper airplanes, NTSB accident numbers SEA84LA220 and ANC21LA064. In addition, three additional rudders with similar structural failures were discovered during the investigation and examined.

In total, five similarly fractured rudders were examined by the NTSB through the course of this investigation; this accident airplane's rudder, a rudder obtained from ANC21LA064, two rudders that were provided by a repair facility and a fifth that was received in response to an FAA "Airworthiness Concern Sheet." The NTSB found that all the rudders examined were consistent with Piper part number 40622, had posts made of American Iron and Steel Institute (AISI) 1025 carbon steel, and had fractured above the upper hinge.

Further NTSB examination identified evidence of a progressive fracture mechanism on each of the rudder posts, including fatigue fracture features on three of the rudder posts. The fracture surfaces on the accident rudder post and the remaining rudder post were too damaged to conclusively identify the specific fracture mechanism. Corrosion, scratches, or surface roughness features were found on each of the rudder posts near the fractures. Fracture origin areas were damaged on all the rudders, but corrosion pits or scratches on the exterior surface were associated with the fatigue origin areas on two of the examined rudder posts.

Piper part number 40622 rudder posts were originally manufactured from AISI 1025 carbon steel tube. In a Piper engineering change order (ECO) dated June 3, 1974, the specified tube material for the rudder post was changed to normalized AISI 4130 low-alloy steel. The ECO allowed for in-process and completed parts to be used to depletion. The material change was incorporated into the part number 40622 engineering drawing in June 1974.

The vintage single-engine Piper airplane model types from which these rudders were obtained were designed for static load conditions as required by the regulations in place at the time they were certified. However, in service, the loading conditions on many parts of these airplanes' structures, including the rudders, are not static and contain dynamic alternating or repeated (fatigue) loads.

Aircraft designed in accordance with modern regulations are required to account for fatigue loads. To assess the implications of fatigue loads on the subject rudder posts, the NTSB conducted a structural load analysis for three of the rudders with no scatter factor applied and found that the bending stresses on the rudder posts from certification gust and maneuver loads are significantly closer to the endurance limit for rudder posts made of AISI 1025 carbon steel than they are for those made of AISI 4130 low-alloy steel.

FAA Advisory Circular 23-27, "Parts and Materials Substitution for Vintage Aircraft," published in 2009, specifically advises that AISI 4130 low-alloy steel may be substituted for AISI 1020 or AISI 1025 carbon steel, including for structural posts on applicable aircraft. The advisory circular clarifies that this is because AISI 4130 low-alloy steel is more widely available and generally has more desirable material properties, such as higher tensile ultimate strength, yield strength, and fatigue strength.

Flight instructor Information

Certificate:	Commercial; Flight instructor	**Age:**	54,Male
Airplane Rating(s):	Single-engine land; Single-engine sea	**Seat Occupied:**	Rear
Other Aircraft Rating(s):		**Restraint Used:**	3-point
Instrument Rating(s):	Airplane	**Second Pilot Present:**	Yes
Instructor Rating(s):	Airplane single-engine	**Toxicology Performed:**	No
Medical Certification:	Class 3 With waivers/limitations	**Last FAA Medical Exam:**	May 3, 2019
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	May 1, 2019
Flight Time:	(Estimated) 6000 hours (Total, all aircraft), 300 hours (Total, this make and model), 180 hours (Last 90 days, all aircraft), 180 hours (Last 30 days, all aircraft), 5 hours (Last 24 hours, all aircraft)		

Pilot Information

Certificate:	Private	**Age:**	65,Male
Airplane Rating(s):	Single-engine land; Single-engine sea	**Seat Occupied:**	Front
Other Aircraft Rating(s):	None	**Restraint Used:**	3-point
Instrument Rating(s):	None	**Second Pilot Present:**	Yes
Instructor Rating(s):	None	**Toxicology Performed:**	No
Medical Certification:	Class 3	**Last FAA Medical Exam:**	March 1, 2021
Occupational Pilot:	No	**Last Flight Review or Equivalent:**	
Flight Time:			

Aircraft and Owner/Operator Information

Aircraft Make:	Piper	**Registration:**	N3188M
Model/Series:	PA 12 No Series	**Aircraft Category:**	Airplane
Year of Manufacture:	1947	**Amateur Built:**	
Airworthiness Certificate:	Normal	**Serial Number:**	12-1867
Landing Gear Type:	N/A; Float	**Seats:**	
Date/Type of Last Inspection:		**Certified Max Gross Wt.:**	
Time Since Last Inspection:		**Engines:**	1 Reciprocating
Airframe Total Time:		**Engine Manufacturer:**	Lycoming
ELT:		**Engine Model/Series:**	O-235 SERIES
Registered Owner:	On file	**Rated Power:**	
Operator:	On file	**Operating Certificate(s) Held:**	None

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Day
Observation Facility, Elevation:		**Distance from Accident Site:**	
Observation Time:	17:53 Local	**Direction from Accident Site:**	
Lowest Cloud Condition:		**Visibility**	10 miles
Lowest Ceiling:	Broken / 3000 ft AGL	**Visibility (RVR):**	
Wind Speed/Gusts:	/	**Turbulence Type Forecast/Actual:**	/
Wind Direction:		**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:	29.81 inches Hg	**Temperature/Dew Point:**	11°C / 7°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	Anchorage, AK	**Type of Flight Plan Filed:**	None
Destination:	Anchorage, AK	**Type of Clearance:**	VFR
Departure Time:		**Type of Airspace:**	Class G

Wreckage and Impact Information

Crew Injuries:	2 None	**Aircraft Damage:**	Substantial
Passenger Injuries:		**Aircraft Fire:**	None
Ground Injuries:		**Aircraft Explosion:**	None
Total Injuries:	2 None	**Latitude, Longitude:**	61.186668,-149.96527

Administrative Information

Investigator In Charge (IIC):	Banning, David
Additional Participating Persons:	David Swartz; FAA, Anchorage ACO Branch; Anchorage , AK
Original Publish Date:	January 27, 2022
Last Revision Date:	
Investigation Class:	Class 3
Note:	The NTSB did not travel to the scene of this accident.
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=101415