Aviation Investigation Final Report

Location:	Memphis, Tennessee	**Accident Number:**	ERA14LA108
Date & Time:	January 29, 2014, 15:15 Local	**Registration:**	N24RB
Aircraft:	Enstrom F 28A	**Aircraft Damage:**	Substantial
Defining Event:	Sys/Comp malf/fail (non-power)	**Injuries:**	2 None
Flight Conducted Under:	Part 91: General aviation - Instructional		

Analysis

The flight instructor reported that he and the student pilot were practicing running landings with a simulated stuck antitorque pedal. At touchdown, the left landing skid collapsed, and the helicopter subsequently came to rest in a forward-pitch attitude.

Postaccident examination of the landing skid revealed that the skid clamp that connects the forward cross tube to the landing gear skid had failed due to fatigue cracking that had initiated in the heat-affected zone adjacent to a weld. The fatigue cracks then propagated inward through the clamp. After the clamp fractured, the bolt hole ring that connected the clamp to the fuselage frame failed in overstress, which caused the landing gear skid to fail. Hardness testing revealed that the weld material, clamp, and ring, significantly differed in hardness. Materials joined with a broad hardness gradient are likely to contain high residual stresses, which in this case, would have been concentrated at the boundary between the clamp and the weld and led to a failure of the weld when the landing load was applied. Because multiple crack initiation sites were found in areas without material defects, the fatigue crack that led to the leg failure probably developed and propagated over a long time under numerous low-stress cycles. The airplane manufacturer placed no life or event limits (hard landing) for replacing landing gear skid tube clamps; it only required periodic visual inspections of the skid tube clamps, which was not adequate for detection of the fatigue cracking because the weld cracks were not visible and could only have been detected by magnetic particle or dye penetrant inspection.

Probable Cause and Findings

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

A skid tube clamp weld failure due to high residual stress, which resulted in a skid collapse during landing. Contributing to the accident was the airplane manufacturer's lack of adequate guidance for periodically inspecting the skid tube clamp.

Findings

Aircraft	Main landing gear attach sec - Fatigue/wear/corrosion
Aircraft	Scheduled maint checks - Not installed/available
Organizational issues	Adequacy of policy/proc - Manufacturer

Factual Information

History of Flight

Landing	Simulated/training event
Landing-flare/touchdown	Sys/Comp malf/fail (non-power) (Defining event)
Landing-flare/touchdown	Landing gear collapse
Landing-flare/touchdown	Nose over/nose down

On January 29, 2014, about 1515 central standard time, an Enstrom F-28A helicopter, N24RB was substantially damaged during landing at General Dewitt Spain Airport (M01), Memphis, Tennessee. The flight instructor and private pilot were not injured. The airplane sustained substantial damage to a main rotor blade and the tail rotor driveshaft. The helicopter was registered to and operated by a flight school under the provisions of 14 Code of Federal Regulations Part 91 as an instructional flight. Visual meteorological conditions prevailed and no flight plan was filed for the local flight that departed M01 about 1340.

According to the flight instructor's written statement, they had practiced several running landings with simulated stuck anti-torque pedal approaches; each approach varied between the right pedal, left pedal, and neutral position. While the student completed some of the landings, the flight instructor guarded the cyclic and collective flight controls and, at times, took control of the helicopter and demonstrated the maneuver to completion. The flight instructor reported that during a low power steep approach the profile and alignment with the landing zone on final approach appeared "correct" and the speed before touchdown was approximately 10 mph. During touchdown, the landing skids collapsed and the helicopter came to rest in a nose-down attitude.

Flight instructor Information

Certificate:	Commercial; Flight instructor	**Age:**	53
Airplane Rating(s):	Single-engine land; Multi-engine land	**Seat Occupied:**	Right
Other Aircraft Rating(s):	Helicopter	**Restraint Used:**	Lap only
Instrument Rating(s):	Airplane; Helicopter	**Second Pilot Present:**	Yes
Instructor Rating(s):	Airplane single-engine; Helicopter; Instrument airplane	**Toxicology Performed:**	No
Medical Certification:	Class 2 With waivers/limitations	**Last FAA Medical Exam:**	January 17, 2014
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	August 1, 2013
Flight Time:	5260 hours (Total, all aircraft), 2000 hours (Total, this make and model), 5005 hours (Pilot In Command, all aircraft), 52 hours (Last 90 days, all aircraft), 19 hours (Last 30 days, all aircraft), 3 hours (Last 24 hours, all aircraft)		

Pilot Information

Certificate:	Private	**Age:**	45
Airplane Rating(s):	None	**Seat Occupied:**	Left
Other Aircraft Rating(s):	Helicopter	**Restraint Used:**	Lap only
Instrument Rating(s):	Helicopter	**Second Pilot Present:**	Yes
Instructor Rating(s):	None	**Toxicology Performed:**	No
Medical Certification:	Class 2 Without waivers/limitations	**Last FAA Medical Exam:**	November 20, 2013
Occupational Pilot:	No	**Last Flight Review or Equivalent:**	August 6, 2013
Flight Time:	(Estimated) 225 hours (Total, all aircraft), 142 hours (Total, this make and model), 141 hours (Pilot In Command, all aircraft), 7 hours (Last 90 days, all aircraft), 1 hours (Last 24 hours, all aircraft)		

The pilot held a flight instructor certificate with ratings for airplane single-engine land, instrument airplane, and helicopter. He also possessed a commercial certificate with ratings for single-engine land, multi-engine land, helicopter, instrument airplane, and instrument helicopter. The pilot reported 5,260 total hours of flight experience, of which about 2,000 hours were in the accident helicopter make and model.

The student held a private pilot certificate with ratings for helicopter and instrument helicopter. He reported 225 total hours of flight experience, of which 142 hours were in the accident helicopter make and model.

Aircraft and Owner/Operator Information

Aircraft Make:	Enstrom	**Registration:**	N24RB
Model/Series:	F 28A A	**Aircraft Category:**	Helicopter
Year of Manufacture:	1971	**Amateur Built:**	
Airworthiness Certificate:	Normal	**Serial Number:**	057
Landing Gear Type:	Skid	**Seats:**	2
Date/Type of Last Inspection:	November 22, 2013 100 hour	**Certified Max Gross Wt.:**	2150 lbs
Time Since Last Inspection:		**Engines:**	1 Reciprocating
Airframe Total Time:	10760 Hrs at time of accident	**Engine Manufacturer:**	Lycoming
ELT:	Not installed	**Engine Model/Series:**	HIO 360 C1A
Registered Owner:	HELICOPTERS INC	**Rated Power:**	205 Horsepower
Operator:	HELICOPTERS INC	**Operating Certificate(s) Held:**	None

The helicopter was a single-engine, three-place helicopter with skid type landing gear. It was

manufactured in 1971 and had accrued 10,000 total aircraft hours. It was powered by a four cylinder, 205 horsepower, Lycoming HIO-360-CIA engine. Its most recent 100 hour inspection was completed on November 22, 2013, at 9,930 total aircraft hours.

According to the maintenance records, the landing gear was inspected on November 22, 2013 in accordance with the 100 hour inspection checklist which stated, "Check landing gear for cracks in weld areas, bolts at all attach and pivot points for excessive wear." The maintenance manual does not require the removal and examination or replacement of any of the skid tube clamps during the lifetime of the helicopter.

Based on the maintainer's recounted history of the helicopter's time in service, the helicopter had three prior hard landing events that resulted in repairs, but the maintenance records did not contain any entries related to the examination, repair or replacement of the skid tube clamp in the helicopter's 44 year history.

According to a representative of the airframe manufacturer, the broken skid tube clamp recovered from the wreckage was identified as part #34 in Enstrom IPC 7-51. This particular clamp connected the landing gear leg to the cross tube. He added that the landing gear leg, oleo strut, and the outboard portion of the cross tube form a triangle. During landing, forces push up on the skid at the bottom corner of the "triangle" where the oleo strut and the leg attach. The "triangle" will pivot around the upper end of the oleo strut where it attaches to the end of the cross tube, which places the skid tube clamp in tension where the top of the leg attaches.

The representative of the airframe manufacturer reported multiple landing gear failures in a span of 20 years. During this time the clamps were either broke or cracked, but the damage was always attributed to overstress due to hard landings, and never examined or evidence of fatigue.

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Day
Observation Facility, Elevation:	MEM,341 ft msl	**Distance from Accident Site:**	9 Nautical Miles
Observation Time:	20:54 Local	**Direction from Accident Site:**	135°
Lowest Cloud Condition:	Few / 25000 ft AGL	**Visibility**	10 miles
Lowest Ceiling:	None	**Visibility (RVR):**	
Wind Speed/Gusts:	/	**Turbulence Type Forecast/Actual:**	/ None
Wind Direction:		**Turbulence Severity Forecast/Actual:**	/ N/A
Altimeter Setting:	30.37 inches Hg	**Temperature/Dew Point:**	1°C / -17°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	MEMPHIS, TN (M01)	**Type of Flight Plan Filed:**	None
Destination:	Memphis, TN (M01)	**Type of Clearance:**	None
Departure Time:	13:40 Local	**Type of Airspace:**	Class G

The 1454 recorded weather at MEM, located about 9 nautical miles south of the accident site, included

calm wind, clear skies, 10 miles visibility, few clouds 25,000 feet, temperature 1 degree C, dewpoint minus 17 degrees C, and an altimeter setting of 30.37 inches of mercury.

Airport Information

Airport:	GENERAL DEWITT SPAIN M01	**Runway Surface Type:**	Grass/turf
Airport Elevation:	225 ft msl	**Runway Surface Condition:**	Dry
Runway Used:		**IFR Approach:**	None
Runway Length/Width:		**VFR Approach/Landing:**	Full stop;Traffic pattern

Wreckage and Impact Information

Crew Injuries:	2 None	**Aircraft Damage:**	Substantial
Passenger Injuries:		**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	2 None	**Latitude, Longitude:**	35.200553,-90.053886(est)

Post-accident examination of the helicopter by a Federal Aviation Administration (FAA) inspector revealed substantial damage to the tail boom and the tail rotor drive shaft. According to photographs taken by the FAA inspector, the tail boom was damaged in multiple sections with evidence of bending. The tailrotor drive shaft was found 100 feet away from the helicopter; one end displayed torsional damage and the other end displayed evidence consistent with shearing. Two of the three main rotor blades were undamaged and the inboard trailing section of the third main rotor blade was split open. The third main rotor blade also exhibited compression wrinkles throughout the length of the blade. Examination of the landing skid revealed a broken skid tube clamp which was recovered to the NTSB materials laboratory for further inspection. The FAA inspector reported no mechanical malfunctions or anomalies with the control system that would have precluded normal operation.

Additional Information

Materials Laboratory

The skid tube clamp was composed of two halves, which were affixed on one side by a bolt. The upper clamp half was bent and twisted outward and the attached ring exhibited features on its fracture surface that were consistent with overstress. The fracture surface of the upper clamp half, opposite a weld,

contained numerous ratchet marks, consistent with progressive cracking from multiple initiation sites. The lower clamp half was fractured near the welded ring; the clamp half exhibited no indications of plastic deformation. The mating fracture surface, adjacent the weld, displayed fatigue striations indicative of fatigue crack propagation. Multiple cracks had initiated at the weld where the ring joined the lower clamp and propagated inward through the thickness of the clamp.

Chemical examination of the lower clamp revealed a composition that was consistent with alloy steel. The composition of the ring was also consistent with an alloy steel; however, different from the clamp and with a notably lower chromium content. The weld material was consistent with commonly used weld filler steels. Hardness testing revealed that the weld material was soft compared to the clamp and ring, which progressively increased in hardness closer to the weld. The hardness was highest between the heat-affected zone near the weld and the weld, which corresponds with the fatigue crack initiation areas of the clamp and ring.

The weld cracks were not visible, and could only be detected by magnetic particle or dye penetrant inspection.

Administrative Information

Investigator In Charge (IIC):	Stein, Stephen
Additional Participating Persons:	David Hayes; FAA/FSDO; Memphis, TN
Original Publish Date:	April 27, 2015
Last Revision Date:	
Investigation Class:	Class
Note:	The NTSB did not travel to the scene of this accident.
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=88738