SOUTH AFRICAN CIVIL AVIATION AUTHORITY

Section/division **Accident and Incident Investigation Division** Form Number: CA 12-12a

AIRCRAFT ACCIDENT REPORT AND EXECUTIVE SUMMARY

Reference:	CA18/2/3/9061

Aircraft Registration	**ZS-HIG**	**Date of Accident**	12 July 2012	**Time of Accident**	1320Z
Type of Aircraft	Robinson R44 Raven I		**Type of Operation**	Private flight	
Pilot-in-command Licence Type	Private Pilot	**Age**	53	**Licence Valid**	Yes
Pilot-in-command Flying Experience	Total Flying Hours	770.0		Hours on Type	114.0
Last point of departure	Farm Vucht, Lephalale district (Limpopo province)				
Next point of intended landing	Game farm Africa Sand Safaris, (Limpopo province)				
Location of the accident site with reference to easily defined geographical points (GPS readings if possible)					
Game farm Africa Sand Safaris (GPS position: South 23°25.465' East 027°35.079'); elevation 2 773 fee t					
Meteorological Information	Surface wind: 225°/20 knots, Temperature: 20℃, Vis ibility: > 10 km				
Number of people on board	1 + 1	**No. of people injured**	1 + 1	**No. of people killed**	0

Synopsis

The pilot, accompanied by a passenger, was engaged in a private flight from a farm near the town of Lephalale, the intended destination being Africa Sand Safaris game farm, located in the Stockpoort district near the border with Botswana. The intention of the flight was to visit some friends on the farm and then to fly back to their point of departure. According to the pilot, he approached the landing area from the north and inspected the area, at the same time assessing the wind, which according to him was from the north-east, which was the heading he approached the landing area. According to the farm manager, who was watching the helicopter approaching to land the wind was from a south-westerly direction at approximately 20 knots. The pilot brought the helicopter into hover flight over the intended landing area at a height of approximately 30 feet above ground level (AGL). The helicopter suddenly started to yaw to the right (in a clockwise direction). According to the pilot he first applied left tail rotor pedal to try and counteract the yaw but it had no effect, he then applied right pedal in an attempt to regain control of the helicopter, but this also had no effect. The helicopter completed four full 360° rot ations and then impacted hard with the ground. This caused the right aft skid gear to collapse and the main rotor blades to strike the tail boom as well as the ground on the right-hand side of the fuselage. The pilot, who was seated on the right-hand side, suffered an injury to his lower back and the passenger injured his right elbow. They exited the helicopter unassisted. Both occupants were admitted to a hospital in Lephalale.

Probable Cause

The pilot experienced loss of tail rotor effectiveness (LTE) and was unable to prevent the helicopter from completing several revolutions before ground impact followed.

ASP Date		Release Date	

AIRCRAFT ACCIDENT REPORT

Name of Owner	**:** Dr. D. Kriel
Name of Operator	**:** Private flight
Manufacturer	**:** Robinson Helicopter Company
Model	**:** R44 Raven I
Nationality	**:** South African
Registration Marks	**:** ZS-HIG
Place	: Africa Sand Safaris
Date	**:** 12 July 2012
Time	**:** 1320Z

All times given in this report are Co-ordinated Universal Time (UTC) and will be denoted by (Z). South African Standard Time is UTC plus 2 hours.

Purpose of the Investigation:

*In terms of Regulation 12.03.1 of the Civil Aviation Regulations (1997) this report was compiled in the interest of the promotion of aviation safety and the reduction of the risk of aviation accidents or incidents and **not to establish legal liability**.*

Disclaimer:

This report is produced without prejudice to the rights of the CAA, which are reserved.

1. FACTUAL INFORMATION

1.1 History of Flight

1.1.1 During the morning of 12 July 2012 the owner of the helicopter, who was also a pilot conducted a private flight with four adults onboard. The duration of the flight was 2.6 hours, which included flying to their intended destination and back to the property of the helicopter owner/pilot. The flight was uneventful.

1.1.2 Later the same day the helicopter owner was approached by a friend who asked him if he could utilise his helicopter for a private flight to a nearby game farm, estimated to be approximately 20 minutes flying time from there. The helicopter owner agreed to the request.

1.1.3 The pilot, accompanied by a passenger, his 14-year old son, took-off from the helicopter owner's property near the town of Lephalale, with their intended destination being Africa Sand Safaris game farm, located in the Stockpoort district near the border of Botswana. The intention of the flight was to visit some friends on the farm and then to fly back to their point of departure (the helicopter owners property).

1.1.4 According to available information the flight en route to the farm was uneventful. The pilot approached the game farm from the north and overflew the intended landing area. He further stated that he was able to assess the prevailing wind during his approach on the basis of dust that was blown up by a vehicle that drove directly over the intended landing area as there was no windsock to assist him in making an accurate wind assessment. According to the farm manager, who was waiting for the helicopter to land and witnessed the accident, he had assessed the wind to be predominantly from the south-west, at approximately 20 knots at the time. He further stated that the wind was constantly changing direction and velocity during the cause of the day. This observation was based on the fact that he had gone hunting during the course of the morning and had returned shortly before the arrival of the helicopter.

1.1.5 The pilot stated that he approached the landing area in a north-easterly direction, into wind, as he assessed it, and entered into hover flight above his intended landing area at a height of approximately 30 feet above ground level (AGL). He then observed a hole in the ground and decided to move slightly forward. While still in hover flight the helicopter began an unanticipated, rather severe yaw to the right (in a clockwise direction). At that stage the aircraft was about 26 to 30 feet (8 - 10 metres) AGL. He first applied left tail rotor pedal to try and counteract the yaw to the right but it had no effect, he then pushed the right tail rotor pedal in an attempt to regain control of the helicopter, but it had no effect. At that stage the helicopter had moved over to a vegetated area, and the pilot opted not to lower the collective pitch lever. He also turned the throttle into the indent spring in an effort to increase the main rotor rpm and pushed the cyclic forward in an effort to fly out of the condition, but without any results.

1.1.6 According to the farm manager, the helicopter completed four 360° rotations before it impacted with the ground in an upright position. He further stated that while the helicopter was rotating it was in a nose-down attitude. It appeared to him that the pilot had managed to level the helicopter at a height of approximately 6-10 feet AGL, where it fell to the ground. The impact caused the right aft skid gear to collapse and the main rotor blades to strike the tail boom and the ground on the right-hand side of the fuselage.

1.1.7 Once the pilot had ascertained that his son, who was sitting next to him had no injuries he instructed him to vacate the helicopter and move to a safe place. After the pilot had switched off the master switch he exited the helicopter and moved to where his son was, it was then when he realised that he had injured his back, he was however still able to walk with difficulty. The passenger then told the pilot that he heard an alarm as the helicopter commenced to yaw to the right. The pilot had no recollection of such an alarm.

1.1.8 The pilot, who was seated on the right-hand side, suffered an injury to his lower back and the passenger injured his right elbow. An ambulance was dispatched to the farm and both occupants were admitted to a hospital in Lephalale.

1.1.9 The accident occurred during daylight conditions at a geographical position that was determined to be South 23° 25.465’ East 027° 35.07 9’ at an elevation of 2 773 feet above mean sea level (AMSL).

1.2 Injuries to Persons

Injuries	Pilot	Crew	Pass.	Other
Fatal	-	-	-	-
Serious	1	-	-	-
Minor	-	-	1	-
None	-	-	-	-

The passenger was discharged from hospital on the same day following a medical check-up and treatment and the pilot was discharged the following day.

1.3 Damage to Aircraft

1.3.1 The helicopter sustained substantial damage during the impact sequence.

Figure 1. A view of the helicopter as it came to rest.

Figure 2. A view from the right aft position with the right aft skid gear flattened.

1.4 Other Damage

1.4.1 There was no other damage caused.

1.5 Personnel Information

Nationality	South African	Gender	Male	Age	53
Licence number	0270180896	Licence type	Private		
Licence valid	Yes	Type endorsed	Yes		
Ratings	Flight test single engine piston				
Medical expiry date	31 May 2013				
Restrictions	Must wear suitable corrective lenses				
Previous accidents	None				

Flying Experience:

Total hours	770,0
Total past 90-days	3,7
Total on type past 90-days	3,7
Total on type	114,0

The column below reflects a summary of the pilots flying experience as it was made available to the authority for the period 15 January to 12 July 2012. The last entry reflects the accident flight.

Date	Type	Duration of the flight
15/01/2012	Robinson R44 II	1 hour 30 minutes
22-24/02/2012	Robinson R44 II	5 hours
9-11/03/2012	Robinson R44 II	3 hours
1-2/06/2012	Robinson R44 II	3 hours 20 minutes
*12/07/2012	Robinson R44 I	20 minutes
Total flying hours for period		13 hours 10 minutes

*NOTE: The accident flight was conducted on the Robinson R44 Raven I model (carburettor equipped engine). The four previous flights were conducted on a Robinson R44 Raven II, which is equipped with a fuel injection engine.

1.6 Aircraft Information

1.6.1 Airframe:

Type	Robinson R44 Raven I	
Serial number	2150	
Manufacturer	Robinson Helicopter Company	
Year of manufacture	2011	
Total airframe hours (At time of Accident)	62,6	
Last MPI (hours & date)	4,0	26 January 2012
Hours since last MPI	58,6	
C of A (Issue date)	2 February 2012	
C of A (Expiry date)	1 February 2013	
C of R (Issue date) (Present owner)	23 January 2012	
Operating categories	Standard Part 127	

*NOTE: The helicopter, a Robinson R44 Raven I, serial number 2150 was imported into South Africa from the United States of America (USA) and arrived in South Africa in December 2011. It was delivered to a Robinson approved aircraft maintenance organisation (AMO) where it was de-crated and re-assembled. Following completion of the assembly process a mandatory periodic inspection (MPI) was conducted and signed out in accordance with the Robinson R44 maintenance manual and the SACAA GMR's. The inspection was signed off on 26 January 2012 in the airframe and engine logbooks and a Certificate of Release to Service was issued after a post maintenance power assurance acceptance flight was conducted by an appropriately rated commercial pilot with a test pilot rating. The duration of the flight test was 1 hour and 45 minutes and all parameters were found to be within limits.

The MPI was conducted in accordance with an approved maintenance schedule. The following sub-heading forms part of the maintenance schedule on pg. 21 of the document:

Air Box & Alternate Air Door: *"Ensure carburettor heat door (O-540 engines only) moves fully from stop to stop. Replace air filter. Check air box for condition and security. Verify spring-loaded alternate air door opens without binding and closes completely."* This subheading was signed off by two people (Engineer and Inspector) as called for on the form. A copy of the applicable page reflecting the subheading can be found attached to this report as Annexure D.

With reference to the re-assembly of the helicopter the manufacturer had provided guidance material in the form of an official document contained in the maintenance manual. The document that was utilized by the AMO in question was the: *Robinson maintenance manual 1.700 Special Instructions for reassembling and flight testing R44 series helicopters after crafting for export.* A copy of the applicable document can be found attached to this report as Annexure C.

It was noted from the airframe logbook that four (4) flight hours was logged on the helicopter prior to it being shipped to South Africa, which was as a result of the factory acceptance test flight procedure, after it was released from the production line. The maintenance inspection that was performed on the helicopter on 26 January 2012 included the following:

1. Track and balancing of the main and tail rotor system.
2. Test flight, which included a power assurance check.
3. Compass swing.
4. Release to service.

On 27 January 2012 a Civil Aviation Authority (CAA) Airworthiness Inspector conducted a Certificate of Airworthiness (C of A) inspection on the helicopter in accordance with checklist CA21-20H (C of A for small rotorcraft below 3175 kg). On 1 February 2012 the CAA Aircraft Review Board approved the issue of the C of A for this helicopter.

The owner took delivery of the helicopter on 15 February 2012 and flew it to his property in the Limpopo province.

1.6.2 Engine:

Type	Lycoming O-540-F1B5
Serial Number	L-27223-40E
Hours since New	62,6
Hours since Overhaul	T.B.O. not yet reached

1.6.3 Weight and balance

Item	Weight (lbs)	Arm (inches)	Moment (kg x inches)
Empty weight	1 448,2	107,6	155 826
Pilot (99 kg)	218	49,5	10 791
Fwd passenger (48 kg)	106	49,5	5 247
Baggage (5 kg)	11	44,0	484
Fuel main tank (40 litres)	63	106,0	6 678
Fuel aux. tank (60 litres)	94	102,0	9 588
Weight on impact	**1 940,2**	**97,2**	**188 614**

The maximum take-off weight for the helicopter was not allowed to exceed 2400 lbs (1089 kg) according to the pilot's operating handbook (POH), section 2, limitations. The duration of the flight was approximately 20 minutes.

The helicopter weight and balance were found to be within the prescribed limitations as stipulated in the POH, section 2 at the time of the accident.

1.7 Meteorological Information

1.7.1 Weather conditions were obtained from the pilot's questionnaire as well as a statement from the game farm manager who witnessed the accident. Their accounts of the prevailing wind differ by approximately 180°, with the pilot indicating the wind to be from the north-east and the farm manager saying it was predominantly from the south-west at the time of the intended landing at approximately 20 knots. Visibility was good with no clouds and the temperature was approximately 20°C and the dew point was unknow n.

1.7.2 There was no official weather station in close proximity to the farm (landing area) from which accurate weather data could be obtained for the time and date of the accident.

1.8 Aids to Navigation

1.8.1 The helicopter was equipped with standard navigational equipment as required by the regulator. There were no recorded defects to the equipment prior to the flight.

1.9 Communications

1.9.1 The helicopter was equipped with standard communication equipment as required by the regulator. There was no recorded defect to the equipment prior to the flight. The flight was conducted outside controlled airspace, below the terminal control area (TMA). The pilot broadcasted his intentions on the VHF frequency 124.80 MHz and no radio communications pertinent to the accident were recorded.

1.10 Aerodrome Information

1.10.1 This accident did not occur at or near an aerodrome.

1.11 Flight Recorders

1.11.1 The helicopter was not equipped with a flight data recorder (FDR) or a cockpit voice recorder (CVR), nor was it required to be fitted to this type of helicopter according to the regulations.

1.12 Wreckage and Impact Information

1.12.1 The helicopter impacted the ground from hover flight, vertical downwards, coming to rest in a north-easterly (045°) direction. No grou nd impact markings were observed that could associate the impact with any lateral movement.

1.12.2 During the impact sequence the right aft skid gear collapsed. As the skid gear collapsed, the lower section of the vertical stabiliser also struck the ground. Due to the deformation of the fuselage, the main rotor blades struck the upper skin surface of the tail boom just aft of the strobe light installation on top of the tail boom. This caused the tail boom sheet metal structure to separate, but the tail rotor controls and tail rotor driveshaft remained secured to the tail rotor gearbox, ensuring continuity from the main drive train. Following the main rotor blade impact the tail rotor assembly rotated through 90° to the left and impact with the soft sand, leaving an imprint in the sand indicating that the rotor hub assembly was still turning at the time. Both tail rotor blades were found to have separated in close proximity to the attachment to the rotor hub assembly and were found approximately 10 m away from the wreckage in the four o' clock position, with the wreckage viewed from behind.

Following the collapse of the skid gear on the aft right-hand side, the wreckage came to rest at an incline, which allowed the main rotor blades to strike the tail boom and then the ground on the right-hand side of the fuselage. The engine (air filter box assembly) was in contact with the sand.

Figure 3. A view of the helicopter as it came to rest.

Figure 4. A view of the tail rotor assembly with rotational evidence visible in the sand.

1.12.3 Substantial structural deformation was observed especially along the lower forward and centre section of the fuselage. One of the main rotor blades displayed a substantial bending moment approximately mid-span along the blade, indicative of impact with an object(s) – in this case the tail boom and then the ground. The front and rear doors on the right-hand side of the helicopter were found detached from airframe and was located some distance away from the wreckage.

1.13 Medical and Pathological Information

1.13.1 Not applicable.

1.14 Fire

1.14.1 There was no pre- or post-impact fire.

1.15 Survival Aspects

1.15.1 The cockpit/cabin area of the helicopter remained intact. However, the pilot's seat structure displayed some degree of deformation associated with the impact sequence. Both occupants were properly restrained by making use of the helicopter's safety harnesses, which met the required certification standards.

1.15.2 The accident was considered survivable as it was associated with low kinetic forces within the range of human tolerance.

1.16 Tests and Research

1.16.1 None considered necessary.

1.17 Organizational and Management Information

1.17.1 The helicopter was owned by a private owner who took delivery of it on 15 February 2012. At the time of the accident he had lent the helicopter to a friend, being the pilot involved in the accident.

1.17.2 The helicopter had accumulated a total of 62,6 hours since new. After it arrived in South Africa it was unpacked from the containers and was re-assembled by an approved aircraft maintenance organisation (AMO) in accordance with the Robinson-approved maintenance manual. The helicopter was released to service on 26 January 2012 after an MPI inspection was certified.

1.18 Additional Information

1.18.1 Pilot’s Operating Handbook (Robinson R44 Raven I)

Section 2, Limitations

1. *Flight when surface winds exceeds 25 knots, including gusts, is prohibited.*

2. *Flight when surface wind gusts exceed 15 knots is prohibited.*

3. *Flight in wind shear is prohibited.*

4. *Flight in moderate, severe, or extreme turbulence is prohibited.*

5. *Adjust forward airspeed to between 60 knots and 0.7 Vne upon inadvertently*

encountering moderate, severe, or extreme turbulence.

Note: Moderate turbulence is turbulence that causes: (1) change in altitude or attitude; (2) variations in indicated airspeed; and (3) aircraft occupants to feel definite strains against seat belts".

Section 3, Emergency Procedures

"Loss of tail rotor thrust during hover.

1. *Failure is usually indicated by right yaw which cannot be stopped by applying left pedal.*
2. *Immediately close the throttle and perform hovering power-off landing.*
3. *Keep ship level and increase collective just before touchdown to cushion landing".*

1.18.2 Loss of tail rotor effectiveness (LTE)

In Annexure A, attached to this report, the reader can obtain additional information on the phenomenon known as LTE, (i.e. what causes it, how to avoid it as well as the recovery techniques).

It should be noted that LTE is not related to a maintenance malfunction and may occur to varying degrees in *all* single main rotor helicopters at airspeeds less than 30 knots.

1.18.3 Federal Aviation Administration (FAA), Advisory Circular (AC) 90-95.

In response to several reports of unanticipated right yaw accidents and incidents in helicopters, the U.S. Federal Aviation Administration issued an 8 page Advisory Circular No. 90-95 in December 1995. This AC aims to provide aviators with essential information on LTE (i.e., the phenomenon of LTE, understanding LTE, flight characteristics, conditions under which it may occur, recovery techniques, etc.).

In Annexure B, attached to this report, the reader can acquaint himself / herself with the content of FAA AC 90-95.

1.18.4 New Information (Post recovery of wreckage).

On Friday, 24 August 2012 the investigator received a call from an AMO who was requested by the helicopter owner to provide him with a quotation for a possible repair of the helicopter following the accident in question. In order to provide a detailed quotation the AMO had to make a proper assessment of the damage and in order to do so certain components, of which the engine, the air filter box and the carburettor needed to be removed. During the removal of the air filter box by an apprentice employed by the AMO a moisture absorbent bag (Container Dri II, Sud-Chemie, Performance Packaging, www.s-cpp.com, Made in U.S.A.) see figure 5 on the next page, was discovered lying in the air filter box directly under the carburettor according to a statement that was made available by the AMO. The apprentice that found the bag then notified his immediate supervisor as well as the Accountable manager, who intern informed the investigator. The investigator then travelled to Wonderboom aerodrome to look at the evidence, which became available after the wreckage was moved several times following the accident. Several photos were taken of the bag which was still intact (no content from the bag was discharged into the engine). At the same time a borro-scope inspection was performed on the engine by an AME from an approved engine maintenance facility. The inspection displayed evidence of sand ingestion into the engine, which was also visible on a number of the spark plugs that was removed. The moisture absorbent bag, which measured 26 x 12 centimetres, was shown to the helicopter owner where after it was placed in a plastic bag and remained in the custody of the investigator.

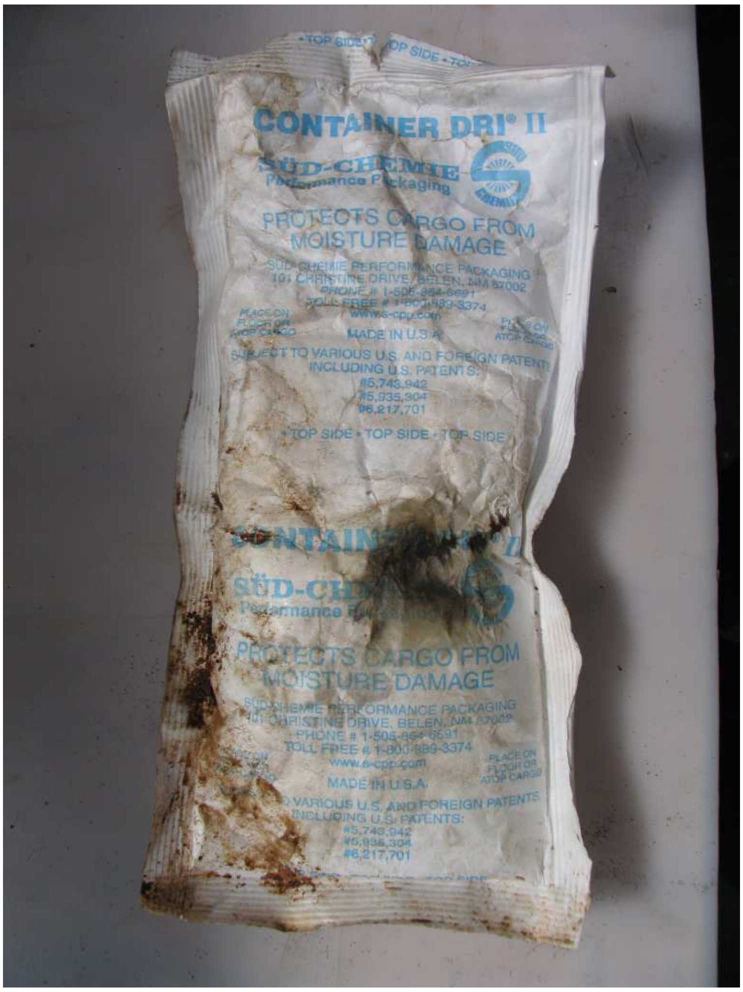

Figure 5. A view of the moisture absorbent bag that was found by the apprentice.

Figure 6. A view of the lower section of the air filter box which was in contact with the sand.

Figure 7. A view of the inside of the air filter box.

Figure 8. A view of the top of the air filter box where the carburettor gets attached to.

Figure 9. A view of the air filter that was in the filter box at the time of the accident.

Taking into consideration that the helicopter had accumulated only 58,6 hours since it was imported into South Africa after it was reassembled by an AMO. The investigator consulted with the AMO who was responsible for the reassembly on 29 August 2012 during which period the required paperwork was assessed and the reassembly procedure was discussed.

The helicopter in question arrived in three wooden containers from the U.S.A. via ship and was offloaded in the port of Durban. From the port of Durban it was transported via road to a Robinson approved maintenance facility where it was de-crated, reassembled, a mandatory periodic inspection (MPI) as well as a post maintenance test flight were carried out.

According to the AMO the reassembly procedure was conducted in accordance with the helicopter manufacturer's guidance material which was contained in the maintenance manual reference: *"Robinson maintenance manual 1.700 Special Instructions for reassembling and flight testing R44 series helicopters after crafting for export".* This document can be found attached to this report for reference as Annexure C.

During the shipment process several moisture absorbent bags are attached to the helicopter at different locations, each bag has a warning label attached to it, which are clearly visible. The photo on the next page (figure 10) was taken of one of the moisture absorbent bags that were removed from the air inlet hose of a new helicopter that arrived in South Africa.

Figure 10. Moisture absorbent bag with the warning label attached used during shipment of a new helicopter.

The air inlet hose, which are located on the right-hand side of the engine and connects to the air filter box had two moisture absorbent bags placed inside the air inlet hose during shipment from the factory (applicable to the new helicopter that arrived in South Africa).

Following correspondence with the helicopter manufacturer they indicated in a written response that moisture absorbent bags does not get placed inside the air box, neither within the air filter area during the shipment process. They further state that it was impossible for a moisture absorbent bag to make its way from the air inlet hose past the air filter to the centre of the air filter box.

The photos in figure 11, 12 and 13 on the next two pages of the report serves as illustration to the reader what a serviceable air box looks like intact. In figure 12 the position of the alternate air door as well as the air filter is clearly visible. In figure 13 the air filter box is close with the air filter in position. With the air filter in position it does not allow any space that would or could allow an object like a moisture absorbent bag (26 x 12 cm) to get pass the air filter to the centre area of the box.

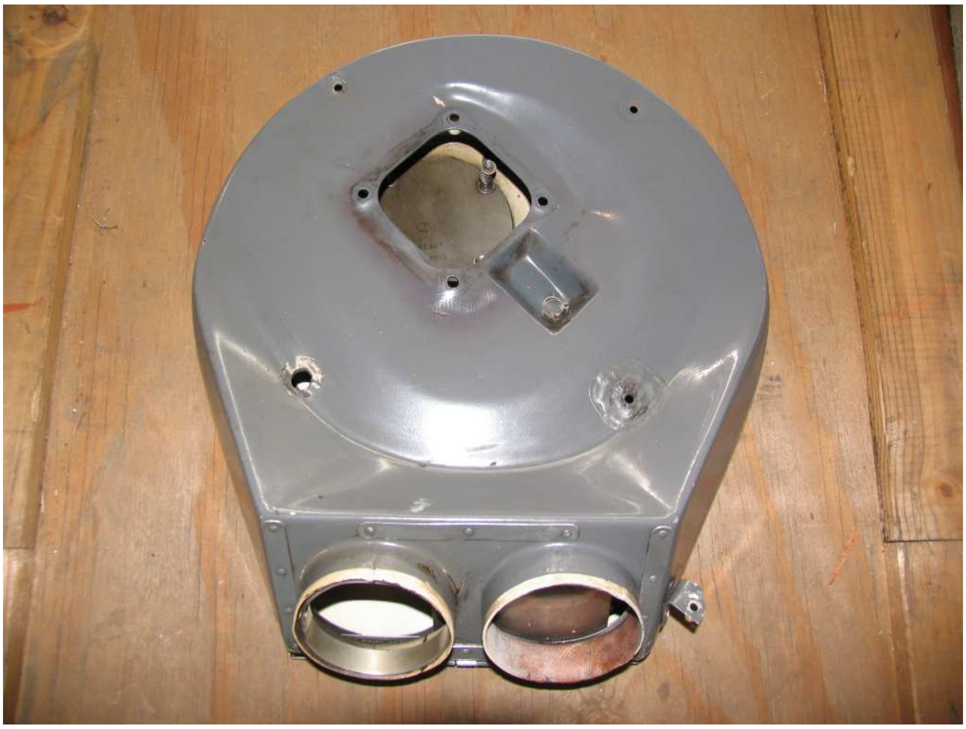

Figure 11. A view of the air box in the close position.

Figure 12. A view of the air filter box in the open position with the air filter and alternate air door visible.

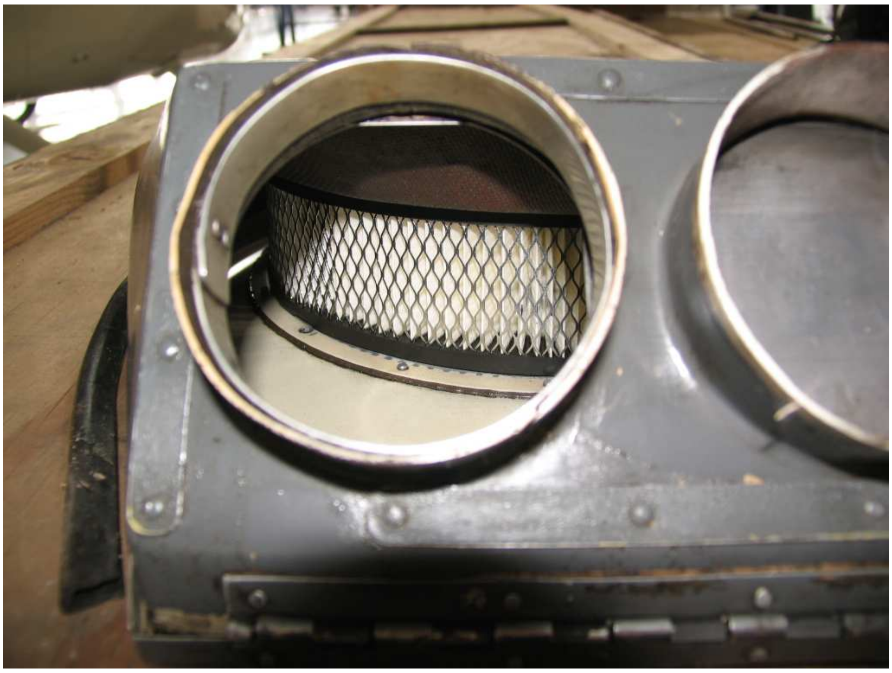

Figure 13. A view of the air box close with the air filter visible in position.

In order to better understand the shipping process and the location of the moisture absorbent bags the investigator inspected a new Robinson R44 that was delivered to a Robinson approved maintenance facility in South Africa. The new helicopter arrived in three separate wooden containers. The one container contained only the doors; the second container, the tail boom, tail rotor assembly, main rotor blades and the skid gear. The forward and centre section of the helicopter, which include the cockpit/cabin area the main rotor transmission and the engine was contained in a third container. Figure 14, on the next page display the position of the two moisture absorbent bags that was located inside the air inlet hose after opening the container. These two moisture absorbent bags had warning labels attached to them via rope as displayed in figures 14 and 15.

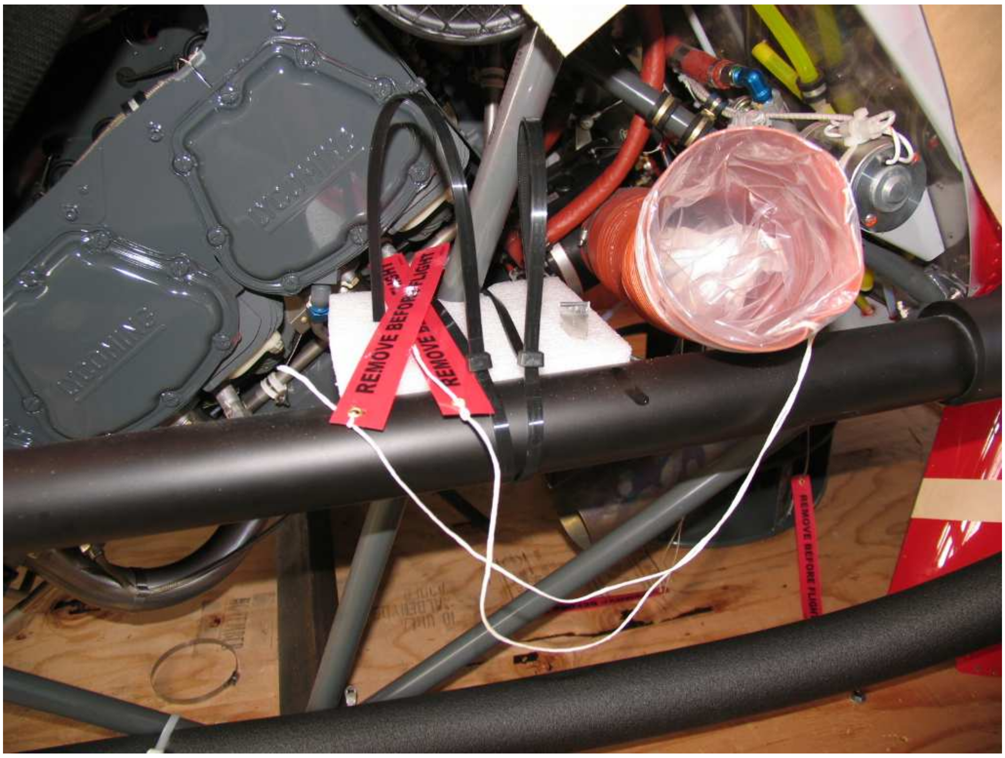

Figure 14. A photo of the air inlet hose with the moisture absorbent bags inside with the warning labels.

Figure 15. The two moisture absorbent bags visible inside the air inlet hose (ropes to the warning labels).

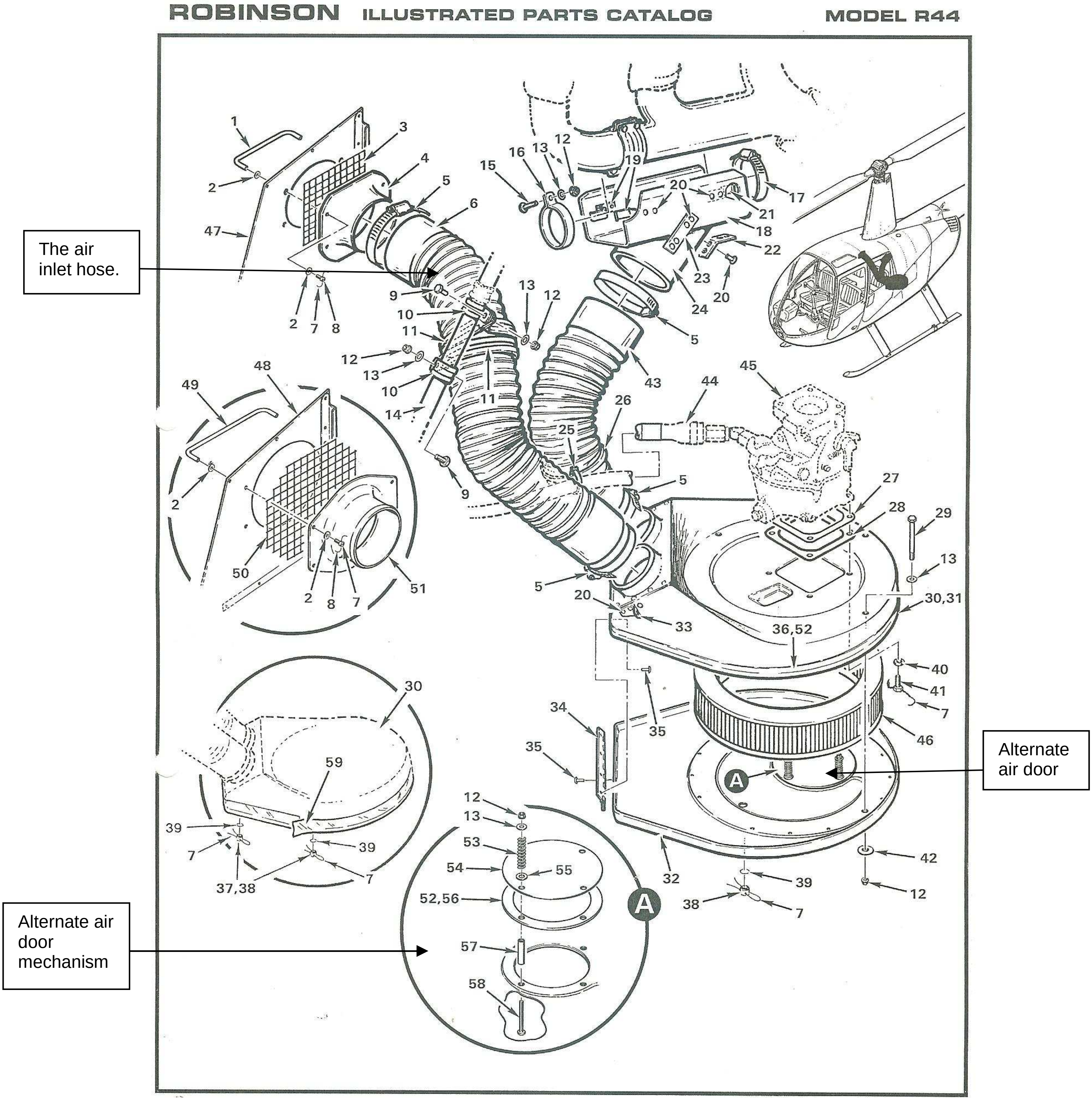

Figure 16. A diagram of the engine air induction system.

1.18.5 The alternate air door.

The alternate air door also referred to as the bypass door (visible in the diagram above) will open when there is a low enough pressure inside the air box (inside the air filter) to overcome the spring pressure, which would only occur if the air filter or the air inlet hose became obstructed. There is nothing to alert the pilot to the opening of the alternate air door. If the air filter or air inlet hose gets obstructed to the point where the alternate air door opens, the pilot should notice a reduction in power, which would be equivalent to 1 inch in manifold pressure or 1000 ft in elevation.

1.18.6 Special instructions for re-assembly after crating for export

The helicopter manufacturer re-assembly document, which is contained in the maintenance manual does not provide any detailed documented guidance on the location and removal of these moisture absorbent bags, nor does it require the aircraft maintenance engineer (AME) to sign it off, or tick it off on a check list as being done on the document. The warning labels therefore do not have a clear documented reference prior to and once removed. It remains the responsibility of the AME that performs the task to ensure that all moisture absorbent bags are removed and accounted for.

1.19 Useful or Effective Investigation Techniques

1.19.1 None.

2. ANALYSIS

2.1 Pilot (Man)

According to available records the pilot was the holder of a private pilot's licence and had the helicopter type endorsed in his logbook. His pilot logbook reflects that he had conducted a flight over the period 1-2 June 2012 of 3 hours and 20 minutes, and the accident flight was his next flight with a duration of approximately 20-minutes, which brings his total flying hours for the 90-day period to 3 hours 40 and minutes (3,7 hours). His last flight prior to the flight mentioned above (according to his logbook) was on 11 March 2012.

The pilot continued with his approach to land in a north-easterly direction following an assessment he had made of the wind by observing the dust from a vehicle that travelled over his intended landing area some time before he opted to land. The pilot depended on this information because there was no windsock or any similar type of device at the intended landing area from which an accurate wind assessment could be made at the time.

The helicopter was established into hover flight over the intended landing area at a height of approximately 30 feet AGL, which met the out of ground effect operational criteria for this helicopter type. Associated with the out of ground effect hover was a high power demand to sustain hover flight.

The wind direction indicated by the game farm manager, who watched the helicopter coming into land differed by approximately 180° from the wind direction as it was assessed by the pilot. The farm manager assessed the wind to be from the south-west.

When considering the wind assessment made by the farm manager it placed the helicopter tail rotor within the 120° to 240° wind azimuth range during approach for landing. With the tail rotor being in this critical wind azimuth range, the helicopter most probably started to weathervane, a condition where the nose of the helicopter wants to turn into the prevailing wind. During such a situation the pilot needed to be vigilant, and a positive tail rotor pedal input was required to counteract this tendency. However, the pilot did not correctly identify nor anticipate such a situation, and the helicopter was allowed to commence with an unanticipated yaw to the right.

The situation was aggravated when the pilot increased the collective pitch lever and at the same time rolled on the throttle into its indent in an attempt to avoid vegetation below. The low rotor rpm audio warning that sounded following this action, as was observed by the passenger, could be associated with a decay in main rotor rpm to below the 97% margin, which at the same time would have resulted in a decay in tail rotor rpm. In order to regain main rotor and tail rotor rpm, the pilot had to unload the rotor system by lowering the collective pitch lever. The collective pitch lever was found to be at its maximum deflection against the stop during the on-site investigation. Recovery from the unanticipated yaw to the right was therefore considered to be highly improbable following the actions taken by the pilot, who by means of his actions aggravated the recovery procedure as stipulated in the pilot's operating handbook, which rendered ground impact inevitable.

2.2 Helicopter (Machine)

The helicopter had accumulated a total of 62,6 flight hours since new. Four (4) of the 62,6 hours were flown at the factory in the U.S.A., prior to it being shipped to

South Africa. Shipment of the helicopter required that it be re-assembled on arrival in South Africa. The re-assembly procedure was conducted by a Robinson approved maintenance facility in South Africa in accordance with the guidelines provided in the Robinson R44 maintenance manual. Following re-assembly of the helicopter an MPI inspection was carried out, the inspection was signed out in the airframe and engine logbooks on 26 January 2012, and a Release to Service Certificate was issued. The helicopter was in possession of a valid Certificate of Airworthiness at the time of the accident flight.

The MPI inspection that was certified following re-assembly of the helicopter required an inspection of the air box and the alternate air door, including replacing the air filter. This task was signed off on the MPI inspection document by an Engineer and an Inspector, indicating the task was completed. It was however, ascertained during an interview with the relevant people that the air filter unit was not replaced during the MPI inspection due to the fact that the filter was still new (helicopter had only flown 4 hours with the filter installed by the time it arrived in South Africa).

No documented evidence could be found that any defects were reported to an aircraft maintenance organisation (AMO) that required immediate maintenance intervention on the helicopter since the owner took delivery of it on 15 February 2013 and prior to the accident flight on the afternoon of 12 July 2012.

The last flight prior to the accident flight was conducted by the owner of the helicopter, also a pilot, on the morning of 12 July 2012. During this flight, which had a duration of 2 hours and 36 minutes (2,6 hours) there were four adults onboard the helicopter. The pilot/owner did not report any problems with the flight characteristics of the helicopter nor was there any performance related defect(s) recorded following the flight. It is believed that the flight on the morning of 12 July 2012 was not the only flight where the helicopter was flown with four occupants onboard since the owner took delivery of it on 15 February 2012.

Flight control and drive train continuity was ascertained during the on-site investigation. It was therefore highly unlikely that a mechanical failure contributed to or have caused the helicopter to enter into an unanticipated right yaw. The helicopter was operated within its approved weight and balance limitations at the time of the accident flight.

Following the discovery of the moisture absorbent bag in the air filter box during disassembly of the helicopter (post accident), its believed that if the moisture absorbent bag was in the air filter box assembly it had very little effect on the power availability of the helicopter following delivery thereof as no defects were reported to an AMO that required immediate maintenance intervention. The actual location of the bag within the air filter box assembly remains questionable, even though the apprentice that found the bag indicated it to be within the centre of the air filter unit directly below the carburettor. As indicated in correspondence with the helicopter manufacturer no such bags get placed in the air filter box, they only get placed within the air inlet hose as illustrated in this report, following inspection of a new Robinson R44 helicopter that arrived in South Africa.

Should a moisture absorbent bag have managed to migrate down the air inlet hose during the shipment process and was not found during the MPI inspection one would have expected to have seen the rope and possible warning tag that gets attached to the bag also inside the air filter box, this was not the case. Should the bag have became dislodged from the rope that secures it and managed to have migrated down the air inlet hose the possibility exists that it could have entered the air filter box but it certainly would not have been able to have proceeded towards the centre of the air filter box as claimed by the apprentice. It was simply not possible for a moisture absorbent bag of this size (26 x 12 cm) to have progressed passed the air filter unless the filter box was opened and the bag had been placed in such position by a third party.

The fact that the bag was still intact (no content was discharged from it) could indicate that the bag was most probably not in the centre area of the air filter box as it most probably would have been sucked into the lower opening of the carburettor, as the suction rate of air entering the carburettor in this area are substantial. Figure 17 on the next page reflects the area covered by the moisture absorbent bag when positioned within the centre area of the air filter, which was in close proximity to the carburettor, which would have been positioned directly above the alternate air door area, at a height of approximately 6,5 cm.

Figure 17. Moisture absorbent bag within the centre of the air filter box (for illustration purposes only).

Figure 18 reflects the moisture absorbent bag to be in an alternate position within the air filter box. Should the bag have managed to migrate down the air inlet hose into the air filter box it most probably would have been located within this area of the air filter box. The actual position of the bag thereof might have been different from the illustration.

Figure 18. Moisture absorbent bag within the air filter box (for illustration purposes only).

2.3 Mission

The accident flight comprised of a take-off, at point A, and flying to point B where the pilot intended to land on the game farm. No special/unusual flight conditions/manoeuvres were required by the pilot to complete the flight in question. There was no windsock or a similar type of wind indication device at the intended landing area that could have been of assistance to the pilot to make an accurate wind assessment just prior to landing. He therefore had to rely on alternate means of assessing the wind and therefore made and assessment from dust blown up by a vehicle.

2.4 Environment

Fine weather conditions prevailed during the flight as well as at the intended landing area. The surface wind velocity at the landing area was reported to be approximately 20 knots, which was within the operating limitations of the helicopter as documented in the POH, section 2. Variation in wind velocity and direction could not be excluded during the landing phase of the flight, which could have caught the pilot off guard, thinking that he was approaching into wind when the wind actually had changed as he was about to land the helicopter.

3. CONCLUSION

3.1 Findings

3.1.1 The pilot was the holder of a private pilot's licence and had the helicopter type endorsed in his logbook.

3.1.2 The pilot was the holder of a valid aviation medical certificate that was issued by a CAA-approved medical examiner with a restriction imposed to wear corrective lenses.

3.1.3 The pilot had flown a total of 3,7 hours during the past 90-days, which included the accident flight of approximately 20 minutes.

3.1.4 The helicopter was in possession of a valid Certificate of Airworthiness.

3.1.5 The helicopter had accumulated a total of 62,6 hours since new and 58,6 hours since it was re-assembled after it was imported into South Africa from the U.S.A.

3.1.6 The air filter was not replaced during the MPI inspection that was signed out on the aircraft after re-assembly in South Africa.

3.1.7 The weight and balance were found to be within the prescribed limits as stipulated in the pilot's operating handbook, with the helicopter being approximately 460 pounds below the maximum certified weight limit on impact.

3.1.8 The accident was survivable, with the cockpit cabin area remaining intact and the occupants making use of the helicopter's safety harnesses.

3.1.9 According to the pilot he approached the landing area in a north-easterly direction, into the wind, as he assessed it, and established the helicopter in hover flight, out of ground effect. There was no windsock or a similar type of device at the intended landing area from which an accurate wind assessment could be made at the time.

3.1.10 The pilot assessed the wind to be from the north-east. The game farm manager, who witnessed the accident, indicated in his statement that the wind at the time was from the south-west at approximately 20 knots.

3.1.11 The helicopter entered into an unanticipated right yaw from hover flight and was observed to have completed four 360° rotations bef ore ground impact followed.

3.1.12 The pilot immediately pushed the left tail rotor pedal in order to try and arrest the right yaw, but it had no effect. He also applied the right pedal but that too had no effect.

3.1.13 The pilot increased the collective pitch lever and rolled on the throttle into the indent during the recovery process which was in contrast to what the emergency recovery procedure required as stipulated in the POH.

3.1.14 No evidence of a mechanical defect/failure was observed that might have contributed to or have caused the helicopter to yaw to the right during the attempted landing.

3.2 Probable cause

3.2.1 The pilot experienced loss of tail rotor effectiveness (LTE) and was unable to prevent the helicopter from completing several revolutions before ground impact followed.

3.3 Contributory factor/s

3.3.1 High power demand while hovering out of ground effect in a region where weathercock-stability could have induced an unanticipated yaw rate.

3.3.2 It would appear that the pilot did not correctly identify operational conditions that could have induced LTE (surface wind at the time of landing).

3.3.3 The pilot did not implement an adequate recovery technique to counteract the onset of an unanticipated right yaw (clockwise direction) by applying power at a critical phase of the flight instead of lowering the collective pitch lever as stipulated in the recovery procedure in the pilot's operating handbook. This action by the pilot should be regarded as a significant contributory factor to this accident.

4. SAFETY RECOMMENDATIONS

4.1 It is recommended to the Director of Civil Aviation that the Testing Standards division within the CAA revise the helicopter training syllabus for all single-rotor helicopters equipped with a conventional anti-torque tail rotor device.

Student/pilots flying these helicopters should be made aware of and understand the LTE phenomenon, both in theory and practice. Particular emphasis should be placed on those flight regimes where a combination of various elements (i.e., relative wind, yaw rate etc.) could lead to or induce an LTE condition.

4.2 It is recommended to the Director of Civil Aviation that aviation training organisations (ATOs) be made aware of the essence of LTE training, and that they should implement LTE as a subheading during recurrent training as well as during flight tests/skills tests when flying helicopters susceptible to this type of phenomenon.

4.3 It is recommended to the Director of Civil Aviation that the SACAA draft an official letter addressed to Robinson Helicopters Company (RHC) via the Federal Aviation Administration (FAA) whereby they request RHC to issue a Safety Notice on the phenomenon of LTE. The Safety Notice should be in line with the information outlined in Bell Operations Safety Notice (OSN) 206-83-10, dated October 31, 1983 as well as FAA AC 90-95. The Safety Notice should be applicable to all current Robinson helicopter models.

4.4 On 27 August 2012 an urgent safety recommendation was forwarded to the Director of Civil Aviation for consideration after the moisture absorbent bag was located within the engine air filter box during a strip down of the helicopter following the accident.

The recommendation request that the document *"Robinson Model R44 Maintenance Manual 1.700 Special Instructions for reassembling and flight testing R44 series helicopters after crafting for export"* be amended with immediate effect, and that a checklist, which require the re-assembly crew to sign off each task should be added. Each warning label installed on the helicopter during the shipment procedure should have a clearly documented reference number to it and the person responsible for the task should be able to sign it off on the checklist. A duplicate inspection should form part of the checklist, which would require an additional column for a signature.

5. APPENDICES

5.1 Annexure A (Unanticipated Yaw / Loss of Tail Rotor Effectiveness {LTE})

5.2 Annexure B (FAA Advisory Circular No. 90-95)

5.3 Annexure C (Robinson Maintenance Manual 1.700 Special Instructions)

5.4 Annexure D (R44 Robinson Mandatory Periodic Inspection pg. 21-59)

UNANTICIPATED YAW / LOSS OF TAIL ROTOR EFFECTIVENESS (LTE)

Source: FAA Rotorcraft Flying Handbook, pages 11-12, 11-13, 11-14

Unanticipated yaw is the occurrence of an un-commanded yaw rate that does not subside of its own accord and, which, if not corrected, can result in the loss of helicopter control. This un-commanded yaw rate is referred to as loss of tail rotor effectiveness (LTE) and occurs to the right in helicopters with a counter-clockwise rotating main rotor and to the left in helicopters with a clockwise main rotor rotation. Again, this discussion covers a helicopter with a counter-clockwise rotor system and an anti-torque rotor.

LTE is not related to an equipment or maintenance malfunction and may occur in all single-rotor helicopters at airspeeds less than 30 knots. It is the result of the tail rotor not providing adequate thrust to maintain directional control, and is usually caused by either certain wind azimuths (directions) while hovering, or by an insufficient tail rotor thrust for a given power setting at higher altitudes.

For any given main rotor torque setting in perfectly steady air, there is an exact amount of tail rotor thrust required to prevent the helicopter from yawing either left or right. This is known as tail rotor trim thrust. In order to maintain a constant heading while hovering, you should maintain tail rotor thrust equal to trim thrust.

The required tail rotor thrust is modified by the effects of the wind. The wind can cause an un-commanded yaw by changing tail rotor effective thrust. Certain relative wind directions are more likely to cause tail rotor thrust variations than others. Flight and wind tunnel tests have identified three relative wind azimuth regions that can either singularly, or in combination, create an LTE conducive environment. These regions can overlap, and thrust variations may be more pronounced. Also, flight testing has determined that the tail rotor does not actually stall during the period. When operating in these areas at less than 30 knots, pilot workload increases dramatically.

MAIN ROTOR DISC INTERFERENCE (285-315°)

Refer to figure 11-10. Winds at velocities of 10 to 30 knots from the left front cause the main rotor vortex to be blown into the tail rotor by the relative wind. The effect of this main rotor disc vortex causes the tail rotor to operate in an extremely turbulent environment. During a right turn, the tail rotor experiences a reduction of thrust as it comes into the area of the main rotor disc vortex. The reduction in tail rotor thrust comes from the airflow changes experienced at the tail rotor as the main rotor disc vortex moves across the tail rotor disc. The effect of the main rotor disc vortex initially increases the angle of attack of the tail rotor blades, thus increasing tail rotor thrust. The increase in the angle of attack requires that right pedal pressure be added to reduce tail rotor thrust in order to maintain the same rate of turn. As the main rotor vortex passes the tail rotor, the tail rotor angle of attack is reduced. The reduction in the angle of attack causes a reduction in thrust and a right yaw acceleration begins. This acceleration can be surprising, since you were previously adding right pedal to maintain the right turn rate. This thrust reduction occurs suddenly, and if uncorrected, develops into an uncontrollable rapid rotation about the mast. When operating within this region, be aware that the reduction in tail rotor thrust can happen quite suddenly, and be prepared to react quickly to counter this reduction with additional left pedal input.

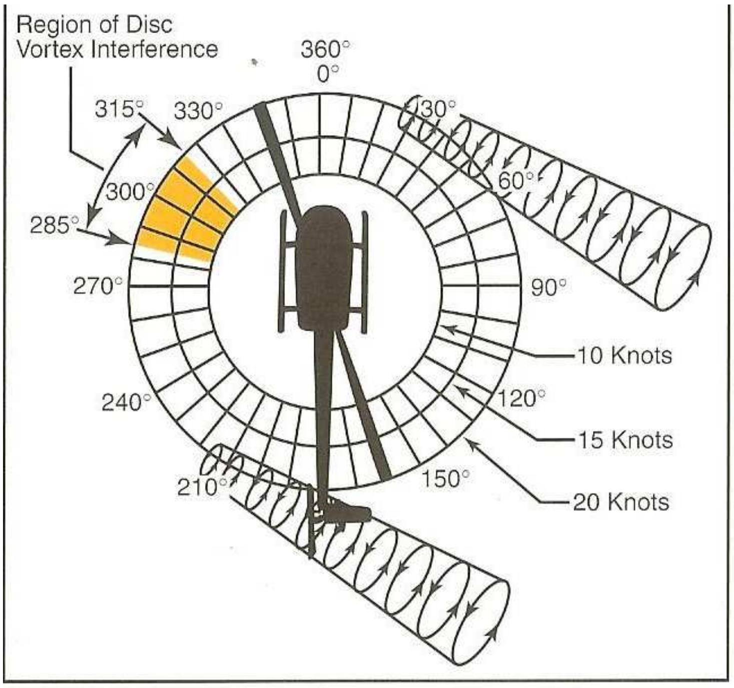

Figure 11-10. Main rotor disc vortex interference.

WEATHERCOCK STABILITY (120-240°)

In this region, the helicopter attempts to weathervane its nose into the relative wind. [Figure 11-11] Unless a resisting pedal input is made, the helicopter starts a slow, un-commanded turn either to the right or left depending upon the wind direction. If the pilot allows a right yaw rate to develop and the tail of the helicopter moves into this region, the yaw rate can accelerate rapidly. In order to avoid the onset of LTE in this downwind condition, it is imperative to maintain positive control of the yaw rate and devote full attention to flying the helicopter.

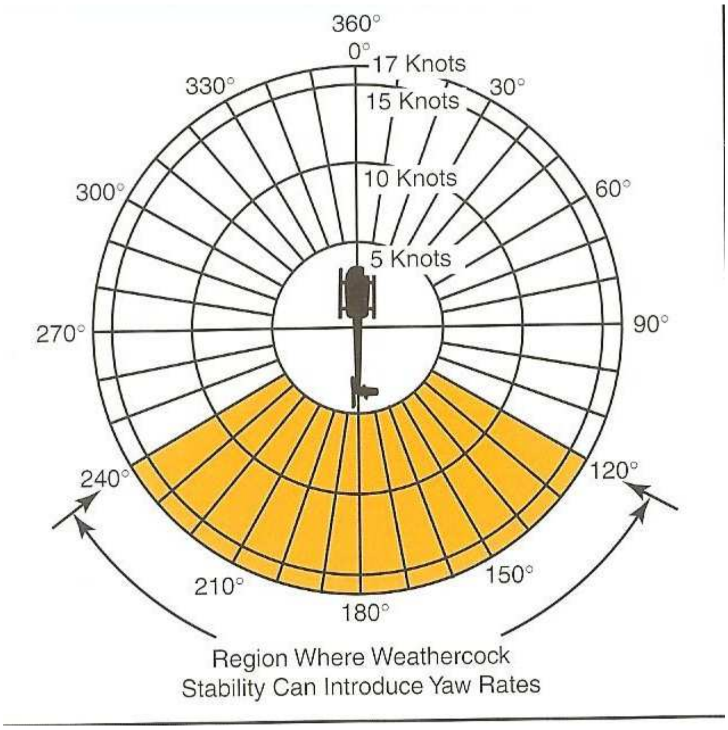

Figure 11-11. Weathercock stability.

TAIL ROTOR VORTEX RING STATE (210-330°)

Winds within this region cause a tail rotor vortex ring state to develop. [Figure 11-12] The result is a non-uniform, unsteady flow into the tail rotor. The vortex ring state causes tail rotor thrust variations, which result in yaw deviations. The net effect of the unsteady flow is an oscillation of tail rotor thrust. Rapid and continuous pedal movements are necessary to compensate for the rapid changes in tail rotor thrust when hovering in a left crosswind. Maintaining a precise heading in this region is difficult, but this characteristic presents no significant problem unless corrective action is delayed. However, high pedal workload, lack of concentration and over controlling can all lead to LTE. When the tail rotor thrust being generated is less than the thrust required, the helicopter yaws to the right. When hovering in left crosswinds, you must concentrated on smooth pedal coordination and not allow an uncontrolled right yaw to develop. If a right yaw rate is allowed to build, the helicopter can rotate into the wind azimuth region where weathercock stability then accelerates the right turn rate. Pilot workload during a tail rotor vortex ring state is high. Do not allow a right yaw rate to increase.

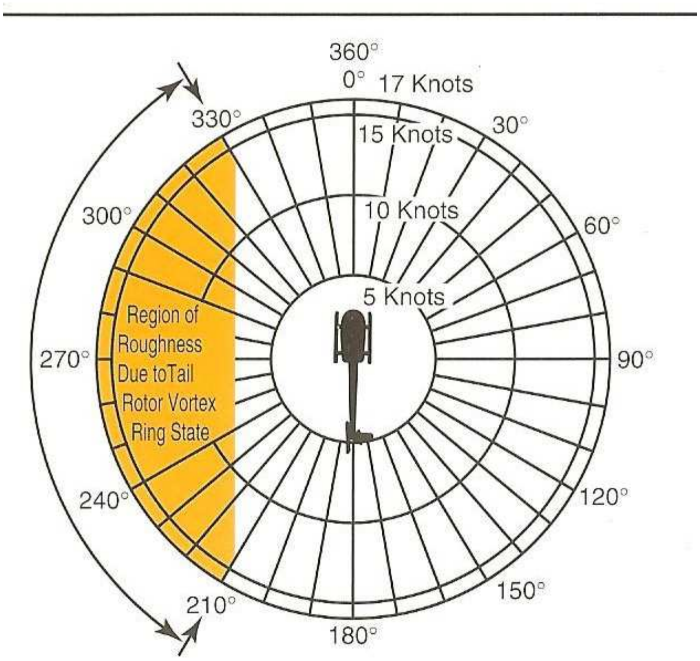

Figure 11-12. Tail rotor vortex ring state.

LTE AT ALTITUDE

At higher altitudes, where the air is thinner, tail rotor thrust and efficiency is reduced. When operating at high altitudes and high gross weights, especially while hovering, the tail rotor thrust may not be sufficient to maintain directional control and LTE can occur. In this case, the hovering ceiling is limited by tail rotor thrust and not necessarily power available. In these conditions gross weights need to be reduced and/or operations need to be limited to lower density altitudes.

REDUCING THE ONSET OF LTE

To help reduce the onset of loss of tail rotor effectiveness, there are some steps you can follow.

1. Maintain maximum power-on rotor r.p.m. If the main rotor r.p.m. is allowed to decrease, the anti-torque thrust available is decreased proportionally.

2. Avoid tailwinds below an airspeed of 30 knots. If loss of translational lift occurs, it results in an increased power demand and additional anti-torque pressures.

3. Avoid out of ground effect (OGE) operations and high power demand situations below an airspeed of 30 knots.

4. Be especially aware of wind direction and velocity when hovering in winds of about 8-12 knots. There are no strong indicators that translational lift has been reduced. A loss of translational lift results in an unexpected high power demand and an increased anti-torque requirement.

5. Be aware that if a considerable amount of left pedal is being maintained, a sufficient amount of left pedal may not be available to counteract an unanticipated right yaw.

6. Be alert to changing wind conditions, which may be experienced when flying along ridge lines and around buildings.

RECOVERY TECHNIQUE

If a sudden unanticipated right yaw occurs, the following recovery technique should be performed. Apply full left pedal while simultaneously moving cyclic control forward to increase speed. If altitude permits, reduce power. As recovery is effected, adjust controls for normal forward flight. Collective pitch reduction aids in arresting the yaw rate but may cause an excessive rate of descent. Any large, rapid increase in collective to prevent ground or obstacle contact may further increase the yaw rate and decrease rotor r.p.m. The decision to reduce collective must be based on your assessment of the altitude available for recovery. If the rotation cannot be stopped and ground contact is imminent, an autorotation may be the best course of action. Maintain full left pedal until the rotation stops, then adjust to maintain heading.

ANNEXURE B

U.S. Department of Transportation

Federal Aviation Administration

Advisory Circular

Subject: **UNANTICIPATED RIGHT YAW IN HELICOPTERS**	Date: **12/26/95** Initiated by: **AFS-804**	AC No: **90-95** Change:

1. PURPOSE. This advisory circular (AC) will examine unanticipated right yaw phenomenon, the circumstances under which it may be encountered, how it can be prevented, and how the pilot should react if it is encountered.

2. RELATED READING MATERIAL. Bell Helicopter Textron, *Supplemental Operating and Emergency Procedures*, Operations Safety Notice, OSN 206-83-10 (October 31, 1983), Bell Helicopter Textron; Bell Helicopter Textron, *Low Speed Flight Characteristics Which Can Result in Unanticipated Right Yaw*, Information Letter 206-84-41 and 206-84-27 (July 6, 1984), Bell Helicopter Textron; Sneelen, D.M., OH-58 Loss of Tail Rotor Effectiveness - Why It Occurs, *U.S. Army Aviation Digest* (September 1984), U.S. Army Aviation Center; Prouty, R.W., The Downwind Turn: Losing Directional Control, *Rotor and Wing* (May 1994), Phillips Business Information, Inc.; More on the OH-58 LTE Problem, *Flightfax: Report of Army Aircraft Mishaps*, Vol. 13, No. 32 (May 22, 1985), U.S. Army Safety Center; Loss of Tail Rotor Effectiveness...When It Is and When It Isn't, *Flightfax: Report of Army Aircraft Mishaps*, Vol. 14, No. 1 (September 25, 1985), U.S. Army Safety Center; U.S. Army, *OH-58 Helicopter Operators Manual*, TM 55-1520-228-10, U.S. Army; U.S. Naval Air Training Command, *Flight Training Instructions, TH-57* (1989), U.S. Naval Air Training Command.

3. BACKGROUND. Unanticipated right yaw, or loss of tail rotor effectiveness (LTE), has been determined to be a contributing factor in a number of accidents in various models of U.S. military helicopters. The National Transportation Safety Board (NTSB) has identified LTE as a contributing factor in several civil helicopter accidents wherein the pilot lost control. In most cases, inappropriate or late corrective action may have resulted in the development of uncontrollable yaw. These mishaps have occurred in the low-altitude, low-airspeed flight regime while maneuvering, on final approach to a landing, or during nap-of-the-earth tactical terrain flying. Typical civil operations include powerline patrol, electromagnetic survey, agricultural spraying, livestock herding, police/radio traffic watch, emergency medical service/rescue, and movie or television support flights.

4. THE PHENOMENA OF LTE.

*a. **LTE is a critical, low-speed aerodynamic flight characteristic*** which can result in an uncommanded rapid yaw rate which does not subside of its own accord and, if not corrected, can result in the loss of aircraft control.

*b. **LTE is not related to*** a maintenance malfunction and may occur in varying degrees in *all* single main rotor helicopters at airspeeds less than 30 knots. LTE is not necessarily the result of a control margin deficiency. The anti-torque control margin established during Federal Aviation Administration (FAA) testing is accurate and has been determined to adequately provide for the approved sideward/rearward flight velocities plus counteraction of gusts of reasonable magnitudes. This testing is predicated on the assumption that the pilot is knowledgeable of the critical wind azimuth for the helicopter operated and maintains control of the helicopter by not allowing excessive yaw rates to develop.

*c. **LTE has been identified*** as a contributing factor in several helicopter accidents involving loss of control. Flight operations at low altitude and low airspeed in which the pilot is distracted from the dynamic conditions affecting control of the helicopter are particularly susceptible to this phenomena. The following are three examples of this type of accident:

(1) A helicopter collided with the ground following a loss of control during a landing approach. The pilot reported that he was on approach to a ridge line landing zone when, at 70 feet above ground level (AGL) and at an airspeed of 20 knots, a gust of wind induced loss of directional control. The helicopter began to rotate rapidly to the right about the mast. The pilot was unable to regain directional control before ground contact.

(2) A helicopter impacted the top of Pike's Peak at 14,100 feet mean sea level (MSL). The pilot said he had made a low pass over the summit into a 40-knot headwind before losing tail rotor effectiveness. He then lost directional control and struck the ground.

(3) A helicopter entered an uncommanded right turn and collided with the ground. The pilot was maneuvering at approximately 300 feet AGL when the aircraft entered an uncommanded right turn. Unable to regain control, he closed the throttle and attempted an emergency landing into a city park.

5. UNDERSTANDING LTE PHENOMENA. To understand LTE, the pilot must first understand the function of the anti-torque system.

a. On U.S. manufactured single rotor helicopters, the main rotor rotates counterclockwise as viewed from above. The torque produced by the main rotor causes the fuselage of the aircraft to rotate in the opposite direction (nose right). The anti-torque system provides thrust which counteracts this torque and provides directional control while hovering.

b. On some European and Russian manufactured helicopters, the main rotor rotates clockwise as viewed from above. In this case, the torque produced by the main rotor causes the fuselage of the aircraft to rotate in the opposite direction (nose left). The tail rotor thrust counteracts this torque and provides directional control while hovering.

NOTE: This AC will focus on U.S. manufactured helicopters.

c. Tail rotor thrust is the result of the application of anti-torque pedal by the pilot. If the tail rotor generates more thrust than is required to counter the main rotor torque, the helicopter will yaw or turn to the left about the vertical axis. If less tail rotor thrust is generated, the helicopter will yaw or turn to the right. By varying the thrust generated by the tail rotor, the pilot controls the heading when hovering.

d. In a no-wind condition, for a given main rotor torque setting, there is an exact amount of tail rotor thrust required to prevent the helicopter from yawing either left or right. This is known as tail rotor trim thrust. In order to maintain a constant heading while hovering, the pilot should maintain tail rotor thrust equal to trim thrust.

e. The environment in which helicopters fly, however, is not controlled. Helicopters are subjected to constantly changing wind direction and velocity. The required tail rotor thrust in actual flight is modified by the effects of the wind. If an uncommanded right yaw occurs in flight, it may be because the wind reduced the tail rotor effective thrust.

f. The wind can also add to the anti-torque system thrust. In this case, the helicopter will react with an uncommanded left yaw. The wind can and will cause anti-torque system thrust variations to occur. Certain relative wind directions are more likely to cause tail rotor thrust variations than others. These relative wind directions or regions form an LTE conducive environment.

6. CONDITIONS UNDER WHICH LTE MAY OCCUR.

a. Any maneuver which requires the pilot to operate in a high-power, low-airspeed environment with a left crosswind or tailwind creates an environment where unanticipated right yaw may occur.

b. There is greater susceptibility for LTE in right turns. This is especially true during flight at low airspeed since the pilot may not be able to stop rotation. The helicopter will attempt to yaw to the right. Correct and timely pilot response to an uncommanded right yaw is critical. The yaw is usually correctable if additional left pedal is applied immediately. If the response is incorrect or slow, the yaw rate may rapidly increase to a point where recovery is not possible.

c. Computer simulation has shown that if the pilot delays in reversing the pedal control position when proceeding from a left crosswind situation (where a lot of right pedal is required due to the sideslip) to downwind, control would be lost, and the aircraft would rotate more than 360° before stopping.

d. The pilot must anticipate these variations, concentrate on flying the aircraft, and not allow a yaw rate to build. Caution should be exercised when executing right turns under conditions conducive to LTE.

7. FLIGHT CHARACTERISTICS.

a. Extensive flight and wind tunnel tests have been conducted by aircraft manufacturers. These tests have identified four relative wind azimuth regions and resultant aircraft characteristics that can, either singularly or in combination, create an LTE conducive environment capable of adversely affecting aircraft controllability. One direct result of these tests is that flight operations in the low speed flight regime dramatically increase the pilot's workload.

b. Although specific wind azimuths are identified for each region, the pilot *should be aware* that the azimuths shift depending on the ambient conditions. *The regions do overlap.* The most pronounced thrust variations occur in these overlapping areas.

c. These characteristics are present only at airspeeds less than 30 knots and apply to all single rotor helicopters. Flight test data has verified that the tail rotor does not stall during this period.

d. The aircraft characteristics and relative wind azimuth regions are:

(1) Main rotor disc vortex interference (285° to 315°). (See figure 1.)

(a) Winds at velocities of about 10 to 30 knots from the left front will cause the main rotor vortex to be blown into the tail rotor by the relative wind. The effect of this main rotor disc vortex is to cause the tail rotor to operate in an extremely turbulent environment.

(b) During a right turn, the tail rotor will experience a reduction of thrust as it comes into the area of the main rotor disc vortex. The reduction in tail rotor thrust comes from the air flow changes experienced at the tail rotor as the main rotor disc vortex moves across the tail rotor disc. The effect of this main rotor disc vortex is to increase the angle of attack of the tail rotor blades (increase thrust).

(c) The increase in the angle of attack requires the pilot to add right pedal (reduce thrust) to maintain the same rate of turn.

(d) As the main rotor vortex passes the tail rotor, the tail rotor angle of attack is reduced. The reduction in the angle of attack causes a reduction in thrust and a right yaw acceleration begins. This acceleration can be surprising, since the pilot was previously adding right pedal to maintain the right turn rate.

(e) This thrust reduction will occur suddenly and, if uncorrected, will develop into an uncontrollable rapid rotation about the mast. When operating within this region, the pilot must be aware that the reduction in tail rotor thrust can happen quite suddenly and the pilot must be prepared to react quickly and counter that reduction with additional left pedal input.

(2) Weathercock stability (120° to 240°). (See figure 2.)

(a) Tailwinds from 120° to 240°, like left crosswinds, will cause a high pilot workload. The most significant characteristic of tailwinds is that they are a yaw rate accelerator. Winds within this region will attempt to weathervane the nose of the aircraft into the relative wind. This characteristic comes from the fuselage and vertical fin.

(b) The helicopter will make a slow uncommanded turn either to the right or left depending upon the exact wind direction unless a resisting pedal input is made. If a yaw rate has been established in either direction, it will be accelerated in the same direction when the relative winds enter the 120° to 240° area unless corrective pedal action is made.

(c) If the pilot allows a right yaw rate to develop and the tail of the helicopter moves into this region, the yaw rate can accelerate rapidly. It is imperative that the pilot maintain positive control of the yaw rate and devote full attention to flying the aircraft when operating in a downwind condition.

(d) The helicopter can be operated safely in the above relative wind regions if proper attention is given to maintaining control. If the pilot is inattentive for some reason and a right yaw rate is initiated in one of the above relative wind regions, the yaw rate may increase.

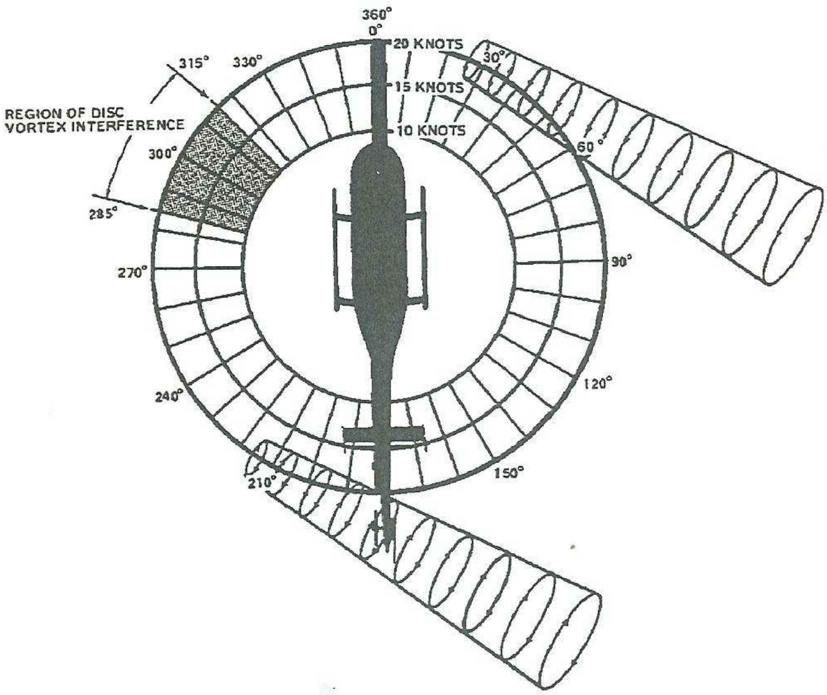

FIGURE 1. MAIN ROTOR DISC VORTEX INTERFERENCE

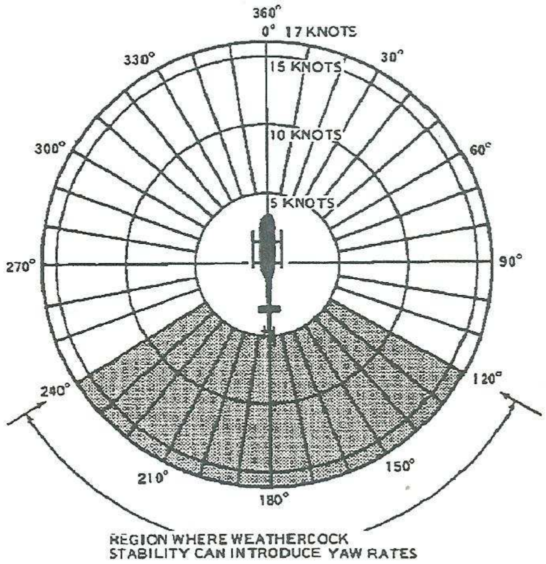

FIGURE 2. WEATHERCOCK STABILITY

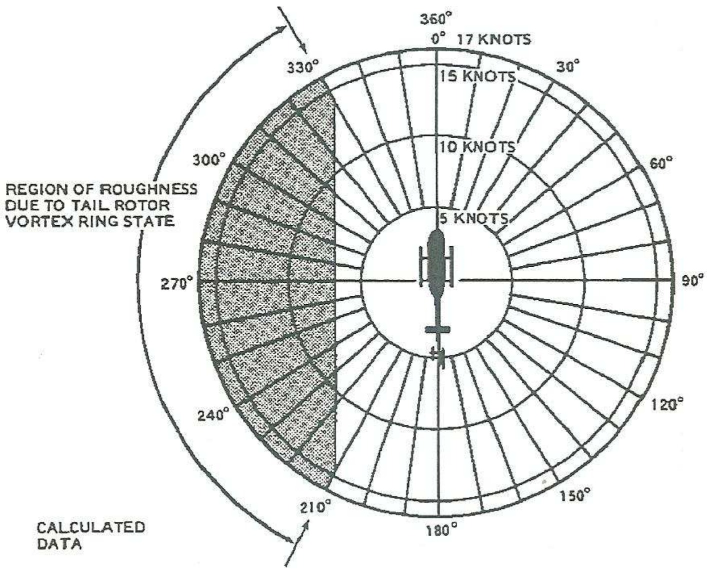

FIGURE 3. TAIL ROTOR VORTEX RING STATE

(3) Tail rotor vortex ring state (210° to 330°). (See figure 3.)

(a) Winds within this region will result in the development of the vortex ring state of the tail rotor. As the inflow passes through the tail rotor, it creates a tail rotor thrust to the left. A left crosswind will oppose this tail rotor thrust. This causes the vortex ring state to form, which causes a nonuniform, unsteady flow into the tail rotor. The vortex ring state causes tail rotor thrust variations which result in yaw deviations. The net effect of the unsteady flow is an oscillation of tail rotor thrust. This is why rapid and continuous pedal movements are necessary when hovering in left crosswind.

(b) In actuality, the pilot is attempting to compensate for the rapid changes in tail rotor thrust. Maintaining a precise heading in this region is difficult. LTE can occur when the pilot overcontrols the aircraft

(c) The resulting high pedal workload in the tail rotor vortex ring state is well known and helicopters are operated routinely in this region. This characteristic presents no significant problem unless corrective action is delayed.

(d) When the thrust being generated is less than the thrust required, the helicopter will yaw to the right. When hovering in left crosswinds, the pilot must concentrate on smooth pedal coordination and not allow an uncontrolled right yaw to develop.

(e) If a right yaw rate is allowed to build, the helicopter can rotate into the wind azimuth region where weathercock stability will then accelerate the right turn rate. Pilot workload during vortex ring state will be high. A right yaw rate should not be allowed to increase.

(4) Loss of translational lift (all azimuths).

(a) The loss of translational lift results in increased power demand and additional anti-torque requirements.

(b) This characteristic is most significant when operating at or near maximum power and is associated with LTE for two reasons. First, if the pilot's attention is diverted as a result of an increasing right yaw rate, the pilot may not recognize that relative headwind is being lost and hence, translational lift is reduced. Second, if the pilot does not maintain airspeed while making a right downwind turn, the aircraft can experience an accelerated right yaw rate as the power demand increases and the aircraft develops a sink rate. Insufficient pilot attention to wind direction and velocity can lead to an unexpected loss of translational lift. When operating at or near maximum power, this increased power demand could result in a decrease in rotor rpm.

(c) The pilot must continually consider aircraft heading, ground track, and apparent ground speed, all of which contribute to wind drift and airspeed sensations. Allowing the helicopter to drift over the ground *with the wind* results in a loss of relative wind speed and a corresponding decrease in the translational lift. Any reduction in the translational lift will result in an increase in power demand and anti-torque requirements.

8. OTHER FACTORS. The following factors can significantly influence the severity of the onset of LTE.

a. Gross Weight and Density Altitude. An increase in either of these factors will decrease the power margin between the maximum power available and the power required to hover. The pilot should conduct low-level, low-airspeed maneuvers with minimum weight.

b. Low Indicated Airspeed. At airspeeds below translational lift, the tail rotor is required to produce nearly 100 percent of the directional control. If the required amount of tail rotor thrust is not available for any reason, the aircraft will yaw to the right.

c. Power Droop. A rapid power application may cause a transient power droop to occur. Any decrease in main rotor rpm will cause a corresponding decrease in tail rotor thrust. The pilot must anticipate this and apply additional left pedal to counter the main rotor torque. All power demands should be made as smoothly as possible to minimize the effect of the power droop.

9. REDUCING THE ONSET OF LTE. In order to reduce the onset of LTE, the pilot should:

a. ***Ensure that the tail rotor is rigged*** in accordance with the maintenance manual.

b. ***Maintain maximum power-on rotor rpm.*** If the main rotor rpm is allowed to decrease, the anti-torque thrust available is decreased proportionally.

c. When maneuvering between hover and 30 knots:

(1) Avoid tailwinds. If loss of translational lift occurs, it will result in an increased high power demand and an additional anti-torque requirement.

(2) Avoid out of ground effect (OGE) hover and high power demand situations, such as low-speed downwind turns.

(3) Be especially aware of wind direction and velocity when hovering in winds of about 8-12 knots (especially OGE). There are no strong indicators to the pilot of a reduction of translational lift. A loss of translational lift results in an unexpected high power demand and an increased anti-torque requirement.

(4) Be aware that if a considerable amount of left pedal is being maintained, a sufficient amount of left pedal may not be available to counteract an unanticipated right yaw.

(5) Be alert to changing aircraft flight and wind conditions which may be experienced when flying along ridge lines and around buildings.

(6) Stay vigilant to power and wind conditions.

10. RECOMMENDED RECOVERY TECHNIQUES.

a. If a sudden unanticipated right yaw occurs, the pilot should perform the following:

(1) Apply full left pedal. Simultaneously, move cyclic forward to increase speed. If altitude permits, reduce power.

(2) As recovery is effected, adjust controls for normal forward flight.

b. Collective pitch reduction will aid in arresting the yaw rate but may cause an increase in the rate of descent. Any large, rapid increase in collective to prevent ground or obstacle contact may further increase the yaw rate and decrease rotor rpm.

c. The amount of collective reduction should be based on the height above obstructions or surface, gross weight of the aircraft, and the existing atmospheric conditions.

d. If the rotation cannot be stopped and ground contact is imminent, an autorotation may be the best course of action. The pilot should maintain full left pedal until rotation stops, then adjust to maintain heading.

11. SUMMARY.

a. The various wind directions can cause significantly differing rates of turn for a given pedal position. The most important principle for the pilot to remember is that the tail rotor is not stalled. The corrective action is to apply pedal opposite to the direction of the turn.

b. Avoiding LTE may best be accomplished by pilots being knowledgable and avoiding conditions which are conducive to LTE. Appropriate and timely response is essential and critical.

c. By maintaining an acute awareness of wind and its effect upon the aircraft, the pilot can significantly reduce LTE exposure.

William J. White
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1.700 SPECIAL INSTRUCTIONS FOR REASSEMBLING AND FLIGHT TESTING R44 SERIES HELICOPTERS AFTER CRATING FOR EXPORT

REASSEMBLY: **TO BE PERFORMED BY A CERTIFICATED MECHANIC**

1. Remove top of cabin assembly crate. Remove wall marked "A" by removing lag bolts painted black. Remove empennage assembly. Remove remaining walls. Remove all parts, except cabin assembly, from crate base. Open main rotor blade and tailcone crate.

2. Reinstall main rotor hub per Section 9.122.

3. Assemble landing gear per Section 5.320.

NOTE
Do not install strut fairings at this time.

4. Attach a hoist to main rotor hub per Section 1.220. Lift aft end of crate while at same time taking up slack in hoist. When helicopter belly is in a horizontal position, lift with hoist until cabin is supported by hoist alone. Remove lag screws and carriage bolts attaching helicopter cabin to crate. Remove crate.

CAUTION
Do not lift helicopter and attached crate using main rotor hub; damage to main rotor gearbox and frames could result.

5. Remove supports from landing gear attachment points and install assembled landing gear per Section 5.120 or Section 5 (float landing gear). Install front cross tube cover panel. If desired, install strut fairings per Section 5.420 (not applicable to utility float landing gear).

6. Remove tailcone cowling and install tailcone per Section 4.312. Install strobe light. Install communication, Loran, and GPS antennas (if equipped). Install tailcone cowling.

CAUTION
Make sure all foam packing material is removed from inside of tailcone before installation; damage to tail rotor drive shaft could result.

7. Install empennage assembly per Section 4.322. Install tail rotor guard per Section 4.330.

8. Fill tail rotor gearbox with A257-2 oil to full level.

9. Install tail rotor per Section 9.212. Match color coded markings on blades with pitch links.

10. Install fan and scroll per Section 6.220.

1.700 SPECIAL INSTRUCTIONS FOR REASSEMBLING AND FLIGHT TESTING R44 SERIES HELICOPTERS AFTER CRATING FOR EXPORT (cont'd)

11. Install engine exhaust per Section 6.520.

12. Install main rotor blades per Section 9.112. Match color-coded markings on blades with markings on hub and pitch links.

13. Perform tail rotor drive shaft runout per Section 7.340.

14. Fill main rotor gearbox with A257-2 oil to full level as required.

15. Fuel helicopter and drain a small amount of fuel through gascolator.

16. If ship is equipped with attitude horizon, directional gyro, turn coordinator, and/or vertical card magnetic compass, install as follows:

    Attitude Horizon, Direction Gyro, and Turn Coordinator:

    Remove warning lights from lower console. Pull out B197 instrument face by removing six (6) securing screws.

    > NOTE
    >
    > Place a piece of foam under B197-1 face to prevent scratching lower face.

    Install required instrument(s) by securing with hardware provided.

    > **CAUTION**
    >
    > Directional gyro mount screws must not exceed 1 inch in length or unit will be damaged.

    Connect existing straight connector(s) to directional gyro and/or turn coordinator. Connect angle connector to attitude horizon, ensuring strain relief points down. Ensure connectors lock in place. Ty-rap excess wiring. Reinstall B197-1 face to console. Reinstall amber FUEL FILTER (IO-540 only), AUX FUEL PUMP (IO-540 only), ALT, & GOV OFF lights and red ENG FIRE & OIL warning lights.

    Vertical Card Magnetic Compass:

    Remove vertical card compass from foam-protected box. Install a 2-inch length of B158-3 heat-shrink tubing over each compass wiring pin. Locate existing wires from windshield center bow. Connect pins from compass to existing sockets (polarity is not critical), cover connection with heat-shrink, then apply heat. Secure compass in mount with four screws and hide and secure wiring atop compass.

1.700 SPECIAL INSTRUCTIONS FOR REASSEMBLING AND FLIGHT TESTING R44 SERIES HELICOPTERS AFTER CRATING FOR EXPORT (cont'd)

17. Install battery (negative ground system).

18. Remove plastic dehydrator plugs from each cylinder's upper spark plug hole.

19. Lubricate provided upper spark plugs with A257-10 spark plug thread lubricant, install, and torque per Section 1.330.

20. Connect ignition leads to upper spark plugs and install spark plug access covers.

21. Disconnect ignition leads from lower spark plugs and remove lower spark plugs.

22. Place a small container under each cylinder's lower spark plug hole. With ignition switch in the OFF position, rotate engine by hand, several revolutions, to force excess preservation oil from cylinders.

23. Temporarily connect a grounding wire from each magneto's primary lead terminal to airframe ground.

24. Activate starter for no more than 12 seconds or until oil pressure is indicated on gage, whichever comes first. Allow starter to cool for 5 minutes after each activation.

25. After oil pressure is indicated remove temporary grounding wire from each magneto.

26. Lubricate lower spark plug threads with A257-10 spark plug thread lubricant, install, and torque per Section 1.330.

27. Connect ignition leads to lower spark plugs.

28. Install belly, left, right, and aft cowling assemblies.

29 Perform Section 2.205 ground check.

30. Perform Section 2.210 run-up.

1.700 SPECIAL INSTRUCTIONS FOR REASSEMBLING AND FLIGHT TESTING R44 SERIES HELICOPTERS AFTER CRATING FOR EXPORT (cont'd)

> NOTE
>
> IO-540 engines should idle at 58-62% rpm with engine warm, clutch engaged.

IO-540 IDLE ADJUSTMENT PROCEDURE

Idle rpm and mixture were set for sea-level standard conditions during factory flight test. If idle and off-idle throttle performance are not satisfactory upon reassembly, adjust as follows:

First set idle rpm to 58-62% rpm with engine warm & clutch engaged. Then, with engine off, disconnect fuel control outlet hose, connect test hose if desired, and measure fuel flow rate at fuel control outlet with mixture full rich, throttle at idle, and electric fuel pump on (ignition key to PRIME position). Adjust idle mixture as required to obtain 16-18 pounds/hour fuel flow (170-190 cc/minute). Clockwise rotation of idle mixture adjustment wheel (viewed from aircraft right side) enriches mixture. Re-check idle rpm after mixture adjustment and repeat as required until both rpm and mixture are within limits. With rpm and mixture set, verify smooth acceleration from idle to 102% rpm with no engine hesitation or smoke from tailpipe. Also verify smooth needle split from 102% to idle with no engine roughness or erratic rpm indications and acceptable idle quality. Note that 16-18 pounds/hour fuel flow should produce acceptable idle quality and off-idle throttle performance under sea-level standard conditions. Richer mixtures may be required for cold temperature operation and leaner mixtures may be required for hot/high altitude operation. Deviate from 16-18 lb/hr recommendation as required for acceptable idle quality and off-idle throttle performance (smooth accelerations and needle splits).

1.700 SPECIAL INSTRUCTIONS FOR REASSEMBLING AND FLIGHT TESTING R44 SERIES HELICOPTERS AFTER CRATING FOR EXPORT (cont'd)

FLIGHT TEST: **TO BE DONE BY A QUALIFIED PILOT AND A CERTIFICATED MECHANIC**

1. Perform preflight inspection per the Pilot's Operating Handbook.
2. Balance fanwheel per Section 6.240.
3. Balance tail rotor per Section 10.240.
4. Perform hover checks per Section 2.220 Step 1. DO NOT proceed into forward flight at this time.
5. Track and balance main rotor per Section 10.200.
6. After completing track and balance, adjust autorotation RPM per Section 10.250. Avoid rotor overspeeds by avoiding higher gross weights and higher altitudes during autorotation checks.
7. While climbing at Maximum Continuous Power (MCP), 60 KIAS, and governor on:
   a. Evaluate roughness and controllability.
   b. Perform 30 degree left yaw to check for adequate directional control.
8. Level flight at 2000 feet density altitude (deviate as required for weather and terrain), MCP, and governor on, evaluate the following:
   a. Longitudinal and lateral cyclic control forces.
   b. Collective control forces.
9. Evaluate roughness at MCP and 130 straight and level flight.
10. Check all instruments, gauges, and avionics for proper operation.
11. During autorotation at 50 KIAS and 90% RPM, perform a 30 degree right yaw to check for adequate directional control.

1.800 REPLACEMENT COMPONENT IDENTIFICATION (DATA) PLATES

In order to issue a replacement component identification plate for field installation, RHC must first receive the old identification plate in legible condition. If old identification plate is lost or destroyed, then RHC must have an original letter (photocopies or faxes are NOT acceptable) from customer's Civil Aviation Authority authorizing identification plate replacement AND stating component name, part number, and serial number for each requested identification plate. There is a charge for each plate issued.

ANNEXURE D

R44 ROBINSON – MANDATORY PERIODIC INSPECTION (MPI)	Engineer's Signature	Inspector's Signature
2.410 Inspection Procedure and Checklist (cont'd)		
6. **Remove Engine Aft (6D), Belly (6C), and both side (6A & 6B) Cowlings.**		
Vertical Firewall: Inspect vertical firewall, especially around structural attachment points, for cracks, buckling or wrinkles.		
Wiring: Verify security, proper installation, and no deterioration		
Fuses: Verify security and no corrosion. Verify correct fuses: -66 wire requires AGC-3 fuse; -1601/-1602 wires require AGC-5 fuse (if installed, -1226 wire requires AGC-3).		
Electric Fuel Pump (IO-540 only): Verify security, proper installation, leakage		
Fuel Line & Hose(s): Inspect condition. Verify security, proper installation, & no leakage.		
Lower Steel Tube Frames: Thoroughly inspect steel tube structure for corrosion and inspect all welds for cracks. Ensure frames are not chafed by wires, hoses, clamps, etc		
Engine Cooling Panels: Inspect cooling panels for cracks and missing fasteners.		
Oil Coolers: Inspect oil cooler(s) and fittings for damage, leaks, cleanliness, and security. Check oil cooler mounting area(s) for cracks.		
Oil Lines: Inspect entire length of all oil lines for cracks, abrasion, broken clamps, and clearance. Wires, ty-raps, and structure must not contact lines.		
Gascolator: With fuel valve OFF, remove and clean gascolator bowl and filter screen. Verify no deterioration of gasket. Reassemble and turn fuel valve ON. Safety wire after ensuring no leaks occur. Verify drain valve is torque-striped		
Mixture Control Cable Clamp: Check clamp securing cable housing to sump-mounted bracket. Clamp must be tight and secure		
Air Box & Alternate Air Door: Ensure carburetor heat door (O-540 engines only) moves fully from stop to stop. Replace air filter. Check air box for condition and security. Verify spring-loaded alternate air door opens without binding and closes completely.		
Engine Air Inlet Hose: Inspect hose at both ends for security. Inspect hose for rips, holes, and collapsed areas. Ensure hose is not chafing frame.		
Carburetor Heat Scoop and Hose (O-540 engines only): Inspect for condition and security.		
Heater Hose: Inspect for condition and security		
Battery and Battery Box (alternate locations under console or under left, front seat): Check cable terminals for cracks. Check each cell electrolyte for quantity and specific gravity if equipment with non-sealed battery. As required, perform capacity test per manufacture's instructions or replace battery. Verify security and no obstructions in drain tube.		
7. **Open Cowling Doors (7A), Remove Tailcone Cowling (7B) & Mast Fairing (9)** Inspect cowling door hinges and latches for condition and security. Inspect tailcone cowling for cracks, air inlet obstructions, and loose rivets.		
Electrical and Antenna Wires: Check for security, chafing, kinks and tight bends.		

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