Australian Government
Australian Transport Safety Bureau

Engine failure and collision with water involving Garlick Helicopters UH-1H, VH-ONZ

Ben Boyd Reservoir, New South Wales, on 9 January 2020

ATSB Transport Safety Report
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Addendum

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Safety summary

What happened

On 9 January 2020, the pilot of a Garlick Helicopters UH-1H, registered VH-ONZ, was tasked at Moruya, New South Wales, to assist fire-ground crews with a bush-fire clean-up operation near the town of Eden. After arriving in the hover overhead the Ben Boyd Reservoir to uplift water, the helicopter's engine failed, resulting in a rapid descent, and impact with the water followed by sinking and rollover. The pilot conducted an underwater escape and sustained a minor injury. The helicopter was substantially damaged and later recovered from the reservoir.

What the ATSB found

The helicopter's engine intake and compressor section were found to be damaged on initial examination by the operator's maintenance organisation and the engine was subsequently sent to Honeywell Engines in the United States for a teardown inspection and failure analysis. Honeywell found indications of a restriction of oil flow to the main bearings in the front section of the engine, which led to their failure. This resulted in contact between the power and compressor shafts, disconnection of rotational drive to the fuel pump and fuel control, and subsequent fuel starvation. As the oil passages for the front section of the engine passed their flow tests, the reason for the restriction could not be determined.

The pilot had completed helicopter underwater escape training about 8 months prior to the accident and credited this as a life-saving course. The training also included elements for emergency breathing systems (EBS), but the pilot did not conduct those elements as the equipment had not been introduced into the company's operation. Survivability research reports have consistently found drowning to be the leading cause of fatalities in helicopter water impact and ditching accidents, and therefore, the ATSB concluded that an EBS would have reduced the risk of drowning.

What has been done as a result

Following the accident, the pilot acquired a compressed air EBS and intends to conduct the EBS elements of future helicopter underwater escape training courses. The operator reported they have started investigating how to implement EBS company-wide, and how to attach the units to their pilots without limiting their movement when conducting long-line operations.

Safety message

Although helicopter fire control operations are predominantly conducted overland, the requirement to uplift water results in repeated approaches and departures overwater. If a catastrophic failure occurs in this period of the operation, the helicopter may have insufficient energy to be manoeuvred clear of water to an emergency landing site. Where helicopter underwater escape training is required for an operation, there is a recognition that an emergency may result in the need for an underwater escape, in which case an EBS would also likely be beneficial.

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The occurrence

On 9 January 2020, at about 0830 Eastern Daylight-saving Time,[1] the pilot of a Garlick Helicopters UH-1H, registered VH-ONZ, was tasked at Moruya, New South Wales, to assist fire-ground crews with a bush-fire clean-up operation near the town of Eden. The helicopter was equipped with a 100 ft long-line and 1,400 L water bucket. It was flown from the left seat, with essential engine instruments and caution lights mounted on the left door for ease of reference. A bubble window was fitted to the left door so that the pilot could view the bucket at the end of the long-line underneath the helicopter.

TracPlus[2] data recorded the helicopter's departure from Moruya Airport at 0957. On arrival at the Eden fire-ground, the pilot made radio contact with the fire-ground crew and received approval to use the Ben Boyd Reservoir as the water source for the day. Two refuels were conducted at Merimbula Airport at 1227 and 1516. The helicopter departed Merimbula on completion of the second refuel at 1547 to return to the fire-ground. The last recorded TracPlus data was overhead the Ben Boyd Reservoir at 1559 (Figure 1).

Figure 1: Flight track and key locations

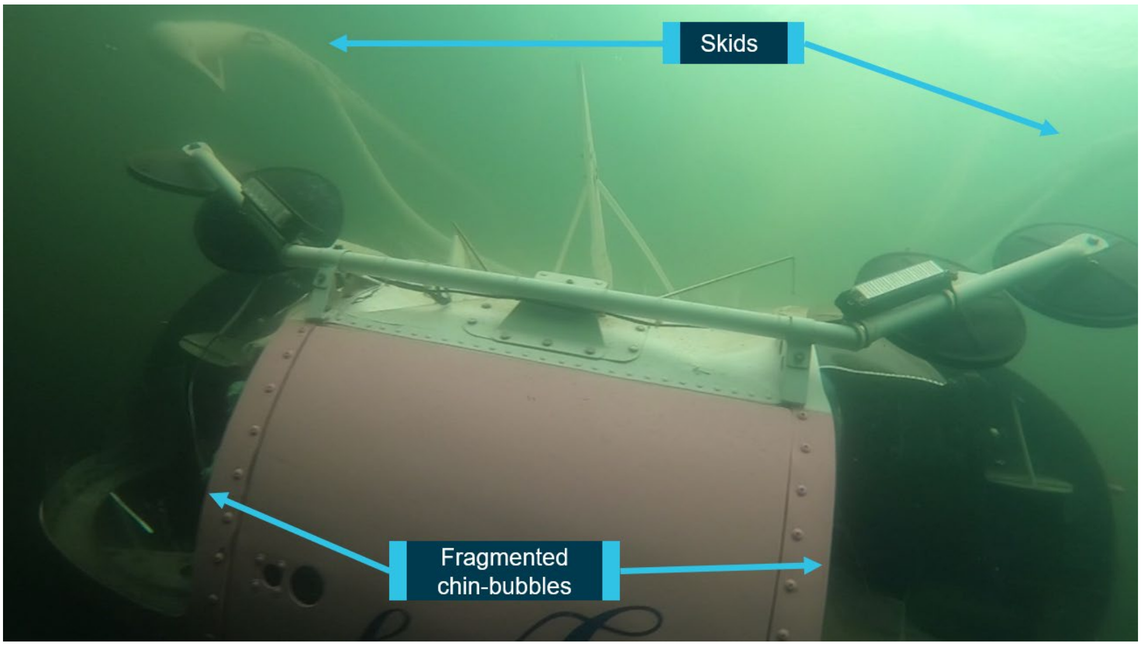
Source: Google earth with TracPlus data supplied by operator, annotated by the ATSB

On arrival in a 100 ft hover over the reservoir, the pilot heard a grinding noise. At that time, the pilot was looking below the helicopter at the bucket and did not notice any engine gauge readings or if any caution lights activated. Following the grinding noise, the pilot jettisoned the long-line and bucket, and applied forward cyclic to move the helicopter forward to a small clearing on a headland. However, a complete loss of engine power occurred before the helicopter could reach land, resulting in an immediate descent into the water.

1 Eastern Daylight-saving Time (EDT): Coordinated Universal Time (UTC) + 11 hours.
2 TracPlus is an asset tracking, reporting and messaging service for aircraft, vessels, vehicles and personnel.

The pilot reported making several emergency broadcasts and using all the main rotor energy available to reduce the rate of descent before the helicopter impacted the water in what was described as a 'belly-flop, straight down'. On impact, the chin-bubbles fragmented, and the helicopter rolled inverted, filled with water, and sank (Figure 2).

Figure 2: Helicopter inverted in reservoir



Source: Department of Defence, annotated by the ATSB

The pilot waited for all motion to cease and attempted to open the pilot's left door using the normal mechanism. The door could not be opened, so the pilot released the lap-strap (harness) and moved across the cockpit to open the co-pilot door. This door could not be opened, and the pilot then moved into the cabin.

In the cabin, the pilot found a pocket of air and 'took a couple of breaths', then attempted to open the cabin sliding doors, but was unsuccessful (the cabin doors comprised a rear sliding door that latched to a forward hinged panel (quarter door)). The pilot then punched out the right sliding door rear window and egressed. No attempts were made to open any of the doors or windows using their emergency release mechanisms.

After exiting the cabin, the pilot inflated the lifejacket, swam to shore, and then walked about 1 km to a road to be collected. About 15 minutes later, an ambulance arrived to take the pilot to hospital for a medical examination. The pilot sustained a minor injury, and the helicopter was substantially damaged and later recovered from the reservoir (Figure 3).

Figure 3: Recovery of VH-ONZ - cabin sliding doors removed

Source: Department of Defence

Context

Pilot information

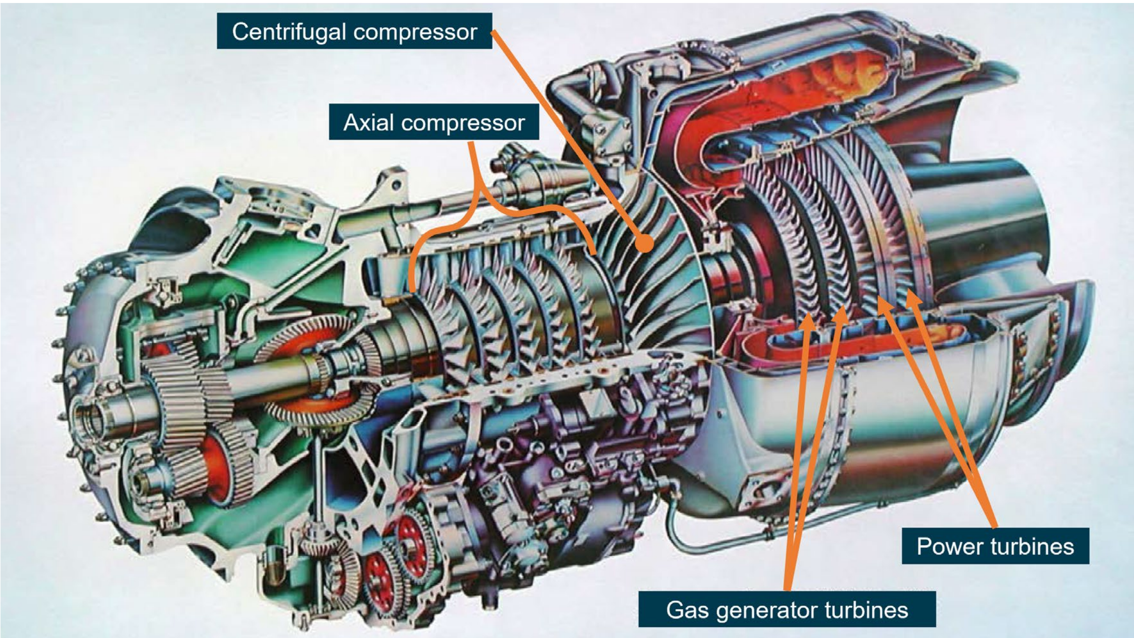
The pilot held a Commercial Pilot Licence (Helicopter) with the required ratings and endorsements for the operation and had accumulated a total of 12,023 flying hours (3,008 hours on the UH-1H). The pilot held a valid Class 1 Aviation Medical Certificate and recalled feeling fully alert at the time of the accident.

Helicopter underwater escape training (HUET) was a New South Wales Rural Fire Service contract requirement with a 3-year currency. The pilot last completed the course on 13 May 2019, about 8 months prior to the accident, and had completed about five to six courses since the requirement was introduced. The HUET course included emergency breathing systems (EBS) for underwater escape, but the pilot did not complete those elements as the equipment had not been introduced into their operation. The carriage of EBS was not a requirement for the operation.

Engine information

The engine was a Honeywell model T53-L-13B, serial number LE-22213R.[3] This model of engine is a five-stage axial, single-stage centrifugal compressor driven by a two-stage gas generator turbine section. Output power is generated by a two-stage power turbine using a reverse flow, annular combustion chamber (Figure 4).

Figure 4: T53-L-13 engine



Source: Honeywell

Maintenance inspection of the engine

Following recovery of the helicopter from the reservoir, the engine was inspected by the operator's maintenance organisation. A borescope inspection of the engine compressor section revealed a rotor blade failure in addition to other rotor blade and inlet guide vane damage (Figure 5). The engine was sent to Honeywell Engines in the United States for a teardown inspection and failure analysis. The following engine information sections summarise their findings.

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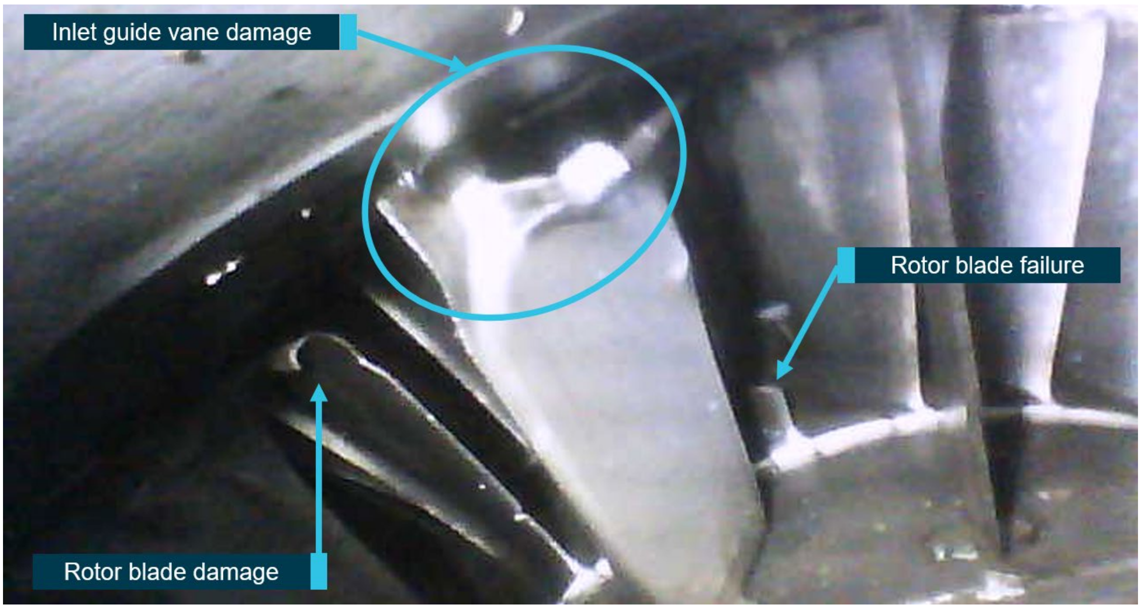
3 The T53-L-13B is the military variant of the T5313B. According to the type certificate holder record, the type certificate passed from Textron Lycoming to AlliedSignal in 1995 and then to Honeywell International Inc. in 1999.

Figure 5: Borescope image of damage to engine inlet and compressor



Source: Operator, annotated by the ATSB

Engine teardown and failure analysis

Honeywell's examination found that the bearings at the front of the engine (no. 1 compressor shaft bearing and no. 21 power shaft bearing) had failed and exhibited excessive heat damage (Figure 6). However, the main bearings located at the rear of the engine (no. 2, no. 3 and no. 4) did not exhibit this damage. This indicated that a reduction in oil flow had occurred to the front section.

The engine is lubricated by filtered oil delivered from the oil pump, driven by the accessory gearbox, into two main flow paths. One flow path is through the internal passages in the inlet housing to the front section of the engine, while the other is through the external oil pressure hose assemblies to the rear section of the engine.

Debris adhering to the engine oil chip detector,[4] located nearest the external oil reservoir, was found to be consistent with the steel base and silver-plating materials for the no. 1 and no. 21 bearings and their cages.[5] This suggested that the bearings were failing while the engine was still rotating and transferring oil through the engine. A continuity check of the engine oil chip detector determined that the circuit was 'closed', which would indicate a chip detection (although none recalled by the pilot).

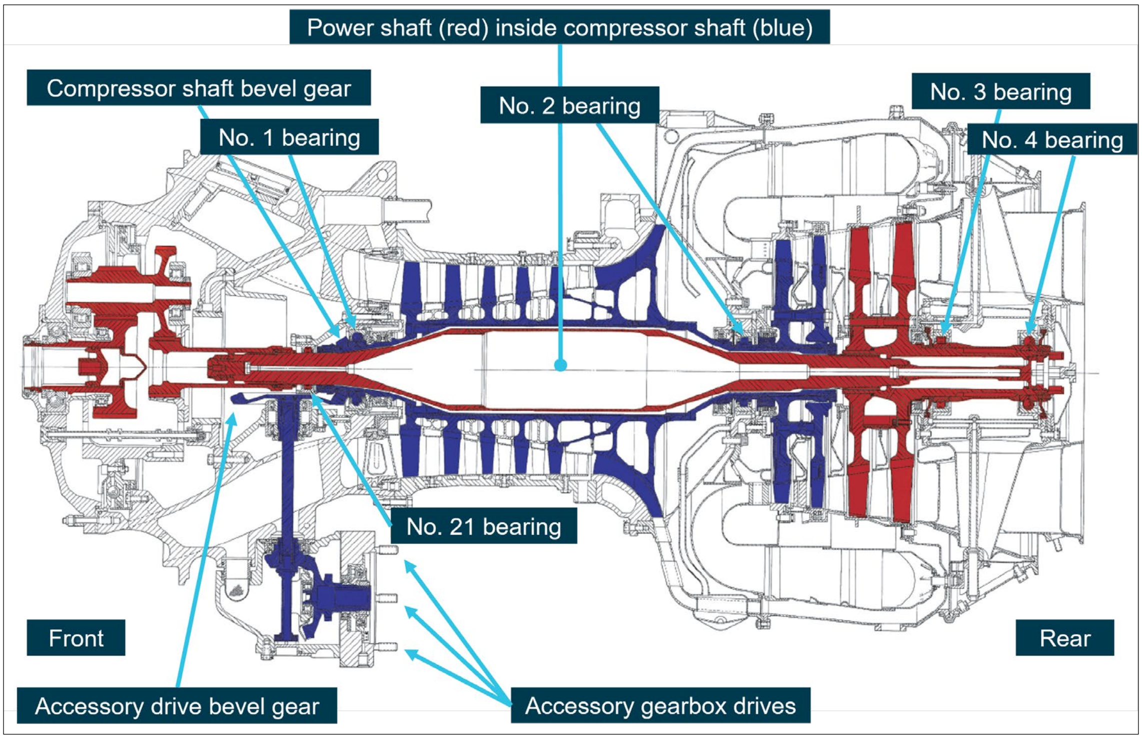
The oil flow passages for the no. 1 and no. 21 bearings were inspected and flow tested with no evidence of a blockage found. Metallic debris, consistent with bearing material, was captured from the power shaft bearing retainer (oil flow pathway to the front section). However, this material was released at a very low-pressure during testing, which indicated the debris was likely transported to this location during the last moments of the engine failure and shutdown and was not likely blocking oil flow during earlier operation. No other debris was noted in the lubrication oil passages to the no. 1 and no. 21 bearings that would have prevented normal operation.

4 Chip detector: a magnetic device used to gather chips of metal from engine or transmission oil to provide early warning to maintenance personnel of impending engine failure. The accident helicopter had two chip detectors linked to an in-cockpit indicating light to provide immediate indication to the pilot.

5 The function of the bearing cage is to hold the rolling elements in proper orientation, so they do not group together.

Figure 6 depicts the compressor (N1 in blue) and power (N2 in red) sections of the engine, the locations of the main bearings for the front (no. 1 and no. 21) and rear (no.2, no.3 and no.4) sections, and the accessory drive system (includes drives for the oil pump and fuel control).

Figure 6: Cross-section of a T53-L-13 engine showing the location of the main components and bearings



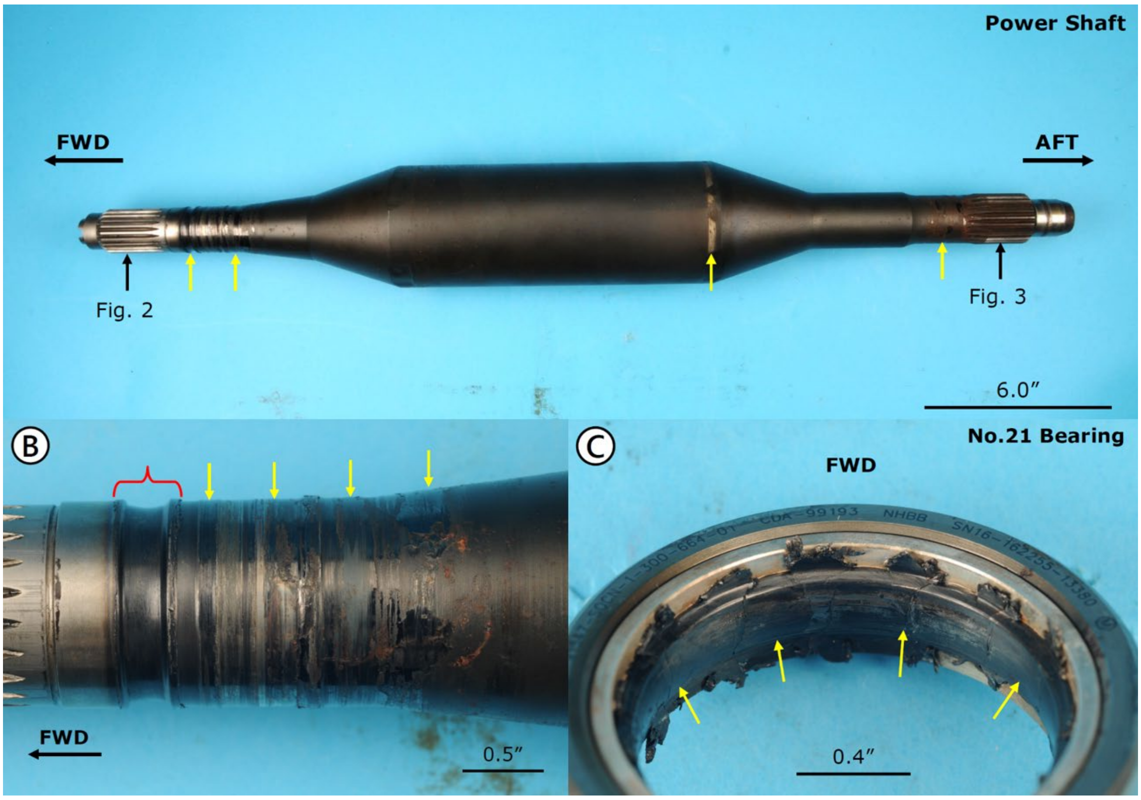
Source: Honeywell, annotated by the ATSB

From the information provided by the pilot, and examination of the engine, Honeywell provided the following sequence of events for the engine failure:

- Lubrication oil to the no. 21 and the no. 1 bearings was reduced or blocked.
- The no. 21 bearing began to overheat and fail, resulting in excessive heat being generated in the power shaft and nearby components.
- The forward compressor shaft seal assembly began to fail resulting in additional heat input to the nearby components.
- The no. 1 bearing began to fail due to excessive heating.
- Due to the no. 1 bearing failing, the forward end of the compressor shaft was no longer properly retained. This allowed contact between the compressor and power shafts as well as axial compressor blade tip contact with their respective shrouds. This likely resulted in the 'grinding noise' heard by the pilot shortly before the loss of engine power.
- The compressor shaft accessory drive bevel gear, attached to the forward end of the compressor shaft, began to lose mesh with the driven accessory drive bevel gear, which provided rotational power to the fuel pump and the fuel control.
- The fuel pump and fuel control stopped rotating due to the loss of drive from the compressor shaft accessory drive bevel gear.
- The engine flamed out due to a loss of fuel flow from the fuel pump and fuel control.
- Power was lost to the engine.

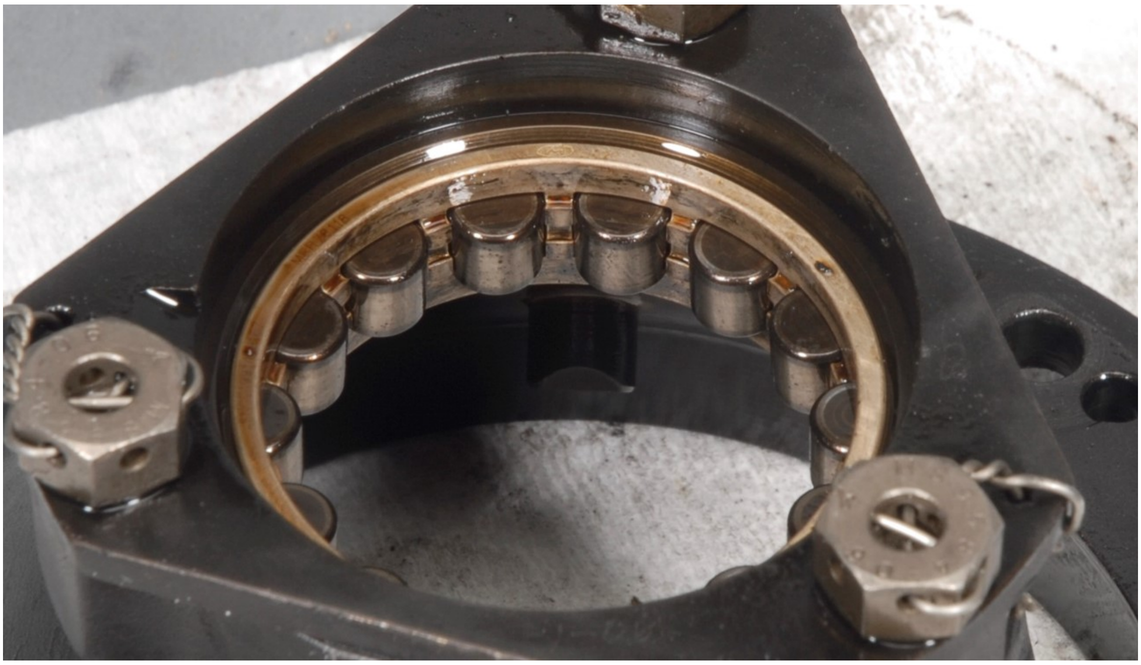
Figure 7 depicts the damage found to the power shaft (top and bottom left) and no. 21 bearing (bottom right). The yellow arrows depict wear, and the red bracket (bottom left) depicts a groove in the shaft at the location of the no. 21 bearing. Figure 8 depicts a comparison no. 21 bearing fitted to its power shaft bearing retainer.

Figure 7: Damaged power shaft and no. 21 bearing



Source: Honeywell

Figure 8: Comparison no. 21 bearing



Source: Honeywell

Engine bearings history

At the previous engine hot section[6] inspection on 22 February 2018, the no. 1 and no. 21 bearings were replaced. The engine inspection facility[7] reported that the no. 1 and no. 21 bearings were replaced for compliance with service bulletins T53-180 and T53-056, respectively. There were no defects regarding wear or discoloration of the removed bearings. Both bearings were replaced with new parts purchased directly from Honeywell. The engine oil supply and scavenge pump was functionally tested by another facility and deemed serviceable.

The engine was subject to 150-hourly oil filter inspections and 300-hourly oil replacements. The last 150-hourly inspection, which included an oil replacement and chip detector inspection, was certified as completed on 9 January 2020, the morning of the accident. No defects were found. The bearings had accumulated about 1,128 hours prior to the accident, at which stage the engine had accumulated about 1,880 hours since the last engine overhaul.

A search by Honeywell did not find any previous no. 21 bearing failures from inadequate lubrication reported to either Lycoming or Honeywell. Honeywell reported that, in the 1970s and 1980s, there were several no. 21 bearing failures attributed to the use of a bronze cage surrounding the rollers. Lycoming released a service bulletin in the 1980s to replace the bronze cage with a steel cage, with a compliance time limit. The accident no. 21 bearing had a steel cage, which did not fail.

A search of the Civil Aviation Safety Authority service defect reporting system found no reports for restriction or blockage of oil flow, or problems with the no. 1 or no. 21 bearings, in the previous 20 years for either the Lycoming T53 family of engines or the Honeywell T5313B engine. However, the ATSB was able to locate a Honeywell report from 29 October 2009 for a T53-L-703 engine failure in the United States. The report concluded that the engine experienced a failure of the no. 1 bearing and that a cage failure may have been the initiating event. This was a bronze cage that had separated into multiple fragments. There was evidence of high metal temperature exposure, but no evidence of oil starvation. The no. 21 bearing was not removed but observed to be intact and rotated freely. The cause of the cage failure and over-temperature condition could not be determined. The accident no. 1 bearing cage did not fail and was a different part number to the earlier 2009 report.

Survival aspects

Underwater exits

The pilot reported that normal and emergency release mechanisms for exits were included in the HUET course, but recalled that during the accident, '[I] didn't think about any of the emergency releases for the doors or windows…if one didn't work, then went for another exit'. The pilot reported that the cabin door window used for the escape was selected as 'daylight' could be seen through it and punched it with the belief that it was the quarter door window. Following the recovery of the helicopter it was found to be the right sliding door rear window that had an emergency release. The pilot could not recall how the air pocket was found in the cabin prior to the escape.

Following the recovery of the helicopter from the reservoir, the operator checked the pilot and co-pilot doors and found that they were both jammed due to airframe distortion and could not be opened. The rear of the airframe was less distorted, and the cabin doors could be opened.

A 2020 European Union Aviation Safety Agency (EASA) research report, *Underwater escape from helicopters*, found that the ability to escape through a particular exit was influenced by several factors. They noted:

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[6] Generally, the hot section of the engine includes the combustion and turbine sections.

[7] Honeywell authorised T53 engine service centre.

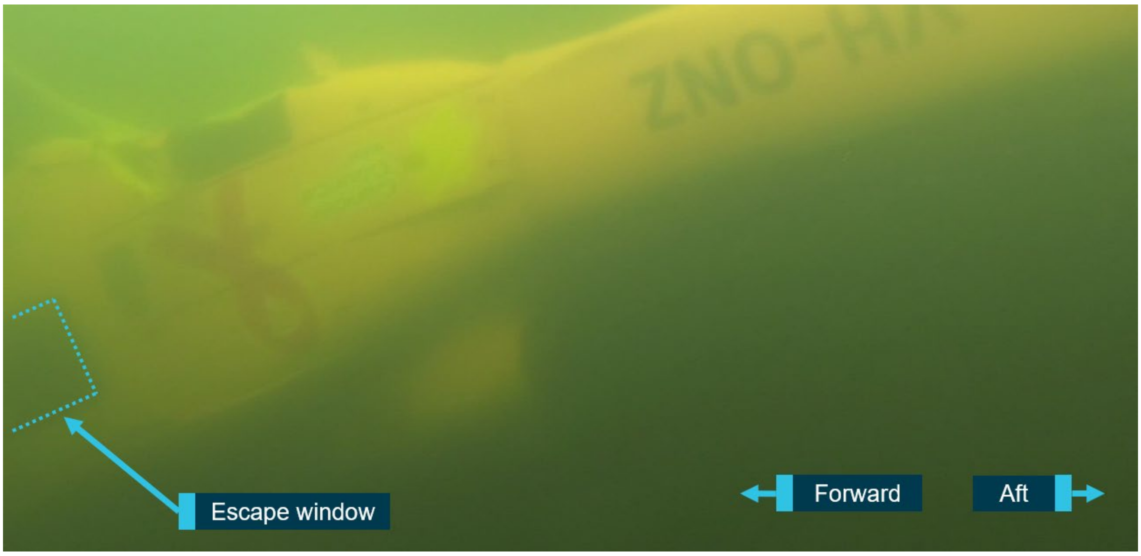
> It is generally accepted that if a helicopter occupant needs to remove an exit or escape window, then it is highly desirable to do this with the seat harness still secured, enabling the individual to apply force effectively. This was confirmed by Mills and Muir (1998, 1999a); a number of their study participants had released their seat belt before operating the exit, making operation of the exit either difficult or impossible.

Despite the difficulty with the underwater escape, the pilot described the HUET course as 'great', and very realistic. When the helicopter impacted the water and started to sink and rollover, the pilot placed one hand on the seatbelt and the other on the door handle and waited for all movement to stop before attempting to escape, in accordance with one of the HUET objectives to maintain orientation. At interview, the pilot reported 'would have been dead without HUET'. As previously emphasised by the ATSB (*Regular helicopter underwater escape training*):

> …HUET (helicopter underwater escape training) is considered to provide individuals with familiarity with the crash environment and confidence in their ability to cope with the emergency situation. Interviews with survivors from helicopter accidents requiring underwater escape frequently mention they considered that HUET had been very important in their survival. Training provided reflex conditioning, a behaviour pattern to follow, reduced confusion, and reduced panic.

Figure 9 depicts the helicopter inverted in the reservoir and the location of the right sliding door rear window, used by the pilot for the underwater escape.

Figure 9: Location of escape window



Source: Department of Defence, annotated by the ATSB

Emergency breathing systems

In May 2001, the North Atlantic Treaty Organization's Research and Technology Organization published report RTO-AG-341, *The Requirements for an Emergency Breathing System (EBS) in Over-Water Helicopter and Fixed Wing Aircraft Operations*. Their report concluded that a persistent 15 per cent fatality rate in helicopter ditching was due to drowning and that the principal cause was the inability to breath-hold long enough to make an escape. They concluded that some form of EBS, whether a rebreather or compressed air unit, would improve survivability.

In their February 2008 manual, the Research and Technology Organization discussed the benefits and limitations of three distinct types of EBS. They were the compressed air, rebreather, and hybrid rebreather systems.

Compressed air system

A compressed air system is based on a self-contained underwater breathing apparatus. This type of equipment is classed as an open-circuit demand system and can be purged underwater prior to use. This means that, when the user breathes out, the exhaled air leaves the demand valve and enters the water. None of the expelled air is collected and reused again, as in the case of a closed-circuit demand system such as a rebreather.

Rebreather system

The rebreather is based on exhaling and rebreathing your own air. As exhaled air contains un-metabolised oxygen, it can be rebreathed many times before the oxygen is used up. The air is collected at atmospheric pressure by the wearer expelling a deep breath into a counter-lung (air bladder) via the mouthpiece prior to submersion. It can then be inhaled and exhaled into the counter-lung when the user is unable to hold their breath anymore.

Hybrid rebreather system

This system works on the same principle as a rebreather, but it also contains a small cylinder of compressed air fitted to the counter-lung. The air cylinder can be automatically activated by saltwater immersion or manually activated using an emergency inflator pull cord. The reason for the cylinder is to provide some air for those who did not get a breath of air before submersion.

Technical standard for emergency breathing systems

In May 2013, the United Kingdom Civil Aviation Authority published CAP 1034, *Development of a technical standard for emergency breathing systems*. The CAP included the following explanation about the need for EBS:

> Drowning is the primary cause of death in helicopter water impact accidents. It is a well documented fact that a helicopter will capsize and/or sink in a high proportion of water impact accidents (e.g. Rice & Greear, 1973; Brooks, 1989; Clifford, 1996). To make a successful escape, the occupant must be conscious, mobile, and be familiar with escape procedures and escape routes. The risk of drowning is very high due to the fact that there is a mismatch between the time needed to escape from the inverted and possibly sinking helicopter and the time that individuals can hold their breath underwater (Cheung et al, 2001). When considering the means of mitigating the risk of drowning, considerable effort has gone into improving both the crashworthiness of helicopters and the ability to keep helicopters afloat (see CAA, 2005 for review of research).
>
> Emergency breathing systems (EBS) provide an alternative or additional means to mitigate the risk of drowning. They are designed to allow helicopter occupants to breathe underwater for at least 1 minute, overcoming the need to make a single breath last for the duration of the escape process. If deployed successfully, EBS use should therefore increase the likelihood of survival.

The CAP draft technical standard proposed two categories of EBS performance. Category ‘A’ systems were those with the capability to be deployed underwater and therefore suitable for use in the worst-case water impact accidents where capsize and/or sinking occur immediately after impact. Category ‘B’ systems were those that were required to be deployed in air, and therefore limited to ditching scenarios where there was sufficient time to deploy the system prior to submersion.

The CAP noted there was a small risk of barotrauma[8] associated with the compressed air EBS and hybrid EBS, and that a few injury cases had been reported during training. Therefore:

> When selecting EBS, the end user must carry out a risk assessment looking at likely conditions of use, training needs, and maintenance and servicing requirements before deciding on a suitable device that best matches those requirements.

Height-speed envelope avoid area

If a helicopter is unable to be safely landed following a loss of power, the manufacturer must provide a limiting height-speed envelope diagram. The diagram must include the avoid areas, which denote the combinations of height and forward airspeed where it may not be possible to establish a satisfactory autorotation prior to contacting terrain. A height of 100 ft and airspeed less

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8 An injury caused by an excessive increase in pressure in cavities such as the lung or ear.

than 40 kt places the UH-1H helicopter with the T53-L-13B engine within the avoid area of its height-speed envelope, which is where the accident helicopter was at the time of the water uplift and engine failure.

Safety analysis

Introduction

While conducting fire control activities in the vicinity of Eden, New South Wales, using the Ben Boyd Reservoir as the water source, the helicopter's engine failed in the hover over the reservoir. This resulted in a rapid descent into the water, followed by a successful underwater escape by the pilot.

This analysis will discuss the collision with water and underwater escape by the pilot, the results of the engine failure analysis and use of emergency breathing systems.

Collision with water and underwater escape

When the pilot heard a mechanical 'grinding noise', their attention was initially focussed on the bucket below the helicopter. The pilot then immediately transitioned to an emergency landing site in front of the helicopter. However, as the helicopter was in the avoid area of the height-speed envelope, the pilot was unable to arrest the rate of descent before impacting the water. The severity of the impact fragmented the chin bubbles and distorted the airframe, which resulted in the helicopter rapidly filling with water and sinking.

The pilot had completed helicopter underwater escape training about 8 months prior to the accident and was able to wait for all motion to cease, then perform the initial actions to maintain orientation. While the pilot did not attempt to open the pilot or co-pilot doors with the emergency release mechanism, it was unlikely the doors would have released due to the airframe distortion.

After moving from the cockpit into the cabin, the pilot found a pocket of air to breathe, but was unable to open the cabin sliding doors. This was likely a result of the underwater environment impeding the pilot's ability to apply sufficient force to overcome the normal static friction of the sliding doors. However, the pilot was able to punch out the rear window of the right sliding door. This highlights the importance of the design of windows as emergency escape routes, and the potential need for a supplementary air supply for underwater escape, which is discussed further in the section on *Emergency breathing systems*.

Engine failure mechanism

Following the discovery of damage to the engine inlet and compressor section by the operator's maintenance organisation, the engine was sent to Honeywell Engines for teardown and failure analysis. Honeywell concluded that the no. 1 and no. 21 bearings in the front section of the engine had failed and exhibited heat damage. This indicated a reduction in oil flow to the front of the engine. There was no evidence of this for the bearings at the rear section of the engine, which were supplied by a separate oil flow pathway.

The failure of the main bearings at the front of the engine resulted in contact between the power and compressor shafts, disconnection of rotational drive to the fuel pump and fuel control, and subsequent fuel starvation. As the oil passages to the bearings at the front of the engine passed their flow tests, it could not be determined how or why a reduction in lubrication occurred. A review by the manufacturer and ATSB found no historical evidence of a similar failure mechanism.

Emergency breathing systems

The ATSB reviewed several research reports into helicopter overwater accident survival and noted that they consistently reported drowning as the leading cause of fatalities. All reports attributed this to the inability of the occupant to breath-hold for the duration of the escape with a variety of contributing factors. In this accident, the cockpit doors were both jammed, which required the pilot to locate an alternate escape route through the cabin. The pilot found an air pocket in the cabin, which enabled the escape time to be extended beyond the initial breath-hold time. This provided the pilot with sufficient oxygen for the physical effort required to attempt to open the sliding doors and then push out a window. It could not be determined if the pilot would have drowned without the air pocket, but it would have increased the likelihood.

While helicopter underwater escape training provides a learning environment for the essential skills of maintaining orientation, location, and operation of exits, it does not address the potential need to extend an individual's breath-hold. Extending breath-hold may be necessary for problem-solving and physical effort during the underwater escape sequence, such as dealing with snagging hazards, obstructions, or inoperative exits that require an alternative escape route, as in this accident. An emergency breathing system would have afforded the pilot sufficient time to perform the escape actions without an air pocket and therefore reduce the risk of drowning.

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 failure involving Garlick Helicopters UH-1H, registered VH-ONZ, near Eden, New South Wales, on 9 January 2020.

Contributing factors

- While hovering over the Ben Boyd reservoir to uplift water for fire control operations, the helicopter's engine failed, which resulted in a collision with water and underwater escape by the pilot.
- For reasons undetermined, the no. 1 and no. 21 bearings at the front of the engine failed due to inadequate lubrication. This resulted in contact between the power and compressor shafts, disconnection of rotational drive to the fuel pump and fuel control, and subsequent fuel starvation.

Other factors that increased risk

- The pilot was not equipped with an emergency breathing system, nor required to be. Although the pilot was able to successfully escape from underwater after finding an air pocket, an emergency breathing system would have reduced the risk of drowning.

Other findings

- The pilot had completed helicopter underwater escape training about 8 months prior to the accident and at 3-year intervals since it was introduced on the New South Wales firefighting aerial support contract.

Safety action

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. All of the directly involved parties are invited to provide submissions to this draft report. As part of that process, each organisation is asked to communicate what safety actions, if any, they have carried out to reduce the risk associated with this type of occurrences in the future. The ATSB has so far been advised of the following proactive safety action in response to this occurrence.

Additional safety action by the pilot and operator

Following the accident, the pilot acquired a compressed air emergency breathing system and has decided to conduct those elements of future helicopter underwater escape training courses. The operator reported they have started investigating how to implement emergency breathing systems company-wide, and how to attach the units to their pilots without limiting their movement when conducting long-line operations.

General details

Occurrence details

Date and time:	9 January 2020 – 1559 EDT	
Occurrence category:	Accident	
Primary occurrence type:	Engine failure or malfunction	
Location:	Ben Boyd Reservoir, New South Wales	
	Latitude: 37º 07.348' S	Longitude: 149º 51.220' E

Aircraft details

Manufacturer and model:	Garlick Helicopters Inc. UH-1H	
Registration:	VH-ONZ	
Operator:	Aerial Agriculture PTY LTD	
Serial number:	5229	
Type of operation:	Aerial work	
Activity:	Fire control	
Departure:	Moruya Airport, New South Wales	
Destination:	Moruya Airport, New South Wales	
Persons on board:	Crew – 1	Passengers – 0
Injuries:	Crew – 1 (minor)	Passengers – 0
Aircraft damage:	Substantial	

Glossary

CAA	Civil Aviation Authority (United Kingdom)
CAP	Civil Aviation Publication (CAA)
EASA	European Union Aviation Safety Agency
EBS	Emergency breathing system
HUET	Helicopter underwater escape training
RTO	Research and Technology Organization (North Atlantic Treaty Organization)

Sources and submissions

Sources of information

The sources of information during the investigation included the:

- Department of Defence (Defence Flight Safety Bureau)
- Honeywell Engines
- operator
- operator's maintenance organisation
- pilot.

References

Brooks CJ, Tipton MJ 2001, *The Requirements for an Emergency Breathing System (EBS) in Over-Water Helicopter and Fixed Wing Aircraft Operations*, North Atlantic Treaty Organization Research and Technology Organization RTO-AG-341.

Coleshaw S, Howson D 2020, *Research report: Underwater escape from helicopters*, European Union Aviation Safety Agency.

Gibbs P 2008, *The Principles of Emergency Breathing Systems (EBS) for Helicopter Underwater Escape*, in Chapter 7 of Survival at Sea for Mariners, Aviators and Search and Rescue Personnel, North Atlantic Treaty Organization Research and Technology Organization RTO-AG-HFM-152.

UK Civil Aviation Authority 2013, Civil Aviation Publication 1034: *Development of a technical standard for emergency breathing systems*, The Stationary Office, May 2013.

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
- Department of Defence (Defence Flight Safety Bureau)
- Honeywell Engines
- the operator
- the operator's maintenance organisation
- the pilot
- United States National Transportation Safety Board.

No submissions were received from the directly involved parties.

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.