COMANDO DA AERONÁUTICA

CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE ACIDENTES AERONÁUTICOS

FINAL REPORT
A-191/CENIPA/2013

OCCURRENCE:	**ACCIDENT**
AIRCRAFT:	**PR-GPM**
MODEL:	**AS 350 B2**
DATE:	**22OCT2013**

NOTICE

According to the Law nº 7565, dated 19 December 1986, the Aeronautical Accident Investigation and Prevention System – SIPAER – is responsible for the planning, guidance, coordination and execution of the activities of investigation and prevention of aeronautical accidents.

The elaboration of this Final Report was conducted taking into account the contributing factors and hypotheses raised. The report is, therefore, a technical document which reflects the result obtained by SIPAER regarding the circumstances that contributed or may have contributed to triggering this occurrence.

The document does not focus on quantifying the degree of contribution of the different factors, including the individual, psychosocial or organizational variables that conditioned the human performance and interacted to create a scenario favorable to the accident.

The exclusive objective of this work is to recommend the study and the adoption of provisions of preventative nature, and the decision as to whether they should be applied belongs to the President, Director, Chief or the one corresponding to the highest level in the hierarchy of the organization to which they are being forwarded.

This Report does not resort to any proof production procedure for the determination of civil or criminal liability, and is in accordance with Appendix 2, Annex 13 to the 1944 Chicago Convention, which was incorporated in the Brazilian legal system by virtue of the Decree nº 21713, dated 27 August 1946.

Thus, it is worth highlighting the importance of protecting the persons who provide information regarding an aeronautical accident. The utilization of this report for punitive purposes maculates the principle of "non-self-incrimination" derived from the "right to remain silent" sheltered by the Federal Constitution.

Consequently, the use of this report for any purpose other than that of preventing future accidents, may induce to erroneous interpretations and conclusions.

N.B.: This English version of the report has been written and published by the CENIPA with the intention of making it easier to be read by English speaking people. Taking into account the nuances of a foreign language, no matter how accurate this translation may be, readers are advised that the original Portuguese version is the work of reference.

SYNOPSIS

This is the Final Report of the 22OCT2013 accident with the AS 350-B2 aircraft, registration PR-GPM. The accident was classified as "Engine Failure In-Flight".

During the final approach to land at the destination, when the aircraft was at an indicated speed of 50kt and an approximate height of 100ft, there was an engine power loss along with the low rotor alarm signal from the main rotor. The pilot performed an auto-rotation followed by landing on a dirt road.

The aircraft suffered substantial damage.

All occupants were unharmed.

An Accredited Representative from the BEA - Bureau d'Enquêtes et d'Analyzes pour la Sécurité de l'Aviation Civile, France (State where the aircraft was designed) was designated for participation in the investigation.

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GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

ABNT	Brazilian Association of Technical Standards
ANAC	(Brazil's) National Civil Aviation Agency
AQI	DCTA Chemistry Division
CA	Airworthiness Certificate
CENIPA	Aeronautical Accident Investigation and Prevention Center
CHT	Technical Qualification Certificate
CMA	Aeronautical Medical Certificate
CTA	Fuel Tanker Truck
DCTA	Aeronautics' Science and Technology Department
FCU	Fuel Control Unit
FORM	Form
FT-IR	Infrared with Fourier Transform
GRAER-BA	Bahia Military Police Air Group
IAE	Aeronautics and Space Institute
LAT	Latitude
LONG	Longitude
NBR	Brazilian Association of Technical Standards' Rule
PCH	Commercial Pilot License - Helicopter Category
PPH	Private Pilot License - Helicopter Category
QAV	Aviation Fuel
SERIPA	Regional Aeronautical Accident Investigation and Prevention Service
SIPAER	Aeronautical Accident Investigation and Prevention System
UTC	Universal Coordinated Time

1. FACTUAL INFORMATION.

Aircraft	**Model:** AS 350 B2 **Registration:** PR-GPM **Manufacturer:** Helibras	**Operator:** Secretary of Public Security of Bahia
Occurrence	**Date/time:** 22OCT2013/2006 UTC **Location:** Alpina Hotel I **Lat.** 12°58'32"S **Long.** 041°19'57"W **Municipality – State:** Mucugê - BA	**Type(s):** Engine Failure In-Flight **Subtype(s):**

1.1 History of the flight.

The aircraft took off from the outskirts of the city Rio de Contas, BA, at 04:30 pm, local time, to the city of Mucugê, BA, with two crewmembers and three passengers on board.

The flight lasted 36 minutes. During the final landing approach, when the aircraft was at an indicated speed of 50 knots (kt.) and an approximate height of 100 ft., there was a loss of engine power, along with the low rotor alarm signal from the main rotor.

The pilot landed on a dirt road.

The aircraft suffered substantial damage.

All occupants were unharmed.

1.2 Injuries to persons.

Injuries	Crew	Passengers	Others
Fatal	-	-	-
Serious	-	-	-
Minor	-	-	-
None	2	3	-

1.3 Damage to the aircraft.

The skis were ripped off. The fuselage, below the cockpit, was broken. There was the folding of the tail boom in the area near the back of the cabin. The engine compressor presented restrictions on free rotation.

1.4 Other damage.

Nil.

1.5 Personnel information.

1.5.1 Crew's flight experience.

Hours Flown		
	Pilot	Copilot
Total	1.200:00	1.480:00
Total in the last 30 days	20:00	20:00
Total in the last 24 hours	00:00	02:00
In this type of aircraft	1.100:00	1.350:00
In this type in the last 30 days	20:00	20:00
In this type in the last 24 hours	00:00	02:00

N.B.: The Data on flown hours were obtained from declarations of the crewmembers themselves.

1.5.2 Personnel training.

The pilot took the Private Pilot course - Helicopter (PPH) at *Escola de Aviação* EFAI - Contagem, MG, in 2004.

The copilot took the Private Pilot course - Helicopter (PPH) at *Escola de Aviação* EFAI - Contagem, MG, in 2004.

1.5.3 Category of licenses and validity of certificates.

The pilot had the Commercial Pilot - Helicopter (PCH) license. He had valid aircraft technical qualifications in the H350 type and of Instrument Flight Rules (IFR).

1.5.4 Qualification and flight experience.

The pilots were qualified and had experience on this kind of flight.

1.5.5 Validity of medical certificate.

The pilots had valid Aeronautical Medical Certificates (CMA).

1.6 Aircraft information.

The aircraft, serial number 4122, was manufactured by Helibras in 2006 and was registered in the category of Public Direct State Administration (ADE).

The aircraft had valid Airworthiness Certificate (CA).

The airframe and engine logbooks records were up-to-date.

The last inspection of the aircraft, "7 days (weekly) - Airframe / 7 days or 15 hours - Engine" type, was performed on 16OCT2013, having flown 8 hours and 35 minutes after the inspection.

The engine had not performed a general overhaul because it had not reached the hours provided by the engine maintenance program.

1.7 Meteorological information.

Nil.

1.8 Aids to navigation.

Nil.

1.9 Communications.

Nil.

1.10 Aerodrome information.

The occurrence took place outside the Aerodrome. In the off-site locations, a Fuelling Truck Tank (CTA) belonging to the aircraft operator carried out the refueling of the helicopter.

1.11 Flight recorders.

Neither required nor installed.

1.12 Wreckage and impact information.

After the impact on the ground, the aircraft moved approximately five meters ahead, dragging itself, leaning on the front of the skis until full stop (Figures 1 and 2)

Figure 1 - Overview of the accident site.

Figure 2 - View of the aircraft marks on the ground.

1.13 Medical and pathological information.

1.13.1 Medical aspects.

There was no evidence that physiological or disability considerations had affected the performance of the flight crew members.

1.13.2 Ergonomic information.

Nil.

1.13.3 Psychological aspects.

There was no evidence that physiological or disability considerations had affected the performance of flight crew members.

1.14 Fire.

There was no evidence of fire in flight or after impact.

1.15 Survival aspects.

Nil.

1.16 Tests and research.

Fuel samples were collected from the aircraft and the tanker truck (CTA). In both cases, it was observed the presence of a light brown substance in the collected fuel, as well as the presence of an analogous substance inside the CTA filters (Figures 3 and 4).

Figure 3 - Sample of fuel collected from the aircraft at the accident site.

Figure 4 - Aspect of the internal part of the CTA filter body.

The manufacturer of the filter used in the truck that fuelled the crashed aircraft contraindicated the use of these filters associated with fuel additives. This positioning of

the manufacturer was due to the possibility of the presence of salt in the fuel added triggering filter failures.

Based on this information, the fuel samples collected from the aircraft and the tanker truck were sent for analysis. The results obtained from these analyzes were as follows:

- the substance (gum) found in the samples was not associated with the material used to make the filters of the tanker truck;

- the presence of water in the analyzed fuel was not identified; and

- it was not possible to conclude if there was the presence of an additive in the analyzed fuel.

Also at the accident site, it was found that the rotation of the axial compressor of the helicopter's engine occurred with difficulty, accompanied by a characteristic noise of friction. The aircraft engine was collected for component disassembly and analysis at a specialist workshop. In the lubrication system, no malfunction was observed which could cause engine malfunction.

Due to the characteristics of the samples that were collected at the accident site, the studies were directed to the fuel system of the aircraft. Fuel Control Unit (FCU) was the main focus of the studies, being the component responsible for the supply and dosage of fuel for the engine. The obtained results were as follows:

- the intake filter, the main filter and the filter of the amplifier piston of the FCU presented contamination with a characteristic similar to that found at the accident site;

- The metering valve was inoperative and locked in the closed position. The valve was driven to the open position by its drive lever, but no success was achieved; and

- the free turbine shaft started to rotate normally, without friction, at the time of the uncoupling between the high pump / FCU and the gearbox.

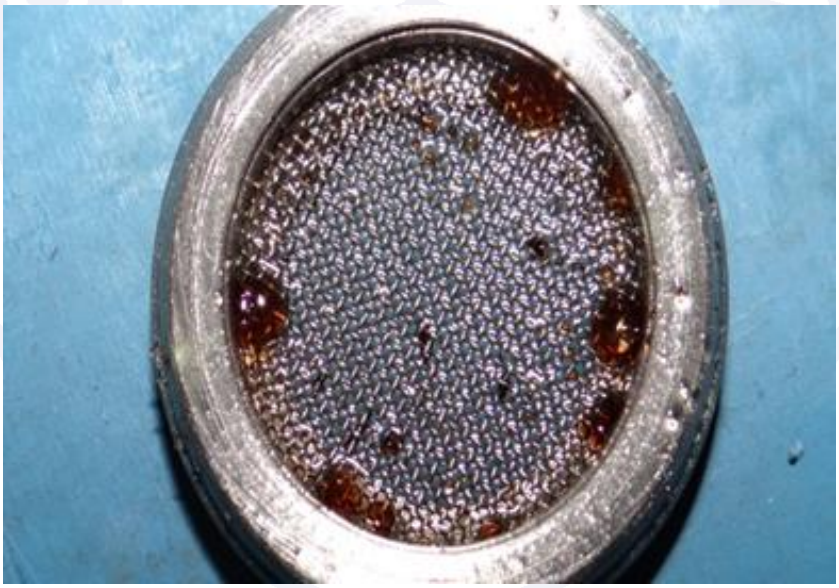


Figure 5 – FCU's input filter, netting type.

Figure 6 - FCU main filter.

Figure 7 – FCU's filter of the amplifier piston.

Figure 8 - FCU inner chamber.

Figure 9 - FCU metering valve needle.

Figure 10 - Enlarged image of the metering valve needle.

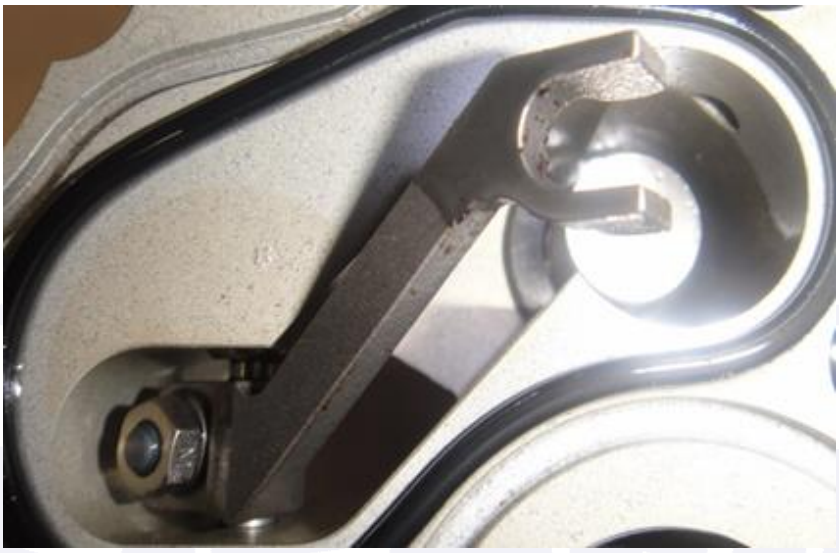


Figure 11 – Actuating rod of the FCU metering valve.

Figure 12 - Enlarged image of the Actuating rod of the FCU metering valve.

After the visual identification of this contamination (Figures 5, 6, 7, 8, 9, 10, 11 and 12), contaminant samples were collected and analyzed in the laboratory. The analyzes found that the residue found was polyacrylic acid salt (sodium polyacrylate)

The truck's fuel filters were also collected for analysis. Two filters were analyzed from the truck that fuelled the aircraft and a new filter, which had not yet been used (Figures 13, 14, 15, 16 and 17).

Figure 13 - Filters taken from the fuel tanker truck (CTA).

Figure 14 - Storage of one of the CTA filters.

Figure 15 - Two filters taken from the CTA (left) and a new filter (right).

In the filters removed from the fuel tanker truck the same contamination described previously was found in considerable volume. The analyzes indicated that it was the same chemical found in aircraft tanks, that is polyacrylic acid salt (sodium polyacrylate).

Figure 16 - New filter (left) without contamination and filter removed from CTA (right) with contamination.

Figure 17 - Detail of the contamination in the internal structure of one of the filters removed from the CTA.

In response to a query from SIPAER researchers, PETROBRAS technicians reported that sodium polyacrylate is not part of the chemical composition of the Aviation Fuel. Studies developed by the scientific community point to the relation between sodium polyacrylate and the material used in the manufacture of fuel monitors filters.

An assay was conducted to try to identify the source of the contaminant substance found. The test consisted in placing additive fuel in contact with the filter element of the new filter and comparing the substance produced in the test with the substance found in the aircraft and in the CTA. The chemical composition resulting from the test performed had different characteristics of the residue found on the crashed aircraft and CTA. Thus, it was not possible to determine the origin of the pollutant.

1.17 Organizational and management information.

The Air Group of the Military Police of Bahia (GRAER-BA), created in 08NOV2006, through State Law No. 10,403, was located at the Congressman Luís Eduardo Magalhães Aerodrome**,** in Salvador-BA.

GRAER-BA carried out Public Security and Civil Defense missions, such as searches; terrestrial and aquatic rescue; control of road, rail and urban traffic; prevention and firefighting; and operations related to airport activity.

To do so, it had a fleet composed of three helicopters: an AS 350 B2 (*Esquilo*), an EC-145 helicopter, a Cessna 208 Grand Caravan aircraft and two *Super Ximango* AMT 200 SO models.

GRAER-BA owned fuel tanker trucks (CTAs) to support aircraft in off-site operations. Professionals of GRAER's own staff operated these CTAs. Some of the CTA operators were unfamiliar with the English language.

1.18 Operational information.

The packaging and documentation relating to the filters that fitted the fuel tanker truck (CTA) contained the following guidelines, issued by the manufacturer:

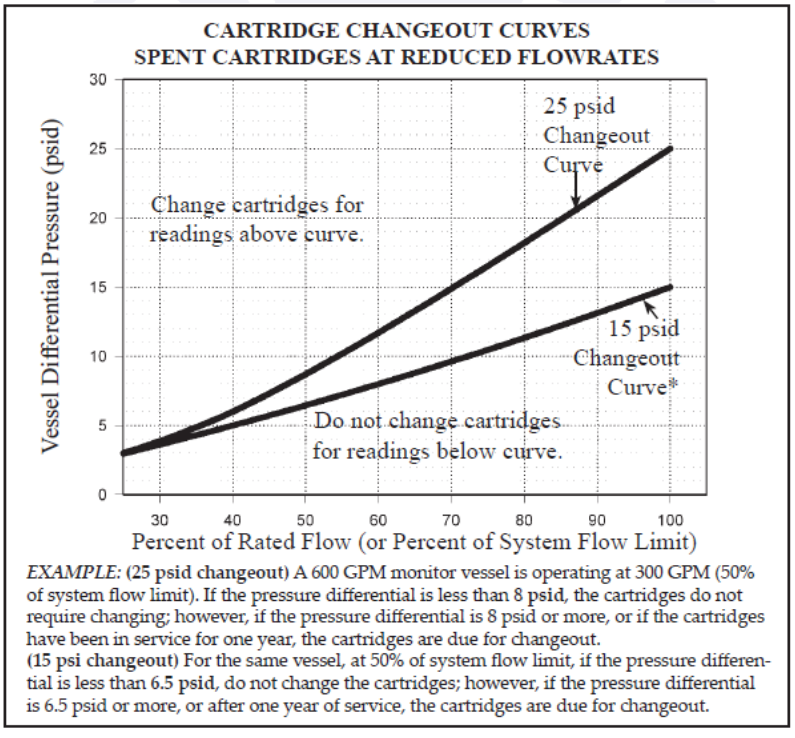
- avoid the use of additives;

- install a differential pressure gauge or other means of reading the pressure differential in the truck; and

- Provide replacement of the filter element whenever the pressure differential exceeds 25 PSID, or if there is a reduction in fuel flow or after one year of use, whichever occurs first.

The CTA used to fuel the crashed aircraft was equipped with two fuel gauges, one at the inlet of the monitor filter and the other at the outlet. However, the truck had no differential pressure manometer or other means of reading this parameter.

The manufacturer's guidelines included a chart illustrating the filter replacement, based on pressure differential measurements (Figure 18).



Decal #1846 - Cartridge Changeout Curve for cartridges with 25 psid changeout requirements
**Decal #1979 - Cartridge Changeout Curve for cartridges with 15 psid changeout requirement (per ATA 103)*

Figure 18 - Graphic of the substitution of monitors elements by reduction of flow.

As it can be seen in Figure 18, the filter manufacturer's guidelines are all in the English language.

1.19 Additional information.

During the investigation, it was verified that there was contamination, similar to that found in the present accident, in three helicopters and two CTAs belonging to GRAER-BA.

The fuel distributor serving GRAER-BA also provided services to other operators. However, only GRAER-BA aircraft showed contamination. No signs of impurities were found in the fuel of any other aircraft that has been supplied by the same distributor.

Other fuel distributors have been consulted and confirmed that the additive fuel should not get in contact with the filters used in the CTA. These vehicles shall be equipped with a specific tank to store the additive. The manipulation of the additive should be performed after the fuel has passed through the CTA filters, already in the supply hose.

Aero police operators, whose operational activities were supported by CTA, were the subject of research during the investigation. It was found that there was a lack of knowledge or a lack of familiarity of pilots and mechanics in relation to the recommendations contained in the manufacturers' manuals of the fuel monitor filters.

ABNT NBR 13310 regulated the construction and operation characteristics of the CTA, defining the installation of a direct differential pressure-reading manometer (fuel monitor element input and output).

The manufacturer of the filters, through Service Bulletin of 05NOV2003, among other points, established that:

> […] The analytical work carried out by filters of this manufacturer indicates the presence of sodium chloride (salt) in the absorption of water and polymers. This salt can degrade the performance of water absorption by the filter monitor for the formation of absorbent polymers. At this stage, it is not clear how salt is entering the fuel system - more testing and analysis are being conducted.
>
> Again, all monitors with compromised performances showed presence of salt in the water and formation of absorbent polymers. This occurred because of the exposure of the monitors to a high-pressure differential (in excess of 25 PSID) during the test. [...]

Factors that led to the failure of the monitor filters, generating contamination of this nature were researched in several countries. However, at the time of the conclusion of this Report, there was no news of the completion of this work.

Regarding the use of the fuel with antifreeze additive, we also had to:

- FSII (Fuel System Icing Inhibitor) is an acronym used to refer to the antifreeze additive that may have several chemical compositions, one of which is diethyleneglycolmonomethyl ether - DEGMME (*Prist*).
- - API / IP1583 (API / IP-American Petroleum Institute / Institute of Petroleum - UK) recommended that for the use of monitors on FSII fuels, great care should be taken to ensure that both FSII and fuel have the water content as low as possible and that the injection of FSII into the stream was done after the monitor (filter).
- The ABNT standard NBR15216 specified in Note 1 of item 5.7 that the antifreeze additive should be injected downstream of the filter (after the filter) monitor of the aircraft supply units.

No mechanism or rules have been identified that establishes criteria for the approval / certification of ATCs that support aircraft operations, as well as for regular monitoring of the technical and operational conditions of such vehicles.

1.20 Useful or effective investigation techniques.

Nil.

2. ANALYSIS.

The aircraft presented loss of power when it was in the final landing approach, with about 50kt of indicated speed and 100ft of height. The low rotor alarm of the main rotor

rang. The crew acted on the collective command by moving the lever down in order to try to keep the main rotor RPM within normal operating parameters and attempted to perform an auto-routing procedure. A drift landing was made on a dirt road.

The flight was in a region far from the GRAER-BA's operations base. In operations like this, a CTA was used to refuel the aircraft. Fuel samples were collected from the aircraft and from the CTA.

During the examinations performed on the components of the aircraft, it was found that the helicopter's fuel system was contaminated with a light brown substance. The same contamination was found inside the CTA filters used to refuel the aircraft.

A survey was carried out with other operators who supplied their aircraft with the same fuel distributor, which provided services to GRAER. The fact that there was no contamination in the fuel of the aircraft belonging to the other operators raised the suspicion that the contamination originated in the fuel distributor.

It was suspected that the failure of the aircraft engine could be associated with the presence of water in the fuel. However, the results of the analysis of the collected fuel samples led to the exclusion of this possibility.

Tests on fuel samples indicated the presence of a substance identified as sodium polyacrylate, which was not part of the chemical composition of the Aviation fuel (QAV). The analyzes also showed that the substance found was not associated with the material used to make the CTA monitor filter, operated by GRAER-BA.

However, studies developed by the scientific community point to the relation between sodium polyacrylate and the material used in the manufacture of fuel filters. Although these works are not conclusive, there were indications that the failure of the filter elements could be related to the presence of salt in the additive fuel. In general, studies suggest that the salt reacts with the absorbent paper of the filter element and impairs its water retention capacity.

It points to the possibility that GRAER-BA's CTA has been inadvertently fueled with additives. As a rule, GRAER-BA aircraft AS 350 B2 do not use additives. The antifreeze additive could have been used in CTAs operated by GRAER-BA, since it was injected after the fuel monitor filter. If the additive was injected before the filters, the chemical compound could contaminate them.

In order to verify this hypothesis, a test that placed added fuel in contact with the filter element of a new filter was performed. The results showed a chemical compound with different characteristics of the residue found in the fuel system of the crashed aircraft and the CTA. In addition, the analyzes were not conclusive as to the presence of additive in the collected fuel samples. Thus, it was not possible to establish that the contamination started in the use of fuel additives in the CTA.

Another possible scenario is the premature wear of the monitor filter element. If the differential pressure limits set by the filter manufacturer had been exceeded at some point in the CTA operation, this could have led to premature wear of the component. The CTAs operated by GRAER-BA were not equipped with a differential pressure gauge for fuel pressure or other means that would allow the direct reading of this parameter, as established by the manufacturer of the filters. For this reason, this possibility was not discarded.

Based on the above considerations, it was not possible to determine exactly the origin and circumstances that led to the appearance of the contaminant substance. It is assumed that sodium polyacrylate was initially formed in the CTA and subsequently transferred to the fuel tank of the helicopter. The presence of this substance caused the

contamination of the fuel system of the aircraft, the locking of the metering valve in the "closed" position and the consequent loss of power observed.

A survey carried out with the airport operators identified that the professionals who acted as responsible for the operation of the CTA were unaware of the recommendations issued by the manufacturer of the filters. This lack of knowledge was even more pronounced regarding the restriction of the use of fuel added with filter elements, as well as the installation of a differential pressure gauge for fuel pressure or other means that would allow the direct reading of this parameter in the CTA. This condition was attributed to the lack of familiarity of these professionals with the English language, a language used by the manufacturer of the filters in their publications.

During examinations in the aircraft engine, it was found that the free turbine shaft started to rotate normally (no friction) once the high pump / FCU assembly was decoupled from the gearbox. In view of this fact, it was possible to infer that the friction found in the turbine was due to damages caused by the contamination of the fuel in the high-pressure pump / FCU.

The FCU analyzes showed that the metering valve was inoperative and locked in the closed position. This valve, belonging to the FCU, had the function of dosing the fuel for the engine, according to the power required to keep the main rotor RPM constant. The FCU's work on fuel dosing was summarized as follows: every time the pilot drove the collective pitch lever upward, the pitch angle of the blades increased and the RPM of the main rotor tended to decrease. To keep RPM constant, the FCU would open the metering valve and inject fuel into the engine, which in turn, would provide more power to the main rotor for RPM maintenance. The reverse occurred when the pilot drove the collective step lever down.

With the metering valve in the "closed" position, the FCU would be providing the minimum fuel needed for the engine to run. This valve position was consistent with low-engine operation.

During the final approach to land, helicopters describe a profile that demands little engine power initially. As the aircraft approaches the ground, the pilot acts on the controls in order to slow down until a hovering flight (at 0kt speed) is possible near the ground. The transition between flying with speed ahead and hovering demands action on the collective pitch lever upwards by the pilots. This actuation in the controls will require more engine power to maintain the RPM of the main rotor and, consequently, of the actual flight.

The metering valve of the crashed aircraft was found locked in the "closed" position. During the final approach, the pilot would naturally have to drive the collective lever downward and, as a result, the metering valve would move to a position closer to the "closed" position, in accordance with arrangements in which the collective lever is "low". With the reduction of the speed ahead and approach with the ground, the pilot would have to command, gradually, the lever of the collective upwards. This displacement of the collective control would cause the FCU to move the metering valve to a position closer to the "open" position, consistent with regimes in which the collective lever is "up". If the metering valve does not open at this time, the power supplied to the engine would be less than the power required to maintain the RPM of the main rotor due to problems in the fuel dosage.

Based on the above considerations, it is possible to infer that the pilot lowered the collective pitch lever during the final approach. The metering valve moved to the "closed" position and locked in this position due to contamination by a viscous substance, identified as sodium polyacrylate. As the pilot ran the collective step upwardly during the transition from flying ahead to hovering, the metering valve did not move from the "closed" position to the "open" position, as expected. With the increase of the collective pitch, the engine

would need more fuel in order to provide the power needed to keep the main rotor RPM constant. However, with the valve locked in the "closed" position, the fuel dosage did not increase and the engine was not able to provide more power to the main rotor system. The RPM of the main rotor has decreased to the point of sounding the low-rotation alarm. The crew had to lower the collective pitch lever again to try to keep the main rotor RPM within limits and enter autorotation. The procedure resulted in a forced landing.

3. CONCLUSIONS.

3.1 Facts.

a) The pilots had valid Aeronautical Medical Certificates (CMA);

b) the pilots were qualified and had experience in that type of flight;

c) the aircraft had valid Airworthiness Certificate (CA);

d) the aircraft was within the weight and balance parameters;

e) the operation took place outside the Aerodrome;

f) a fuel tanker truck (CTA), owned by the operator, supported the operation;

g) the free engine turbine of the helicopter presented friction characteristics during the exams performed at the site of the occurrence;

h) fuel samples were collected from the aircraft and from the CTA;

i) the collected samples showed contamination by sodium polyacrylate;

j) the aircraft's fuel system was contaminated by the same chemical;

k) the FCU metering valve was found locked in the "closed" position;

l) CTA filters presented contamination similar to that found in the CTA and aircraft fuel samples;

m) the pollutant substance found was not part of the chemical composition of the aviation fuel (QAV);

n) the substance found was not associated with the material used to make the CTA monitor filter;

o) the analyzes of the fuel samples collected from the aircraft and the CTA did not present any water;

p) the analyzes of the fuel samples collected from the aircraft and the CTA were not conclusive as to the presence of additive.

q) the CTA was not equipped with a differential manometer or other means that would allow direct reading of the fuel pressure differential;

r) airport operators consulted showed that they did not have knowledge about the recommendations issued by the manufacturer of the CTA filters;

s) the filter manufacturer's recommendations were in the English language;

t) the CTA operators were not fluent in the English language;

u) there was loss of engine power during final approach to land;

v) the crew made an emergency landing on a dirt road;

w) the aircraft suffered substantial damage; and

x) the occupants were unharmed.

3.2 Contributing factors.

- **Training – a contributor.**

The training of CTA operators contributed to the occurrence at hand. According to research conducted, there was a lack of knowledge or unfamiliarity with the recommendations contained in manufacturers' manuals of fuel monitor filters.

- **Support equipment – undetermined.**

It is possible that the absence of a differential pressure gauge in the monitor filter or other means that would allow the direct reading of this parameter, during the operation of the CTA, contributed to the occurrence of the accident. This type of device is intended to allow the monitoring of the differential pressure of the fuel, parameter taken by the manufacturer of the filters as important for the replacement of the same ones.

- **Support personnel – undetermined.**

It is possible that the inadequate performance of the personnel involved in the operation of the CTA, for ignorance of the recommendations of the manufacturer of the filters, contributed to the accident.

- **Managerial oversight – a contributor.**

The fact that the operator's top management did not identify any shortcomings in the training process of the CTA operators, the lack of proficiency in English by these professionals, and failures in the actual operation of CTAs contributed to the occurrence of this accident.

4. SAFETY RECOMMENDATION.

A measure of preventative/corrective nature issued by a SIPAER Investigation Authority or by a SIPAER-Link within respective area of jurisdiction, aimed at eliminating or mitigating the risk brought about by either a latent condition or an active failure. It results from the investigation of an aeronautical occurrence or from a preventative action, and shall never be used for purposes of blame presumption or apportion of civil, criminal, or administrative liability.

In consonance with the Law n°7565/1986, recommendations are made solely for the benefit of the air activity operational safety, and shall be treated as established in the NSCA 3-13 "Protocols for the Investigation of Civil Aviation Aeronautical Occurrences conducted by the Brazilian State".

Recommendations issued prior to the publication of this report:

None.

Recommendations issued at the publication of this report:

To the National Agency of Petroleum, Natural Gas and Biofuels (ANP), it is recommended:

A-191/CENIPA/2013 - 01 **Issued on: 10/05/2018**

Ensure the installation of a differential manometer or other means that allows direct reading of the differential pressure of the fuel in the CTA operated by GRAER-BA, according to Form 1839-R20 03/13.

A-191/CENIPA/2013 - 02 **Issued on: 10/05/2018**

Work with the representative of *Velcon* in Brazil, in the sense that the instruction manual of the monitors used in the CTA that support aeronautical activities, as well as the related Service Bulletins, are duly printed and published in the Portuguese language.

A-191/CENIPA/2013 - 03 **Issued on: 10/05/2018**

Ensure that the methods used by GRAER-BA are adequate for the monitoring of the fuel used in the aircraft coming from its CTAs.

A-191/CENIPA/2013 - 04 **Issued on: 10/05/2018**

Ensure that GRAER-BA's CTA operators have been guided and trained to comply with the provisions of Form 1839-R20 03/13 of *Velcon*. Notably with regard to monitoring the substitution curve of monitors by reduction of flow.

A-191/CENIPA/2013 - 05 **Issued on: 10/05/2018**

Instruct the GRAER-BA, in the sense that warning plates are installed in a visible place of the CTA, based on Note 1 of item 5.7 of ABNT NBR15216, alerting its operators about the restriction to the use of additives.

A-191/CENIPA/2013 - 06 **Issued on: 10/05/2018**

Ensure that the operation of fuel tanker trucks (CTAs) occurs in accordance with the instructions contained in the instruction manuals of the fuel monitor elements of the equipment, in relation to the monitoring of the differential pressure of fuel applied to the monitors' filters of these vehicles.

A-191/CENIPA/2013 - 07 **Issued on: 10/05/2018**

Ensure that the construction and operation of the CTAs comply with the instructions contained in ABNT NBR 13310, in particular with regard to the installation of the differential pressure manometer or other means that allows the direct reading of this parameter.

5. CORRECTIVE OR PREVENTATIVE ACTION ALREADY TAKEN.

It was made a DIVOP 010/2014 to aware the need to comply with the recommendations contained in Form 1839-R20 03/13 and to alert the various aero police operators supported by fuel tanker trucks (CTA), among other aspects.

On May 10th, 2018.