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Swiss Transportation Safety Investigation Board STSB

Final Report No. 2332 by the Swiss Transportation Safety Investigation Board STSB

concerning the accident involving the Enstrom 280C helicopter, HB-XLS,

on 22nd January 2016

at Buttwil Airport (LSZU) / AG

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General information on this report

This report contains the Swiss Transportation Safety Investigation Board's (STSB) conclusions on the circumstances around and causes of the accident under investigation.

In accordance with article 3.1 of the 10th edition of annex 13, effective from 18th November 2010, on the Convention on International Civil Aviation of 7th December 1944 and article 24 of the Federal Aviation Act, the sole purpose of an aircraft accident or serious incident investigation is to prevent further accidents or serious incidents from occurring. Legal assessment of the circumstances and causes of aircraft accidents and serious incidents is expressly excluded from the aircraft accident investigation. It is therefore not the purpose of this report to establish blame or to determine liability.

Should this report be used for purposes other than those of accident prevention, this statement should be given due consideration.

The German version of this report constitutes the original and is therefore definitive.

Unless otherwise indicated, all information relates to the time of the accident.

For privacy reasons, this report uses the masculine form for all natural persons, irrespective of their actual gender.

Unless otherwise indicated, all of the times mentioned in this report are given in local time (LT). For the region of Switzerland, Central European Time (CET) was the local time at the time of the accident. The relationship between LT, CET and Universal Time Coordinated (UTC) is as follows: LT = CET = UTC + 1 h

Final Report

Aircraft type	Enstrom 280C	HB-XLS
Operator	Flugschule Eichenberger AG, Buttwil Airport, 5632 Buttwil	
Owner	Flugschule Eichenberger AG, Buttwil Airport, 5632 Buttwil	

Flight instructor	Swiss citizen, born 1980
Licence	European Aviation Safety Agency (EASA) commercial pilot licence helicopter (CPL(H)), issued by the Federal Office of Civil Aviation (FOCA)

Flying hours	**Total**	1,891 h	**During the last 90 days**	105 h
	On the accident type	946 h	**During the last 90 days**	8:28 h
	As flight instructor	1,332 h		

Trainee pilot	German citizen, born 1980
Licence	None

Flying hours	**Total**	98:13 h	**During the last 90 days**	6:32 h
	On the accident type	94:43 h	**During the last 90 days**	6:32 h

Location	Buttwil Airport (LSZU) / AG	
Coordinates	--	**Altitude** --
Date and time	22nd January 2016, approx. 09:45	

Type of operation	training
Flight rules	Visual flight rules (VFR)
Point of departure	Airport Buttwil (LSZU)
Point of destination	Airport Buttwil (LSZU)
Flight phase	On the ground
Type of accident	Loss of control of the tail rotor control system

Injuries to persons

Injuries	Crew members	Passengers	Total no. of occupants	Third parties
Fatal	0	0	0	0
Serious	0	0	0	0
Minor	0	0	0	0
None	2	0	1	n/a
Total	2	0	1	0

Damage to aircraft Minor damage

Third-party damage None

1 Factual information

1.1 Background and course of the accident

1.1.1 General

The statements given by the trainee pilot, the flight instructor and an eyewitness as well as documents from the maintenance company have been used for the following description of the background and course of the accident.

The flight was a training flight. For this purpose, dual controls had been fitted in the helicopter.

1.1.2 Background

The trainee pilot began his practical training for the private pilot licence helicopter (PPL(H)) in September 2013 with the flight school Flugschule Eichenberger AG at Buttwil Airport (LSZU). From the beginning of his training, he was trained in the Enstrom 280C helicopter type, registered as HB-XLS.

With effect from 20th November 2014, the trainee pilot suspended his practical training in order to first complete his theory training. By this time, the trainee pilot had accumulated a total flying time of 84:45 h with dual controls and 3:46 h flying solo. On 8th April 2015, the trainee pilot, together with the flight instructor, flew across the Alps in the Bell 206B ‘Jet Ranger’ helicopter type. On 9th November 2015, the trainee pilot resumed his practical training. Between this date and the time of the accident, the trainee pilot completed a further 6:32 h of flying time with dual controls.

At approximately 08:30 on 22nd January 2016, the trainee pilot arrived at Buttwil Airport, which was covered in snow. With the help of two maintenance company employees, he pulled the helicopter HB-XLS to the take-off area to the left of the fuel station. The helicopter’s nose pointed towards the hangar (see illustration 1), the tail protruded from the take-off area and pointed towards the runway. The trainee pilot subsequently carried out the preflight inspection using the checklist; no discrepancies were found. The helicopter was then refuelled.

At about 09:00, the trainee pilot and the flight instructor met in the office and performed the necessary preparation for a training flight. They also discussed the planned training programme, which included flying traffic patterns, autorotations and, potentially, solo flights in the hovering area.

On several occasions the flight instructor pointed out to the trainee pilot that the helicopter could start to turn around its vertical axis if, on a snow-covered or icy take-off area, the torque was changed abruptly. The engine speed must therefore only be changed slowly using the twist-grip throttle. The magneto check should also be carried out carefully to avoid accidentally turning the ignition key to the OFF position, thereby switching off the engine.

During his training, the trainee pilot had often operated the helicopter at the airport on snow-covered ground.

1.1.3 Course of the accident

After the flight briefing, the trainee pilot and the flight instructor boarded the helicopter HB-XLS. The trainee pilot started the engine and began to work through the preparation checklist. When the drive belt between the engine and the drive shaft was tensioned by the clutch and the engine had warmed up, the trainee pilot noticed that the emergency location transmitter (ELT) had not been fitted to the helicopter. In HB-XLS, this was normally mounted on the trainee pilot’s side of the aircraft below the collective pitch control lever. The flight instructor told the trainee pilot he would enquire about the ELT with the maintenance company and that the trainee pilot could complete the remaining checks on his own. Before the flight instructor disembarked from the helicopter, he once again pointed out to the trainee pilot the dangers associated with carrying out the magneto check on snow-covered ground.

Subsequently, the trainee pilot opened the throttle to carry out the magneto check at an engine speed of approximately 2,900 rpm[1]. Shortly before this speed was reached, the helicopter began to turn slowly around its vertical axis to the left. The trainee pilot then applied the right anti-torque pedal to stop the helicopter's rotation. However, he was not able to remember, whether the helicopter turned back to the initial position in the process. At this moment, the helicopter suddenly started to turn to the left again. From then on, the trainee pilot initially did not take any measures to counter the rotation as everything happened very quickly. After approximately four rotations, the trainee pilot reduced the engine speed using the twist-grip throttle. This resulted in the helicopter coming to a standstill. During the rotations, the helicopter slid towards the snow-covered meadow (see illustration 1). The flight instructor ran back to the helicopter, opened the door, shut down all of the systems and closed the fuel valve. The trainee pilot was able to disembark from the helicopter unharmed.

1.2 Meteorological information

1.2.1 Weather conditions at the time and location of the accident

Switzerland was on the edge of a high-pressure system which was over the Czech Republic. At altitude, a small ridge extended from France eastwards.

1.2.2 Weather at the time and location of the accident

Above the snow-covered Swiss Central Plateau, there were scattered low stratus clouds with a base at approximately 3,200 ft AMSL[2]. Cold air at ground level followed the valley's slope. There was wind of 2 to 5 kt from SSE. On the ridges of the higher Central Plateau, the wind turned SW and reached 5 to 10 kt.

Weather/clouds	3/8 to 4/8 at approx. 800 ft AAE[3]
Visibility	approx. 6 km
Wind	Variable, 3 kt
Temperature / dew point	-3°C / -4°C
Atmospheric pressure QNH	1,029 hPa
Hazards	None

1.2.3 Astronomical information

Light conditions	Daytime	
	Azimuth	139°
	Elevation	13°

[1] rpm: revolutions per minute

[2] AMSL: above mean sea level

[3] AAE: above airport elevation

1.3 Information on the accident site and initial findings

1.3.1 Accident site

No snow had been cleared from the entire airport area. The tracks made by the rotating helicopter, i.e. by the skids, were clearly visible in the snow; as were the tracks which had been created when rolling the helicopter from the hangar to the take-off area (see illustration 1). The take-off area was approximately 17 m from the hangar and approximately 4 m from the fuel station.

Illustration 1: The final position of the helicopter HB-XLS, looking towards the runway ①. The fuel station can be seen on the left. The rolling tracks ② ran from the hangar to the take-off area.

1.3.2 Initial findings

Immediately after the incident, it could be established that the left tail rotor control cable had snapped (see illustration 2). In addition, there were marks visible on both tail rotor blades indicating contact with the control cable.

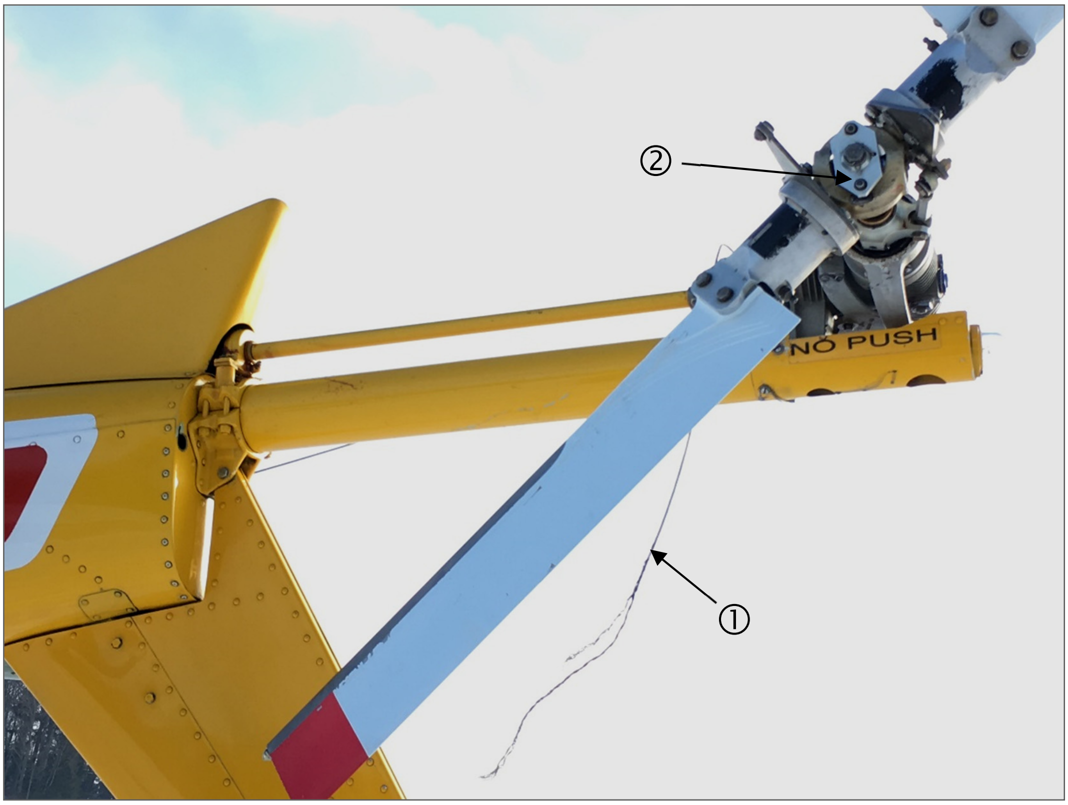

Illustration 2: The condition of the tail rotor assembly of HB-XLS on the day of the accident: the snapped left control cable ① and the static stop ② that limits the tail rotor's wobbling motion (see section 1.4.) can be seen.

Initial investigations showed that the tail rotor's left control cable had snapped in two different places near the cable pulley that guides and deflects the cable and is mounted furthest back in the tail boom (see illustration 3).

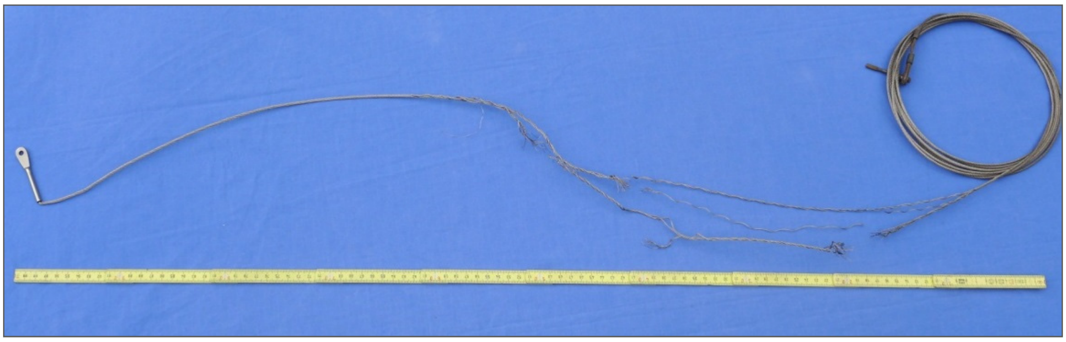

Illustration 3: The snapped left tail rotor control cable after removal from the helicopter. The fitting to the tail rotor control can be seen on the left.

1.4 Information on the aircraft

1.4.1 General

The Enstrom 280C is a light helicopter with skid landing gear and three seats. When viewed from above, the main rotor turns anti-clockwise. Torque balance is provided by a conventional two-blade tail rotor, which is controlled via cables using the anti-torque pedals in the cockpit. The helicopter is fitted with a turbo-charged, air-cooled piston engine.

1.4.2 Maintenance

1.4.2.1 General

The last scheduled maintenance work on the helicopter HB-XLS was carried out between 20th November and 5th December 2015 by the maintenance company based at the airport (see section 1.7). This was a 200-hour and annual inspection carried out at 6,454 operating hours. There was neither a list of materials nor a work report in the technical files.

1.4.2.2 Tail rotor control cables and cable pulleys

The left and right tail rotor control cables are each made up of two sections which are connected by turnbuckles (see illustration 4). These are used to adjust the cables' tension. The tail rotor control cables' range of travel between the right and left anti-torque pedals when fully applied is 40-45 mm.

In the inspection guide used by the maintenance company, the manufacturer stipulated the following points which must be checked on the tail rotor controls during each 100-hour or annual inspection:

"*14. Flight Controls*

C. Tail Rotor Controls:

1) Inspect the tail rotor control cables and turnbuckles for wear, corrosion, proper operation, proper cable tension, correct range of travel, and security of installation.

2) Inspect the pulleys and fairleads for wear, proper operation, and security of installation.

3) Inspect the pedal assemblies, control rods, and bellcranks for excessively worn rod end bearings/bushings, condition, and security of installation."

In the manufacturer's maintenance manual (MM), maintenance of the control cables is described as follows:

"*10-7 Tail Rotor Cables*

A. Tail Rotor Cable – Inspection

(1) Remove wraparound cowling and baggage box.

(2) Remove seat cushions and fiberglass seat deck.

(3) Inspect cables for wear, strand separations and fraying.

(4) Visually inspect cable pulleys for wear and security.

(5) Inspect turnbuckles for security.

(6) *Cable tension – 35 to 40 lbs with cable tensiometer.*"

Measuring of the control cables' tension was certified on the job sheet from 5th December 2015. However, the measured values were not recorded.

The control cables were last replaced on 12th April 2006, the turnbuckles on 8th February 2002. According to the information provided by the maintenance company, a new tail boom was fitted to the helicopter in the year 1986. At what time the cable pulleys were replaced was not evident from the files.

The turnbuckles were corroded and deposits were present on their safety wires. No signs of inspection or adjustments could be found (see illustration 4).

The manufacturer stipulates that, during the inspection, these parts must be checked on condition to ensure safe operation. According to the manufacturer, the operating life of the fitted control cables and cable pulleys is not limited.

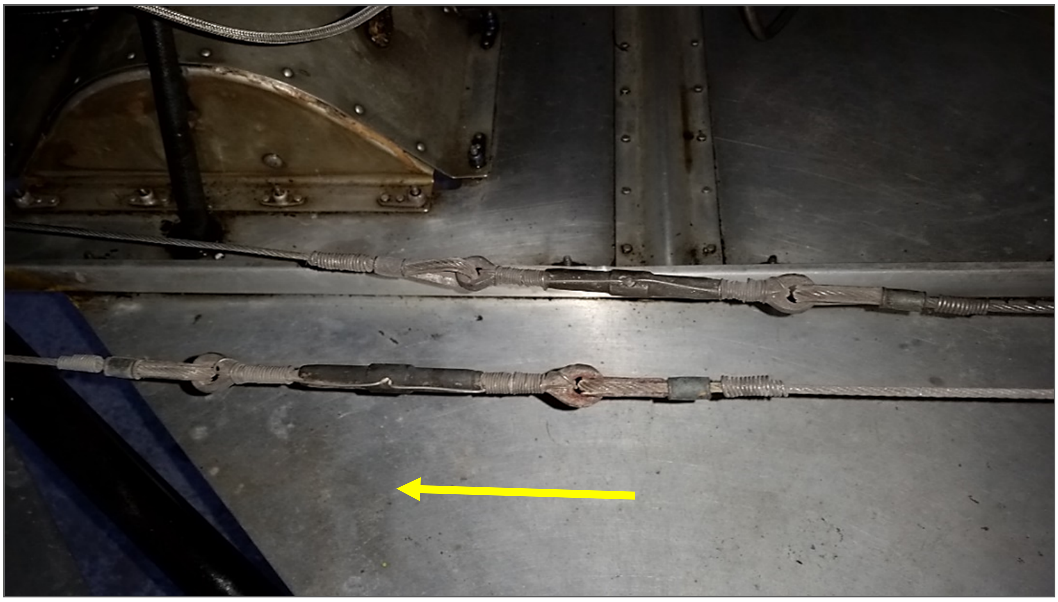

Illustration 4: The turnbuckles of the right and left tail rotor control cables with safety wire to prevent undesired loosening. In HB-XLS, they are located near the engine. The yellow arrow indicates the direction of flight.

1.4.2.3 Tail rotor blades

On 25th October 2007, HB-XLS was fitted with two new tail rotor blades with serial numbers 2951 and 2958 at 5,632:34 operating hours. These were the blades that were installed on HB-XLS at the time of the accident.

The records in the technical files and the component cards were inconsistent and their traceability is not assured.

1.4.2.4 Static stop

A static stop, which reduces the tail rotor's wobbling motion, is fitted to the far end of the tail rotor driveshaft (see illustrations 2 and 5). Two rubber teeter stop bumpers are fitted for shock absorption.

The manufacturer stipulates that the rubber teeter stop bumpers must be checked on condition to ensure safe operation; neither timescales nor minimum measurements are defined. With regards to this matter, the manufacturer refers to the service directive bulletin no. 0075 (see section 1.4.3.2).

At the time of the accident, both rubber teeter stop bumpers were worn and soft. It was not evident from the technical files when the rubber teeter stop bumpers were last replaced.

Illustration 5: The tail rotor driveshaft of HB-XLS with hub and static stop showing a defective rubber teeter stop bumper (circled in white). This photograph was taken on the day of the accident.

1.4.3 Service directive bulletin

1.4.3.1 General

A service directive bulletin (SDB) is a document that is published by an aircraft or engine manufacturer and contains changes and improvements to or inspections of an aircraft or engine.

The decision to implement a service directive bulletin rests with the aircraft operator. However, the manufacturer deems it mandatory to implement an SDB.

1.4.3.2 Tail rotor cable blade strikes

Service directive bulletin no. 0075 (see appendix 1) was published on 8th July 1987. This SDB was recorded in the technical files of HB-XLS under 'List of completed manufacturer's instructions' with a due date interval of 100 h.

The background to this SDB was that the manufacturer had been notified of three incidents with the C and F models, in which the left tail rotor control cable had been separated in flight due to severe steering manoeuvres. The reason for this was that the tail rotor blade tip severed the left tail rotor control cable at a point just aft of the fairlead of the tail boom's rearmost bulkhead. A full and hard deflection of the right anti-torque pedal resulted in the tail rotor assembly hitting the rubber teeter stop bumpers of the static stop. A distance of 25 to 28 mm was measured between the tail rotor blade tip and the control cable.

The helicopter manufacturer came to the following conclusion:

"*(1) Sudden airborne maneuvers by themselves do not result in tail rotor blade motions which would intercept the tail rotor control cable.*

(2) Sudden airborne maneuvers do not result in deflections of the fuselage, tail-cone, stinger tube or cables which would contribute to the possible interception of the tail rotor blade and cable.

(3) It was concluded, however, that slack cable tension resulting from improper rigging in conjunction with worn teeter stops, low rotor rpm, and a severe maneuver

(such as sudden left yaw), could result in the slack cable being thrown outward and into the rotating path of the tail rotor blade."

The manufacturer therefore requested that all operators carried out the following inspections without delay:

"*(1) An immediate inspection for proper cable tension and condition of tail rotor teeter stop rubber bumpers must be made. With full hard right or left pedal applied, any visible sag in the cable should be considered low tension and the aircraft should not be flown until cable tension and experienced maintenance personnel check rigging. Rubber teeter stop bumpers found to be brittle, cracked, missing, or with heavily-worn screw heads, should be replaced prior to the next flight.*

(2) Tail rotor cables found to have little or no sag and teeter stops with minor wear should be checked for proper rigging and cable tension by experienced maintenance personnel within the next 5 hours of service.

(3) Proper rigging and cable tension must be verified at each subsequent 100 hour inspection."

1.4.3.3 Tail rotor control cable inspection

Service directive bulletin no. 0093 (see appendix 2) was published on 9th December 2003. This SDB was not recorded in the technical files of HB-XLS under 'List of completed manufacturer's instructions'.

The background to this SDB was that the manufacturer had been notified of frayed and worn left tail rotor control cables near the cable-guide pulley that is mounted furthest back in the tail boom.

This SDB requested that the condition of the tail rotor control cables be inspected.

In one comment, the inspection interval is described as follows:

"*Maintenance personnel should pay particular attention to this area during subsequent 100 hour/annual inspections. Enstrom recommends using the procedure outlined in paragraph 5.1 for cable inspections in this area. This is especially important on aircraft which have a history of cable wear.*"

Generally, the manufacturer's inspection manual requests that the cable pulleys, fairleads, alignment and the cables' tension be checked at every 100-hour and annual inspection.

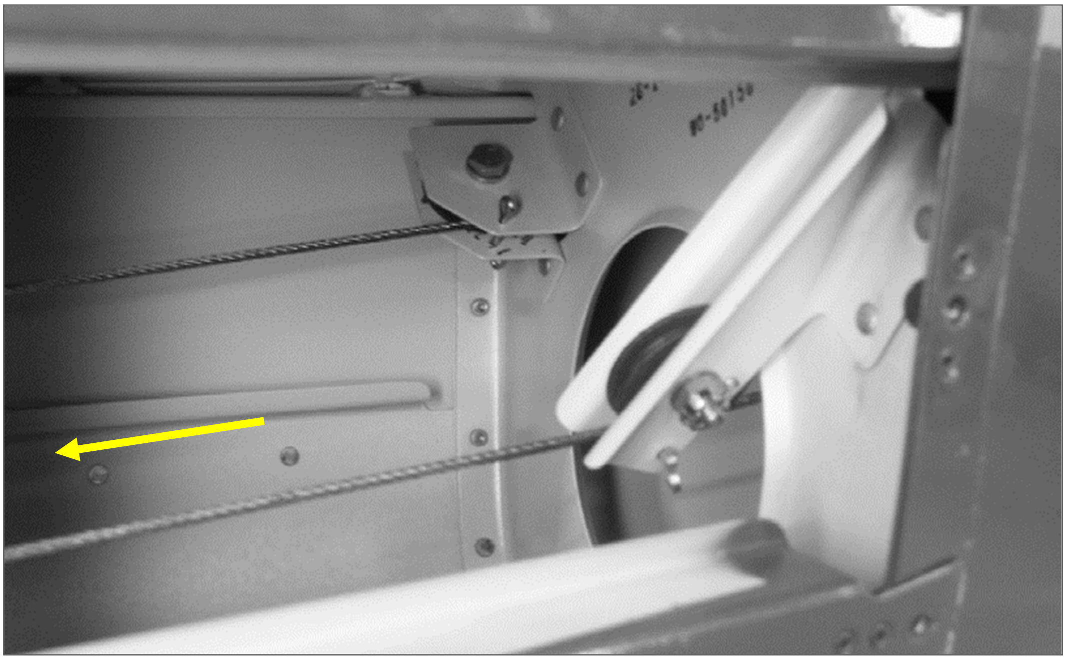

Illustration 6: The layout of the left cable pulley in the rear area of the tail boom, as displayed in the manufacturer's service directive bulletin. The yellow arrow indicates the direction of flight.

Illustration 6 was taken from the SDB and shows a modified version of the installed left cable pulley mount. The left fairlead is located approximately 20 mm towards the tail boom's centre and approximately 60 mm lower (see illustration 7). This increases the distance between the tail rotor blade tip and the control cable.

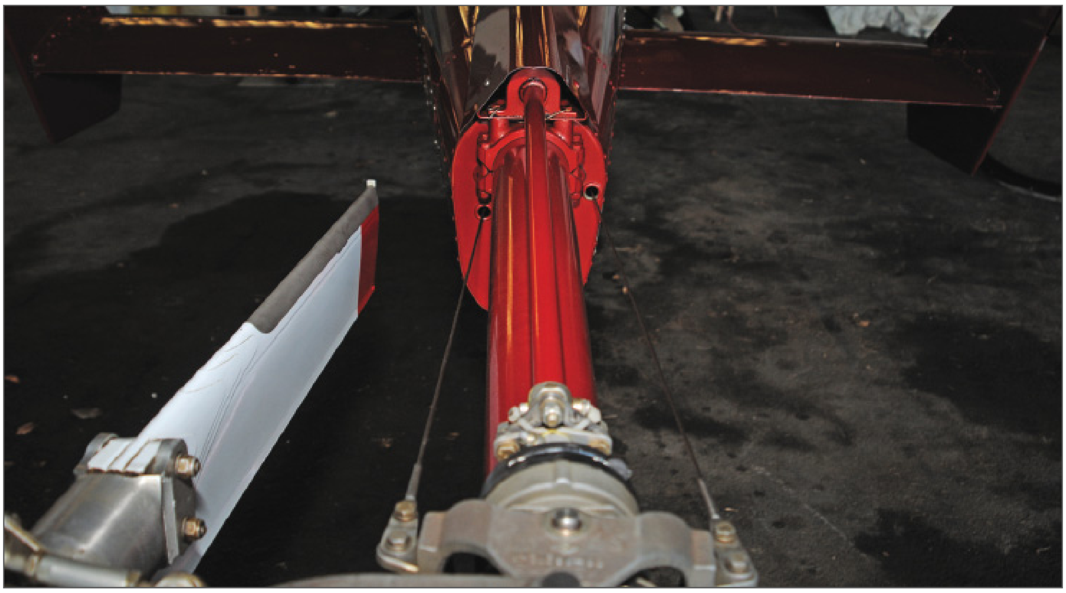

Illustration 7: A modified fairlead in a helicopter of the same type.

In HB-XLS, the left and right cable guide systems were mounted identically and symmetrically (see illustration 8).

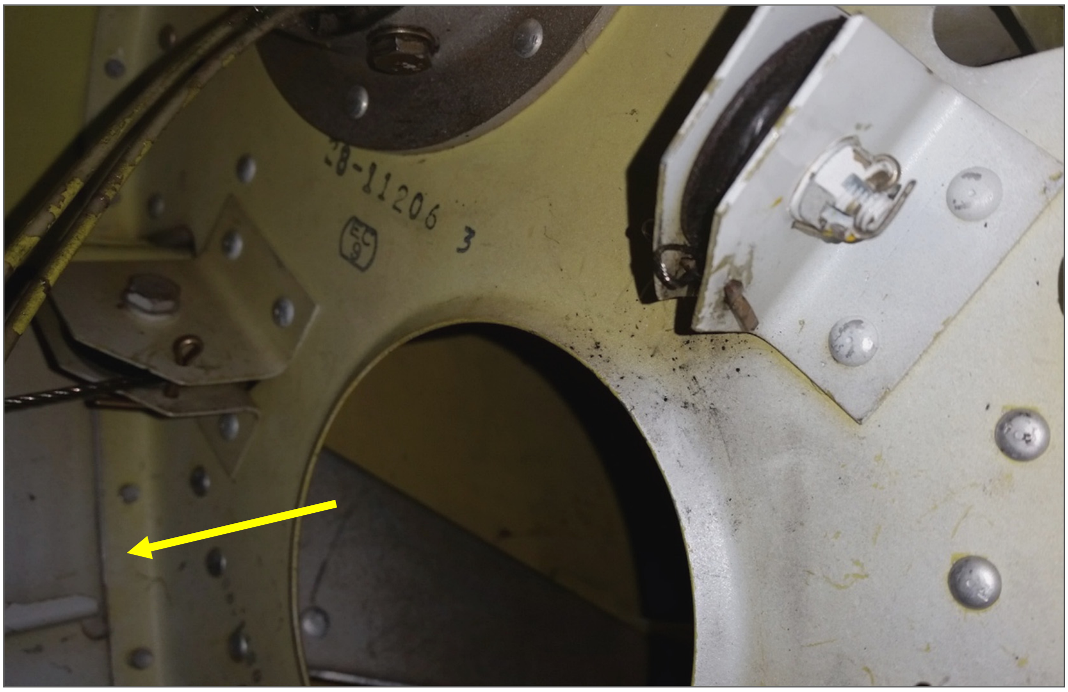

Illustration 8: The symmetrical cable guide system in HB-XLS. The yellow arrow indicates the direction of flight.

According to the helicopter manufacturer, no modification of the cable guide system was requested.

1.5 Tests and research results

1.5.1 Forensic investigation

1.5.1.1 Tail rotor blades

The metal plates mounted on the rotor blade tips as strike indicators showed substantial indentations indicating hard contact with the control cable (see illustration 9). In addition, one indicator was bent outwards and backwards in the tail rotor's direction of rotation. In the outer area of both rotor blades, contact marks from the control cable could be detected in the form of scratch marks. On one blade, the marks run 370 mm along the leading edge towards the blade hub. On the other blade, they run 160 mm in the same direction (see illustration 10). These marks were caused by the snapped control cable.

Illustration 9: The indentation on the strike indicator and contact mark on the tail rotor blade's leading edge (no. 1).

Illustration 10: Contact marks on the tail rotor blade's leading edge (no. 2) and bent strike indicator

With the left anti-torque pedal fully applied, the distance between the control cable and tail rotor blade tip was approximately 40 mm. When the tail rotor blade was pressed against the static stop's rubber teeter stop bumper with a small amount of force, the distance was reduced to 25 mm.

A slight increase in lateral force, caused by dynamic effects, resulted in the tail rotor blade tip to come into contact with the left control cable.

1.5.1.2 Bulkhead

The tail boom's rearmost bulkhead was manufactured from a 1-mm aluminium sheet (aluminium 2024). Arranged symmetrically, this bulkhead had fairleads for the left and right control cables which featured plastic edge protection (see illustration 11).

The incision running upwards from the left fairlead showed signs that it had been caused by the control cable. The left fairlead's edge protection was no longer present. A part of the protection was found near the take-off area.

Illustration 11: The tail boom's rearmost bulkhead with the incision in the left fairlead.

A splinter was found on the inside of the bulkhead. This pointed towards the inside of the tail boom (see illustration 12).

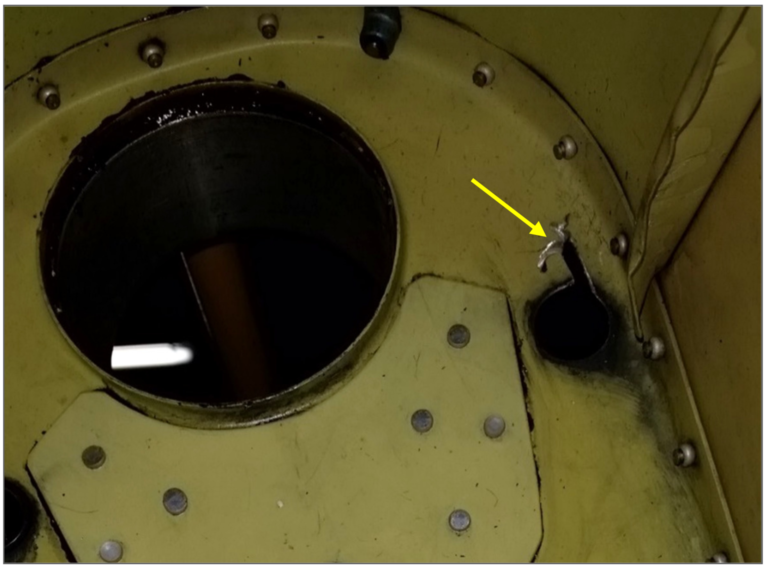

Illustration 12: The inside of the bulkhead. The splinter can be seen at the edge of the incision (yellow arrow).

Yellow paint particles were found on the left control cable near the bulkhead's fairlead. These were different shades of yellow due to the different paint on the inside and outside of the tail boom.

1.5.2 Dimensions and mechanical material properties

The left and right control cables had a diameter of 2.45 mm. Both cables are of an identical design and consisted of 7 strands each containing 7 wires. The 49 wires had a diameter of 0.25 mm; the cables' metallic cross-sectional area was calculated as 2.40 mm^2. The cables were made from stainless steel. Test pieces were taken from the undamaged right cable and the tensile strength was checked using a tensile test. The control cables complied with the manufacturer's specifications.

The two tail rotor control cables were deflected at the tail boom's second-rearmost bulkhead. The cable pulley had a diameter of almost 25 mm; consequently, the ratio of cable diameter to cable pulley diameter was 1:10 and the ratio of cable wire diameter to cable pulley diameter was 1:100.

According to information from the helicopter manufacturer, there are no concrete guidelines for the ratio between the cable pulley diameter and cable diameter. By contrast, in military aviation there are guidelines for fatigue tests of such layouts. For the cable type used in HB-XLS, the ratio of cable diameter to cable pulley diameter was 1:13 in these tests. The cable’s tensile strength determined by this fatigue test can drop to 60% of the original figure.

1.5.3 Metallographic investigation

Mainly ductile fractures (shear, sliding and torsion fractures), which occurred under maximum shearing stress, were detected on the snapped left control cable. This fracture scenario corresponds well to the almost static tensile test on the undamaged right control cable. One fracture on the left control cable showed signs typical of fatigue damage in high-strength wires. The surfaces of both cables showed relatively prominent damage such as chafe marks, dents etc. Prior corrosive damage was not found.

The fractures showed significant necking, some were funnel-shaped, some had a shear lip on one side (see illustration 13). Fracture combs could be seen across the entire fracture cross-section. The pattern matched that of a ductile shearing stress fracture. Fatigue could not be proven.

Another fracture was consistent with fatigue damage. However, vibration marks could not be proven, although this is not unusual in wire fractures with small wire diameters and high strain hardening (see illustration 14).

Individual wires of the left control cable’s strands fractured over a long period of time as a result of fatigue. This led to mechanical weakening of the cable.

No abnormalities were detected on the right control cable.

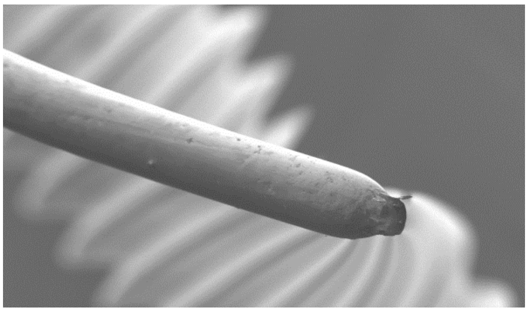

Illustration 13: Significant necking

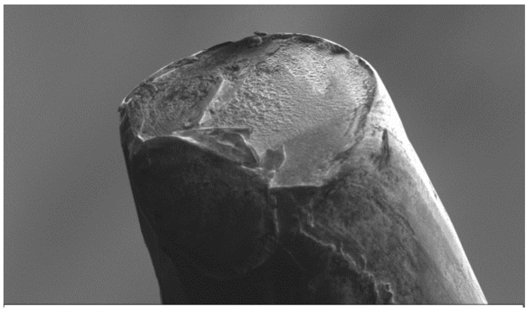

Illustration 14: Fatigue damage

1.6 Medical information

There is no evidence of any health problems affecting either the flight instructor or the trainee pilot at the time of the accident.

1.7 Maintenance company

1.7.1 General

The maintenance company has held the European Aviation Safety Agency (EASA) Part 145 approval since 26th November 2004. The maintenance company’s organisation and procedures are defined in the maintenance organisation exposition (MOE) and are binding whenever work is carried out under the terms of the EASA Part 145 approval.

The company maintains various aircraft types below 5,700 kg as well as Enstrom helicopters. The maintenance company is also the Swiss sales and service centre for this helicopter type.

1.7.2 Maintenance organisation exposition

1.7.2.1 General

This section quotes relevant excerpts from the maintenance organisation exposition, version 22 dated 25th August 2015.

1.7.2.2 Maintenance procedures, part 2

"2.1.3 Maintenance documentation and its completion

Checklists are usually used for work on aircraft. To this end, the mechanic copies the inspection lists and the cover sheet (to check the revision status) from the service or maintenance manuals which are valid at that time. For this, quality control management creates a cover sheet which additionally contains information such as job number, registration, date, operating hours etc. as well as protocols for engine testing and inspection flight. The mechanic writes down the individual items from these lists after they have been completed. Where tolerance values have to be met as part of the work, the actual values are to be recorded.

[…]

2.14 Filing of the maintenance documentation

[…]

b) Other maintenance documentation such as EASA form 1, work reports, component cards, supplemental type certificates (STCs) *or similar are also filed with the technical documents.*

[…]"

2 Analysis

2.1 Technical aspects

The condition of the two rubber teeter stop bumpers on the static stop of the tail rotor was poor (see section 1.4.2.4). They should have been replaced during the last inspection at the latest.

The left control cable showed signs of prior damage. Individual wires in the cable's strands had fractured over a long period of time as a result of fatigue. This led to mechanical weakening which went undetected.

Cable fatigue depends on the cable tension, the number of cable movements and, in particular, the diameter of the cable pulleys. According to the fatigue tests mentioned in section 1.5.2, considerable reduction in the cables' strength due to fatigue is to be expected when using cable pulleys with a diameter of approximately 32 mm. When using cable pulleys with smaller diameters, such as those fitted in HB-XLS, the loss of tensile strength due to fatigue is correspondingly greater.

Material fatigue, wire fractures and cable surface wear are mainly to be expected near the cable pulleys. The cable pulley diameter at the tail boom's second-rearmost bulkhead was approximately 25 mm and was small in relation to the cable diameter (see section 1.5.2). As a result of this, fatigue damage to the control cable had to be expected after a certain operating time due to increased bending stress. It is therefore very important that the control cables are checked for damage at the specified intervals. A control cable that has fractured wires or worn surfaces must be replaced without delay. The manufacturer had emphasised this with service directive bulletin (SDB) no. 0075 (see appendix 1).

The tail rotor control cables on HB-XLS had last been replaced approximately 10 years ago.

According to the technical documents, measurement of the control cables' tension was certified as part of the inspection on 5th December 2015. However, the measured values were not recorded. Therefore, traceability was not assured and the stipulations of the maintenance organisation exposition were not implemented.

It is highly likely that the tension of the control cables was too low at the time of the accident. The attempt to stabilise the helicopter around its vertical axis on the snow-covered ground resulted in the tail rotor's plane of rotation being deflected and ultimately resulted in the contact between the tail rotor blades and left control cable. In turn, this led to the left control cable being severed. The poor condition of the rubber teeter stop bumpers, which led to increased play for the tail rotor's wobbling motion, contributed to this.

The original variant of the cable guide system was installed at the tail boom's second-rearmost bulkhead on HB-XLS. This resulted in a shorter distance between the left control cable and the tail rotor blade tips compared to the modified version. The risk of contact between the tail rotor and left control cable increased accordingly.

2.2 Human and operational aspects

2.2.1 Flight instructor and trainee pilot

Generally speaking, operating a helicopter – particularly one with skid landing gear – on snow-covered or icy ground with reduced traction is demanding. Due to torque changes, the helicopter can move and turn to the left or right around its vertical axis.

In the present case, the trainee pilot was surprised by the helicopter's yaw. The decision to stop the helicopter from rotating by reducing the engine speed using the twist-grip throttle was correct.

Because of the trainee pilot's overall experience, the flight instructor could expect him to carry out the subsequent actions independently. However, given the general prevailing conditions, the snow-covered take-off area near a fuel station and the fact that the trainee pilot had not received much training recently, the flight instructor's decision to leave the helicopter was not safety-conscious.

2.2.2 Choice of take-off area

The take-off area of HB-XLS was approximately 17 m from the hangar and approximately 4 m from the fuel station. In the event of the helicopter rotating around its vertical axis, as in the present case, there was a risk of the helicopter colliding with the fuel station. A demarcated take-off area with a sufficient safety distance to the fuel station would be desirable.

2.2.3 Maintenance company

The technical documents of HB-XLS were not kept complete. Tracing installed components was very difficult, in parts impossible. The procedures defined in the maintenance organisation exposition were not followed in their entirety (see section 1.7).

3 Conclusions

3.1 Findings

3.1.1 Crew

- The flight instructor and the trainee pilot held the necessary licences for the flight.
- The trainee pilot began his flight training in September 2013 and continued this with several interruptions.
- By the time of the accident, the trainee pilot had accumulated a total flying time of 98:13 h, 3:46 h of which he had flown solo.

3.1.2 The course of the accident

- Whilst working through the preparation checklist, the trainee pilot noticed that the emergency location transmitter (ELT) was missing.
- Having consulted the trainee pilot, the flight instructor disembarked from the helicopter in order to enquire about the ELT. The trainee pilot carried out the remaining checks with the permission of the flight instructor.
- The trainee pilot opened the throttle to carry out the magneto check at an engine speed of 2,900 rpm.
- Shortly before this speed was reached, the helicopter began to turn slowly around its vertical axis to the left on the snow-covered ground.
- The trainee pilot applied the anti-torque pedals to stabilise the helicopter on its longitudinal axis. This resulted in the tail rotor's plane of rotation being deflected and ultimately resulted in the contact between the tail rotor blades and the left control cable. In turn, this led to the left control cable being severed.
- The helicopter suddenly started to turn to the left again.
- After approximately four rotations, the trainee pilot reduced the engine speed using the twist-grip throttle. This resulted in the helicopter coming to a standstill.

3.1.3 Technical aspects

- The helicopter had the required permissions for VFR traffic.
- The mass and centre of gravity were within the permissible limits of the rotorcraft flight manual (RFM).
- The last scheduled maintenance work on the helicopter HB-XLS was carried out between 20th November and 5th December 2015.
- The technical documents of HB-XLS were not kept complete. Tracing installed components was very difficult, in parts impossible.
- Measuring of the control cables' tension was certified on the job sheet from 5th December 2015. However, the measured values were not recorded.
- The control cables were last replaced on 12th April 2006, the turnbuckles on 8th February 2002. At what time the cable pulleys were replaced was not evident from the files.
- The turnbuckles were corroded and deposits were present on their safety wires.
- The left control cable showed signs of prior damage.

- The condition of the two rubber teeter stop bumpers on the static stop of the tail rotor was poor.

3.1.4 General conditions

- The weather had no influence on the accident.
- The surface of the take-off area was covered in snow.
- The take-off area of HB-XLS was in close proximity to the fuel station.

3.2 Causes

The accident emerged from a loss of control of the tail rotor control system, which can be attributed to the fact that the tail rotor severed a control cable.

Improper maintenance of the helicopter was found to be the cause of the accident. This led to the following deficiencies that made the accident possible, either individually or in combination:

- poor condition of the rubber teeter bumpers on the static stop;
- prior damage to the left control cable;
- in all likelihood, insufficient tension in the control cables.

The fact that the helicopter was being operated on ground that offered reduced traction contributed to the accident.

4 Safety recommendations, safety advice and measures taken since the accident

4.1 Safety recommendations

None

4.2 Safety advice

None

4.3 Measures taken since the accident

None

This final report was approved by the Board of the Swiss Transportation Safety Investigation Board STSB (Art. 10 lit. h of the Ordinance on the Safety Investigation of Transportation Incidents of 17 December 2014).

Bern, 14th August 2018 Swiss Transportation Safety Investigation Board

Appendix 1: Service directive bulletin no. 0075

ENSTROM HELICOPTER CORPORATION

2209 22ND STREET, P.O. BOX 490, MENOMINEE, MICHIGAN 49858-0490 USA

SERVICE DIRECTIVE BULLETIN

SERVICE DIRECTIVE BULLETIN NO. 0075
Page 1 of 2

DATE: June 8, 1987

SUBJECT: Tail Rotor Cable Blade Strikes

MODELS: F28C, 280C, F28F, 280F and FX Models

EFFECTIVITY: As noted in the following text

There have been three reported occurrences of tail rotor cable separation in flight on "C" and "F" model helicopters during severe maneuvering. These occurrences were the result of the tail rotor blade tip striking the left tail rotor control cable at a point just aft of the last tailcone bulkhead fairlead.

In an effort to determine the cause of these tail rotor control cable strikes, several helicopters including an old "C" model and three new production helicopters were closely examined for proper rigging and operating clearances. With full right pedal and the tail rotor assembly teetered hard against the teeter stop rubber bumper, a minimum clearance of 1.00 to 1.10 inches was measured between the tail rotor blade tip and the control cable.

With consideration of the flight sequences of the individual occurrences provided to Enstrom and Enstrom s examination of the operational clearances of the tail rotor control system, the following conclusions have been reached concerning the reported tail rotor cable strikes:

(1) Sudden airborne maneuvers by themselves do not result in tail rotor blade motions which would intercept the tail rotor control cable.

(2) Sudden airborne maneuvers do not result in deflections of the fuselage, tailcone, stinger tube or cables which would contribute to the possible interception of the tail rotor blade and cable.

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Page 2 of 2

(3) It was concluded, however, that slack cable tension resulting from improper rigging in conjunction with worn teeter stops, low rotor rpm, and a severe maneuver (such as sudden left yaw), could result in the slack cable being thrown outward and into the rotating path of the tail rotor blade.

NOTE: In one occurrence, an intercept of the blade and cable was encountered on a new "F" model helicopter in which subsequent investigation revealed the rigging and cable tension to be correct. Attempts to simulate the maneuver which precipitated the cable strike always resulted in adequate clearance. It was concluded that this incident was unique and probably due to a combination of pedal reversals on the ground, extremely low rpm and teeter stop pounding in gusty wind conditions so severe as to actually bend the blades chordwise until an intercept was encountered.

Enstrom is therefore requiring that all owners and operators perform the following inspections upon receipt of this Service Directive Bulletin.

(1) An immediate inspection for proper cable tension and condition of tail rotor teeter stop rubber bumpers must be made. With full hard right or left pedal applied, any visible sag in the cable should be considered low tension and the aircraft should not be flown until cable tension and rigging is checked by experienced maintenance personnel. Rubber teeter stop bumpers found to be brittle, cracked, missing, or with heavily-worn screw heads, should be replaced prior to the next flight.

(2) Tail rotor cables found to have little or no sag and teeter stops with minor wear should be checked for proper rigging and cable tension by experienced maintenance personnel within the next 5 hours of service.

(3) Proper rigging and cable tension must be verified at each subsequent 100 hour inspection.

NOTE: (a) Complete rigging information on the tail rotor control cables for F28C and 280C can be found in Enstrom Maintenance Manual page MM-24-8. Rigging information for the Enstrom "F" and "FX" models is in the F Model Maintenance Manual, 1986 Edition, starting on page MM-10-1.

(b) With stops and travel properly rigged, the tail rotor cables must have 35 to 40 lbs of tension on them, verified by the use of a tensiometer. The clearance between the tail rotor blade and the cable must be at least 1.00 inch with the blade teetered full forward and the rubber stop compressed.

Appendix 2: Service directive bulletin no. 0093

ENSTROM HELICOPTER CORPORATION

2209 22ND STREET, P.O. BOX 490, MENOMINEE, MICHIGAN 49858-0490 USA

SERVICE DIRECTIVE BULLETIN

SERVICE DIRECTIVE BULLETIN NO. 0093
Revision 1
Page 1 of 4

DATE: December 9, 2003

1. SUBJECT: Tail Rotor Control Cable Inspection

2. MODEL: F-28A, F-28C(-2), F-28F, 280, 280C, 280F, and 280FX

3. EFFECTIVITY: All serial numbers equipped with tail rotor control cable pulleys installed in the tailcone (Refer to paragraph 4)

4. BACKGROUND:

Enstrom has received reports from inspection personnel in the field of frayed and worn tail rotor control cables. The reports indicate that the wear is occurring at the pulleys (See Figure 1) in the tailcone located aft of the horizontal stabilizers. These pulleys are installed in tailcone assemblies installed on all 280FX model aircraft and F-28F model aircraft, S/N 744 and subsequent.

280, 280C, and 280F model aircraft and F-28A, F-28C(-2), and F-28F (other than the previously listed F-28F serial numbers) model aircraft may have had the pulleys installed as a modification to their tailcones.

Failure of a tail rotor control cable could result in partial or complete loss of tail rotor control. The maintenance manual applicable to the models listed above requires inspecting the tail rotor control cables for "Wear at pulleys, fairleads, proper alignment and tension (30/40#)" during the 100 hour/annual inspection. While very general in terms, the inspection requirement may call for a more detailed inspection of the tail rotor control cables if the condition of the cables cannot be adequately determined. This Service Directive Bulletin requires a one time inspection of the tail rotor control cables and provides more detailed guidance for inspecting tail rotor control cables.

5. COMPLIANCE:

For aircraft with more than 200 hours total time, within the next 10 flight hours, inspect the tail rotor control cables in accordance with paragraph 5.1 of this Service Directive Bulletin.

For aircraft with less than 200 hours total time, at the next 100 hour/annual inspection, inspect the tail rotor control cables in accordance with paragraph 5.1 of this Service Directive Bulletin.

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Revision 1
December 9, 2003 Page 2 of 4

5.1. INSPECTION:

NOTE

Perform all maintenance procedures in accordance with applicable maintenance manual for the aircraft model.

1. Remove the access panel located aft of the horizontal stabilizer on the left side of the tailcone (See Figure 2) and determine if the tailcone is equipped with the pulleys.

NOTE

Figure 1 shows the latest tail rotor control cable pulley installation. On earlier installations, the left side pulley installation is a mirror image of the right side pulley installation.

2. If the tailcone is not equipped with the pulleys, reinstall the access panel and return the aircraft to service. Proceed to the next paragraph if the tailcone is equipped with the pulleys.

NOTE

The inspection requirements of this Service Directive Bulletin do not apply to aircraft that do not have the pulleys installed in the tailcone; however, Enstrom recommends, at a minimum, a visual inspection of the tail rotor control cables in the vicinity of the fairleads since the access panel is now already removed from the tailcone.

3. Disconnect the tail rotor control cables from the tail rotor pitch change assembly and attach strings to the end of the cables.

4. Partially pull the tail rotor control cables out of the tailcone through the access opening and inspect the areas of the tail rotor control cables that pass over the pulleys and inspect the pulleys in accordance with FAA Advisory Circular 43.13-1B, paragraph 7-149, Cable System Inspection (Appendix A to this Service Directive Bulletin). If the pulleys are rubbing on the mounting brackets, AN960-10L Washers may be used as shims to eliminate the interference.

5. Replace/Reinstall the tail rotor control cables and/or pulleys as required. Set the control cable tension and tail rotor rigging in accordance with the maintenance manual.

6. Reinstall the access panel.

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5.2. PARTS:

Refer to the applicable Illustrated Parts Catalog for replacement parts as required.

6. SPECIAL TOOLS:

Tool Number	Description
T-0080 (C and F Models)	Tail Rotor Rigging Tool
T-0012 (A Models)	Tail Rotor Rigging Tool
---------	Cable Tensiometer

7. MAN-HOURS:

1 Man-hour for inspection, 4 Man-hours for inspection and cable replacement.

8. WARRANTY: Standard Enstrom Warranty

9. WEIGHT CHANGE: None

10. LOG BOOK ENTRY: Enter compliance with this Service Directive Bulletin.

11. REPETITIVE INSPECTIONS: None

NOTE

Maintenance personnel should pay particular attention to this area during subsequent 100 hour/annual inspections. Enstrom recommends using the procedure outlined in paragraph 5.1 for cable inspections in this area. This is especially important on aircraft which have a history of cable wear.

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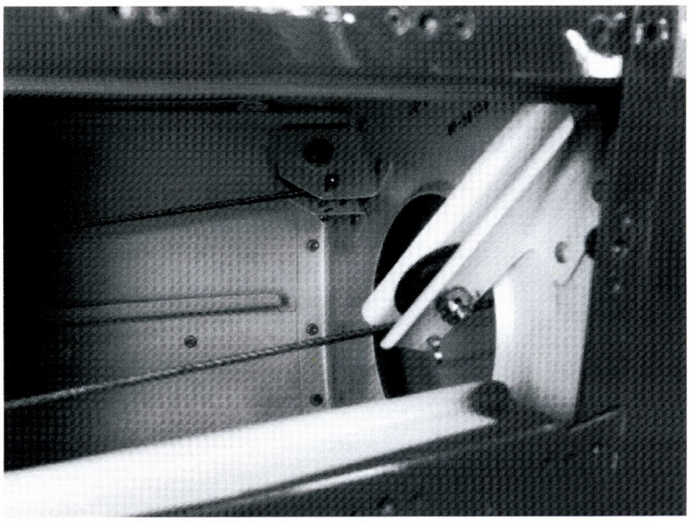

Figure 1. Tail Rotor Control Cable Pulley Installation

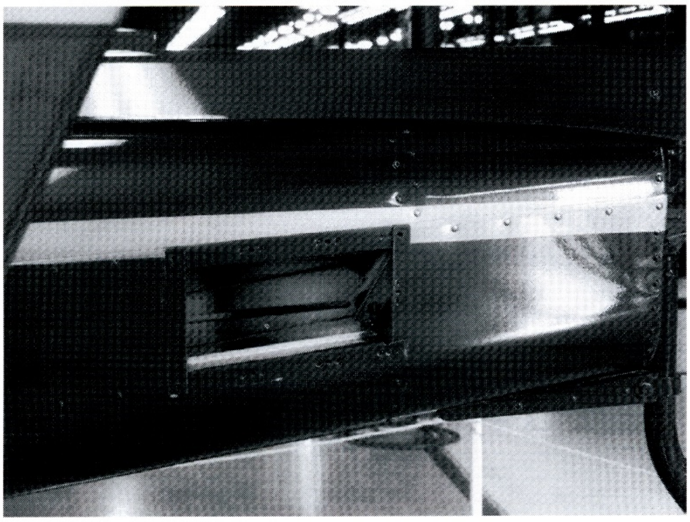

Figure 2. Access Panel Location