Norwegian Safety Investigation Authority

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REPORT AVIATION 2025/03

Serious aviation incident at Skjetten in Akershus County, Norway on 20 January 2024 involving an Aquila AT01, LN-NRC

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The Norwegian Safety Investigation Authority (NSIA) has compiled this report for the sole purpose of improving flight safety.

The purpose of the NSIA's investigations is to clarify the sequence of events and causal factors, elucidate matters deemed to be important to the prevention of accidents and serious incidents, and to make possible safety recommendations. It is not the NSIA's task to apportion blame or liability.

Use of this report for any other purpose than for flight safety should be avoided.

Photo: East Police District

This report has been translated into English and published by the NSIA to facilitate access by international readers. As accurate as the translation might be, the original Norwegian text takes precedence as the report of reference.

1. Factual information

The Norwegian Aviation Act section 12.6 cf. (EU) No 996/2010 establishes that all reports should be in a form appropriate to the type and seriousness of the incident. The report format established in ICAO Annex 13 was not used in this investigation.

1.1 Incident data

Aircraft:	
Type and reg.:	Aquila AT01, LN-NRC
Production year:	2018
Engine:	Rotax 912 S3
Operator:	Nedre Romerike flying club
User:	Private (club)
Date and time:	Saturday 20 January 2024, around 1000 hrs
Incident site:	Skjetten, Akershus County, Norway
ATS airspace:	Uncontrolled airspace Class G
Type of incident:	Engine failure with subsequent emergency landing
Type of flight:	Private
Weather conditions:	Fine, cold weather with no wind
Light conditions:	Daylight
People onboard	1
Personal injuries:	Minor
Damage to aircraft:	Fractured nose wheel leg and minor damage to the front. The engine was destroyed.
Other damage:	None
Pilot:	
Certificate:	Private Pilot License, PPL(A)
Flight experience:	72 hours and 15 minutes at the time of the incident. One hour in the last 30 days.
Sources of information:	Interview with the pilot, information from the airplane and the engine manufacturer as well as the NSIA's own investigations.

All times in this report are local times (UTC + 1 hour), unless otherwise stated.

1.2 Course of events

On Saturday 20 January 2024, the pilot was to fly a local flight over the Oslo region. He arrived at Kjeller airport (ENKJ) just before 0900 hrs and started the daily inspection. It was a cold morning; the pilot has stated that it was -24 °C. The pilot did not notice anything abnormal during the daily inspection or during the pre-start-up checklists. He took his time doing the checklists after he had started the engine so that it could warm up.

The pilot has explained that all the engine instruments indicated normal values before take-off at 0955 hrs from runway 30. Right above Nitelva river, about 1.1 NM from the runway threshold of runway 30, the pilot noticed a slight reduction in engine RPM from about 2,300 to 2,150. Immediately afterwards, he heard what he described as a 'clunck' and the propeller stopped. The altitude indicator displayed about 600 ft, which is about 250 ft above the terrain. The pilot activated the ELT[1] and made a Mayday call on the Kjeller Traffic frequency of 119.100 MHz.

The pilot is familiar with the area around the airport and immediately started a left hand turn to land in a snow-covered field at Skjetten (Figure 1). The field is well known among pilots at Kjeller as a suitable emergency landing site if the engine should cut out during climb-out from runway 30. The pilot considered he had enough energy and elected not to fly over some houses and performed the emergency landing as normal as possible. The deceleration was so sudden that the nose-wheel broke (Figure 2). After the emergency landing, the pilot shut off power and the fuel supply. He then evacuated the aircraft and notified the emergency services.

Figure 1: Satellite image of Kjeller airfield. The aircraft flight path is illustrated by the NSIA. The red circles are take-off position and engine failure, the red star is the emergency landing site. Photo: © norgeskart.no Illustration: NSIA

[1] *Emergency Locator Transmitter*

Figure 2: LN-NRC after the emergency landing in the field. Photo: NSIA

1.3 Aircraft and engine

Aquila AT01-100 is a 'Very Light Aircraft' certified aircraft. It received type certification in 2013, and it has a maximum take-off weight of 750 kg. The aircraft has two seats, is low-winged and constructed mainly of composite materials. The aircraft has a double set of controls and is used extensively for instruction flying. The engine is a four-cylinder Rotax 912 S3 and the propeller is a MT-Propeller MTV-21-A/170-05 with variable pitch. The aircraft has a glide ratio of 14 which means that the aircraft can theoretically glide about 2.3 NM per 1,000 ft altitude.

LN-NRC was imported to Norway and received its Certificate of Airworthiness on 22 March 2018. The Airworthiness Review Certificate was renewed on 15 April 2023 and was valid until 16 April 2024. The NSIA has estimated that, at the time of the incident, the aircraft mass and balance were within the limitations set by the manufacturer in the aircraft flight manual.

At the time of the incident, the aircraft had flown 71.5 hrs since its last scheduled maintenance check, which was a 200-hour inspection. The next scheduled maintenance check was a 100-hour inspection.

1.3.1 ENGINE INSPECTION

The NSIA participated in the removal of the engine at Kjeller airport on 6 February 2024. The engine was then sealed and shipped to the manufacturer BRP-Rotax GmbH & Co KG (Rotax) in Gunskirchen in Austria.

On 7 May 2024, the NSIA inspected the engine together with representatives from the Austrian Safety Investigation Authority[2] and Rotax.

The investigation started by verifying that the sealed shipment had not been opened. The engine was then mounted in an engine cradle. During the visual inspection, it was quickly established that

[2] *Sicherheitsuntersuchungsstelle des Bundes, SUB*

connecting rod #3 had punched its way through the crankcase, see Figure 3. Further disassembly showed that both big end bearings of connecting rod #2 and #3 had failed with clear indications of heat damage, see Figure 4 and Figure 5.

The engine oil pump and oil filter were inspected. There were no particles in the oil filter and the oil pump did not show any signs of failure or damage. There was less oil in the crankcase than expected, but no clear signs of oil leakage. Inspection of the oil tank showed that it was completely full, holding around 3 litres of oil, see Figure 6. The engine should have held between 2.55 and 3 litres of oil. No internal blockages were found in the oil line between the oil tank and the oil cooler or the line from the oil cooler to the oil pump. Nor were any internal blockages found in the oil cooler.

There were no other signs of damage in the engine.

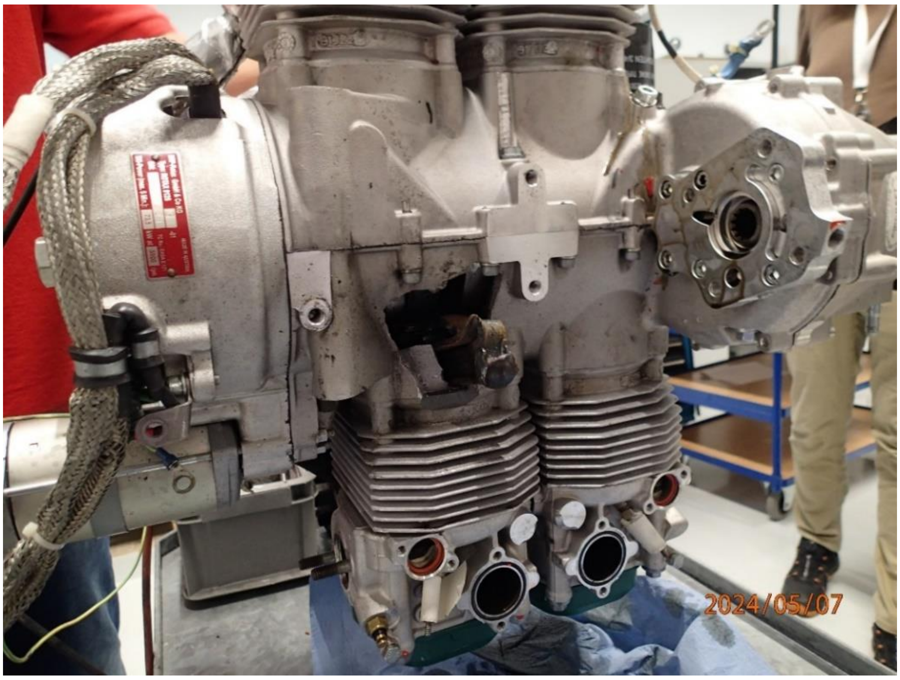

Figure 3: The connecting rod of cylinder number three which has punched through the crankcase. Photo: Rotax/NSIA

Figure 4: Connecting rod number three and two which had failed. Photo: Rotax/NSIA

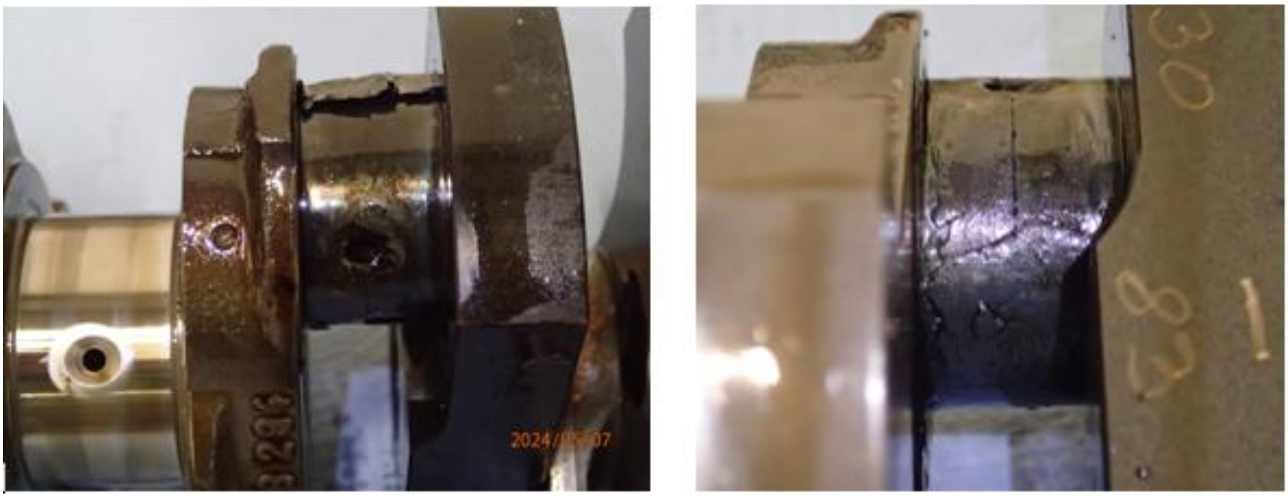

Figure 5: Close-up of connecting rod big end bearing three and two with clear signs of heat damage. Photo: Rotax/NSIA

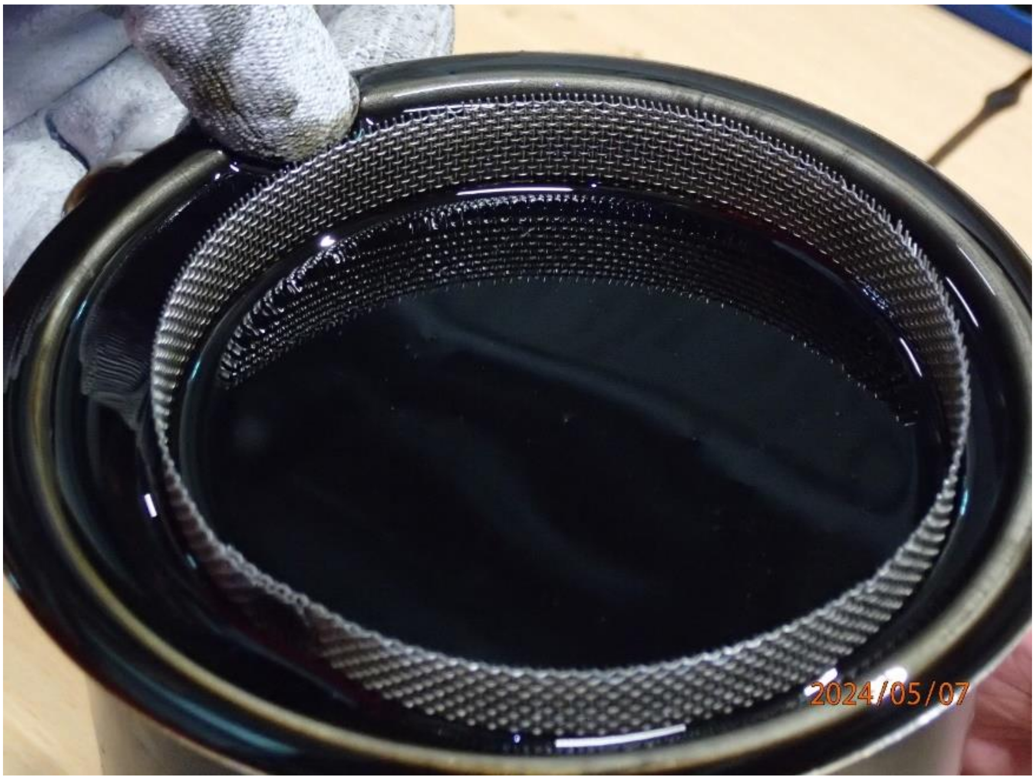

Figure 6: The oil tank was found to be completely full. Photo: Rotax/NSIA

1.3.2 THE OIL SYSTEM FOR THE ROTAX 912 S3

The aircraft manufacturer has not provided its own description of the oil system but refers to technical documentation prepared by Rotax. The oil system in the Aquila AT01 is designed and installed in accordance with the requirements set out in the relevant documentation by Rotax.

Rotax 912 has a dry sump system. The oil pump is driven directly by the camshaft and the sensors for oil temperature and oil pressure are in the oil pump housing. The oil is sucked from the external oil tank, via the oil cooler before being distributed in the engine. After circulating in the engine, the oil collects at the bottom of the crankcase and is forced back to the oil tank by the pressure that develops in the crankcase when the engine is turning. To measure the correct oil level before starting, the engine must be hand cranked such that any oil that has collected at the bottom of the crankcase is forced back to the oil tank. See Figure 7 for system description.

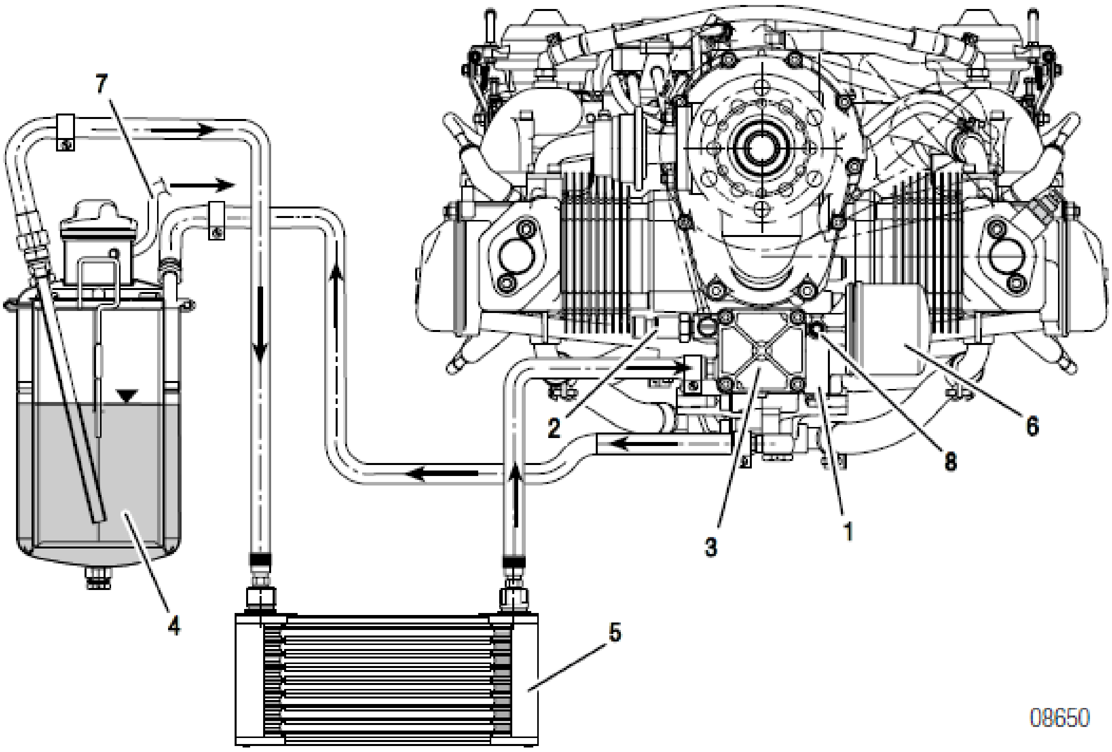

Figure 6: Lubrication system

- *1 Pressure regulator*
- *2 Oil pressure sensor*
- *3 Oil pump*
- *4 Oil tank*
- *5 Oil radiator*
- *6 Oil filter*
- *7 Venting tube*
- *8 Oil temperature sensor (oil)*

Figure 7: Illustration of the Rotax 912 lubrication system. Source: Rotax/NSIA

1.3.2.1 Information about cold weather operations

The engine manufacturer, Rotax, recommends in their installation manual for the Rotax 912 series engines that an oil thermostat should be installed in parallel with the oil cooler to establish a bypass function when operating in low ambient temperatures, see Figure 8. LN-NRC did not have an oil thermostat installed, and Aquila has not installed these on the AT01-100. The installation manual also includes a warning stating that the oil pump might not have adequate flow at low ambient temperatures, see Figure 9.

1.3.2.2 Cavitation

Every pump has a value known as ‘Net Positive Suction Head Required (NPSHR)’. To prevent cavitation, the system before the pump must be able to supply a flow rate higher than NPSHR. As the flow rate increases, the NPSHR increases, while there is an upper limit for the flow rate the system can supply. At some point, the NPSHR will be greater than what the system can supply, and cavitation occurs. In a lubrication pump, cavitation will lead to loss of efficiency and reduced lubrication.

LOW AMBIENT TEMPERATURE

⚠ WARNING

Non-compliance can result in serious injuries or death!
At operation below normal operating temperature, formation of condensate in the oil system might negatively affect oil quality and may lead to corrosion.

Low temperature **NOTE**

When operating at low temperatures, installation of an oil thermostat, parallel to the oil cooler is recommended.

⚠ WARNING

Non-compliance can result in serious injuries or death!
If an oil thermostat is being used and the ambient temperature is low, there is a possibility that the oil may congeal briefly when in a steep descent flight. Pay extra attention to the oil pressure and oil temperature during these abnormal conditions. If necessary, revert to a cruising or climb situation..

Advantages of oil thermostat:

- safe oil pressure after cold start
- prevention of fuel and water accumulation in the oil

See the Service Letter SL-912-011 “Use of an oil thermostat”, current issue.

Figure 8: Excerpt from the engine manufacturer’s installation manual about low ambient temperature operations. Source: Rotax/NSIA

⚠ WARNING

Non-compliance can result in serious injuries or death!
The vacuum must be verified over the complete engine operation range. If the oil is cold, the flow resistance increases, which means that not enough oil will flow on the suction side.

Figure 9: Warning from the installation manual that not enough oil will flow to the oil pump if the oil is cold. Source: Rotax/NSIA

1.3.2.3 Approved lubrication oils

The proper oil viscosity is dependent on ambient temperature. The instructions in the aircraft flight manual are shown in Figure 10, while the engine manufacturer’s instructions in the engine operating manual are shown in Figure 11. The Rotax ‘Service Instruction’ SI-912-016R15 recommends using SHELL ® AeroShell Oil Sport Plus 4, which is a 10W-40 oil, and this was the oil used in LN-NRC. On 21 February 2024, SI-912-016R15 was replaced by SI-912-016R16 where XPS ® Full Synthetic Aviation Engine Oil, which is a 5W-50 oil, is also recommended. The 5W-50 oil has a lower viscosity at lower temperatures and will be more fluid.

AQUILA	POH / AFM AQUILA AT01-100A	Section 1 *GENERAL*

1.9 ENGINE OIL AND COOLANT

1.9.1 Engine Oil

Use only oil with an API classification of “SG” or higher. Heavy duty 4-stroke motor oils tend to meet these requirements. For more information regarding engine oil selection, please refer to the Operator’s Manual for all versions of the 912 engine series, section 10.2.3, and to the current issue of the ROTAX® Service Instruction SI-912-016.

The following chart shows the recommended oil viscosity as a function of the climatic conditions. The use of multi-grade oils is recommended.

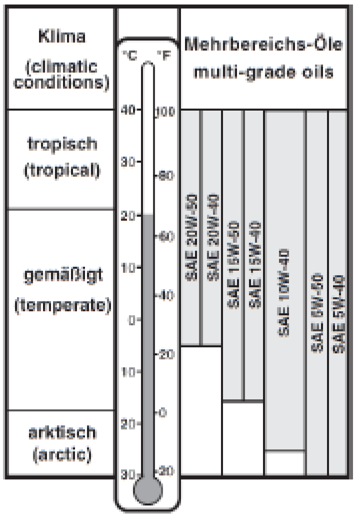

Figure 1-2

CAUTION

Do <u>not</u> use aviation grade oil!

*When operating the engine with AVGAS do **not** use full synthetic oil!*
If the engine is operated extensively on AVGAS 100LL (more than 30hrs within 100hrs) the interval between oil changes shall be reduced to 50 hrs!
(please refer to the current issue of the ROTAX® Service Instructions SI-912-016)

Max. Oil Capacity:	3.17 US quarts	(3.00 l)
Difference between Max/Min:	0.475 US quarts	(0.45 l)
Max. Oil Consumption:	0.063 US quarts/hr.	(0.06 l/h)

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Figure 10: Excerpt from the Aquila AT01 aircraft flight manual concerning engine oil. Source: Aquila/NSIA

NOTE

Multi-viscosity grade oils are less sensitive to temperature variations than single grade oils.
They are suitable for use throughout the seasons, ensure rapid lubrication of all engine components at cold start and get less fluid at higher temperatures.

Table of lubrication

Since the temperature range of neighboring SAE grades overlap, there is no need for change of oil viscosity at short duration of ambient temperature fluctuations.

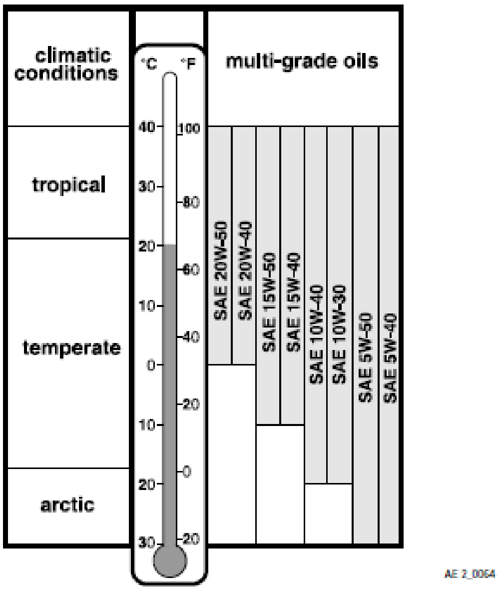

Figure 1: Temperature range

Figure 11: Excerpt from the engine operation manual concerning recommended oil viscosity . Source: Rotax/NSIA

The engine and aircraft manufacturer give different temperature ranges for a 10W-40 oil. The aircraft manufacturer states that a 10W-40 oil can be used down to -25 °C while the engine manufacturer states -20 °C as a lower limit. At the same time, the engine manufacturer states that there is an overlap between neighbouring oil viscosity grades, so that there is no need to change oil viscosity during temperature fluctuations of a short duration.

1.3.3 COLD WEATHER OPERATIONS KIT

LN-NRC was fitted with a ‘Cold Weather Operations Kit’ from Aquila. The kit is optional and is provided for users operating in cold ambient temperatures. The system consists of two main elements:

- Baffle – Mounted on and covers part of both the oil cooler and radiator to limit air flow and therefore cooling. Two sizes are available, where the smaller should be removed at ambient temperatures above 10 °C and the bigger should be removed at ambient temperatures above 5 °C. At the time of the incident, LN-NRC was fitted with the largest baffle.
- Engine preheater system – Two electrical heating pads, one mounted on the oil tank and the other mounted on the bottom of the crankcase. These heat up the oil in the oil tank and at the bottom of the crankcase. The oil in the oil lines and the oil cooler is not heated.

Documentation provided by Aquila shows that the heating element on the oil tank maintains a temperature of 115±15 °C while the heating element on the crankcase maintains a temperature of 140±15 °C. According to Aquila, the preheating system can be used for a maximum of two hours, since prolonged use can overheat the oil tank. The intended operation is to turn the system on shortly before engine start-up. This is not documented as a limitation in the aircraft flight manual, either in chapter 2 ‘Limitations’ or in the supplement ‘Cold Weather Operations’.

Figure 12 shows the situation before start-up and Figure 13 shows a possible situation after start-up.

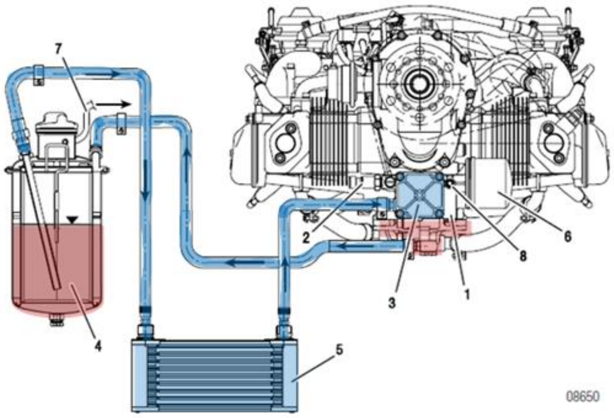

Figure 12: Situation before engine start. Blue is cold oil; red is warm oil. Illustration: Rotax/NSIA

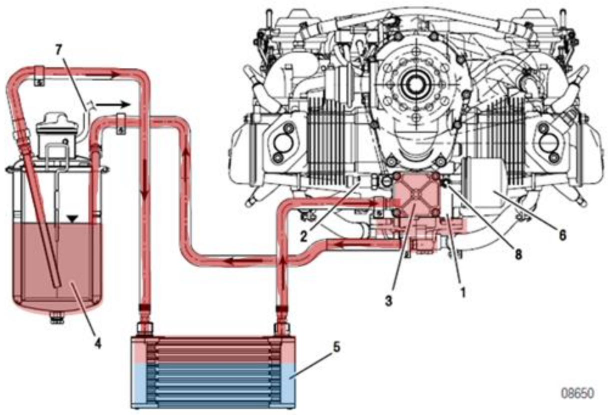

Figure 13: Possible situation after engine start. Blue is cold oil; red is warm oil. Illustration: Rotax/NSIA

1.3.4 LIMITATIONS FOR THE AIRCRAFT AND THE ENGINE

With respect to temperature, the following limitations are given in the aircraft flight manual:

2.4 POWER PLANT LIMITATIONS

2.4.1 Engine
…
h) Minimum temperature to start the engine

Minimum: -13 °F (-25 °C)
At an OAT below -13 °F (-25 °C) the engine must be preheated.

2.14 TEMPERATURE LIMITATIONS

Parts of the aircraft structure that are exposed to direct vertical sunlight must be painted WHITE.

Figure 14 below shows what the engine operating manual states about temperature limitations at start-up. Note that the maximum temperature is ambient temperature, while the minimum temperature is oil temperature.

Engine start, operating temperature

Max.	50 °C (122 °F) (ambient temperature)
Min.	-25 °C (-13 °F) (oil temperature)

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Figure 14: Excerpt from the engine operating manual concerning temperature limitations. Source: Rotax/NSIA

1.4 Weather

The weather was cold and fine. The forecasted weather and temperature measurements from the meteorological station at Kjeller airport are presented below. It was almost -30 °C at 0800 hrs.

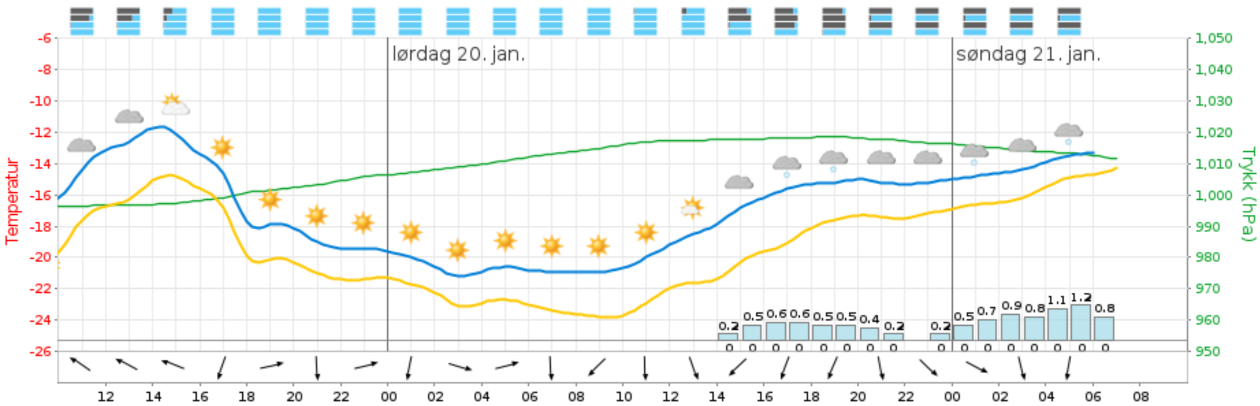

Figure 15: Meteogram for Kjeller airfield. The forecasted temperature was warmer than the recorded temperature. Source: Norwegian Meteorological Institute/NSIA

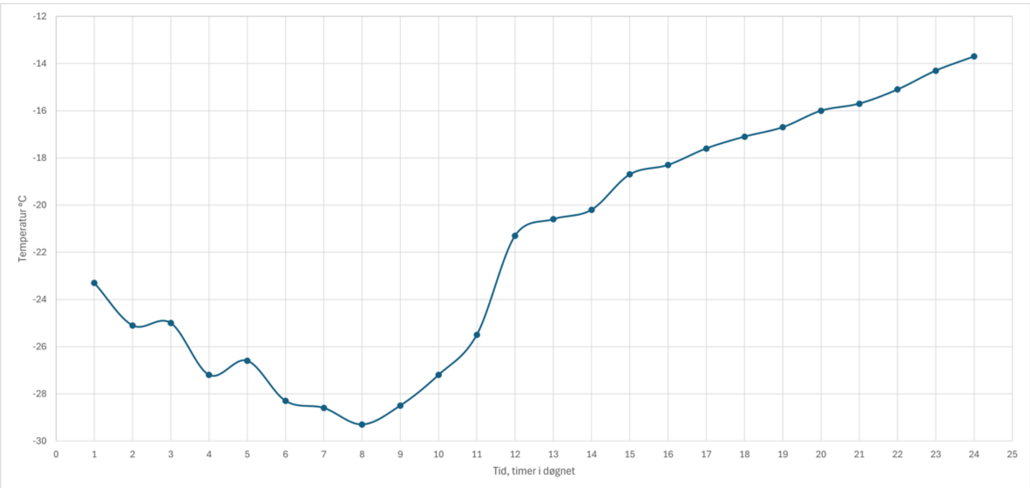

Figure 16: Recorded temperatures at Kjeller meteorological station on 20 January 2024. Source: Norwegian Meteorological Institute/NSIA

1.5 Operational factors

Since LN-NRC was a club aircraft used by Nedre Romerike flying club, it had several users with varying experience. The club management can introduce limits and clarify terms of use. The club had not introduced a temperature limitation prior to the incident. However, they have since instructed that the aircraft shall not be used when it is colder than -15 °C.

The club has also explained that the normal procedure during late autumn and winter is for the engine preheater system to be on, and a cover placed over the engine room while the aircraft is parked.

1.6 Reliability issues

The flying club has informed the NSIA that they have had reliability issues with the engines in their Aquila AT01-100 aircraft for a number of years. The engine in LN-NRC has also previously been found to have been calibrated to run too lean. Cylinder no. 1 in the engine of another of the flying club's Aquila AT01-100s, LN-NRA, has also been replaced due to detonation. Severe detonation can sometimes lead to connecting rod damage.

2. The NSIA's assessments

The engine inspection quickly established that two connecting rod big end bearings had sustained considerable damage. Both bearings had split due to the damage and connecting rod number three had punched through the crankcase. This meant the engine suddenly seized. The NSIA and the engine manufacturer Rotax agree that the damage was caused by a lack of oil lubrication.

No faults were found with the lubrication system during the inspection. The amount of oil found in the oil tank equals the maximum normal capacity. The fact that the oil tank was full indicates that the oil has not circulated as expected and that the issue lies between the oil tank and the oil pump, ref. Figure 7. The NSIA considers it likely that a combination of the oil system design and the engine pre-heating system gave rise to a situation where the engine received enough oil on idle and during run-up, but not enough oil when the engine was running at a high RPM for the max power setting during take-off.

The NSIA believes this was caused by the oil cooler being filled with very cold oil. After engine start and running at idle, warmer oil would start to circulate as shown in Figure 13. Heated oil would circulate through the oil lines, the upper part of the oil cooler and the oil pump housing, where the oil temperature and oil pressure sensor is found. The oil pressure could then be within expected values and the oil temperature above minimum for take-off. Since the oil pump is driven directly by the camshaft, the rotation speed would increase significantly when the engine power increases during take-off. The oil pump then needs to suck a substantially larger volume of oil from the oil tank and through the cold oil cooler. The NSIA considers it likely that this caused low enough pressure to cause cavitation and air bubbles in the oil pump. This would significantly decrease the oil pump's ability to deliver the correct oil pressure. The lubrication requirements are great during maximum power output from the engine, and the initial reduction in RPM that the pilot noticed was most likely caused by a developing bearing failure.

Internal combustion engines produce water vapour that mixes with the oil. When operating at normal oil temperatures, this moisture evaporates. When running the engine on the ground, or operating with low oil temperatures, it is possible that water might accumulate in the oil. This water would sink to the lowest parts of the oil system, for example the lowest parts of the oil cooler, and can freeze. The NSIA cannot rule out that ice was present in the oil but does not have a theory about how any potential ice could have caused the engine failure. The NSIA cannot see a link between the engine failure and the flying club's reported engine reliability issues.

The NSIA considers it a shortcoming that users of the aircraft struggle to obtain an overview of the applicable temperature limitations. There are no clear limitations in the aircraft flight manual, which states the engine must be preheated when the temperature is below -25 °C, and LN-NRC was equipped with preheating. At the same time, the oil that was used was not recommended by the engine manufacturer for use in temperatures below -20 °C. The NSIA believes it is unfortunate that the preheating does not provide a homogenous oil temperature and considers it likely that this contributed to concealing the issue from the pilot.

Although it will always be the pilot's responsibility to ensure that the aircraft is operated within its limitations, the NSIA is also of the opinion that aircraft and engine manufactures have a responsibility to make this information easily available. The investigation has found that this information is not unambiguous and that the aircraft flight manual and the engine operating manual provide different information. This is the case both with respect to which oil should be used and the use of engine preheating.

The flying club is responsible for the technical condition of their aircraft. The NSIA therefore also believes that flying clubs have a responsibility to ensure their members have the best possible prerequisites for correct use. Among other things, flying clubs have the possibility to set limits and terms of use for their aircraft. It is positive that the flying club has introduced a temperature limit that provides a buffer to the lowest temperature for the oil viscosity they have chosen.

Rotax recommends an oil thermostat for bypass function when operating at low ambient temperatures, but some special considerations must be taken as described in Figure 8. The problem can be avoided by not flying in such cold conditions, or by running the engine on the ground for an extended period. The NSIA has decided not to issue a safety recommendation but, following dialogue with both the engine and aircraft manufacturer, expects the aircraft manufacturer in collaboration with the engine manufacturer to clarify information for users.

The pilot had very limited manoeuvring possibilities when the engine failed at an altitude of about 250 ft above the ground. The NSIA believes the pilot acted correctly and made a very wise decision to land in the chosen field.

Norwegian Safety Investigation Authority
Lillestrøm, 18 February 2025