CIVIL AVIATION AUTHORITY
OF NEW ZEALAND

AIRCRAFT ACCIDENT REPORT

OCCURRENCE NUMBER 05/2733

ROBINSON R22

ZK-HVN

MURCHISON

26 AUGUST 2005

Glossary of abbreviations used in this report:

AC	Advisory Circular
AGL	above ground level
AMEL	aircraft maintenance engineer licence
AMM	aircraft maintenance manual
ARA	annual review of airworthiness
CAA	Civil Aviation Authority
CAR(s)	Civil Aviation Rule(s)
CEO	chief executive officer
C of G	centre of gravity
E	east
ft	foot or feet
Hp	horsepower
ELT	emergency locator transmitter
Kg	kilogram(s)
Km	kilometre(s)
LAME(s)	licensed aircraft maintenance engineer(s)
MHz	megahertz
m	metre(s)
mm	millimetre(s)
RCCNZ	Rescue Co-ordination Centre of New Zealand
NZDT	New Zealand daylight time
S	south
TAIC	Transport Accident Investigation Commission
TSO	technical standard order
UTC	coordinated universal time

AIRCRAFT ACCIDENT REPORT

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Aircraft type, serial number and registration:	Robinson R22, 0048, ZK-HVN
Number and type of engines:	One Lycoming O-320-A2B
Year of manufacture:	1980
Date and time:	26 August 2005, 1715 hours[1] (approx)
Location:	Murchison Latitude[2]: S 41° 53.09' Longitude: E 172° 14.80'
Type of flight:	Private
Persons on board:	Crew: 1 Passengers: 1
Injuries:	Crew: 1 fatal Passengers: 1 serious
Nature of damage:	Aircraft destroyed
Pilot-in-command's licence:	Commercial Pilots Licence
Pilot-in-command's age:	51 years
Pilot-in-command's total flying experience:	Approximately 1000 hours, all on type.
Information sources:	Civil Aviation Authority field investigation
Investigator in Charge:	Mr S J Walker

[1] Times are NZDT (UTC + 12 hours)

[2] WGS 84 co-ordinates

Synopsis

The Civil Aviation Authority was notified of the accident at 1800 hours on Friday 26 August 2005. The TAIC was notified shortly thereafter, but declined to investigate. A CAA site investigation commenced the following day.

During the approach to land at the pilot's home base, at the end of a local flight, the helicopter was seen to yaw rapidly to the right and then continue to rotate uncontrollably. The helicopter subsequently crashed inverted in a paddock close to the intended landing site. The pilot was killed and the passenger suffered serious injuries.

1. Factual information

1.1 History of the flight

1.1.1 ZK-HVN had been stored at the premises of a maintenance organisation since April 2005 to undergo a main rotor blade replacement, a 100 hour/annual inspection and defect rectification.

1.1.2 Prior to lunchtime on the day of the accident, and being satisfied that the helicopter was operating correctly, the pilot departed from the maintenance organisation for the flight to his home base. He flew for approximately 120 minutes, stopping briefly in the Owen River valley to visit a friend. He mentioned to the friend that he was generally pleased with the helicopter; however he also said that there was still a slight vibration which he thought was caused by the new main rotor blades. He took off at approximately 1500 hours to continue the flight to his home.

1.1.3 The pilot arrived at his home base at 1515 hours. Later that afternoon a friend of the family visited the household and as the weather was favourable for flying and the pilot was eager to use his helicopter, he invited his friend to be the shooter on a short deer hunting flight.

1.1.4 The helicopter was refuelled sufficient for 90 minutes flight and the pilot and his passenger took off at approximately 1630 hours. The 45 minute flight was without incident and after unsuccessfully pursuing some deer the pilot elected to return home.

1.1.5 At approximately 1715 hours the pilot's son realised that ZK-HVN was approaching home base from the north (directly over the house) which was unusual, but due to the light wind from the south, it was an appropriate approach path to the landing site. The pilot routinely used a westerly approach over the adjacent road as the prevailing wind is from the north east. The son described the turn and flare to land as being more abrupt than normal, and almost immediately the helicopter began to rotate to the right, apparently out of control. He heard the engine noise decrease rapidly and observed the helicopter rotate to the right two or three times at approximately 30-40ft AGL. It moved away from the house toward the neighbouring paddock, and suddenly fell to the ground in an almost inverted attitude. He reported that the engine sounded normal throughout the time that the helicopter was airborne.

1.1.6 The passenger, who had flown with the pilot previously, said that as they approached to land all seemed normal. As the helicopter was flaring to land he saw that the hook of the deer recovery strop was bouncing around on the floor of the cabin. This caught his attention, as it was something he had not seen before. The passenger reported that almost immediately after this observation, the vibration increased significantly, the helicopter's nose rapidly yawed to the right and then continued to spin to the right for a number of rotations. He looked across at the pilot who was struggling to maintain control of the helicopter. The passenger recalls the helicopter hitting the ground and being extricated from the wreckage.

1.1.7 The pilot's son immediately ran to the aircraft to render assistance. The passenger had partially extricated himself from the wreckage, but the pilot had died at the scene.

1.1.8 The accident occurred in daylight, at approximately 1715 hours NZDT, at Murchison Station, at an elevation of 670 feet. Grid reference 260-L29 475244; latitude S 41° 53.09', longitude E 172° 14.80'.

1.2 Injuries to persons

Injuries	*Crew*	*Passengers*	*Other*
Fatal	1	0	0
Serious	0	1	0
Minor/None	0	0	

1.3 Damage to aircraft

1.3.1 The aircraft was destroyed.

1.4 Other damage

1.4.1 Nil.

1.5 Personnel information

1.5.1 The pilot held a current commercial helicopter pilot licence, CPL (H).

1.5.2 His last biennial flight review was conducted on 21 February 2004 in conjunction with the issue of his category 'C' helicopter instructor rating.

1.5.3 The pilot had approximately 1000 flying hours logged in the R22 until the last logbook entry on 13 February 2005.

1.5.4 The pilot held a current Class 2 medical certificate. His Class 1 medical certificate was issued on 4 September 2004 and, being valid for 6 months, had expired.

1.6 Aircraft information

1.6.1 ZK-HVN, a Robinson R22, was manufactured in 1980 and first registered in New Zealand on 27 September 1985. It was issued with a non terminating airworthiness certificate on 2 November 1993.

1.6.2 ZK-HVN was fitted with a Lycoming O-320-A2B engine.

1.6.3 The helicopter's total time in service recorded in the maintenance logbook, up to the release to service from maintenance on the day of the accident, was 1995 hours.

1.7 Meteorological information

1.7.1 The weather conditions at the time of the accident were reported to be clear with no significant wind. The weather conditions were not a factor in the accident.

1.8 Aids to navigation

1.8.1 Nil.

1.9 Communications

1.9.1 Not applicable.

1.10 Aerodrome information

1.10.1 Not applicable.

1.11 Flight recorders

1.11.1 Not applicable.

1.12 Wreckage and impact information

1.12.1 The accident site was located in a dry flat pasture, approximately 5km north of Springs Junction Murchison, 15 metres to the east of State Highway 65.

1.12.2 The helicopter struck the ground in an almost inverted attitude on its right side approximately 50m from the intended landing site. The forces of the impact were absorbed mainly in the area of the upper right side of the cabin structure and main rotor mast assembly.

1.12.3 The forces involved in the ground impact and the disturbance from the ensuing rescue of the occupants meant that it was not possible to accurately determine the position of the engine and flight controls at the time of the accident. However pre impact flight control integrity was positively established.

1.12.4 There were indications that the helicopter had fallen to the ground vertically. The main rotor head had been forced into the ground to a depth of approximately 150mm with no evidence of a significant lateral component to the direction of travel of the helicopter at the time of ground impact.

1.12.5 The tailcone skin was slightly deformed and the structure to which the tailcone attaches was broken allowing the tailcone to droop toward the ground. The tip of the horizontal stabiliser had contacted the ground resulting in minimal damage. The tail rotor transmission and blades had not suffered a strike during the accident and were intact.

1.12.6 There was evidence that no rotational energy remained in the main rotor blades at ground impact. However, damage sustained to one main rotor blade indicated that prior to ground impact, the blade had entered the cabin structure and struck the left landing skid front crosstube. This strike stopped the main rotor disc in flight. Evidence of 'mast bumping' was also found, along with one droop stop that had failed, indicating that blade flapping had occurred.

1.12.7 There was fuel present in the fuel tank and examination of the contents of the airframe fuel filter bowl revealed no significant contamination to be present.

1.12.8 The gross weight of the helicopter was calculated to be outside the limits specified by the manufacturer in the flight manual, both at the time of take off and possibly at the time of the accident However this is considered not to be a significant factor in the accident. The C of G of the helicopter was calculated to be within the specified limits.

1.12.9 The wreckage was recovered to a maintenance facility where a detailed examination was conducted.

1.12.10 It was found that the tail rotor drive shaft (TRDS) flange had failed completely around the circumference of the root weld. Additionally, the TRDS was no longer supported by the damper bearing as the bearing supporting link had also failed. The TRDS was removed from the tailcone, leaving the flange (normally an integral part of the TRDS) still attached to the aft flexplate and yoke that make up the TRDS aft coupling assembly.

1.12.11 Further examination of the aft coupling revealed that it was assembled incorrectly, (refer to Figures 1 and 2, page 8).

1.12.12 The bolts designed to attach the flexplate to the tail rotor gearbox input yoke had been inserted through the yoke, the flexplate, and then directly into the attachment holes in the flange. Correct assembly would have the bolts inserted through the yoke, the flexplate, and then through two small bushes. The function of the bolts is to attach the flexplate to the yoke, not the yoke to the flange. Two other bolts designed to attach the flexplate to the flange had been incorrectly used to attach the two small bushes to the flexplate. This incorrect assembly had the effect of securing the TRDS directly to the yoke thus removing the ability of the flexplate to compensate for any misalignment or flexing of the TRDS.

Comparison of Correct and Incorrect Method of Aft Coupling Assembly

FIGURE 1

SHOULD BE ASSEMBLED THIS WAY

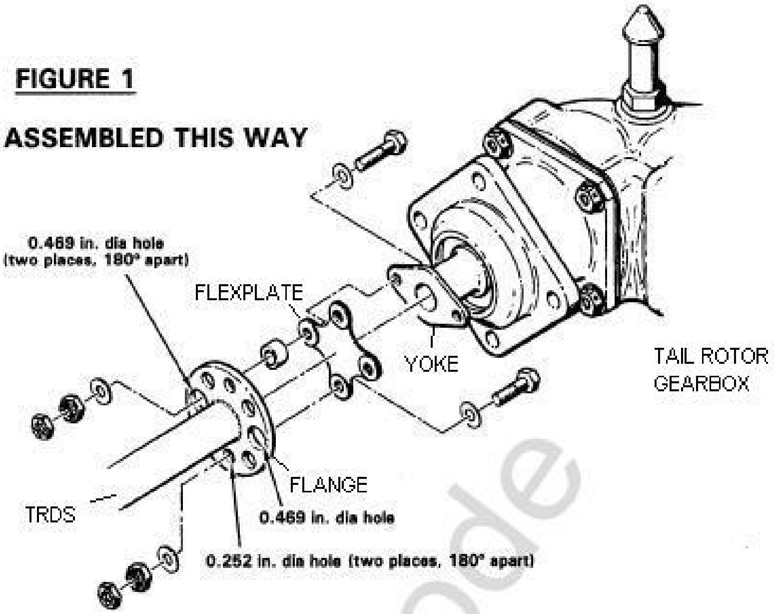
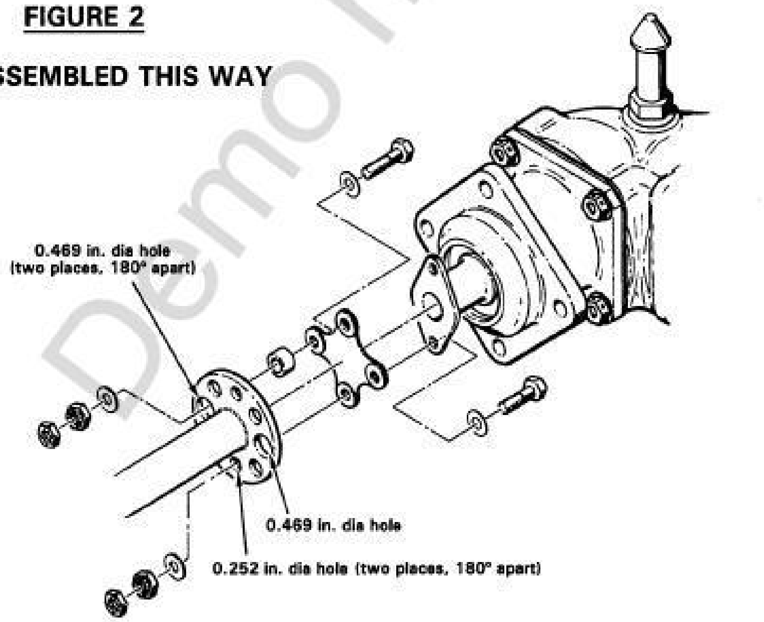


FIGURE 2

WAS ASSEMBLED THIS WAY



Failed TRDS in Situ with Incorrectly Assembled Aft Coupling

1.13 Medical and pathological information

1.13.1 The post-mortem examination revealed that the pilot died of blunt object head trauma evidenced by significant skull fracturing, with no other medical factors present which could have contributed to the accident or any other injuries which would have proven fatal.

1.13.2 There was no evidence of drugs or alcohol in the pilot's bloodstream.

1.13.3 The passenger suffered serious injuries. The most severe injuries were multiple fractures of his legs which were consistent with the intrusion of the main rotor blade into the cockpit.

1.14 Fire

1.14.1 Fire did not occur.

1.15 Survival aspects

1.15.1 The pilot was seated on the right side (nearest the ground at impact) and was wearing a protective helmet and combination lap and shoulder harness. The open face helmet, of the type normally worn by pilots, was not in good condition but its pre accident structural integrity appeared to have been satisfactory. It encompassed built in headphone speakers, microphone and visor attachment. The helmet appeared initially to be intact; however closer examination revealed that there was damage to the helmet on the rear right side. The fibreglass shell of the helmet had been depressed momentarily by a considerable force or pressure on one point, resulting in splitting of the composite material in a star shaped pattern. Once the pressure was removed, the helmet returned to its normal shape. Internally, the helmet padding and shock absorbing material appeared to be undamaged. The position of the pilots head as the aircraft hit the ground would have been proximal to the cockpit aft bulkhead which also forms the forward face of the main rotor transmission compartment. This area exhibited substantial crushing damage as it absorbed the initial impact loads. It appears that the pilots head may have been situated in this area when the initial impact occurred and fatal head injuries were sustained as a consequence of the structural deformation.

1.15.2 The passenger's lap and shoulder harness lower left side attachment point on the aircraft structure had failed due to the forces involved in the accident. However had he not been wearing this harness, which restrained him in his seat during the initial impact, he would likely have received more critical injuries.

1.15.3 The ACK Technologies Inc TSO C91a, 121.5 MHz, ELT which was switched to the 'armed' position did not activate as a result of this accident and no transmission was detected by the RCCNZ. The ELT was still connected to its antenna and the system appeared to be undamaged. Once removed from the wreckage the ELT was tested which revealed that it transmitted normally when switched to the 'on' position. This model of ELT is equipped with an integral single axis 'G' switch which is designed to trigger the ELT to transmit a signal upon being subjected to a force of a certain magnitude. The unit is required to be mounted in the aircraft so that an impact along the longitudinal axis of the aircraft is most likely to activate the ‘G’ switch. The ‘G’ switch may not have activated because of the low forces involved in the accident and/or the impact was not in the direction for which the ‘G’ switch is designed to function.

1.15.4 This was a survivable accident. Had the passenger not been injured by the main rotor blade intrusion, it is possible that he could have been able to vacate the wreckage without assistance.

1.16 Tests and research

1.16.1 The engine, which was intact, was removed from the wreckage at an approved engine overhaul facility and installed in a purpose built frame to test its performance. The engine started and ran satisfactorily. The initial pre run-up checks found that number 1 spark plug lead was crushed and causing a single magneto RPM drop. The damage to the spark plug lead was consistent with accident damage. After this was rectified the engine tests were carried out revealing that the engine ran smoothly with excellent throttle response. The engine ran up to full power, with 156hp being delivered, exceeding the nominal specification for the power output from this type of engine.

1.16.2 Detailed metallurgical examination of the failed TRDS flange was performed at a specialised laboratory by a qualified metallurgist. The report revealed that: *“The occurrence of fatigue cracking around several parts of the circumference of the shaft indicates that the shaft failed due to rotational bending fatigue. The fatigue initiated in the toe of the fillet weld on the shaft side of the weld*”.

The report concluded: “*The cause of the fatigue was probably the reported incorrect assembly between the drive shaft and the gearbox, introducing bending and probably vibration stresses brought about by the inability of the shaft to absorb small differential movements during rotation”.*

1.16.3 The metallurgist also examined the failed damper bearing support link and concluded in his report: “*The bearing bracket failed due to cyclic loading above the yield stress followed by shear and tensile overload. The bracket probably failed due to forces imposed on it by the motion of another or other components. No evidence was found to indicate that the material and condition of the bracket may have been suspect before the accident”.*

1.17 Maintenance Information

1.17.1 The company that performed the maintenance on ZK-HVN immediately prior to the accident was not a certificated maintenance organisation, nor was it required to be one for the maintenance performed. The CEO employed unlicensed tradesmen on a full time basis to perform maintenance on customers’ helicopters. He used the services of local LAMEs as ‘contractors’ to perform the duties of certifying LAMEs and to release customers’ helicopters to service.

1.17.2 The personnel involved with the maintenance of ZK-HVN on this occasion were:

- A tradesman with over five years experience on R22 helicopters, but no formal training on the R22, was tasked with performing the required maintenance on ZK-HVN. The tradesman did not hold an AMEL.

- A LAME assisted with the work, but was not experienced in helicopter maintenance. He received his New Zealand AMEL on 16 May 2003 after completing eight years work as an aircraft engineer in Australia. He did not hold a rotorcraft category AMEL and therefore is considered by the CAA to be unlicensed in respect of helicopter maintenance.

- The "contractor" who was the certifying LAME tasked with completing the release to service for ZK-HVN, had full time employment elsewhere as a freelance contractor with a large aircraft operator. He obtained his AMEL on 25 September 1978. He held various fixed wing aircraft group ratings, power plant ratings and rotorcraft group ratings 1-3, but had not completed any formal training on the Robinson R22. Formal training is not required for the issue of a group rating on this type of helicopter.

- The CEO of the maintenance organisation also assisted when required, but did not hold an AMEL.

1.17.3 ZK-HVN had been stored at the maintenance organisation's premises since April 2005 to undergo an ARA, a 100 hour/annual inspection, main rotor blade replacement and defect rectification. An inspection the previous year revealed that the TRDS was corroded beyond manufacturer's limits and it was therefore replaced during this maintenance visit.

1.17.4 A new TRDS was acquired, but was found to be a '-3' version. The manufacturer's parts catalogue does not list this as a replacement for the older '-1' version TRDS fitted into the early style tailcone on ZK-HVN. However, rather than return it to the supplier or contacting the manufacturer, the tradesman, on the instructions of the CEO, modified the TRDS by transposing the damper bearing support link from the old shaft to the new one. The R22 maintenance manual does not contain any specific instructions on performing this modification, and the manufacturer does not encourage anyone to do so. The installation of the incorrect part number TRDS was performed without the maintenance organisation personnel obtaining the required technical data from the manufacturer, a conformity inspection being carried out, or approval of the modification being sought from the CAA or other CAA approved design organisation.

1.17.5 The tradesman who was tasked with returning ZK-HVN to service experienced difficulties in completing installation of the new TRDS. The Robinson R22 maintenance manual requires that a certain clearance be achieved at the intermediate coupling located at the forward end of the TRDS in order to maintain the correct forces on the tail rotor drive system during normal operation. It appears that the new TRDS may have been marginally different in length to the old one which changed the initial clearance obtained at the intermediate coupling.

1.17.6 The TRDS installation proved sufficiently difficult for the CEO to request advice from outside sources that were perceived to be more knowledgeable on the aircraft type. Under the instruction of the CEO and LAME, the tradesman attempted to adjust the clearance in accordance with the maintenance manual by using a different length yoke on the clutch shaft, and removing previously existing non-standard spacers on the engine mounts. This action eventually resulted in the required clearance being achieved. However, the problems experienced with the installation meant that the TRDS had to be installed and removed multiple times which required the assistance of various personnel.

1.17.7 The R22 maintenance manual requires a 'runout' check on the TRDS after the TRDS has been installed. The purpose of a runout check is to detect any unacceptable radial movement of the installed TRDS ('wobbling', not exceeding .025 of an inch). To perform this check a special adaptor is called for by the helicopter manufacturer to allow a dial test indicator to be placed in 4 specifically designed ports along the tailcone. The clutch shaft is then rotated by hand and the measurement of radial runout (shown by the deflection of the indicator pointer) is recorded. An average of three measurements is then calculated. This procedure is completed at each of the four locations along the tailcone. The maximum runout at any location must not exceed .025 inch or the drive shaft must be repaired or replaced. This procedure specified by the manufacturer was not performed in this instance. Instead, the tradesman reported that under the instruction of the certifying LAME he performed a runout check of the TRDS prior to installation by using the dial test indicator to take measurements whilst the TRDS was on 'V' blocks on the hangar floor.

1.17.8 The tail rotor drive system is designed with 'flexplates' at two places along its length. The aft flexplate is installed between the aft flange of the TRDS and the tail rotor gearbox input yoke. This design allows normal shaft rotation for transmitting power to the tail rotor gearbox, while permitting misalignment between the TRDS and the tail rotor gearbox without overstressing the TRDS (shaft misalignment normally occurs in two modes; at start up and shut down because of clutch motion, and in flight as a result of tailcone deflections due to tail rotor thrust changes, air loads, and inertia loads from the stabilizers). A damper bearing is also installed one third of the way from the front of the TRDS to add support and eliminate certain harmonic vibrations during normal operation. The aft coupling has a fail safe design using two small bushes extending into clearance holes in the flange enabling continuous drive to the tail rotor gearbox in the event of the failure of the aft flexplate.

1.17.9 During final installation of the TRDS into the helicopter the aft coupling of the tail rotor drive system was assembled incorrectly (as explained in 1.12.12). The aft flange of the TRDS was bolted directly to the input yoke of the tail rotor gearbox effectively changing the role of the flexplate from that of a flexible drive coupling component to that of a rigid spacer. This incorrect assembly resulted in the elimination of the designed flexibility of the aft coupling and the function of absorbing TRDS misalignment loads was now transferred to the next most suitable location, the root weld of the TRDS flange itself. This change caused flexing of the weld resulting in fatigue cracking that was followed soon after by failure of the TRDS resulting in a complete loss of tail rotor drive and yaw control**.**

1.17.10 The certifying LAME, who would occasionally be present in the hangar to check on the tradesman's progress, was not present when the final installation of the TRDS into the helicopter was being completed. He stated that when he arrived in the hangar the helicopter had already been put back together and therefore he did not observe the reassembly of the TRDS. He believed that he may have visually checked the aft TRDS coupling through the small viewing aperture above the aft coupling but must have missed the incorrect assembly. Nevertheless he was of the opinion that nothing could go wrong with the assembly of the aft coupling, and he trusted the personnel who reassembled the helicopter.

1.17.11 The following relevant excerpts from the CAR Part 43 General Maintenance Rules prescribe the minimum safety standards when performing maintenance:

43.51 Persons to perform maintenance

(a) Except as provided in paragraphs (b) and (c), a person shall not perform maintenance on an aircraft or aircraft component unless they—

(1) hold a current aircraft maintenance engineer licence and an appropriate type rating issued under Part 66; or

(2) hold a current aircraft maintenance engineer licence and an appropriate type rating issued by the civil aviation authority of Australia, and—

(i) have had that licence registered by the Director in New Zealand; or

(ii) have applied to the Director for registration of that licence in New Zealand; or

(3) are authorised by the holder of an aircraft maintenance organisation certificate, issued under Part 145, to perform maintenance within the scope of that certificate; or

(4) hold a current certificate of maintenance approval issued under Part 66; or

(5) perform maintenance under the direct supervision of—

(i) the holder of an aircraft maintenance engineer licence with an appropriate type rating, issued under Part 66, and the maintenance is within the scope of that licence.

43.53 Performance of maintenance

(a) A person performing maintenance on an aircraft or component must—

(1) be familiar with the maintenance actions required for the continued airworthiness of that aircraft or component; and

(2) use adequate housing and facilities for the necessary disassembly, proper inspection, and reassembly of the aircraft; and

(3) use methods, techniques, and practices that—

(i) are prescribed in the current manufacturer's maintenance manual or Instructions for Continued Airworthiness; or

(ii) are acceptable to the Director; and

(4) use materials, parts, and appliances in accordance with Part 21, Subpart K; and

(5) use the tools, equipment, and test apparatus necessary to ensure completion of the work in accordance with paragraph (a)(3); and

(6) use any special or test equipment recommended by the manufacturer, or equivalent equipment that ensures the equipment being tested is in operable condition; and

(7) perform the maintenance so as to ensure that the aircraft or component meets all applicable airworthiness requirements; and

(8) when performing maintenance specified in the Airworthiness Limitations section of a manufacturer's maintenance manual or Instructions for Continued Airworthiness, perform the maintenance in accordance with that section; and

(9) when performing maintenance in accordance with a maintenance programme approved under Part 91 or accepted under Part 119—

(i) at the start of the maintenance programme, inspect the aircraft completely; and

(ii) after the initial inspection, conduct routine inspections and detailed inspections in accordance with the maintenance programme; and

(10) on completion of the maintenance, ensure that the condition of the aircraft or component is satisfactory for release to service and is at least equal to its original or properly modified condition with regard to—

(i) aerodynamic function; and

(ii) structural strength; and

(iii) resistance to vibration and deterioration; and

(iv) other qualities affecting airworthiness; and

43.103 Certifying requirements

(a) A person shall not certify an aircraft or aircraft component for release to service after maintenance unless that maintenance has been performed in accordance with the CAR and, in respect of that maintenance, the aircraft or aircraft component is fit for release to service

The following is an excerpt from Advisory Circular AC43-1B, This document provides methods acceptable to Director of Civil Aviation for showing compliance with the applicable CARs:

AC43.1B - 43.51 Persons authorised to perform maintenance

Maintenance may only be carried out by, or under the direct supervision of, the persons meeting the requirements of 43.51.

Supervision, involves a form of active participation and includes the acceptance by the supervisor of a responsibility to see that the task will be carried out appropriately. Consequently a supervisor should—

- *know when the work is being undertaken*
- *see that the work is done at crucial stages*
- *approve or disapprove of the work at those important stages*

When the task involves the maintenance or repair of an aircraft, so that the work is directly related to human safety, such supervision could only be achieved by the personal physical presence of the supervisor. In other words, the supervising engineer should be on site or in the vicinity of the aircraft being repaired.

1.17.12 Where any control system has been disturbed during maintenance the CAR 43.113 requires that a 'duplicate inspection' be performed before the aircraft can be released to service. This means that two persons must inspect the control system, the first (in this case) being the certifying LAME and a second, who must be a person that the certifying LAME considers to be sufficiently competent to undertake the inspection. The tail rotor drive is part of a control system (yaw control) and therefore the CAR requirement for a duplicate inspection is applicable. As the access to physically check the aft coupling assembly is limited to the small viewing aperture once it has been installed into the tailcone, the associated duplicate inspection should have been performed in two stages; firstly, after the aft coupling was assembled, with the TRDS outside the tailcone, and secondly, after the TRDS and tail rotor gearbox had been installed. The duplicate inspection statements had been stamped into the maintenance worksheets and the certifying engineer had signed the statement relating to his part of the inspection, but without actually being present to carry out an adequate duplicate inspection. The second signature was not present in the worksheets for any of the duplicate inspections relating to control systems that had been disturbed during the maintenance, including the TRDS.

1.17.13 The maintenance worksheets show that the tradesman had certified the installation of the replacement of the TRDS in accordance with the manufacturer's maintenance manual. The certifying LAME had signed the statement of release to service (RTS) in the worksheets and in the maintenance logbook for all of the maintenance performed, but without the duplicate inspection certifications being completed.

1.17.14 The pilot arrived at the maintenance organisation a few days before the day of the accident to perform testing and to fly his helicopter home. During the post maintenance ground test running the pilot detected a high frequency vibration from helicopter and as a result, the helicopter remained with the maintenance organisation for further rectification. After 5 hours of test running, and attempted balancing of the engine cooling fan, this vibration was reported to have been eventually eliminated by replacement of the engine fan. Then approximately 5 hours of test flying were carried out, mostly with the tradesman accompanying the pilot onboard the helicopter.

1.17.15 A CAA field safety adviser had visited the maintenance organisation during the time that the maintenance was being carried out on ZK-HVN. The CAA officer discussed the issue of the absence of a full time certifying LAME with the CEO and gave him advice on the requirements in respect of direct supervision of the unlicensed personnel by the certifying LAME.

1.19 Useful or effective investigation techniques.

1.19.1 Nil.

2. Analysis

2.1 It appears that the pilot tried to reduce the severity of the ground impact. It is likely that the location where the helicopter hit the ground was where the pilot intended to attempt a forced landing. Had the helicopter remained upright, a successful forced landing would have been possible. The rapidity of a helicopter's rotation caused by a loss of tail rotor increases rapidly, and the probability of a positive outcome reduces the longer that the aircraft remains airborne and/or the lower the forward speed. Without forward speed to assist in maintaining directional stability, the pilot's ability to control a helicopter is inevitably completely lost, generally resulting in main rotor blade contact either with the helicopter structure or the ground.

2.2 During final assembly of the helicopter, the aft coupling of the TRDS was assembled incorrectly. One or more of the unsupervised, unlicensed personnel incorrectly bolted the aft flange of the TRDS directly to the input yoke of the tail rotor gearbox which eventually resulted in failure of the TRDS.

2.3 The risk taking behaviour exhibited during the maintenance of ZK-HVN firstly allowed a critical defect to be built in to the helicopter's tail rotor drive system, and secondly, allowed it to remain undetected. Compliance with the applicable CARs and the associated AC would have prevented this accident. The compliance failures noted were as follows:

- The certifying LAME should not have signed the release to service statement as he was not personally and physically present to directly supervise at critical stages during the maintenance.
- The certifying LAME should not have signed the release to service statement without ensuring that the duplicate inspection had been completed and correctly certified, and an adequate physical check had been carried out by the second person.
- The unlicensed personnel should not have assembled the TRDS without being directly supervised by the certifying LAME.
- The assisting LAME, though not rated on the helicopter, would have known that the certifying LAME was required to have been present to directly supervise the reassembly of the helicopter at critical stages during the maintenance. He should have intervened and brought this to the attention of the CEO or the CAA.
- The CEO had been made aware of the requirements for direct supervision and should have halted the critical maintenance tasks until the certifying LAME was available to be present to directly supervise the maintenance being performed.

2.4 Various opportunities to prevent the non compliances with the approved maintenance processes from culminating in a critical safety occurrence were missed, and they are summarised as follows:

- If the unlicensed personnel had been directly supervised, the incorrect assembly of the TRDS aft coupling would probably have been prevented.
- If the duplicate inspection of the TRDS had been performed correctly, the incorrect assembly of the aft coupling would have probably been detected.
- If the tradesman had performed the TRDS runout check correctly as required by the R22 AMM then indications of the incorrect installation of the TRDS may have been evident in the measurements taken during the check.

2.5 The certifying LAME elected to release the helicopter to service without having taken the required steps to comply with the rules. His decision eliminated multiple layers of safety, prescribed by the CARs, which have been developed specifically to prevent human error from causing a critical safety occurrence.

2.6 Prior to 1992, legislation required that all maintenance organisations be approved by the Director of Civil Aviation, and because of this the CAA had an active inspectorial role for. Maintenance organisations were regularly visited by the CAA inspectors to check performance against standards set out in both the company procedures manual and the existing regulations. The legislative amendments of 1992 brought about by the 'Swedavia McGregor report' changed the way aircraft maintenance was regulated. In general terms, organisations maintaining larger airline type aircraft are required to have quality systems in place and hold a CAR Part 145 *Aircraft Maintenance Organisations* certificate. The smaller general aviation maintenance companies performing maintenance on aircraft under 5700kg, or of 9 seats or less were, and still are, no longer required to be approved. The CAA does not currently conduct scheduled inspections to measure the performance of these organisations, but has in the past conducted unscheduled 'spot checks'. The CAA relies on entry and exit controls within the licensing system and promulgation of educational advice to maintain the standard of the LAMEs involved in general aviation engineering. Furthermore, no formal process to measure the on-going safety performance of individual LAMEs is currently in place. LAMEs maintaining aircraft in accordance with CAR Part 43 who may currently be performing to a less than acceptable standard, and the organisations that employ them or contract their services, operate mostly unchecked until there is an occurrence or concern which brings them to the attention of the CAA. The exception to this is where a LAME has been nominated by a CAR Part 135 *Air Operator* to certificate the maintenance of an aircraft which they operate. This provides an opportunity for the CAA to indirectly audit the safety performance of the LAME in respect of that operator.

2.7 All persons involved with the maintenance of aircraft are required to comply with the rules currently in force; however there appears to be no CAA policy in place for the ongoing control and monitoring of the performance of individual LAMEs or non certificated maintenance organisations performing maintenance in accordance with CAR Part 43 *General Maintenance Rules*.

3. Conclusions

3.1 The pilot was appropriately qualified for the flight.

3.2 For the purposes of this flight, the pilot held a valid Class 2 Medical Certificate.

3.3 ZK-HVN had been issued with a non terminating airworthiness certificate, which was effectively no longer valid, as the maintenance had not been conducted in accordance with the requirements of CAR 21.179 (a)(2) which states in part – *the airworthiness certificate remains in force …provided that maintenance on the aircraft is performed in accordance with Part 91 and Part 43*.

3.4 The certifying LAME did not directly supervise the unlicensed personnel as he was required to do during the final assembly of the TRDS.

3.5 Without supervision, the aft coupling on the TRDS was assembled incorrectly.

3.6 The certifying LAME did not adequately check the work carried out by unlicensed personnel and therefore did not detect the incorrect assembly.

3.7 A duplicate inspection as required by CARs, which may have detected the incorrect assembly prior to the release of the helicopter to service, was not correctly completed by the certifying LAME.

3.8 The certifying LAME released the aircraft to service when maintenance had clearly not been carried out in accordance with the manufacturer's instructions or the CARs currently in force.

3.9 The TRDS failed in flight causing the helicopter to become uncontrollable during the landing phase resulting in this fatal accident.

3.10 The significant weight of evidence indicates that the cause of the TRDS failure was the incorrect assembly of the TRDS aft coupling.

4. Safety actions

4.1 An action was accepted by the General Manager of CAA Personnel Licensing and Aviation Services Group that he carry out such actions as necessary to satisfy the Director that the certifying LAME is presently complying with the CARs currently in force.

The LAME's licence is currently suspended and at his request the matter has been placed on hold to give him the opportunity to make submissions following the outcome of investigations by other authorities.

4.2 An action was accepted by the General Manager of CAA Personnel Licensing and Aviation Services Group that he considers the suitability of the assisting LAME to hold an AMEL. This is currently on hold pending the outcome of investigations by other authorities.

4.3 The General Manager CAA General Aviation Group has proposed that a plan for systematic surveillance of Part 43 maintenance providers is developed in the year to July 2007. This action appears in the CAA Business plan for the fiscal year 2006-2007.

4.4 An action was accepted by the General Manager of the CAA Government Relations Group to consider a rule amendment which would require that all aircraft maintenance be performed by appropriately certificated organisations employing full time, appropriately rated, LAMEs. This was considered to be a significant CAA policy change and thus has been tabled to be discussed with the relevant sectors of the aviation industry at the next Issue Assessment Group meeting for maintenance issues provisionally, scheduled for late 2006.

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