Australian Government
Australian Transport Safety Bureau

Engine malfunction and forced landing involving Robinson R22 Beta II, VH-NKV

85 NM north-east of Karumba aerodrome, Queensland, on 6 August 2022

ATSB Transport Safety Report
Aviation Occurrence Investigation (Short)
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Addendum

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Executive summary

What happened

On the morning of 6 August 2022, the pilot of a Robinson R22 Beta II, registered VH-NKV, was flying at about 500–600 ft en route to conduct aerial mustering north-east of Karumba aerodrome, Queensland. After some time in cruise, the helicopter suddenly began to 'shake and vibrate'. In response, the pilot conducted an autorotation, flaring the aircraft just above the trees in a heavily wooded area. The aircraft collided with trees and was destroyed. The pilot was uninjured, and there was no fire.

What the ATSB found

The ATSB found that the engine issues prompting the pilot to attempt a forced landing were likely the result of carbon deposits that had accumulated on the valve stem of the no. 2 cylinder exhaust valve and within its guide, reducing clearance to less than the specified minimum. The reduced clearance likely resulted in the valve binding in the guide, and not fully closing. While these deposits would have begun to accumulate from the time the cylinder entered service, its progression to the point where it resulted in a degradation in engine performance would not normally be detected by the aircraft's existing maintenance regime.

Cylinder durability issues, predominantly affecting R22 and R44 helicopters used in mustering operations across the northern regions of Australia have reportedly increased since 2016. However, there was insufficient data available relating to the extent and nature of these failures to identify strategies for prevention.

What has been done as a result

The ATSB has released a safety advisory notice to strongly encourage maintainers, operators, and pilots of Robinson R22 and R44 helicopters fitted with Lycoming O-360 and O-540 series engines to complete a Lycoming cylinder durability investigation group defect report form any time engine cylinder issues are identified.

Safety message

The pilot responded appropriately to a sudden and unexpected emergency, greatly reducing the likelihood of injury. This accident highlights the importance for pilots to be cognisant of changes in performance during day-to-day operations, and always be prepared for the rapid onset of an in-flight emergency.

The investigation

Decisions regarding the scope of an investigation are based on many factors, including the level of safety benefit likely to be obtained from an investigation and the associated resources required. For this occurrence, a limited-scope investigation was conducted in order to produce a short investigation report, and allow for greater industry awareness of findings that affect safety and potential learning opportunities.

The occurrence

On the morning of 6 August 2022, the pilot of a Gulf Coast Aviation Robinson R22 Beta II, registered VH-NKV, was preparing the helicopter to conduct mustering operations. The pilot had planned to rendezvous with another helicopter that had departed from a different location and then both would proceed north to the mustering area, which was on a property about 160 km north-east of Karumba aerodrome, Queensland.

After take-off, the pilot climbed to about 500–600 ft and tracked north. The pilot reported that initially the engine indications were normal, and that after some time in cruise, the helicopter suddenly began to 'shake and vibrate', and that this could also be felt through the cyclic.[1] The pilot observed the engine manifold pressure rise, along with a drop in main rotor and engine RPM.

In response, the pilot initially raised the collective, then after recognising the engine and rotor RPM continuing to decrease, rapidly lowered the collective to maintain rotor RPM. The pilot commenced an autorotation, flaring the aircraft just above the trees in a heavily wooded area. The aircraft collided with trees and was destroyed (Figure 1). The pilot was uninjured, and was able to exit the aircraft unaided. There was no fire, and after it was safe to do so, the pilot returned to the aircraft to shut the fuel and master switch off.

[1] The cyclic is the primary helicopter flight control. Similar to aircraft control column, it is moved in the desired direction to move the helicopter about its pitch or roll axis.

Figure 1: VH-NKV at the accident site

Source: Gulf Coast Aviation, annotated by the ATSB

Context

Pilot information

The pilot commenced flying in 2017 and was issued a Civil Aviation Safety Regulation Part 61 Commercial Pilot (Helicopter) Licence in 2018. At the time of the accident, the pilot had accumulated about 4,100 hours total aeronautical experience and had been flying for Gulf Coast Aviation for about 18 months.

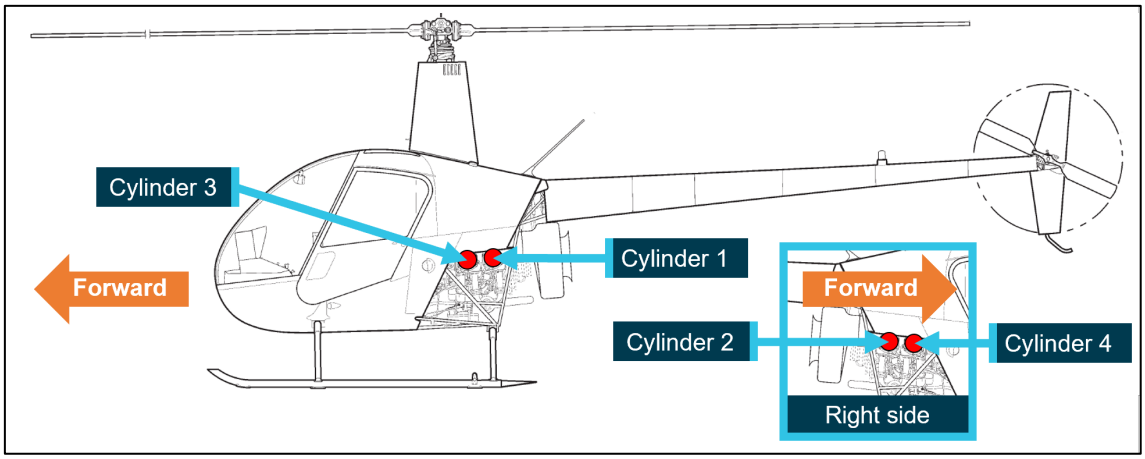
Helicopter information

The helicopter was a Robinson R22 Beta II powered by a 4-cylinder, horizontally opposed, Lycoming O-360-J2A engine, which was fan cooled. VH-NKV was manufactured in 2013 and first registered in Australia on 19 March 2014. At the time of the accident, VH-NKV had about 5,778 hours total time in service and had flown about 64 hours since its last periodic inspection.

Airworthiness and maintenance history

The engine cylinder layout is shown in Figure 2. An overhauled engine was installed on 26 October 2020 and in the following 18 months, 15 cylinders were changed across the 4 cylinder positions because they were found to have low compression when tested[2] (Table 1). Cylinders fitted to positions 3 and 4, located closest to the engine firewall, had been changed on more occasions than cylinders fitted to positions 1 and 2. The last cylinder replacements (numbers 1, 2 and 4) were made during the periodic inspection carried out on 13 May 2022. The compressions on all cylinders were within limits when tested during subsequent periodic inspections carried out on 23 June and 20 July 2022 (Table 2).

Figure 2: R22 Beta II engine cylinder layout



Source: Robinson Helicopter Company, annotated by the ATSB

Table 1: VH-NKV cylinder changes since overhaul

Hours since overhaul	Date	Cylinders changed	Reason for removal
94.1	6 January 2021	3 & 4	Low compression, reason not recorded
194.1	25 March 2021	3 & 4	Low compression, reason not recorded
283.6	4 May 2021	4	Low compression, reason not recorded
383.6	1 June 2021	3 & 4	Low compression, exhaust guides
483.2	30 June 2021	2 & 4	Low compression, exhaust guides
583.2	27 July 2021	3 & 4	Low compression, exhaust guides
683.2	15 September 2021	2	Low compression, exhaust seat
1148.9	13 May 2022	1, 2 & 4	Low compression, exhaust guides

[2] Compression checks are used to determine the condition of an aircraft cylinder and its components. It is accomplished with a differential compression tool which measures the leak rate of a cylinder compared to the leak rate through an orifice within the tool. Air is supplied to the tools regulator and adjusted to 80 psi on the air supply pressure gauge, and a measurement is read on a second gauge.

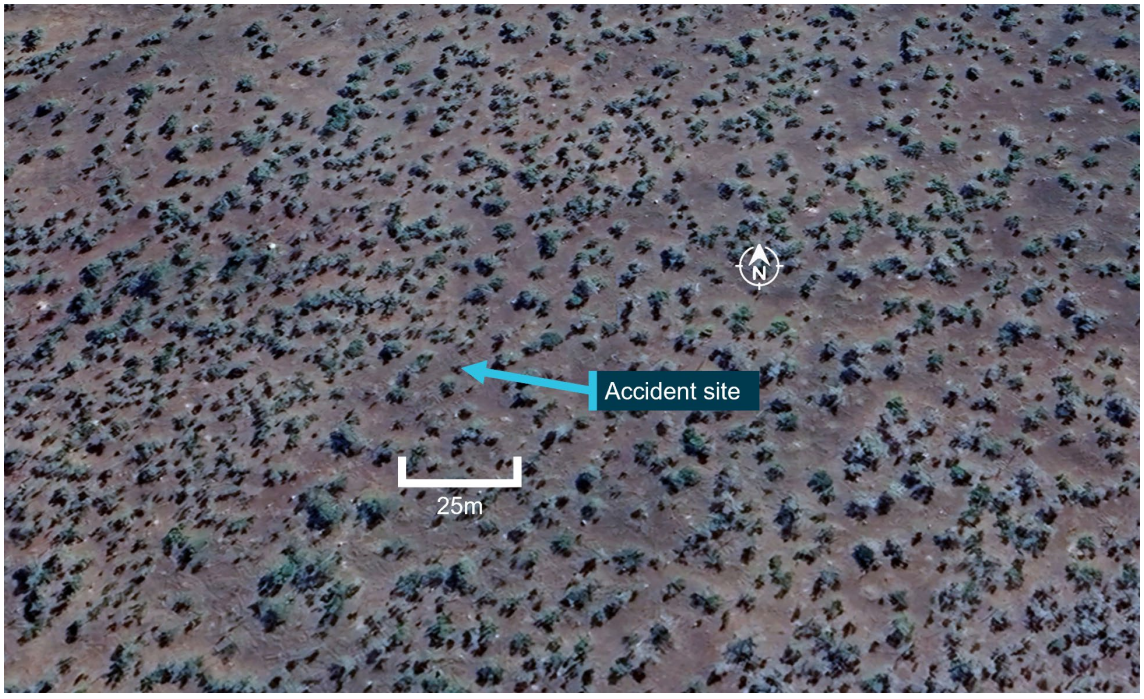
Table 2: VH-NKV recent cylinder compression checks

Cylinder	Measurement/supply pressure (psi) 23 June 2022	Measurement/supply pressure (psi) 20 July 2022
1	78/80	79/80
2	76/80	79/80
3	78/80	75/80
4	76/80	75/80

Wreckage information

The accident site was located in a heavily wooded area with limited clearings to successfully complete an autorotation (Figure 3). The ATSB did not attend the accident site. The operator, Gulf Coast Aviation, recovered the wreckage, after which it was transported to an independent maintenance provider. The engine and a selection of components were removed for detailed examination by the ATSB. This examination revealed that multiple components showed evidence of the engine running at impact, however the level of power that would have been available could not be determined.

Figure 3: Accident site overview



Source: Google Earth, annotated by the ATSB

Engine examination

The engine was disassembled and examined at a Civil Aviation Safety Authority (CASA) approved engine overhaul facility under the supervision of the ATSB. The engine was in good overall condition, and the cylinders fitted to the no. 1, 3 and 4 positions were within the manufacturer's specifications. However, the cylinder fitted in the no. 2 position had very low compression when tested. Further investigation showed that the exhaust valve was not fully closing, likely because of carbon deposits accumulated on its stem and within the valve guide. The deposits had reduced the clearance of the valve stem within its guide to less than the specified minimum. Additionally, the no. 2 cylinder inlet plenum showed discolouration, possibly from the abnormal presence of

exhaust gas which could be the result of the inlet valve sticking. Valves that do not fully close or become stuck in engines installed in helicopters can result in airframe vibration and a reduction in power.

The magnetos were bench tested, disassembled, and examined at another CASA-approved facility. The magnetos functioned correctly, and there were no defects evident.

The air and oil filters, oil, oil pump, and carburettor showed no significant abnormalities and there was no evidence of internal damage. No other relevant defects were identified.

R22 and R44 engine durability issues in northern Australia

R22 and R44 series helicopters have been used extensively in northern Australia for the aerial mustering of livestock. From around 2016, some operators of R22 and R44 helicopters fitted with Lycoming O-320, O-360 and O-540 series engines[3] reported an increase in engine cylinder failures due to low compression.[4] This was typically detected by engine cylinder compression checks carried out during periodic inspections and required the affected cylinders to be changed. Undetected loss of compression on one or more cylinders can lead to a reduction in power, and the possibility of an in-flight emergency.

In response, CASA published Airworthiness Bulletins AWB 85-024 – *Robinson R22/R44 Engine Exhaust Valve and Valve Guide Distress* and AWB 85-025 – *Robinson R22/R44 Engine Intake Valve and Valve Seat Distress* (Civil Aviation Safety Authority, 2018). Both bulletins showed typical defects that prompted cylinder removals, a list of relevant technical publications from Robinson and Lycoming, outlined the investigations and testing carried out by the engine manufacturer and industry groups, and contained recommendations to reduce cylinder changes.

Additionally, the bulletins noted that:

> A clear understanding of all potential causative factors needs to be established before any permanent solutions can be implemented through design, manufacturing, operational or maintenance changes.
>
> At this time, the airworthiness concern described in this Airworthiness Bulletin is not considered an unsafe condition that would warrant Airworthiness Directive action under Part 39 of the Civil Aviation Safety Regulation 1998.

In 2018 the ATSB received correspondence suggesting R22 and R44 engine serviceability issues may be linked to the December 2015 change of fuel supplied to the northern region of Australia from green-coloured Avgas 100/130 to blue-coloured Avgas 100LL (low lead). At the time, the ATSB analysed the available safety occurrence records and found there had been ‘no discernible increase in reported engine failures or malfunctions in northern Australia after the introduction of Avgas 100LL in December 2015’ (ATSB, 2018).

In 2019, the Lycoming Cylinder Durability Investigation Group (LCDIG) was formed by the following organisations to gather further information:

- CASA’s Airworthiness & Engineering Branch
- Lycoming
- Robinson Helicopter Company
- Viva Energy Australia[5]
- the Australian Helicopter Industry Association (AHIA).

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[3] The standard R-44 Raven II has an IO-540 series engine with a different cylinder head layout. This model was not reported to exhibit the same type of problem.

[4] Civil Aviation Safety Authority 2018a, Civil Aviation Safety Authority 2018b, and Australian Helicopter Industry Association 2019.

[5] A major fuel supplier.

The LCDIG subsequently published a 4-page defect reporting form[6] specific to Lycoming engine durability issues in R22 and R44 helicopters. This was sent to 597 R22/R44 operators via email, and 57 operators via traditional mail requesting their assistance. The response rate to this request was about 10%.

The AHIA convened a specialist panel to investigate the cylinder failures, and from that work published *Durability issues – Lycoming O-320, O-360 and O-540 engines fitted to Robinson Helicopter Co R22 and R44 Models* (Australian Helicopter Industry Association, 2019). This report stated:

> The broad issue of poor operational durability of Robinson Helicopter Company model R22 and R44 engine cylinders was principally one of accelerated valve, valve guide and valve seat wear, leading to loss of cylinder compression and the potential for partial power loss events during engine operation.

The report identified other factors in relation to the issue, including:

- The accelerated wear was attributable to the cumulative effect of deposits on the valve stems and exposure to sustained high temperatures.
- These deposits had also been associated with the exhaust valve 'sticking' and preventing the valve from fully closing, where the free movement of the valve is inhibited by the stem accumulations.
- Changes to the constituents of aviation gasoline (Avgas) supplied to northern Australia had the potential to contribute to the engine durability issues.
- Ambient air temperature directly affected engine operating temperatures because of the ‘forced flow’ design of R22/R44 engine cooling.
- Aircraft operating in northern Australia would be routinely exposed to higher ambient air temperatures, particularly those involved in aerial mustering.

As part of this investigation, the ATSB reviewed reported R22 and R44 safety occurrences to identify examples of engine failures, malfunctions or abnormal indications resulting from engine cylinder compression loss. The review was hampered by a lack of data, and no conclusions were able to be drawn from it.

Safety analysis

Engine power loss

While in cruise, en route to conduct mustering, the helicopter began to vibrate, there was a rise in engine manifold pressure, and a drop in main rotor and engine RPM. This prompted the pilot to conduct a forced landing, during which the helicopter hit trees in a heavily wooded area and was destroyed.

Compression on the no. 2 cylinder was within limits when fitted, when tested on 23 June 2022, and when tested on 20 July 2022. Further, maintenance records show there was no significant degradation in cylinder compression over that time. However, in the 64 flying hours since the last periodic inspection, accumulation of carbon deposits on the valve stem and within the valve guide likely progressed to a point where the valve became stuck and did not fully close, reducing power and causing the rough running.

The accumulation of deposits on the exhaust valve stem and within the valve guide was consistent with one of the failure mechanisms identified in the AHIA report. This would have begun from the time the cylinder entered service, and its progression to the point where it resulted

[6] Lycoming cylinder durability investigation group defect report form 1529, available at https://www.casa.gov.au/lycoming-cylinder-durability-investigation-group-defect-report.

in a degradation in engine performance would not always be detected by the aircraft's normal maintenance regime.

Pilot response

The pilot's initial response (raising the collective) reduced the rotor RPM, and was likely reflexive. Had this response continued, rotor stall and a loss of control would have been likely. However, the pilot recognised the decreasing engine and rotor RPM and rapidly lowered the collective to maintain rotor RPM and enter autorotation. The deliberate and timely application of this procedure almost certainly improved the outcome of this event for the pilot.

Engine cylinder changes

Since 2016, considerable investigation work has been carried out by Robinson, Lycoming, industry groups, and CASA to identify the factors contributing to cylinder failures affecting R22 and R44 helicopters used in mustering operations across the northern regions of Australia.

Although this is an ongoing concern, there was insufficient data available relating to the extent and nature of these failures to identify strategies for prevention. Only 10% of operators who were sent the Lycoming Cylinder Durability Investigation Group (LCDIG) request for data responded to it, limiting the group's ability to identify a solution.

Given that more data could assist in determining the precise reason for increased cylinder failures, the ATSB is issuing a safety advisory notice (AO-2022-038-SAN-01). Its purpose is to encourage operators, maintainers, and pilots to complete and return the LCDIG defect report forms any time engine cylinder issues are identified, and to reiterate the importance of doing so.

Findings

ATSB investigation report findings focus on safety factors (that is, events and conditions that increase risk). Safety factors include 'contributing factors' and 'other factors that increased risk' (that is, factors that did not meet the definition of a contributing factor for this occurrence but were still considered important to include in the report for the purpose of increasing awareness and enhancing safety). In addition 'other findings' may be included to provide important information about topics other than safety factors.

These findings should not be read as apportioning blame or liability to any particular organisation or individual.

From the evidence available, the following findings are made with respect to the engine malfunction involving Robinson R22 Beta II, VH-NKV 85 NM north-east of Karumba aerodrome, Queensland, on 6 August 2022.

Contributing factors

- The no. 2 cylinder exhaust valve clearance had reduced well below the minimum due to carbon build-up, resulting in the valve not closing fully, reduced power, and rough running.

Other findings

- The pilot initially raised the collective which reduced the rotor RPM, however after recognising the decreasing engine and rotor RPM, rapidly lowered the collective to maintain rotor RPM and enter autorotation.
- While there had been a reported increase in cylinder failures in Robinson R22 and R44 helicopters used in mustering operations across the northern regions of Australia, there was insufficient data available relating to the extent and nature of these failures to identify strategies for prevention.

Safety actions

Whether or not the ATSB identifies safety issues in the course of an investigation, relevant organisations may proactively initiate safety action in order to reduce their safety risk.

Safety advisory notice to Robinson R22 and R44 operators

SAN number:	AO-2022-038-SAN-01

The ATSB strongly encourages maintainers, operators, and pilots of Robinson R22 and R44 helicopters fitted with Lycoming O-320, O-360 and O-540 series engines to complete a Lycoming cylinder durability investigation group defect report form 1529 any time engine cylinder issues are identified.

General details

Occurrence details

Date and time:	6 August 2022 – 0640 EST	
Occurrence class:	Accident	
Occurrence categories:	Engine failure or malfunction, Forced / Precautionary landing, Collision with terrain	
Location:	85 NM north-east of Karumba aerodrome, Queensland	
	Latitude: 16.4859º S	Longitude: 141.9193º E

Aircraft details

Manufacturer and model:	Robinson Helicopter Company R22 Beta II	
Registration:	VH-NKV	
Operator:	Gulf Coast Aviation	
Serial number:	4637	
Type of operation:	Part 91–General operating and flight rules - other	
Activity:	General aviation / Recreational - Other general aviation flying - ferry flights	
Departure:	Lotus Vale Station, Queensland	
Destination:	Lotus Vale Station, Queensland	
Persons on board:	Crew – 1	Passengers – 0
Injuries:	Crew – 0	Passengers – 0
Aircraft damage:	Destroyed	

Sources and submissions

Sources of information

The sources of information during the investigation included:

- the pilot
- Gulf Coast Aviation
- Robinson Helicopter Company
- Lycoming.

References

Australian Transport Safety Bureau (2018), investigation AR-2018-058, *Exploration of change in aviation gasoline lead content in northern Australia on reported engine–related occurrences.*

Civil Aviation Safety Authority (2018a), *AWB 85-024 – Robinson R22/R44 Engine Exhaust Valve and Valve Guide Distress.*

Civil Aviation Safety Authority (2018b), *AWB 85-025 – Robinson R22/R44 Engine Intake Valve and Valve Seat Distress.*

Australian Helicopter Industry Association (2019), *Durability issues – Lycoming O-320, O-360 and O-540 engines fitted to Robinson Helicopter Co R22 and R44 Models.*

Submissions

Under section 26 of the *Transport Safety Investigation Act 2003*, the ATSB may provide a draft report, on a confidential basis, to any person whom the ATSB considers appropriate. That section allows a person receiving a draft report to make submissions to the ATSB about the draft report.

A draft of this report was provided to the following directly involved parties:

- Civil Aviation Safety Authority (CASA)
- pilot
- Gulf Coast Aviation
- Robinson Helicopter Company
- Lycoming.
- Submissions were received from the pilot and Gulf Coast Aviation. The submissions were reviewed and, where considered appropriate, the text of the report was amended accordingly.

Australian Transport Safety Bureau

About the ATSB

The ATSB is an independent Commonwealth Government statutory agency. It is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers.

The ATSB's purpose is to improve the safety of, and public confidence in, aviation, rail and marine transport through:

- independent investigation of transport accidents and other safety occurrences
- safety data recording, analysis and research
- fostering safety awareness, knowledge and action.

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia, as well as participating in overseas investigations involving Australian-registered aircraft and ships. It prioritises investigations that have the potential to deliver the greatest public benefit through improvements to transport safety.

The ATSB performs its functions in accordance with the provisions of the *Transport Safety Investigation Act 2003* and Regulations and, where applicable, international agreements.

Purpose of safety investigations

The objective of a safety investigation is to enhance transport safety. This is done through:

- identifying safety issues and facilitating safety action to address those issues
- providing information about occurrences and their associated safety factors to facilitate learning within the transport industry.

It is not a function of the ATSB to apportion blame or provide a means for determining liability. At the same time, an investigation report must include factual material of sufficient weight to support the analysis and findings. At all times the ATSB endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, in a fair and unbiased manner. The ATSB does not investigate for the purpose of taking administrative, regulatory or criminal action.

Terminology

An explanation of terminology used in ATSB investigation reports is available on the ATSB website. This includes terms such as occurrence, contributing factor, other factor that increased risk, and safety issue.