FINAL REPORT

AAIU Synoptic Report No: 2004-002
AAIU File No: 2002-0024
Published: 23/1/2004

In accordance with the provisions of S.I. 205 of 1997, the Chief Inspector of Accidents, on 4 May 2002, appointed Mr Graham Liddy as the Investigator-in-Charge to carry out a Field Investigation into this occurrence and prepare a Synoptic Report.

Aircraft Type and Registration:	Schweizer Model 269C [1] EI-LRS
No. and Type of Engines:	1 x Lycoming HIO-360-D1A
Aircraft Serial Number:	S1701
Year of Manufacture:	1995
Date and Time (UTC):	3 May 2002 @ 10.00 hrs
Location:	Lisacul, Co. Roscommon
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 0
Injuries:	Crew - 0 Passengers - 0
Nature of Damage:	Economic write-off
Commander's Licence:	PPL(H)
Commander's Age:	54
Commander's Flying Experience:	313 hours of which 211 were on type
Information Source:	AAIU Field Investigation

SYNOPSIS

The helicopter was hovering after take-off when it swung uncontrollably to the left. The skids made ground contact and the helicopter toppled. The Investigation concluded that the clutch cable had separated, resulting in a loss of transmitted engine power.

[1] This is the USA FAA model designation. The commercial designation is Schweizer 300

FINAL REPORT

1. FACTUAL INFORMATION

1.1 Background

The owner, who was also the pilot on the accident flight, had purchased the helicopter new in 1995. He normally kept the helicopter in a purpose-built hangar at his home.

1.2 History of the Flight

The pilot's intention was to fly the helicopter from his home base to Knock Airport (EIKN), a distance of about 5 miles, in order to obtain fuel for the helicopter. There was approximately 70 litres of fuel on the aircraft prior to the flight. He performed a pre-flight inspection and moved the helicopter from the hangar to a hard surface pad near the hangar. He started the engine, engaged the rotor and achieved engine-rotor synchronisation. He then performed the pre-take off checks. No abnormalities were noted. He then lifted off into a hover, at a height of about 5 ft. In the course of performing the post-lift-off checks, he engaged the engine speed governor. At this point, the engine speed suddenly increased very rapidly. Simultaneously, the helicopter "*spun viciously*" to the left. After rotating about 150º, the undercarriage skids made ground contact and dug into the earth. This caused the helicopter to topple over.

1.3 Damage to the Helicopter

The main blades were severely distorted and the main gearbox casing support to the main rotor cracked through. The tail rotor and rear section of the tail boom also made heavy ground contact and the tail boom failed at its forward end. One tail rotor blade disintegrated. The cabin structure was distorted in the rollover, but remained intact. Some of the Perspex panels of the cabin were broken.

1.4 Weather

The weather at the time of the accident was excellent, with clear blue sky and no wind.

1.5 Witness Information

Apart from the pilot, there were no visual witnesses to the accident. However, the event was heard by a number of people who were nearby. All of these witnesses reported hearing the engine race or "scream" immediately before impact.

1.6 Wreckage Investigation

The helicopter was initially inspected at the site of the accident and subsequently at the AAIU facility at Gormanston. The initial site investigation found that the clutch cable had failed. All other fractures, particularly in the tail boom area were examined. All these fractures were consistent with sudden overload single event failures. No evidence was found of pre-existing damage. In particular the Clutch Cable Pulley Bracket (**Appendix A**) had not failed and was still attached to the structure (there had been previous occurrences on the Schweizer Model 269C where this had separated). The Investigation noted that the helicopter had been well maintained and was in excellent overall condition.

At Gormanston the engine was ground run. Due to the damage to the transmission system and rotors, running under load was impossible. However the engine started easily and ran well in a no-load condition.

1.7 Description of the Clutch System

On the Schweizer 269C, the engine is connected to the Main Gearbox by means of eight V Belts. When the engine is started these belts are not tensioned, and are therefore free to slip. This ensures that the engine is not connected to the drive system, and not under load, when it is started. After starting, the engine is accelerated to 1500 RPM, using the throttle on the collective lever. The belt-tensioning switch is set to ENGAGE, which tensions the V Belts. When the engine RPM drops by 100 RPM, the switch is moved to HOLD until the engine RPM re-achieves 1500 RPM. This procedure is repeated until the engine and rotor RPM needles on the RPM gauge are superimposed and speed synchronisation is achieved. At this stage there is no belt slip and the belt-tensioning switch is left engaged. The pilot then advances the throttle until the normal operating speed of 3100 (engine) RPM is achieved.

The belt-tensioning system consists of an electrically operated linear actuator, which transmits a tension via a clutch cable assembly to an idler pulley acting on the V Belts. When the belt-tensioning switch on the instrument panel is activated, the linear actuator draws in and tensions the clutch cable, which in turn draws in the idler pulley and tensions the V Belts. When the V Belts are so tensioned there is no slip in the system, and the engine and rotor RPM are thus synchronised.

This helicopter was equipped with an electrically-powered limited authority governor which adjusted the engine throttle in order to ensure that the engine RPM is maintained within nominal values in flight. The governor is designed to maintain the engine speed with ± 50 RPM during normal manoeuvres and within ± 150 RPM during abrupt or rapid changes in flight conditions. It is not a full authority rotor RPM controller. This is an optional feature on the Schweizer Model 269C, and its operation is covered in the optional equipment section of the Flight Manual.

The pilot stated that while he was being instructed on the 269C, he was taught to take off with the governor disengaged, stabilise the helicopter in the hover and to then engage the governor. This is to reduce wear on the governor system when the pilot manually feeds in a large throttle input to compensate for the sudden increase of rotor drag when collective lever is applied for lift-off. In response to the draft report of this Investigation, the manufacturer stated: "*The* (Flight) *manual's only statements that may be interpreted as cautionary are to not use the governor in practice autorotations and to follow the twist grip during take off or landing to verify there is no over-speed, items 6 and 8. I am not aware of any official or verbal recommendations about not using it during take off."*

The Normal Operations Sections of the 269C Flight Manual, dealing with start-up, hover and take-off, have no reference to the use of the governor. In the relevant section of the Optional Equipment Supplement, there is a note which says that the "*Governor may be turned on at any time, but will not engage with the "GOV-DIS" switch in the DIS position or until the rpm is within 200 rpm of the preset speed. Throttle friction is to be completely off for proper operation of the governor.*"

It may also be noted that when the entire clutch control spring assembly is complete, the ball terminal, and the end of the cable going into it, are not visible. This makes inspection of the cable end for any indications of untwisting impossible.

1.8 Clutch Control Cable Assembly

The clutch control cable assembly, **(Appendix A)**, connects the linear actuator to the idler pulley, and consists of a cable, adjustment turnbuckle and a clutch control spring assembly. The cable assembly terminates at the linear actuator end in a turnbuckle and has a swaged ball terminal at the other end, which is held in the clutch control spring assembly, **(Appendix B).** The correct tension in the cable is set by adjusting the turnbuckle until the internal springs in the clutch control spring assembly are compressed to a degree that the spring guide alignment band is in line with the black bands on the housing strap **(Appendix B)**. The maintenance manual specifies that the linear actuator should be retracted (i.e. the cable should be under tension) when this adjustment is being made. It also states that when the mark is aligned, the tension in the cable will be 230 lbs (+ or – 5 lbs).

The cable consists of 7 strands, 6 being spiral wound about the straight inner strand. Tests conducted on the undamaged section, remote from the failure, found that the cable failed at a load of 841 lbs.

1.9 Inspection of Clutch Cable

The Investigation found that the clutch cable had failed inside the swaged ferrule directly underneath the ball terminal. Metallurgical examination found that:

- Separation had occurred in the cable at and adjacent to the ferrule swaged onto its rear end. Only one of the wires in one of the outer strands had started to pull through.

- The outer strands of the cable had been twisted in a manner that exposed the core [heart] strand. This can be caused by twisting of the cable during tensioning, and results in overloading of the core strand when the cable is subjected to service loads.

This examination also found indications that a grips (pliers or vice-grips) had been used on the turnbuckle. This indicated that such a tool might have been used to prevent the turnbuckle from turning when the turnbuckle was being adjusted. It should be noted that a hole is provided in the turnbuckle, into which a tommy bar can be inserted, in order to prevent rotation while adjustment is being made.

This examination concluded that:

- The fracture of the cable occurred by overload as a result of unequal strand loading. It is also considered probable that the unequal loading occurred because the cable was twisted during tensioning at the last belt change.

- Service loading, under the conditions described above, resulted in the core strand in the cable carrying a disproportionate share of the load.

- Depending on the degree of twist and the magnitude of the load, fracture can occur:

    (a) Immediately a service load is applied, or

    (b) By a high stress, very low cycle fatigue mechanism.

- If the service loads are low relative to the strength of the cable, fracture will not necessarily occur. It is thought probable that, in this case, condition (b) above applied.

1.10 Recent Maintenance.

The helicopter underwent an annual inspection in October 2001. The helicopter was handed back to the owner after this inspection on 4 January 2002. On a short flight from the maintenance facility, near Dublin, to a local airfield, for the purpose of refuelling, the owner noted that the governor was failing to maintain engine RPM and that he had to use the manual throttle. The helicopter was then returned to the maintenance facility. The engine speed governor components, comprising the Throttle Drive Motor p/n 2432-2A s/n 365 and the Throttle Governor Control Assembly p/n 2432-1C s/n 446, were removed and were shipped to Schweizer for repair. At Schweizer these components were certified as repaired and serviceable. The components were then refitted on the helicopter. Before the helicopter flew again, a 50 hr inspection was completed on 28 March 2002. At this time, the V Belts were replaced, as they were 7 years old.

Following replacement of the V Belts, the tension of the clutch cable was adjusted as specified in the Maintenance Manual. Following this maintenance, the operation of the governor system was checked and signed out as serviceable. The clutch cable was the original cable fitted to the helicopter when built and had completed 212 (logged) flight hours and 230 DATCON hours at the time of this maintenance. The helicopter flew only twice following this maintenance. On 6 April 2002 another pilot flew it from the maintenance facility to the owner's home. The owner flew the helicopter for 12 minutes locally on 3 May 2002. Thus the helicopter flew a total of 1½ hours between the maintenance and the accident.

1.11 Other accidents

The AAIU has experience of one other accident involving a Schweizer 269C. In this accident the helicopter pitched inverted over end and suffered considerably more damage than EI-LRS. The clutch cable did not fail in this other accident. The Investigation also discussed the cable failure with an experienced helicopter accident investigator of the National Transportation Safety Board (NTSB) in the USA. He stated the cable rarely failed, even in very severe accidents.

1.12 Other Information

It is noted by the Investigation that the manufacturer has, on later models of this helicopter, installed a new design of clutch cable, which features a heavier cable and a different method of end attachment. A feature of the modification is that the end of the cable is not hidden from view inside the clutch control spring assembly. It is understood that this new design can be retrofitted to earlier models, such as EI-LRS. However, the revised cable had not been offered to owners of earlier models by means of a service bulletin or other methods at the time of this accident. The Investigation understands that Schweizer has subsequently presented Service Bulletin B-280 to the US FAA for review. This bulletin details the installation of a different cable with changed end fitting into the original spring mechanism.

2. ANALYSIS

The evidence of the accident is consistent with clutch cable failure. The effect of cable failure would result in the total loss of friction in the V Belts and consequent disconnection of the engine from its rotor load. This would result in an immediate over-speed of the engine. This over-speed was clearly heard by the pilot and other witnesses. Also, in the hover the pilot would have had to apply left pedal to counteract the engine torque. When the engine was effectively disconnected suddenly, this pedal caused the helicopter to yaw violently to the left. Also with the disconnection of the engine power input, the main rotor RPM would decay rapidly, resulting in a loss of lift and a loss of height. Thus, the evidence from the accident site is consistent with clutch cable failure.

It may also be noted that no defect was subsequently found in the engine nor was any pre-existing defect found in the helicopter's control systems.

Because of the applied tension on the cable and the friction between the terminal ball and its seat in the clutch control spring assembly, it is probable that the terminal ball would not have rotated in its seat if the cable was allowed to twist while the turnbuckle was being adjusted. The nature of the failure indicates that the turnbuckle end of the cable did rotate to some degree during the tensioning adjustment, and as a result the natural twist in the cable was opened up. This reduced the load carried on the outer strands and caused the inner strand to carry a disproportionate portion of the load. This caused the inner strand to fail in overload. Subsequently the outer strands failed. The precise nature of the failure of these strands is not full understood, as the remaining strands should have been able to withstand the normal operating tension of 230 lbs. However it is noted that the failure occurred when the governor was switched-on. It is possible that if the engine RPM was a little low at the time the governor was turned ON, the resulting surge may have created an additional load on the cable, which caused the remaining strands to fail.

The Investigation is concerned that the procedure of adjusting the cable under tension, as specified in the Maintenance Manual, is likely to produce cable twisting. The Investigation therefore considers that there is merit in reviewing the procedure, to see if it is possible to devise a sequence for adjusting the cable off-tension. This would facilitate the ball terminal rotating in its seat, thereby reducing the possibility of cable twisting.

The Investigation also believes that the Maintenance Manual should contain a caution regarding the possible consequences of cable twisting. In addition, the correct use of the hole in the turnbuckle to prevent cable twisting should be explained, and a caution added to advise that the turnbuckle should not be held in a grips during adjustment.

The Investigation is concerned that the selection of the governor to ON in the hover may have contributed to the failure of the clutch cable. Furthermore it gave the pilot virtually no opportunity of recovery in the event of difficulties at this phase of flight. It is a matter of concern that while the helicopter's manufacturer does not recommend this practise, there is evidence that some students are being instructed to turn the governor "ON" while in lower hover. Consequently this Investigation believes that the matter should be clarified in the Flight Manual.

In response to the draft report of this Investigation, the manufacturers stated that they considered, in regard to Safety Recommendations 3.1 and 3.2 below, that such adjustment methods were common knowledge and practice of licensed engineers. The Investigation accepts this viewpoint. However due to the impossibility, in this particular set up, of inspecting the end of the cable within the clutch spring assembly after adjustment, and the fact that there is clear evidence that twisting did occur in this case, the Investigation believes that these safety recommendation should stand.

3 SAFETY RECOMMENDATIONS

3.1 The helicopter manufacturer should review the Maintenance Manual of the Schweizer Model 269C in order to caution maintenance personnel against allowing the clutch cable to twist during adjustment of the clutch cable tension. **(SR 2 of 2004)**

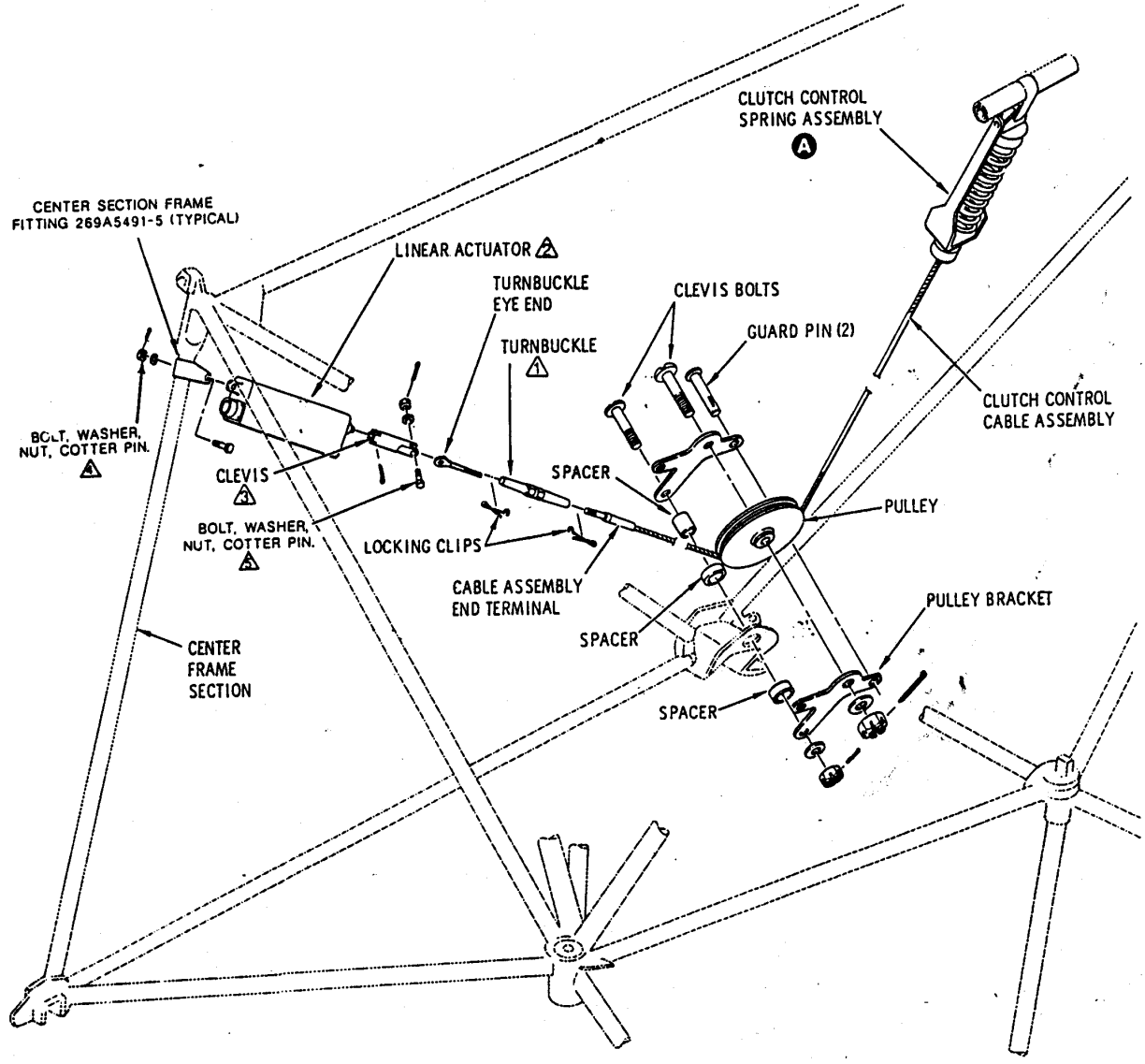
3.2 The helicopter manufacturer should review the Maintenance Manual of the Schweizer Model 269C in order to instruct maintenance personnel to use the hole in the turnbuckle to prevent rotation of the clutch cable while it is being adjusted, and to point out that holding the turnbuckle in a grips is inadvisable. **(SR 3 of 2004)**

3.3 The helicopter manufacturer should review the maintenance procedure of the Schweizer Model 269C for adjustment of the clutch cable with a view to making the actual adjustments of the clutch cable turnbuckle when the cable is not under tension. **(SR 4 of 2004)**

3.4 The helicopter manufacturer should pursue the approval of Service Bulletin B-280 and offer it to Schweizer Model 269C operators as a modification/upgrade. **(SR 5 of 2004)**

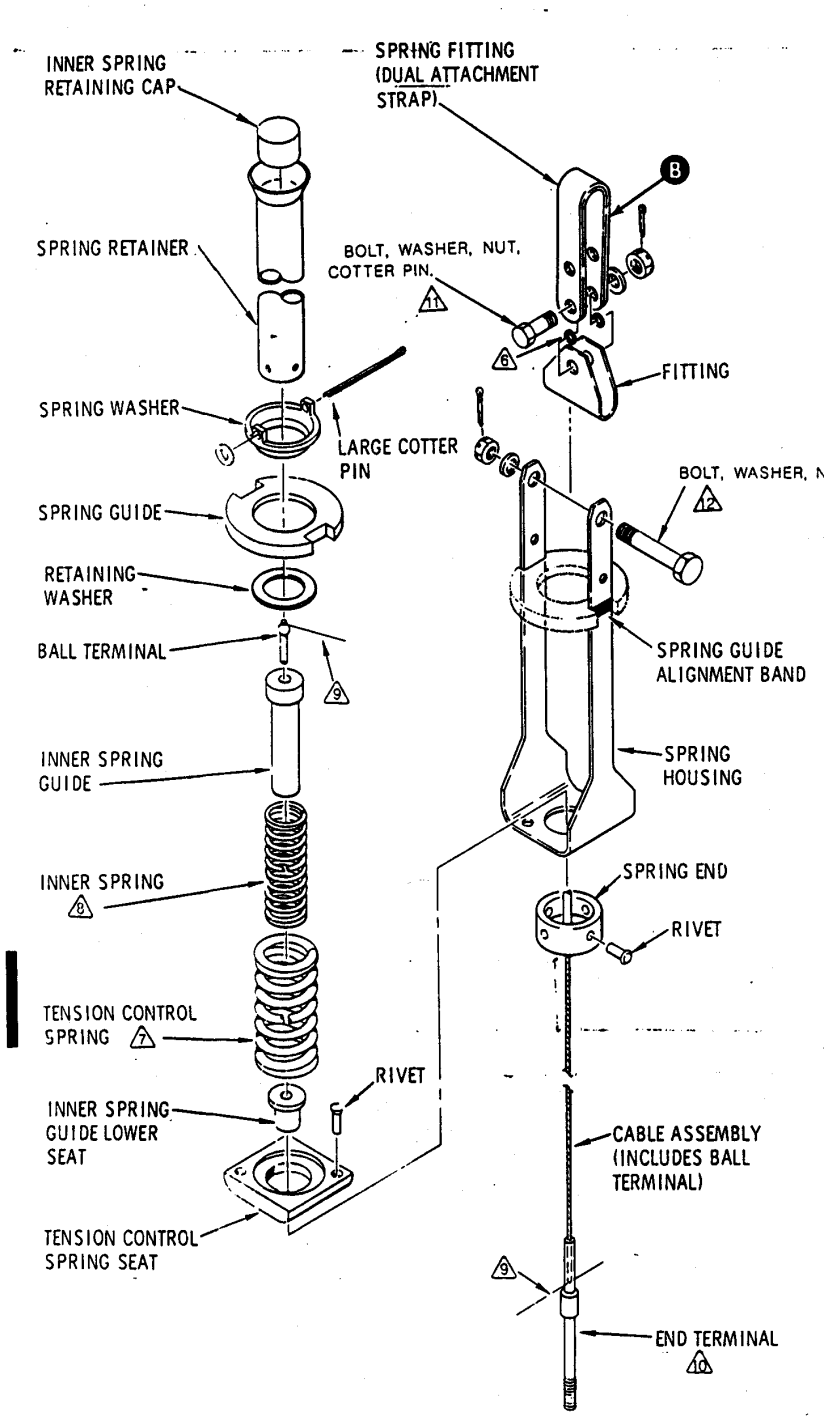
3.5 In light of the instruction being given in some helicopter schools, the helicopter manufacturer should review procedures for the use of the engine speed governor, with regard to the advisability of leaving the governor OFF for take-off and the selection of Governor ON in a hover. Following such a review the Flight Manual for the Schweizer Model 269C should be amended as appropriate. **(SR 6 of 2004)**

APPENDIX A



Layout of Clutch System Components

APPENDIX B



Layout of Clutch Cable Assembly