Aviation Investigation Final Report

Location:	Anchorage, Alaska	**Accident Number:**	ANC21LA064
Date & Time:	July 23, 2021, 15:10 Local	**Registration:**	N4206H
Aircraft:	Piper PA-14	**Aircraft Damage:**	Substantial
Defining Event:	Flight control sys malf/fail	**Injuries:**	1 None
Flight Conducted Under:	Part 91: General aviation - Personal		

Analysis

The pilot reported that while in level cruise flight, frequent left and right rudder inputs were required to keep the inclinometer centered, similar to a light turbulence encounter. The airplane then began to experience a constant yaw, with elevator adjustments required to maintain level flight. He stated that the oscillation then stopped and a “very large right rudder input” was required to maintain the course heading. The pilot was able to maintain control of the airplane and land uneventfully.

An initial examination of the rudder revealed that the vertical spar tube separated above the upper hinge point and the top portion of the rudder folded over the horizontal stabilizer tail brace wires. Further examination of the accident airplane’s rudder post found radial features with crack arrest lines, consistent with fatigue from multiple origins at the outer diameter. The piece of post from the upper side of the fracture was further examined using a scanning electron microscope. Multiple fatigue origins were identified on the right side that originated from corrosion pits on the exterior surface. Fatigue fracture features were identified around approximately 1/4 of the circumference on the right side, but the total extent of fatigue cracking could not be determined conclusively due to post-fracture contact damage on the surfaces.

Analysis of the rudder post’s material composition found it to be consistent with Piper part number 40622. According to engineering drawings, part number 40622 rudder posts were originally manufactured from American Iron and Steel Institute (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.

As part of the NTSB's investigation of a similar rudder failure on a Piper PA-12, the NTSB performed a rudder loads study that analyzed various structural loads and associated stresses on three other similarly fractured rudders; the posts from these rudders were also found to be consistent with part number 40622 and composed of AISI 1025 carbon steel. The structural load analysis 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.

In addition, corrosion, scratches, or surface roughness features were observed on each of the rudder posts examined as part of the NTSB's study, and, as previously stated, examination of the post from this accident identified corrosion pits on the exterior surface. 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

Maneuvering	Flight control sys malf/fail (Defining event)

On July 23, 2021, about 1510 Alaska daylight time, a float-equipped Piper PA-14 airplane, N4206H, sustained substantial damage when it's rudder structurally failed in flight about 15 miles southeast of Anchorage, Alaska. The commercial pilot was uninjured. The airplane was being operated as a Title 14 *Code of Federal Regulations* Part 91 flight.

The pilot reported that while in level cruise flight, frequent left and right rudder inputs were required to keep the inclinometer centered, similar to a light turbulence encounter. The airplane then began to experience a constant yaw, with elevator adjustments required to maintain level flight. He stated that the oscillation then stopped and a "a very large right rudder input" was required to maintain the course heading. The pilot was able to maintain control of the airplane and land uneventfully.

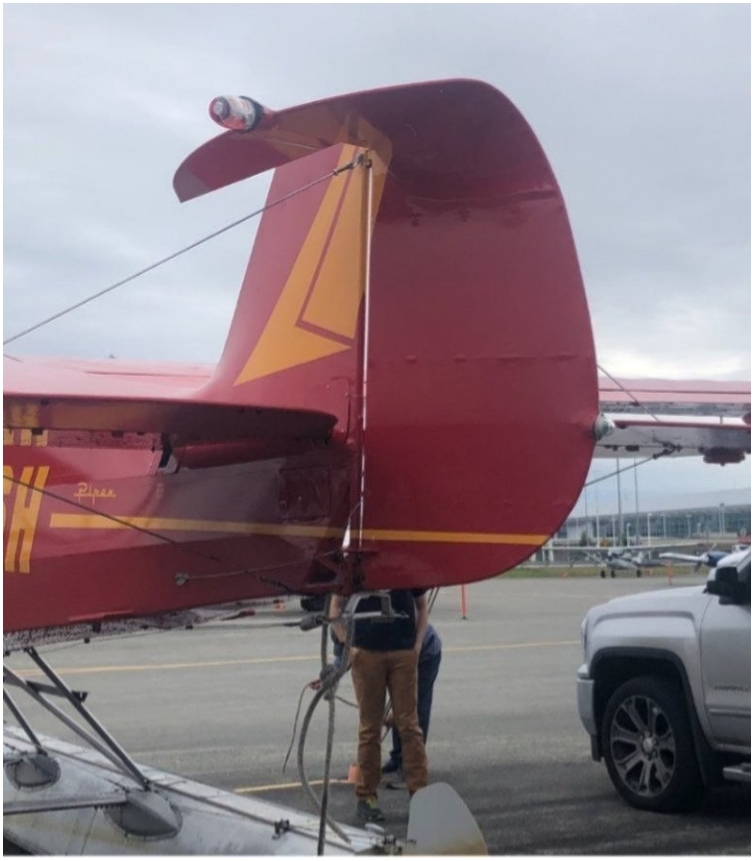

Figure - Photo of the damaged rudder. Photo provided by FAA.

An initial examination of the rudder revealed that the vertical spar tube separated above the upper hinge point and the top portion of the rudder folded over the horizontal stabilizer tail brace wires. (See figure).

When the accident airplane's rudder was examined, radial features with crack arrest lines were observed, consistent with fatigue from multiple origins at the outer diameter. The piece of post from the upper side of the fracture was further examined using a scanning electron microscope (SEM). Multiple fatigue origins were identified on the right side that originated from corrosion pits on the exterior surface. Fatigue fracture features were identified around approximately ¼ of the circumference on the right side, but the total extent of fatigue cracking could not be determined conclusively due to post-fracture contact damage on the surfaces.

The NTSB does not know the exact date of manufacture for this rudder, only the date of manufacture for the airplane. The composition of the rudder post was analyzed using an Olympus Vanta C-Series alloy analyzer. The material associated with the rudder post was identified as carbon steel, consistent with American Iron and Steel Institute (AISI) 1025 carbon steel originally specified for use in the rudder post.

According to engineering drawings, the rudder post for Piper part number 40622 was originally manufactured from 0.875-inch diameter, 0.035-inch wall thickness 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 existing 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. It is well documented that fatigue failures in metal occur at stress levels well below the static strength stress levels.

Aircraft designed in accordance with modern regulations are required to account for fatigue loads. To assess the implications of this, 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 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.

Pilot Information

Certificate:	Commercial	**Age:**	51,Male
Airplane Rating(s):	Single-engine land; Single-engine sea; Multi-engine land	**Seat Occupied:**	Left
Other Aircraft Rating(s):	None	**Restraint Used:**	4-point
Instrument Rating(s):	Airplane	**Second Pilot Present:**	
Instructor Rating(s):	None	**Toxicology Performed:**	
Medical Certification:	Class 2 With waivers/limitations	**Last FAA Medical Exam:**	May 27, 2021
Occupational Pilot:	No	**Last Flight Review or Equivalent:**	May 27, 2021
Flight Time:	1900 hours (Total, all aircraft), 304.1 hours (Total, this make and model), 1826.2 hours (Pilot In Command, all aircraft), 92 hours (Last 90 days, all aircraft), 24.9 hours (Last 30 days, all aircraft), 7.1 hours (Last 24 hours, all aircraft)		

Aircraft and Owner/Operator Information

Aircraft Make:	Piper	**Registration:**	N4206H
Model/Series:	PA-14	**Aircraft Category:**	Airplane
Year of Manufacture:	1948	**Amateur Built:**	
Airworthiness Certificate:	Normal	**Serial Number:**	14-9
Landing Gear Type:	None; Float	**Seats:**	4
Date/Type of Last Inspection:	May 4, 2021 Annual	**Certified Max Gross Wt.:**	1935 lbs
Time Since Last Inspection:	29.3 Hrs	**Engines:**	1 Reciprocating
Airframe Total Time:	2691.1 Hrs at time of accident	**Engine Manufacturer:**	LYCOMING
ELT:	C126 installed, not activated	**Engine Model/Series:**	O-320 SERIES
Registered Owner:	On file	**Rated Power:**	160 Horsepower
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:	PALH,90 ft msl	**Distance from Accident Site:**	0 Nautical Miles
Observation Time:	17:53 Local	**Direction from Accident Site:**	139°
Lowest Cloud Condition:		**Visibility**	10 miles
Lowest Ceiling:	Overcast / 6000 ft AGL	**Visibility (RVR):**	
Wind Speed/Gusts:	4 knots / None	**Turbulence Type Forecast/Actual:**	/
Wind Direction:	180°	**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:	29.9 inches Hg	**Temperature/Dew Point:**	17°C / 11°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 D

Airport Information

Airport:	LAKE HOOD LHD	**Runway Surface Type:**	Water
Airport Elevation:	79 ft msl	**Runway Surface Condition:**	Water-calm
Runway Used:	N/S	**IFR Approach:**	None
Runway Length/Width:	1930 ft / 200 ft	**VFR Approach/Landing:**	Full stop;Straight-in

Wreckage and Impact Information

Crew Injuries:	1 None	**Aircraft Damage:**	Substantial
Passenger Injuries:		**Aircraft Fire:**	None
Ground Injuries:		**Aircraft Explosion:**	None
Total Injuries:	1 None	**Latitude, Longitude:**	61.181371,-149.97211(est)

Administrative Information

Investigator In Charge (IIC):	Williams, David
Additional Participating Persons:	Charles Strange; FAA; 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=103552