FINAL REPORT

ACCIDENT 2020/2362

State Commission on Aircraft Accidents Investigation (PKBWL)

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FINAL REPORT

Accident

OCCURRENCE NO – 2020/2362

AIRCRAFT – Helicopter Robinson R44 Raven II, SP-SVW

DATE AND PLACE OF OCCURRENCE – 13 August 2020, Vistula river, near Sady, Mazowieckie Voivodship

The Report is a document presenting the position of the State Commission on Aircraft Accidents Investigation concerning circumstances of the air occurrence, its causes and safety recommendations. The Report was drawn up on the basis of information available on the date of its completion.

The investigation may be reopened if new information becomes available or new investigation techniques are applied, which may affect the wording related to the causes, circumstances and safety recommendations contained in the Report.

Investigation into air the occurrence was carried out in accordance with the applicable international, European Union and domestic legal provisions for prevention purposes only. The investigation was carried out without application of the legal evidential procedure, applicable for proceedings of other authorities required to take action in connection with an air occurrence.

The Commission does not apportion blame or liability.

In accordance with Article 5 paragraph 6 of the Regulation (EU) No 996/2010 of the European Parliament and of the Council on the investigation and prevention of accidents and incidents in civil aviation […] and Article 134 of the Act – Aviation Law, the wording used in this Report may not be considered as an indication of the guilty or responsible for the occurrence.

For the above reasons, any use of this Report for any purpose other than air accidents and incidents prevention can lead to wrong conclusions and interpretations.

This Report was drawn up in the Polish language. Other language versions may be drawn up for information purposes only.

WARSAW 2022

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Abbreviations

Abbreviation	Meaning
AGL	Above Ground Level
AMSL	Above Mean Sea Level
AMO	Aircraft Maintenance Organisation
ARC	Airworthiness Review Certificate
ATC	Air Traffic Control
AVGAS	Aviation gasoline
CAA/ULC	Civil Aviation Authority of the Republic of Poland
CAMO	Continuing Airworthiness Management Organization
CPL(H)	Commercial Pilot Licence (Helicopter)
CS 27	Certification Specifications 27
EPMO	Warsaw Modlin Airport
FAR 27	Federal Aviation Regulations 27
FATO	Final Approach and Take-Off Area
FH	Flight Hours
FI	Flight Instructor
ft	Feet
kt	Knot
kW	Kilowatt
LMT	Local Mean Time
LPR	Polish Medical Air Rescue
MS	Maintenance Statement
NOTAM	Notice to Airman
P/N	Part Number

PF	Pilot Flying
PIC	Pilot-in-Command
POH	Pilot Operating Handbook
RHC	Robinson Helicopter Company
R44 II	Robinson R44 Raven II
S/N	Serial Number
SCAAI/ PKBWL	State Commission on Aircraft Accidents Investigation
SP	Aircraft
OPC/KTP	Operator Proficiency Check
TWR	Aerodrome Control Tower or aerodrome control
UTC	Coordinated Universal Time

General information

Occurrence reference number:	2020/2362			
Type of occurrence:	ACCIDENT			
Date of occurrence:	13 August 2020			
Place of occurrence:	Vistula river, near Sady, Mazowieckie Voivodship, Poland			
Type and model of aircraft:	Helicopter Robinson R44 Raven II			
Aircraft registration marks:	SP- SVW			
Aircraft user/operator:	Salt Aviation Sp. z o.o.			
Aircraft Commander:	CPL(H)			
Number of victims/injuries:	Fatal	Serious	Minor	None
	-	2	-	-
Domestic and international authorities informed about the occurrence:	Polish Civil Aviation Authority			
Investigator-in-Charge:	Mieczysław Wyszogrodzki			
Investigating Authority:	State Commission on Aircraft Accidents Investigation (PKBWL)			
Accredited Representatives and their advisers:	Not appointed			
Document containing results:	Final Report			
Safety recommendations:	NONE			
Addressees of the recommendations:	Not applicable			
Date of completion of the investigation:	12 April 2022			

Synopsis

On 13 August, 2020, a familiarisation flight with the candidate for flight training[1] on Robinson R44 II helicopter was planned. The helicopter took off at 11:15 hrs UTC from the Warsaw-Modlin aerodrome (EPMO) to the flight zone flight zone, located between the India and Hotel waypoints on the northern side of EPMO aerodrome. In the above-mentioned area, the pilot performed a low height flight with a demonstration of off-field landing. Then the pilot performed a circuit flight to the EPMO FATO descending to the hover height without touchdown. After re-establishing communication with the EPMO TWR, the pilot was cleared to continue the flight south of the aerodrome aerodrome in the Uniform waypoint zone, over the mouth of the Narew river, where it meets the Vistula river. The pilot performed a westward flight, after flying over the Vistula river bridge, he began a descent. According to the pilot, when he tried to stop descending, (at a height of 500 ft AGL), the collective was blocked, and then the helicopter collided with the water surface of the Vistula river. Persons on board were seriously injured and the helicopter was destroyed. The pilot and the candidate were picked up from the water and taken ashore by the Police river patrol. Emergency services took the injured to hospitals for medical treatment.

The investigation was conducted by the PKBWL Investigation Team in the following composition:

- Piotr Richter – Investigator-in-Charge until 06.10.2020
- Mieczysław Wyszogrodzki – Investigator-in-Charge from 06.10.2020 (PKBWL)
- Tomasz Makowski (PKBWL)
- Krzysztof Błasiak (PKBWL)
- Grzegorz Pietraszkiewicz (PKBWL)
- Piotr Borowik (PKBWL)
- Bartłomiej Czerkowski (PKBWL)

Cause of the occurrence:

Incorrect estimation of the flight height during descend above the river's surface.

Contributing factor:

Performing flight below permissible height.

PKBWL has not proposed safety recommendations after the investigation.

[1] The term candidate for aviation training is used because the start of her training has not been reported to CAA. The term "candidate" is used throughout the rest of the report.

1. FACTUAL INFORMATION

1.1. History of the flight

On August 13, 2020, the Approved Training Organization (ATO) scheduled an hour-long familiarisation flight with a potential student considering R44 helicopter training. After arriving at the EPMO aerodrome, the pilot began preparations for the flight.. He got acquainted with the traffic and meteorological situation of the EPMO aerodrome area and filled the flight plan. He refueled the helicopter with 30 liters of AVGAS 100 LL (in total the amount of fuel for the flight was 113 liters). The pilot performed a pre-flight inspection in accordance with the Flight Manual, during which no faults or irregularities were found (which was confirmed in aircraft technical log). The candidate arrived at the headquarters of the organization around 10.30 hrs. The pilot made a presentation of the company showing the hangar and office rooms, and the helicopter. The pilot acquainted the candidate with the construction of the helicopter and drew her attention to the elements that should be checked before the flight. After that the candidate took the right seat in the helicopter cockpit. The pilot took the left seat and proceeded to do the engine pre- start checklist.

The Investigation Team found discrepancies in the statements of the pilot and the candidate regarding safety instructions given to the candidate by the pilot.

The pilot received clearance from TWR EPMO to start the engine and take off. At 11:15 hrs UTC, the helicopter took off towards the flight zone located on the north side of EPMO aerodrome between the India and Hotel waypoints. The pilot stated that he performed the familiarisation flight program on his own terms. At an height of approximately 1300 ft AMSL, the pilot allowed the candidate to take the helicopter controls. The candidate testified that she was afraid to touch other controls except for the cyclic. She maintained control of the helicopter for a few minutes, and the pilot kept his hand near the cyclic and corrected the position of the helicopter. Then the pilot performed a flight with 60° bank angles and demonstrated how the ground speed is felt when flying at low height. The candidate stated that the flight was performed below the treetops. Then the pilot demonstrated how to choose a landing place if there was a necessity to land outside of the aerodrome.

The next portion was the return flight to the EPMO FATO. The pilot obtained clearance to land and take off subsequently.

The pilot took-off from hovering and flew south over the EPMO Uniform waypoint. He climbed to 1300 ft AGL over the Narew river, than turned right and continued the flight along the Narew river to the point where it joins with the Vistula river (Fig. 1). When the helicopter flew over the Vistula river, the candidate asked whether it was possible to fly (over water) at a height similar to the one over ground. The pilot confirmed that it was possible, than he flew over the bridge of the S7 route and started descending, saying that during descent performed over water “you need to know where you are flying, because there may be some cables or wires above the water, but according to the law...", after these words the helicopter collided with the water surface.

The occurrence took place at 11:52 hrs UTC at a speed of about 78 kt (according to the radar). A while after the impact, the pilot left the wreckage unaided and surfaced. At the accident site the Vistula river had around a 1.2 m depth. The helicopter rested on its left side in the water (Fig. 2). The pilot approached the right side of the fuselage to assist the candidate. The whole situation was seen by an angler on the shore, several dozen meters from the site. According to his statement, the helicopter descended, with no engine problems, until it hit the water surface.

The pilot stated that at an height of 500 ft AGL, when he tried to recover the helicopter from descent, the collective was blocked. However, it should be noted that during the final portion of the flight (just before collision with water) the pilot did not report any problems on board and continued his chat with the candidate.

After getting out of the water, the pilot asked the angler to contact the owner of the helicopter and to report the incident to the emergency telephone number 112. After about 10 minutes, a river Police patrol arrived at the site. Police officers took the candidate and the pilot on board the motorboat. The pilot was taken to hospital by ambulance and the candidate was transported by HEMS to another hospital. The helicopter was destroyed.

Fig. 1. Flight path recreated from radar markers [source: PKBWL][2]

Based on the radar recording, the most probable flight path from the EPMO FATO to the accident site was recreated.

The recorded parameters of the helicopter just before the collision with water surface (at 11:52:29 hrs UTC) were: flight altitude 400 ft AMSL, speed 78 kt.

[2] Unless otherwise stated, source: PKBWL.

1.2. Injuries to persons

Table 1. Information – injuries to persons

Injuries	Crew	Passengers	Others	Total
Fatal	-	-	-	-
Serious	1	1	-	2
Minor	-	-	-	-
None	-	-	-	-

1.3. Damage to aircraft

The helicopter was destroyed. At the site of the accident, the right side of the fuselage (without tail boom) protruding above the water surface was found with damaged cabin and main rotor blade.

After recovering the wreckage from the river the following was found:

- front part of the cabin separation from the wreckage;
- destroyed cockpit separated from the cabin;
- main rotor mast deformation (from the base to the hub);
- deformation of the main rotor blades;
- deformation of the tail boom detached from the fuselage;
- deformation of the engine fairings ;
- front part of left skid break;
- destruction of the kinematic continuity of the helicopter flight control system.

Fig. 2. Helicopter wreckage - the bridge of the S7 route in the background

Fig. 3. Helicopter wreckage after recovery from the river

1.4. Other damage

The helicopter fuel and lubricants leaks slightly polluted the river.

1.5. Personnel information (crew data)

Pilot:

- male, aged 25, holder of the:
- CPL(H) , issued by the ULC on 30 January, 2018 (valid for unlimited period);
- Robinson R44 Type Rating (valid until : 31 January, 2021);
- FI rating (valid until: 30 June, 2022);
- Class 1 aero-medical certificate (valid without limitations)

Table 2. Pilot flight time information

	24 hours	7 days	90 days	Total flight time
All types:	2:07	4:46	129:59	796:33
On Robinson R44:	2:07	4:46	129:59	796:33

Total flight time as an instructor: 303 hours and 40 minutes.

Table 3. The last 10 flights prior to the accident

Date (DD.MM.RRRR)	Aircraft type	Flight type	Flight time (HH:MM)	Comments
31.07.2020	R44	ATO Training	01:40	
03.08.2020	R44	ATO Training	01:11	
03.08.2020	R44	ATO Training	01:14	
06.08.2020	R44	ATO Training	01:31	
06.08.2020	R44	ATO Training	02:03	
07.08.2020	R44	ATO Training	00:59	
07.08.2020	R44	NCO / private	01:30	
12.08.2020	R44	ATO Training	01:01	
12.08.2020	R44	ATO Training	00:29	
13.08.2020	R44	Familiarisation flight	00:37	Accident flight

The Pilot:
- in the last 48 hours was rested;
- met the criteria of the crew flight and rest times, included in the Operator's Operations Manual;
- during the occurrence occupied the left front seat (which was in accordance with the Flight Manual);
- was the Pilot Flying (PF);
- performed flights systematically, was in current training.

1.6. Aircraft information

1.6.1. General information

The Robinson R44 Raven II helicopter is manufactured by the Robinson Helicopter Company based in Torrance, USA. The R44 Raven II is a four-seat, single-rotor, single-engine metal-composite helicopter, equipped with a fixed landing gear with two skids.

The main supporting structure of the fuselage consists of a welded steel frame and truss, and duralumin load-bearing elements. Steel firewalls are located in front of and above the engine. The tailcone is a semi-monocoque structure made of duralumin. The helicopter cabin is made of composite materials and thermoplastics.

The main rotor consists of two all-metal blades mounted to the hub. The main rotor hub is mounted to the (main) drive shaft by a teeter hinge.

Fig. 4. The accident helicopter [source: Facebook.com AirModlin]

The blades are made of metal, with a steel spar, covered with a duralumin sheet, filled with an aluminum honeycomb structure.

The two-blade tail rotor is mounted on an elastomeric "Delta-3 Hinge" joint. The tail rotor blades consist of a single, formed sheet of duralumin with aluminum root fitting and a honeycomb spar.

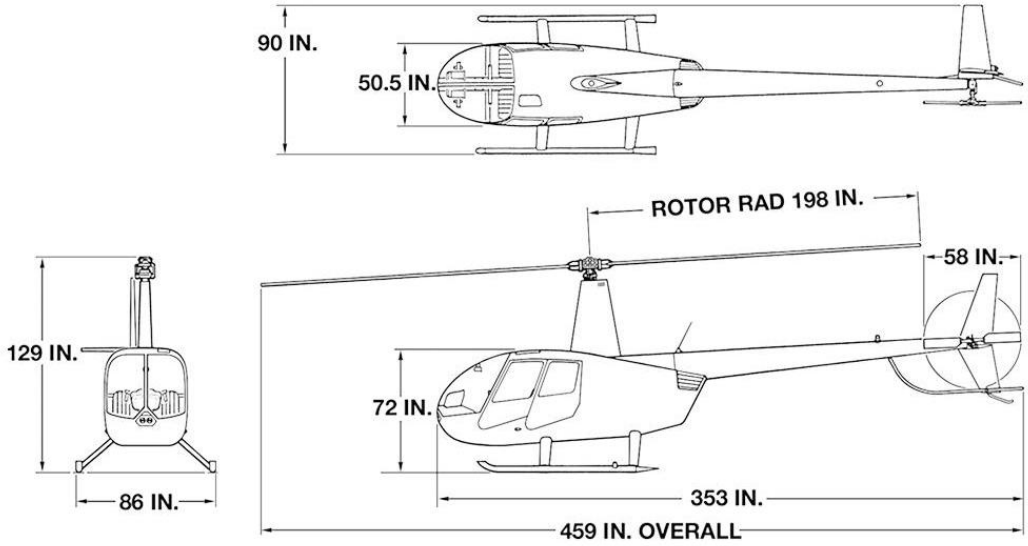

Fig. 5. Robinson R44 Raven II dimensions [source: R44 II POH doc. no. RTR 462]

1.6.2. Helicopter data

Table 4. Airframe

Year of Manufacture	Manufacturer	Serial number	Registration marks	Register number	Registration date
2006	Robinson Helicopter Company	11457	SP-SVW	**841**	**21.01.2020 r.**

(ARC) issued on:	23.06.2020
valid till:	23.06.2021
TSN:	2005:27 FH
TSO:	62:37 FH
Aircraft flight time since the last check:	62:37 FH
Overhaul life until the next major repair:	2137:63 FH
Date of the last periodic check:	21.05.2020
– after TSN:	1942:90 FH
– effected by:	AIR MODLIN
MS valid until :	2042:90 FH (100:00 FH) or 08.12.2020
Next periodic operations :	100:00 FH or annual

Table 5. Engine data

Year of Manufacture	Manufacturer	Type	Serial number
2006	**Textron Lycoming**	**IO-540-AE1A5**	**L-31520-48A**

Date of the new engine installation:	28.09.2006
Date of the last major repair:	19.03.2020
TSN:	2005:27 FH
TSO:	62:37 FH
Overhaul life till next major repair:	2137:63 FH
Date of last periodic check:	09.08.2020
with the total aircraft flight time:	1991:34 FH (engine hour meter: 48:44)
carried out by:	AIR MODLIN

Next periodic check:	100 FH
with the total aircraft flight time:	2042:90 FH (100:00 FH)

The helicopter was serviced on time and in accordance with applicable regulations with a certified maintenance organization and its continuing airworthiness documentation was properly maintained.

Oil & lubricants prior to the flight:

- Fuel: AVGAS 100LL, 113 liters
- Oil: Aeroshell 100about 8 US qt

Aircraft mass:

- empty mass: 690,63 kg
- fuel mass: 81,36 kg
- crew mass: 134 kg (62 kg + 72 kg)
- baggage mass: 10 kg

Total mass :

- permissible: 1134 kg
- actual: 915,99 kg

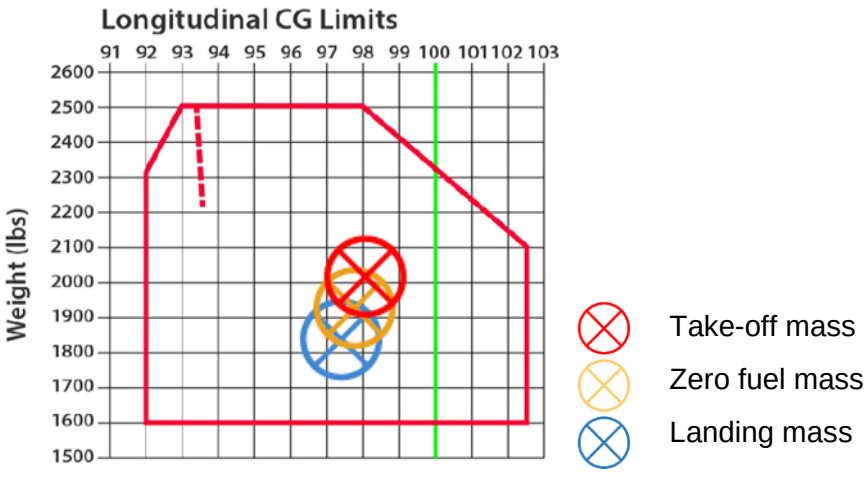

Fig. 6. Longitudinal location of the helicopter center of gravity

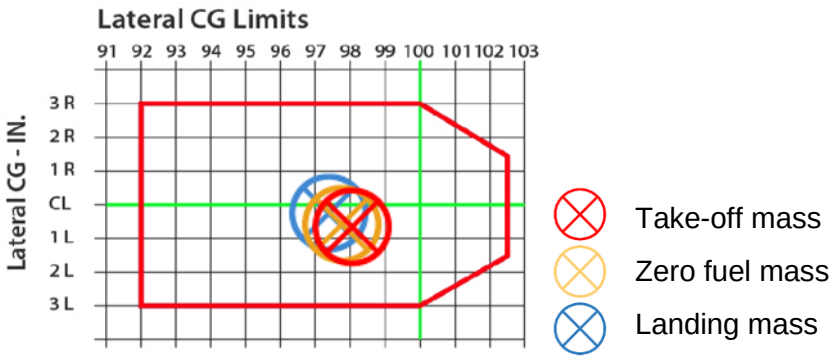

Fig. 7. Lateral location of the helicopter center of gravity

The weight and center of gravity of the helicopter were within the limits specified in POH.

1.6.3. Aircraft flight control system

The helicopter is equipped with a single flight control system, in which the forces exerted on the controls are transferred by push-pull tubes and bellcranks. The control system is completed with double controls. All bearings in the control system are maintenance-free or self-lubricating.

The flight control system of the helicopter is conventional. The cyclic is placed in the center (between the pilots) and suspended on the articulated joint, with two grips s that allow control from the right or left seat.

The collective pitch control is conventional. The engine throttle control is correlated to collective by a mechanical linkage. The collective pitch control is provided by the dual lever located on the left side of each pilot seat.

Control inputs from the collective and the cyclic are summed by the Aft Bottom Bracket Assembly located between the rear seats. Each collective lever is equipped with athrottle control twist grip.

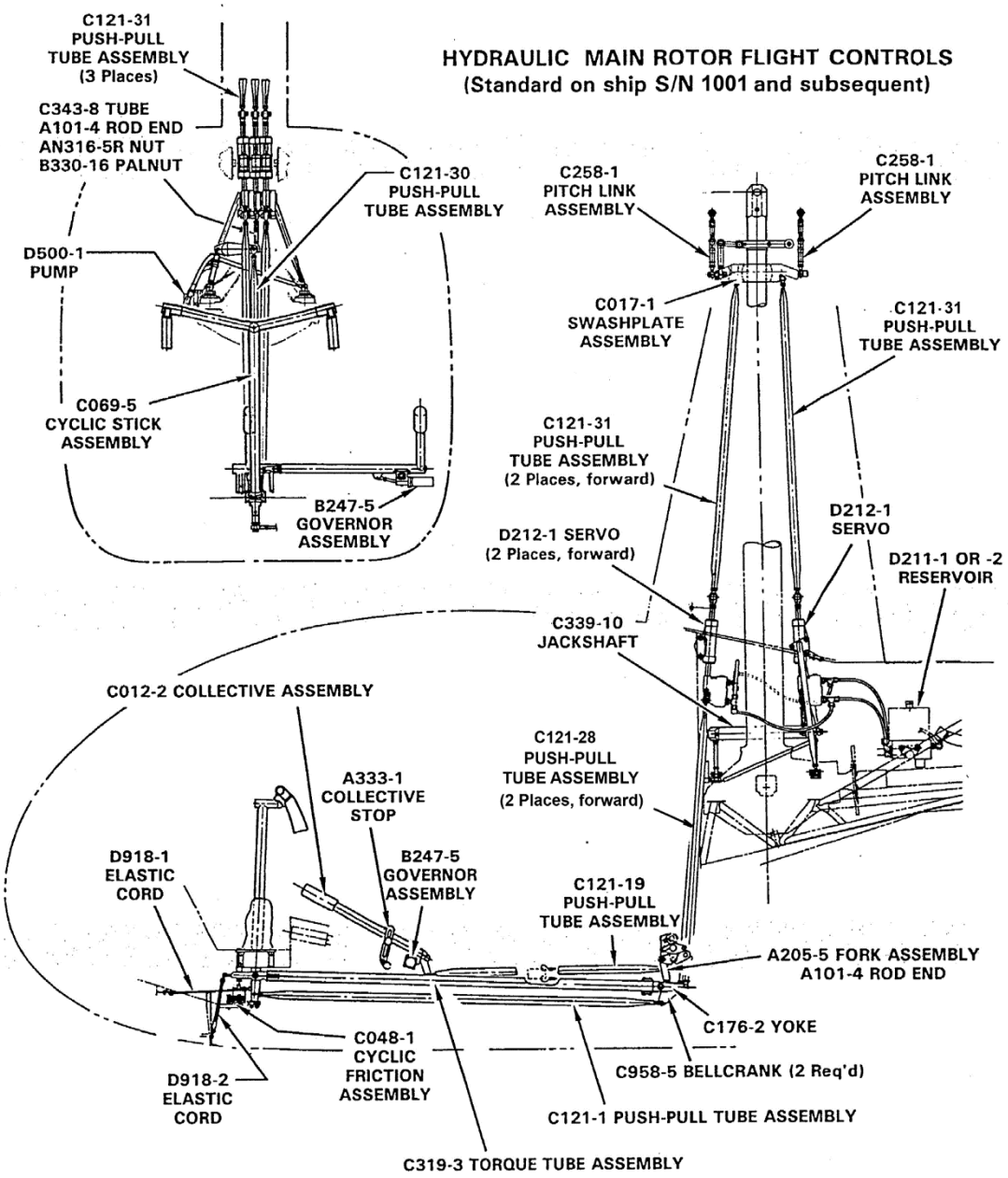

Fig. 8. Cyclic and collective pitch control system of the main rotor.
[source: RTR 460 figure 8.1 on page 8.1B]

The cyclic and the collective are equipped with adjustable friction devices. The collective friction adjuster is located at the rear part of the lever (Fig. 10). Moving the regulator backwards increases the friction, and thus the force needed to move the lever, and in the extreme rear position the lever applies maximum friction. Moving the adjuster forward reduces the force needed to move the lever.

The cyclic friction knob is located on the left side of the cyclic panel. Turning the knob clockwise increases friction, and turning the knob counterclockwise reduces friction. The

Flight Manual (POH) Chapter 7 pp. 7-6 provides the following rules for the use of friction regulators in flight:

CAUTION
Control friction must be used with caution during flight. Excessive friction may make the helicopter difficult to control.

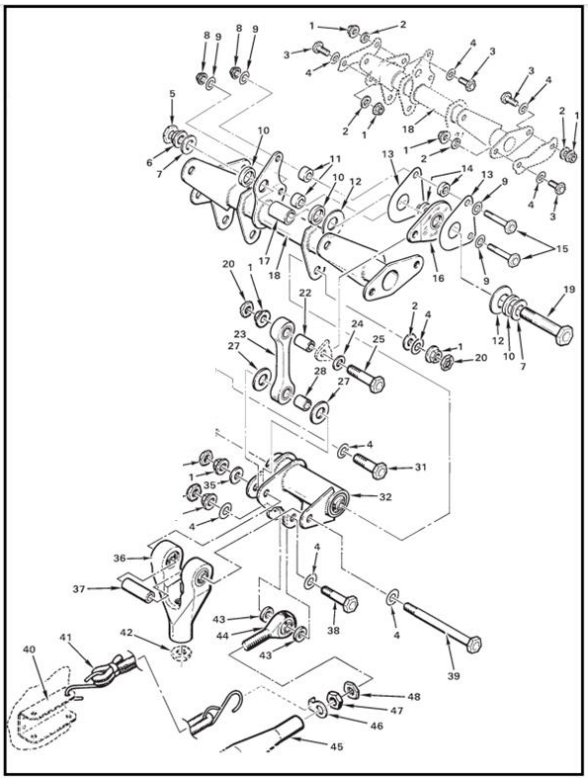

Fig. 9. Aft Support Assembly [source: RTR 460 vol. 2 page 67-40]

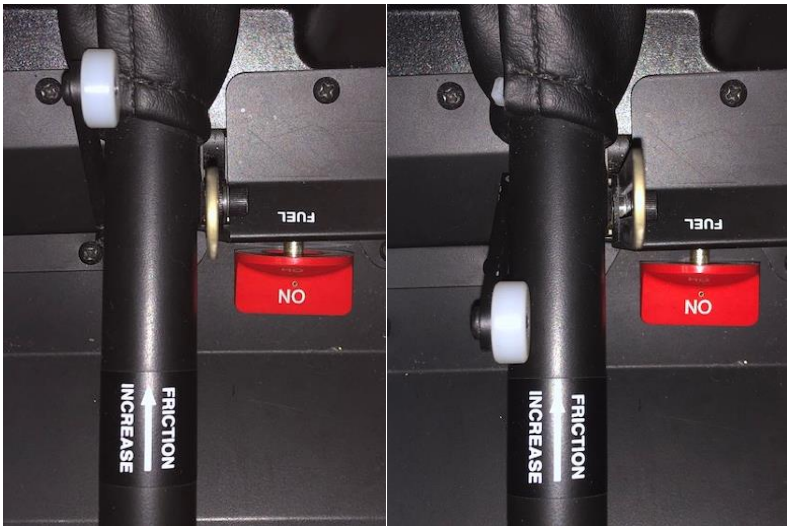

Fig. 10. Collective friction adjuster (on the left - maximum friction, on the right - minimum friction)

Fig. 11. Cyclic friction adjuster

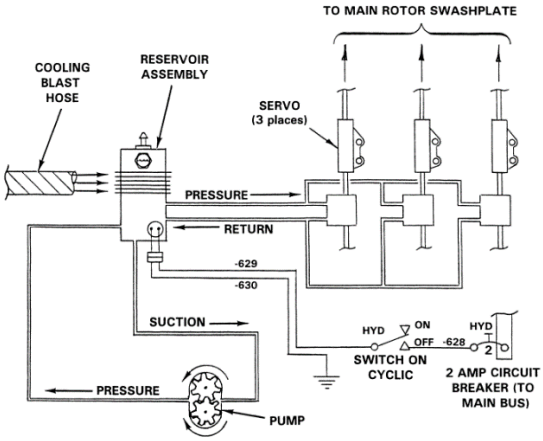

Fig. 12. Hydraulic system scheme [source: RTR 460 vol. 1]

The hydraulically boosted flight control system eliminates the feedback forces resulting from the aerodynamic loads of the helicopter. The hydraulic system consists of a pump driven by the main gearbox , three servos, a hydraulic fluid reservoir and interconnecting lines.

The hydraulic system is filled with hydraulic fluid according to MIL-H-5606 standard (Aeroshell Fluid 41 is the most commonly used), the operating pressure in the system is in the range from 450 to 500 psi.

The swashplate is controlled by three push-pull tubes which transmit the control inputs from the collective and the cyclic via servos.

The shut-off switch activates a by-pass valve which interrupts the flow of hydraulic fluid, with the consequent pressure drop in the system. This leads to the disabling of the servos, which in turn increases the forces needed to move the cyclic and the collective, however, control of the helicopter is still possible and safe.

The by-pass valve is electrically operated by a pilot with a switch on the right hand grip of the cyclic. The valve control system is of the "fail-safe" type, i.e., if a power failure occurs, the valve remains open (system is ON), and when the switch is turned off, the valve is activated, and the hydraulic system is OFF.

Swashplate

The swashplate consists of an upper rotating part (rotating with the main rotor hub) and a non-rotating lower part (immobilized in relation to the main gearbox housing).

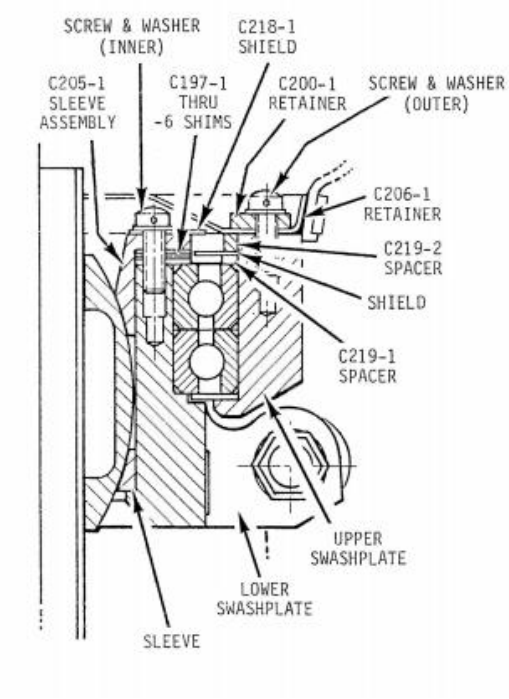

Fig. 13. Cross-section of the swashplate with the mast [source: RTR 460 vol. 1]

The upper part of the swashplate is connected to the main drive shaft through the Upper Fork Assembly..

The lower part of the swashplate is immobilized with the Lower Fork Assembly..

The change of the blades pitch angle depends on the position of the swashplate and is effected by two pitch links.

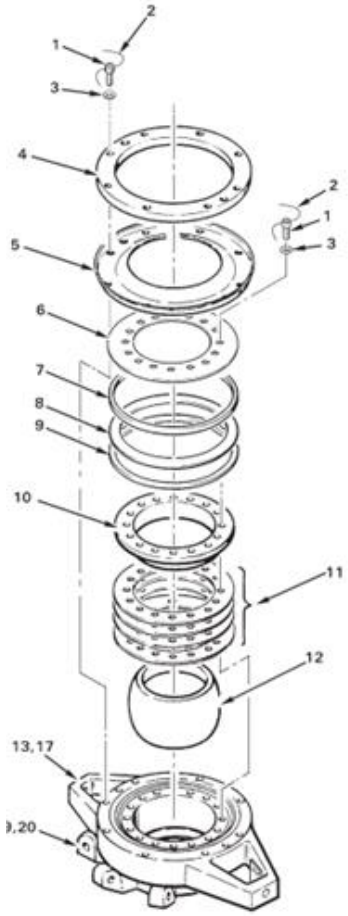

Fig. 14. Swashplate scheme P/N: C017-6 [source: RTR 460 vol. 2]

The collective pitch control is performed by moving the entire swashplate assembly (lower and upper parts) up or down in along the main shaft axis. This is done by displacing the swashplate in relation to the sleeve attached to the main gear mast housing.

The swashplate has two teflon slip rings (permanently glued to the inner surface of the swashplate ball) to minimize friction between the swashplate and the anodized sliding sleeve.

The change of the cyclic pitch is effected by changing the angle between the swashplate plane and the main shaft axis, which is achieved by tilting of the swashplate around sliding ball. The swashplate has two Teflon slip rings to minimize friction between the swashplate assembly and the ball.

1.6.4. Helicopter Power Unit

The R44 II helicopter is powered by a single Textron Lycoming IO-540-AE1A5 engine 260 HP power and maximum take-off speed of 2800 RPM.

The engine is a six-cylinder, air-cooled, fuel-injected, horizontally-opposed engine with a wet sump oil system.

Engine power and maximum RPM were limited by the helicopter manufacturer to 205 HP of continuous power (MCP) and 245 HP for 5-minute take-off power, by limiting the manifold pressure. The nominal engine speed was set at 2718 RPM, which is 102% of the tachometer reading.

Fig. 15. Lycoming Textron Engine IO-540-AE1A5 [source: www.lycoming.com]

1.7. Meteorological information

The flight took place in VMC, in daylight. Wind - alternating from 210° to 330° with a speed of 3 kt. Visibility greater than 10 kilometers (CAVOK). Temperature 27° C, dew point 9°. Sea level pressure (QNH) 1017 hPa.

1.8. Aids to navigation

Not applicable.

1.9. Communications

The pilot maintained continuous two-way communication with the EPMO TWR until the occurrence. The pilot did not report any emergency.

1.10. Aerodrome information

The take-off took place from the FATO of EPMO aerodrome is shown below.

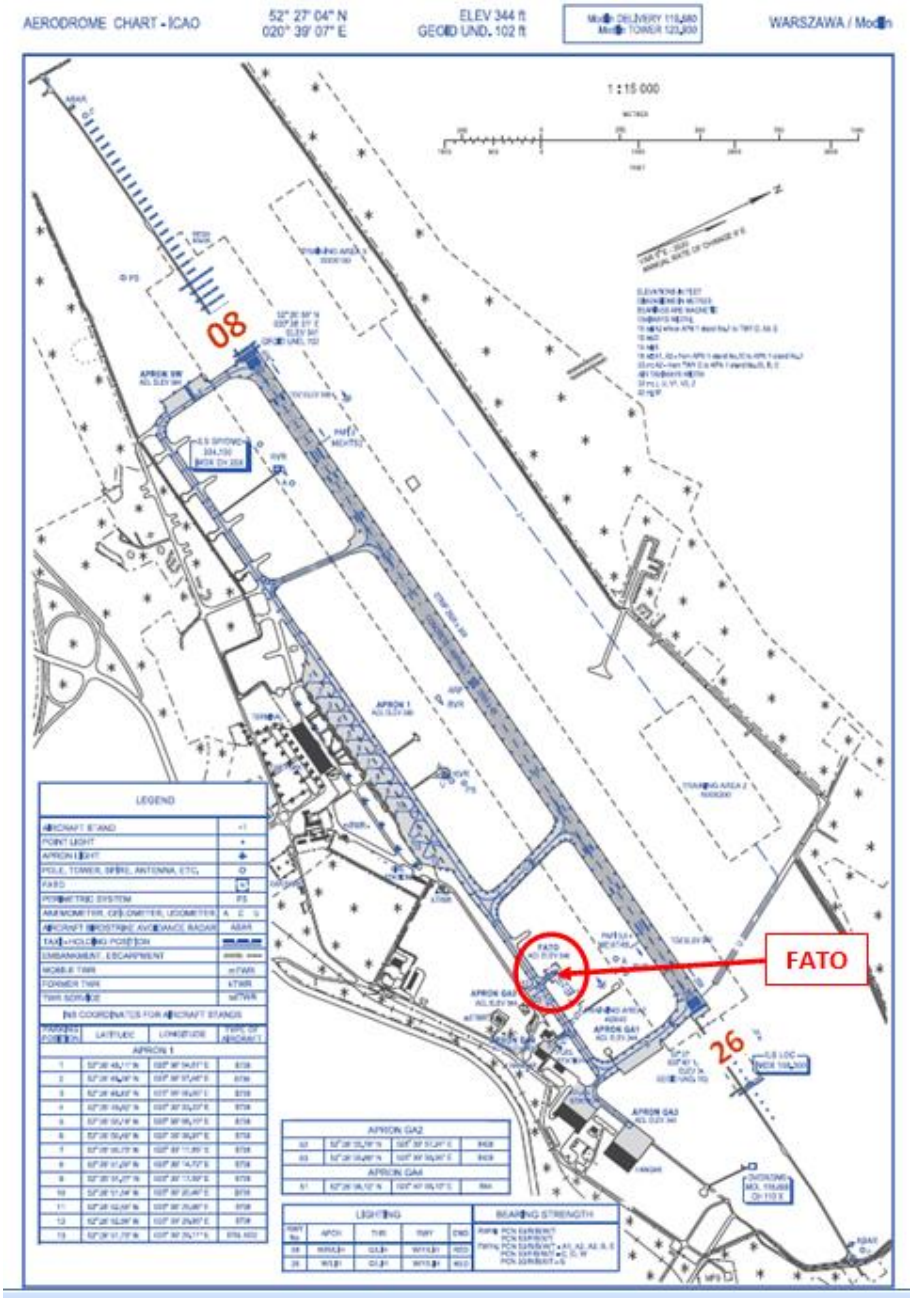

Fig. 16. Take-off point from FATO[source: Poland AIP]

1.11. Flight recorders

The helicopter was not equipped with flight recorders. No type of recorder was required under the applicable regulations.

1.12. Wreckage and impact information

1.12.1 Occurrence site

The collision with the Vistula river surface took place near the village of Sady Mazowieckie Voivodship. Coordinates of the accident site: 52° 25'06 "N; 020° 38'25 "E.

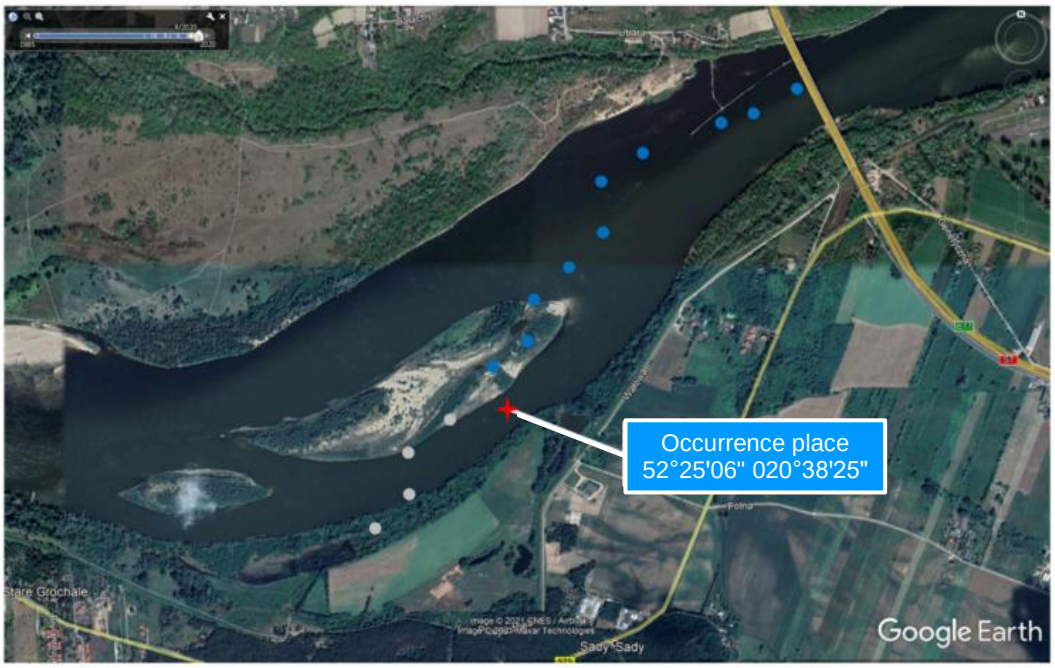

Fig. 17. Flight path recreated from radar markers (blue color). Predictive points calculated by the system (gray color) [source: Google Earth]

1.12.2 Helicopter wreckage

The collision with the Vistula river surface took place at 13:52:31, in a straight flight at a forward speed of about 78 kt, an angle of about 15° and a descent rate of about 1500 ft/min.

The wreckage of the helicopter was turned by 180° in relation to the direction of flight and was in the water at a depth of 1.2 m.

The front part of the cabin with the crew seats was separated from the wreckage of the fuselage. The tail beam was also separated, broken behind the first frame. One of the main rotor blades was bent and partly broken about 1/3 of the length from the root, while the other was partly broken about 2/3 from the root. The blades did not detach from the helicopter. The front part of the left skid was broken close to the attachment point. The engine, main gearbox and drive system did not separate from the wreckage.

1.13. Medical and pathological information

As a result of the accident, the pilot and the candidate were seriously injured. None of them was under the influence of alcohol.

1.14. Fire

No traces of fire in flight or after the collision with water were found.

1.15. Survival aspects

Most of the energy from the collision with water surface was absorbed by the helicopter structure, which was destroyed.

The depth of the river at the accident site was 1.2 meters, which allowed the pilot and the candidate to get out of the wreckage.

Prior to the flight, the candidate was not instructed by the pilot about emergency procedures.

The pilot and the candidate were wearing three-point seat belts.

The emergency services arrived at the scene about 10 minutes after the accident and provided first aid to the victims.

Emergency Locator Transmiter (ELT) was activated.

1.16. Tests and research

1.16.1 Helicopter engine test

Due to the major repair of the engine, approximately 62 FH, before the incident, the engine was commisioned to be verified for possible failures.

The engine test was carried out into two stages:

I. Engine examination at the storage site, which included:
   a) preliminary assessment of the technical condition of the engine and its external damage;
   b) checking compliance of the engine and its accessories with the documentation of continuing airworthiness;
   c) verification of continuing airworthiness documents related to major repair and subsequent maintenance of the engine.
II. Detailed inspection of the engine and its accessories in the PART 145 organization, including:
   a) check of the external condition of the engine and its accessories;
   b) disassembly of the engine and inspection of its components.

An external inspection of the engine revealed only a broken mounting of the oil sump.

No other external damage was found.

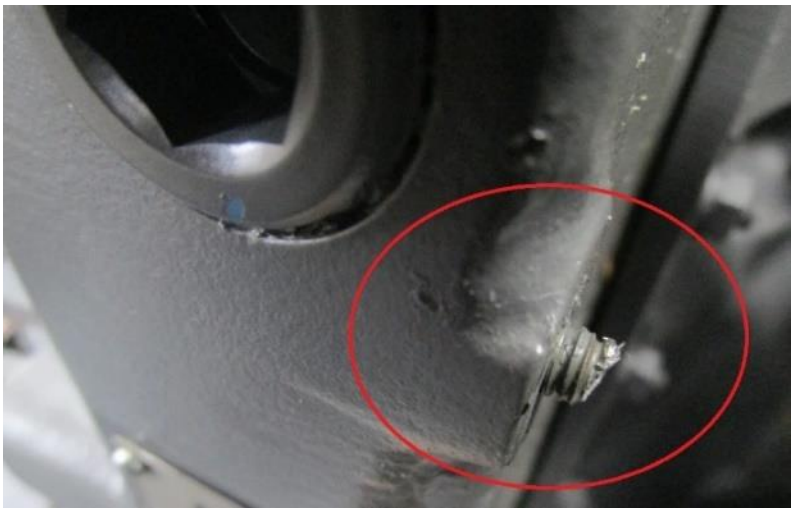

Fig. 18. External engine damage

As a result of disassembly and internal inspection of the engine, it was found:

- no damage or excessive wear of cylinders, pistons, valves and valve guides, except for severe corrosion caused by water penetration into the engine[3]. Traces of sand (river silt) were also found in each cylinder;
- no damage or excessive wear of the camshaft, except for corrosion;
- no damage or excessive wear of the crankshaft. After non-destructive testing and verification, the crankshaft was reused in the engine being repaired;
- no excessive wear and no damage to the engine crankcase;
- no damage to the engine accessories.

Fig. 19. Engine ready for disassembly

[3] The examination was conducted 5 months after the accident.

The inspection revealed that the engine was working properly until the collision with water. Water and traces of sand (river silt) were found in all cylinders and inlet manifolds. The presence of water, and especially sand, in all cylinders indicates that they were sucked through the intake system, i.e. the engine was running until the occurrence took place. As a result of water penetration into the engine and storage time of the wreckage, traces of corrosion appeared on most of the elements.

Fig. 20. Cylinders with signs of corrosion due to prolonged presence of water after accident

Fig. 21. Corroded engine inlet manifolds

1.16.2 Flight control system inspection

The helicopter's flight control system was tested at the wreckage storage site.

The kinematic lines of the pitch control system of the main rotor blades and the tail rotor were broken at the point where the front part of the cabin was torn off. The kinematic lines of the collective and throttle control system were broken due to plastic deformation of the rear part of the cabin. In addition, the tail rotor pitch control push-pull tube was

destroyed at the tail beam fracture. All broken connections of the control systems were checked. No signs of damage during operation were found.

During inspection of the wreckage, a fracture of the pitch link of the blade no 1 was also found. The damage resulted from the collision with the river surface.

The kinematic lines were broken at the moment of the collision with water surface and the following destruction of the helicopter.

Fig. 22. Broken push-pull tube at the collective lever.

The mounting of the Aft Support Assembly and the dual system of the collective were not damaged.

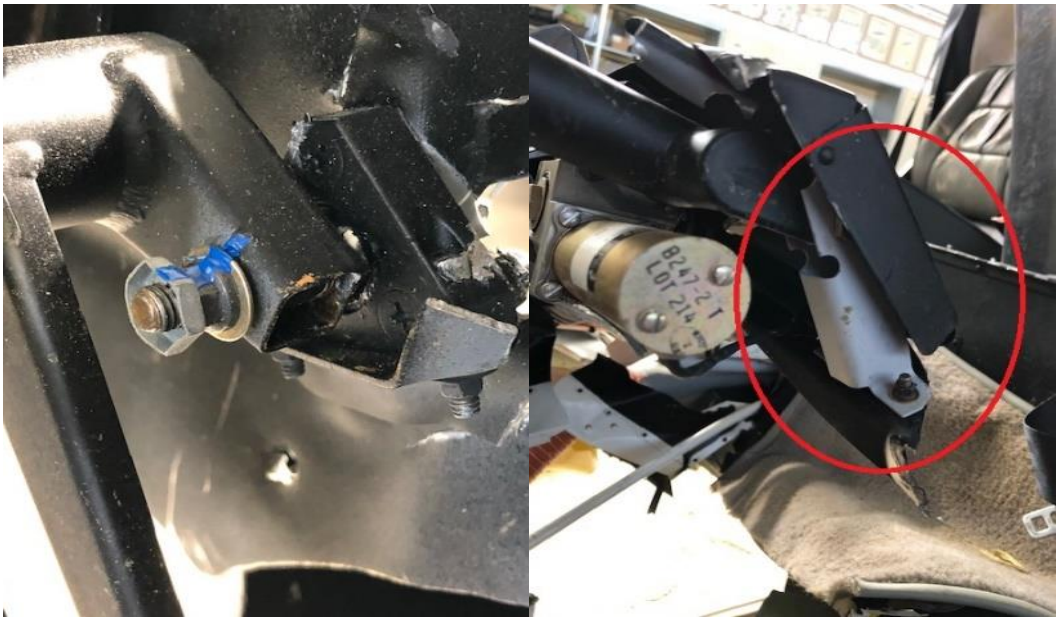

Fig. 23. Collective suspension

Fig. 24. The mounting of the Aft Support Assembly. Visible damage to the push-pull tubes resulted from the deformation of the fuselage during the collision

Due to the destruction of the helicopter structure, it was not possible to check the freedom of movement of the flight control system elements attached to the Aft Support Assembly. It was disassembled and tested in laboratory conditions. No damage to the elements was found, apart from the ones resulting from the impact with water. Functional test without concerns.

Fig. 25. Aft Support Assembly removed from the wreckage

1.16.3 Swashplate inspection

In agreement with the helicopter manufacturer – Robinson Helicopter Company, the swashplate and the its sliding sleeve of the swashplate were removed from the helicopter and tested.

Fig. 26. The removed swashplate assembly with the sliding sleeve

As a result of the external visual inspection of the swashplate and the sliding sleeve, it was found:

- breakage of the mounting of the main rotor RPM sensor ;
- bending of the upper flange of the swashplate ;
- damage to the anodized layer of the sliding sleeve resulting from collision with the bolts of the swashplate;
- shearing 6 out of 8 rivets for securing the sliding sleeve to its base;
- bending of the upper part of the sliding sleeve;
- contamination of the entire assembly with sand.

After consulting the manufacturer again, the swashplate and the sliding sleeve were disassembled for further analysis. All components have been cleaned.

As a result of the disassembly and analysis of individual components of the swashplate, the following was found:

- no damage and no signs of wear of the teflon rings of the swashplate;
- no internal damage of the swashplate;
- no additional damage or excessive wear of the anodized sliding sleeve surface.

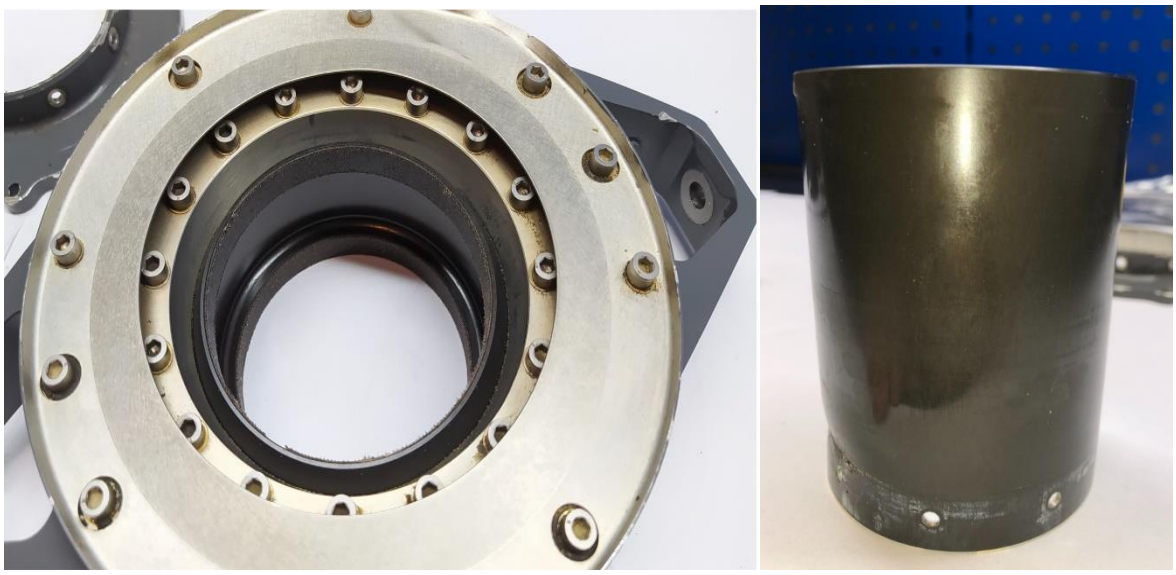

Fig. 27. The disassembled elements of the swashplate assembly

1.17. Organizational and management information

1.17.1 Aircraft operator

Salt Aviation Sp. z o. o. with headquarters in Nowy Dwór Mazowiecki was the aircraft operator. Salt Aviation is an Approved Training Organization (ATO) with certificate No. PL / ATO-72 issued by the President of the Civil Aviation Authority on 12 November , 2014. The organization is authorised, inter alia, to carry out theoretical and practical training for PPL (H) and CPL (H).

The organization was authorized to conduct a familiarization flight as defined in Regulation (EU) No 965/2012 Art. 9.

Salt Aviation Sp. z o. o. has a certificate of the Continuing Airworthiness Management Organization (CAMO) No.PL.MG.065 issued by the President of the Civil Aviation Authority on 04/11/2011. The certificate covers Subgroup 2c (helicopters), including Robinson R44 / R44 II. Salt Aviation Sp. z o. o. was responsible for the Continuing Airworthiness Management of the accident helicopter.

1.17.2 Maintenance organisation

The entire maintenance, including the major repair of the helicopter, was completed in an Approved Maintenance Organization (AMO) Air Modlin Sp. z o. o. with certificate No. PL.145.064 issued by the President of the Civil Aviation Authority on 21 September, 2009. The AMO certificate covers A3 group (helicopters) with R44 / R44 II type ratings.

1.18. Additional information

On 12 November, 2021, the helicopter pilot got acquainted with the Draft Final Report. The pilot made comments on the draft Final Report which were partially taken into account.

On 15 November 2021, the Operator got acquainted with the Draft Final Report and did not submit any comments.

The pilot's remarks, which were not taken into account, were attached to the internal records of the occurrence.

1.19. Useful or effective investigation techniques

The pilot stated that the cause of the accident was blockage of the collective. As the technical tests did not confirm that fact, SCAAI commisioned comparative flights on a helicopter of the same type. The aim of the flights was to recreate the trajectory of the last phase of the flight (descent) before the accident, in similar weather conditions. During the flights and close-to-ground maneuvers, including landing, the possibility of landing with the fully locked collective was tested. Four comparative flights were made with different forward speeds and descent rates. It was assumed that in the final phase of the accident flight, the flight parameters were as shown in Table 6 (reference parameters).

Table 6. Reference parameters

Parameter	Value
Altitude change [ft]:	980
Average ground speed [kts]:	85
Time of descent [s]:	40
Average descent rate [ft/min]:	1500
Distance [km]:	0,94

Table 7. Comparative flights parameters

Parameter	Fligth no 1	Fligth no 2	Fligth no 3	Fligth no 4
Altitude change [ft]:	1000	500	500	700
Average ground speed [kts]:	66	66,5	90	91
Time of descent [s]:	42	67	55	67
Average descent rate [ft/min]:	714	447,62	550	626
Distance [km]:	1,43	2,29	2,56	3,18

As a result of comparative flights, it was found that:

- with the collective blocked, a pilot with basic skills should be able to trade speed for height and control the helicopter;
- despite the blocked lever, the helicopter was fully maneuverable.

2. ANALYSIS

2.1. Flight operations

2.1.1. Reconstruction of the helicopter flight trajectory

The screenshots from the secondary radar were analyzed and then transferred to Google Earth satellite maps. The radar recording allowed to reconstruct the helicopter flight path from the second take-off from FATO until the collision with the water surface. The following parameters of the helicopter were obtained: ground speed, altitude and geographical coordinates as a function of time. The accuracy of the radar altitude indication was 100 ft.

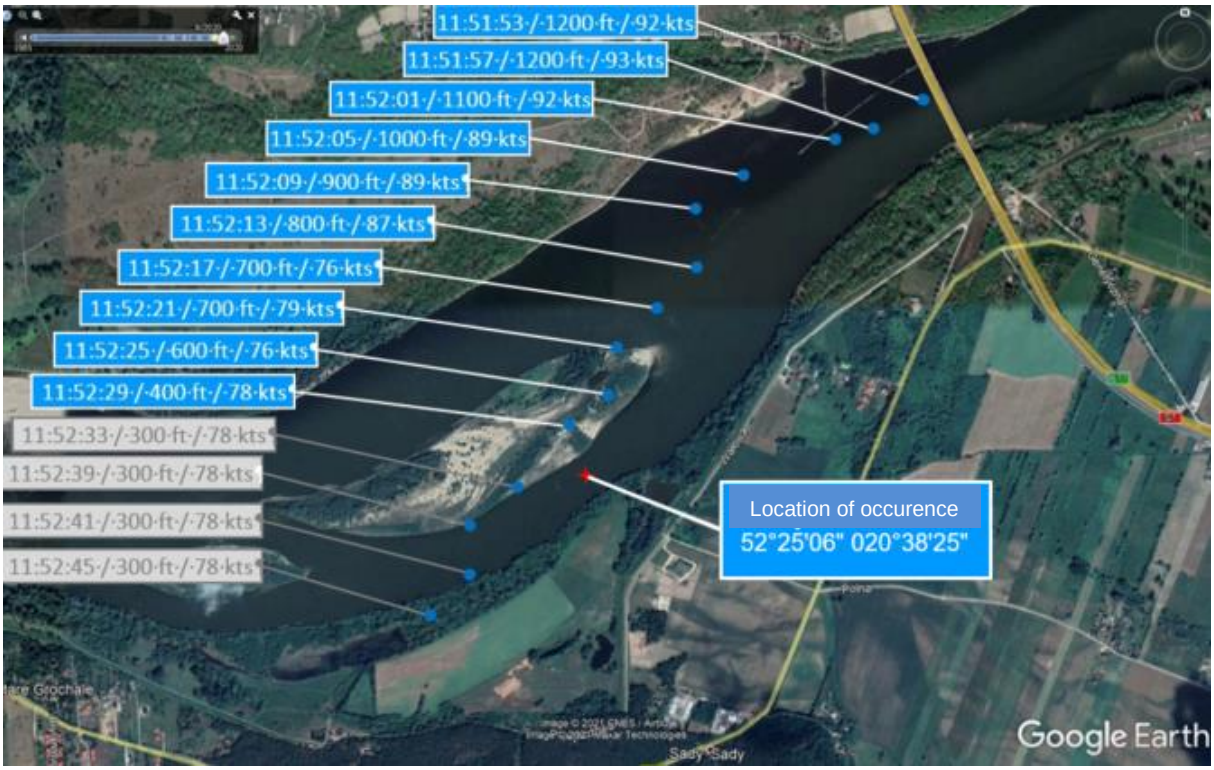

Fig. 28. Flight path with altitude descriptions (AMSL) based on radar recording

The recording also includes the predictive positions of the helicopter calculated by the system (items in gray).

The route determined from the radar display coincides with the accident site (except for the predictive positions.

The average elevation of the Vistula river water surface at the site of the accident, obtained from the Google Earth program is 217 ft.

Based on the recording, an average rate of the helicopter descent, calculated from the beginning of the descent to the collision with water, was approximately 1500 ft / min. The descent rate was relatively constant.

The time from the start of descent to the moment of impact was about 40 seconds. The helicopter was moving at an average speed of 83 kt. The collision speed was around 76 -78 kt.

The water impact angle was calculated to be approximately 15°.

The above data were collected and used for planning of the comparative flights.

2.1.2. Organisation of the familiarisation flight

The pilot performed a pre-flight inspection without finding any malfunction of the helicopter.

The pilot did not give the candidate any instructions related to emergency situations. The relevant information is contained in the Safety Notice No. SN-44, issue February 2017, revision June 2017. This document is attached to Chapter 10 of the Flight Manual and is always on board. The document describes in detail the guidelines and requirements related to the scope of the pre-flight safety briefing. Although the above document contains guidelines for the safety briefing for passengers, the candidate was not a member of the flight crew and such a briefing should have been carried out.

2.2. Aircraft

2.2.1. Helicopter maintenance

In May 2020, the main repair of the helicopter was completed after 2200 FH. The service was performed by an Approved Maintenance Organization in accordance with applicable regulations and manufacturer's requirements.

The scope of the main repair includes, inter alia:

- main rotor blades replacement;
- swashplate and sliding sleeve replacement;
- replacement of components such as the main rotor blade pitch links, Upper and Lower Fork Assembly;
- replacement of hydraulic system components (hydraulic fluid tank, servos and, pump);
- check of the helicopter flight control system in accordance with the inspection sheet after 100 FH.

The entire system for collective and cyclic pitch control was checked by CAMO or replaced with new components provided by the helicopter manufacturer during the main repair.

The helicopter was flown 62:37 FH since the overhaul. There was no information on any problems or malfunctions of the control system in the history of the Technical Log and in the Maintenance Statement.

2.2.2 Alleged malfunction of the flight control system

The pilot stated that when he tried to decrease or stop the descent rate, he was not able to raise the collective because it was blocked..

Following that statement, possible blockages of the collective were analyzed by the Investigation Team together with the manufacturer. As a result of the analysis, the following possibilities were found:

- intentional or inadvertent placement of an object under the collective on the candidate's or pilot's side - however, this would have prevented the downwards movement of the lever only, and would not prevent raising the lever;
- holding the lever by the candidate - according to the testimony, the candidate did not hold the collective ;
- blockage of the movement of the swashplate along the sliding sleeve - the analysis described in item 1.16.3 showed no signs of blockage or limited movement of the collective;
- malfunction of the part of the flight control system installed on the Aft Support Assembly - the analysis described in item 1.16.2. showed no signs of blockage or restriction of movements.

As a result of the analysis no evidence of a blockage of the collective was found.

2.2.3 Analysis of the *Safety Alert* related to hydraulic system pre-flight check

On December 23, 2020 (then amended on January 18, 2021), the Robinson Helicopter Company issued a Safety Alert for hydraulic controls pre-takeoff checks (POH, Section 4 - Normal Procedures).

The Safety Alert was issued due to the fact that RHC received a report of hydraulic controls becoming stiff in flight. According to RHC, one of the three hydraulic servos was found to have excessive internal wear resulting in the servo moving too slowly in one direction. The said servo, according to the information obtained from the manufacturer, had a total flying time of over 2,000 FH.

Following the alert, the Service Bulletin No. SB-109 was issued on June 30, 2021, ordering the pilot to perform a pre-flight check of the control system. The bulletin was issued for hydraulic servos identified by specific serial numbers and production / major repair date before April 2014.

The Safety Alert was issued more than 4 months after the incident. The Commission asked the manufacturer whether the above-mentioned alert concerns the helicopter in question.

The hydraulic servos (3 items) installed on the helicopter involved in the incident were subjected to a major repair, which was completed on March 2, 2020. The helicopter involved in the incident was therefore not covered by the Safety Alert and the SB-109 Service Bulletin.

2.3. Human factor

The Commission did not find any significant and confirmed factors which may have affected the pilot involved in the accident. A psychological factor that may have influenced the occurrence of the accident was the pilot's willingness to show the candidate his own skills or the maneuverability of the aircraft to convince her to start training at ATO.

3. CONCLUSIONS

3.1. Findings

1. The pilot had a valid licence and qualifications to perform the flight in accordance with applicable regulations.
2. The pilot had valid aero-medical certificate.
3. The pilot was rested and not influenced by alcohol.
4. The helicopter mass and balance remained within the limits specified in the Flight Manual.
5. Weather conditions did not affect the occurrence.
6. The pilot did not conduct a proper safety briefing with the candidate.
7. The pilot and the candidate had their seat belts correctly fastened.
8. The rescue services worked efficiently and effectively.
9. The helicopter was airworthy before the flight and had valid third party legal liability insurance.
10. The helicopter was maintained by a certified maintenance organization.
11. Records of the continuing airworthiness of the helicopter were properly maintained.
12. The helicopter was not covered by *Safety Alert* and the *Service Bulletin SB-109.*
13. The pilot performed the flight below the minimum safe height.
14. The blockage of the collective during the flight was determined as very unlikely.
15. Without the use of the collective but with the use of the cyclic alone, the helicopter remained fully maneuverable.

3.2. Causes of the serious incident:

Incorrect height assessment when descending above the water surface.

Contributing factor:

Performing the flight below the minimum safe height.

4. SAFETY RECOMMENDATIONS

PKBWL has not proposed any safety recommendation after completion of the investigation.

5. ANNEXES

None

THE END

Investigator-in-Charge

Signature on original

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