The State of Israel

Ministry of Transport

Aircraft Accidents and Incidents Investigation

Accident Report No. 11/02

Occurred on 24 May, 2002 to Bell 206B III Helicopter Registration

No. 4x-BJH in the "Nesher" Plant Near Ramla, Israel

OCCURRENCE SUMMARY

While performing the first path of a low-level aerial photography mission, conducted over the "Nesher" cement factory, the helicopter's engine flamed-out when it passed through the air exhaust from one of the plant's chimneys. The pilot performed an autorotation descent, and as could not locate an open field suitable for landing, he elected to land on a tall tree.

The helicopter struck the upper section of the tree, then fell down and hit the ground with its forward part of the belly, and crashed on a tall fence. The helicopter was destroyed and its three occupants were seriously injured and evacuated to nearby hospitals.

1. FACTUAL INFORMATION

1ST. PRE-ACCIDENT OCCURENCES RECONSTRUCTION

1) The flight's objective was to photograph the plant facilities and surroundings under an order placed by "Nesher". The film was for use in a promotional picture of the plant.

2) In the flight briefing were the pilot, the photographer, and the director. The pilot emphasized the section concerning flight safety, the manner of harnessing to the seats, as well as egress actions. In addition, the briefing included a part dealing with the fact that the area of Ramla, where the plant is situated, is full of flight obstacles (e.g., power lines), thus no low level photography will be accomplished. The photography height was not brought up in the briefing, and it was left for the pilot's judgment, as he had the most experience. In addition, he had to determine the height as dictated by the encountered obstacles at the site.

3) Based on the pilot and film director's stories, it is possible that they assumed, that the plant chimneys will be deactivated during the mission (as the smoke may impair the photography quality). This assumption was not supported by any of the plant personnel. The plant operates around the clock 365 days a year, including all holidays.

4) The first photography path was conducted from north to south (general heading was 190-200 degrees), and it started from Achisemech village, situated north to the plant, at 300 feet height above ground level (AGL), descending later to lower height.

5) As he approached the plant, the pilot started climbing, passing to the right of one of the chimneys and then he passed over another chimney, approximately 50 feet above its top, at 50-60 knots IAS. As the helicopter passed over the chimney, the windshields were covered with fog, and the engine flamed-out, with indications similar to normal engine shutdown.

6) As a result of the engine failure, while he was above the tall facilities, the nose shifted 40 degrees to the left, towards the center of a large container, that was situated parallel to the flight path. Despite the engine failure, the pilot delayed his actions for a second and lowered the collective pitch stick to enter autorotation descent only after he passed these tall obstacles.

7) Autorotation initiation was approximately 160 degrees heading, and height lower than 300 feet AGL with 50 knots airspeed. The pilot performed an engine shutdown procedure, and transmitted a message on 118.3 MHz to Ben-Gurion ATC, located several miles from the site.

8) The pilot realized that to his right were buildings and power lines, to his left there was a wreckage salvage field, and a tall eucalyptus tree straight ahead.

9) While assessing these conditions, the pilot evaluated all the options he had, and finally decided to land on the tree (as he watched pilots doing in similar events in Vietnam war movies).

10) The pilot started flaring the helicopter in order to reduce the rate of descent (ROD) and speed, and struck the upper third of the tree. As a result, the forward speed was considerably reduced. The helicopter then fell down to the ground, and struck the ground with its lower section of the nose while lightly hitting the roof of a temporary shack near the tree. Several workers were at the shack at the time of the accident.

11) The helicopter came to rest on a tall fence, and a large quantity of fuel spilled about the wreckage. Plant personnel arrived quickly at the occurrence place, and started to rescue the injured helicopter occupants, as well as to report the accident as required. Police and Medevac arrived relatively fast.

12) The injured helicopter occupants were evacuated – two to Tel-Ha'Shomer hospital, and the third to Assaf Ha'Roffe hospital.

2ND. FINDINGS AT ACCIDENT SITE

1) The helicopter was found resting on its LH side, with its nose pointing towards southeast approximately 30 feet away from the tree it struck during the landing.

2) A one story shack with asbestos roof was situated between the tree and the resting place of the helicopter. The roof was found partly broken with parts of the helicopter tail among the debris.

3) The helicopter actually came to rest at the high fence, located in front of a wide yard where various types of barrels are stored along with the plant's old junk. The helicopter struck an angular post of the fence, that penetrated it from side to side at the cockpit section.

4) The tree struck by the helicopter shows many signs of torn off branches, part of them relatively thick. The debris were found at the upper third of the tree at a height of approximately 12-15 meters above ground.

5) The helicopter's tail was torn off behind the horizontal stabilizer, and found resting to the right from the helicopter.

6) The front lower section of the helicopter as well as the entire nose section were severely damaged.

7) The impact signs were recognized on the main rotor blades, especially on their trailing edges.

8) Damaged video cameras were found at the helicopter's bottom. The films were recovered from the wreckage.

9) Many signs on the helicopter's dynamic system indicate that the entire system suffered a sudden stoppage.

3RD. HELICOPTER FACTS

1) The subject matter helicopter, a Bell 206B III JetRanger, serial No. 2224, was manufactured in 1977, procured by "ChimAvir", and was registered in certificate No. 256 on 17 October, 1977.

2) The helicopter ownership was changed on 6 August, 1991, when it was purchased by "Chimnir Air Services Ltd.". A new registration certificate was issued bearing the number 256/1.

3) The helicopter was maintained at Bedek maintenance facilities, and it went through a maintenance schedule approved by the Israeli Aviation Authority (IAA).

4) Two certificates were issued confirming its flight worthiness as follows:

- Normal operation – On 6 September, 2002 for one year.
- Limited operation – Aerial Photography – On 6 September, 2001 for one year.

5) Last scheduled inspection, a 100 hour inspection, was conducted with 6879:12 airframe hours on 19 May, 2002.

4TH. ENGINE FACTS

6) The installed engine was an Allison 250-C-20-B, bearing serial No. CAE-835115. The engine was installed on the helicopter on 23 August, 2000 with recorded 169:18 operating hours.

7) On 4 March, 2002, the engine underwent a 150 hour inspection, when it had 728:28 recorded operating hours. At the time of the accident, the engine accumulated a total of 820:33 hours.

5TH. PILOT FACTS

1) The pilot carried a pilot license No. 1388, issued for aircraft types "a" and "e", with agricultural flight authorization. The pilot carried a valid medical certificate at the time of the accident.

2) The pilot has a vast flying experience, on helicopters in general, and on the subject matter type especially.

6TH. AERIAL PHOTOGRAPHY IN CHIMNIR LTD

1) Chimnir LTD's operational assistance manual has a special section dedicated to aerial photography missions (pages 146-148). Paragraph 3 in that Section describes the process of an aerial photography mission order procedure, that within it, the ordering organization is required to specify the desired aerial photography height (Paragraph 3.1.6).

2) Paragraph 4 of the aerial photography Section describes the actions required for mission planning, that within these the pilot is required to plan the flight routes, altitude/height, time etc.

3) Paragraph 5 describes the flight execution requirements, which within its sub-paragraph 5.3.1 dictates that "the selected photography height will enable the pilot to conduct a safe forced (autorotation) landing at an open field, free of buildings and people, and in any case not less than 1000 feet above a populated area, and 500 feet above an open area, that is except for agricultural purpose photography, where the pilot is allowed to descend to 100 feet, provided that he holds a valid agricultural flight authorization".

4) The investigation team examined the mission's height issue, and found that in 26 October, 1999, the company was granted an authorization to perform low level flights with working crews at 100 feet height AGL.

5) It should be emphasized, that the authorization to perform 100 feet height AGL flights - according to the principle recorded in the regulations - referring to the highest obstacle at 600 meters radius from the helicopter, where it represent the center of the circle, and in any case the pilot must adhere to the minimum permissible height limit, while considering the airspeed, for forced landing.

6) From reconstruction of the helicopter's flight path, accomplished from the recorded video film during the accident from the subject matter helicopter, it is obvious that the helicopter was at an estimated height of 50 feet above the chimney that caused the engine flameout, and much lower than the tall flight obstacles present in the plant's grounds.

7TH. FLYING IN CHIMNEY VICINITY

1) Chimnir Ltd. did not issue a procedure for operating at the vicinity of chimneys. According the company's head of operations "As it is obvious that it is forbidden for many reasons to enter the exhaust area of a chimney".

2) During safety seminars that the company conducted for its pilots in the past and prior to the accident (on 23 April, 2002, where the subject matter pilot attended as well), the speakers talked about the risks of flying through exhaust gases of oil rigs gas torches, as well as of electrical combining station's gas turbines. According to the company's head of operations: "the analogy for flying over chimneys as in "Nesher" is obvious".

8TH. FACTS ON SIMILAR OCCURENCES IN THE WORLD

1) The investigation team displayed the investigation results and the accident's recording video films in front of experts from the US National Transportation Safety Bureau (NTSB), US Federal Aviation Authorities (FAA), Bell Helicopter Textron (BHT) and Rolls Royce.

2) During discussions it became clear that, in the past Bell 206 helicopter accidents were investigated after engine flameout occurred when it flew over chimneys or other obstruction possessing similar characteristics.

3) The investigation team obtained an overview of similar occurrences, and for some of the investigation reports, report summaries, photographs etc. were obtained.

9TH. MAJOR EVENTS DESCRIPTION

Passing Over Smoke Exhaustion Chimneys

1) 1989, Bell 206B Jet Ranger - During the third photography path over chimneys, experienced engine flameout and crashed on its side on a parked vehicle.

NOTE

The event is similar to the subject matter accident. The investigation team obtained the entire accident documentation.

2) 1996, Bell 206L3 Long Ranger - The helicopter passed over a chimney, the engine failed and it crashed.

Flying Aside a Gas Burning Chimney

1) 1995, Bell 206L3 Long Ranger – During final approach to the oil rig pad, the helicopter passed through the side smoke trail of the redundant gas burning chimney. The helicopter's engine lost power and it crashed into the sea. The investigation team obtained a picture of the rig and a drawing depicting the landing approach path.

Active Volcanoes

1) 1992, Bell 206B JetRanger - While flying over an active volcano in Hawaii, the helicopter's engine lost power, and the pilot was forced to land on the inner slopes of its opening. The pilot was rescued safely, however the helicopter was lost.

2) 1994, Bell 206L3 LongRanger - While flying over an active volcano, the helicopter's engine lost power, and the pilot was forced to land inside its opening.

During Fire Fighting Missions

1) At a later stage, the investigation team was exposed to an article that discusses the issue of mid-air engine failures during fire fighting missions. The author said that helicopter accidents of great numbers and varieties occurred around the world during fire fighting missions while employing water tanks. Some of these helicopters were equipped with an Automatic Re-Ignition Kit, that practically

saved the lives of the crews as well as the aircraft. According to the author, the common thread that links all these cases is the absense of sufficient relative oxygen in the air above the fire area, chimneys etc.

Summary: Despite his knowing the effect of chimney exhausted air on the Bell 206 engine, the manufacturer failed to publish an appropriate service letter instructing operators how they should act concerning flying over chimneys. Based on this investigation, the manufacturer promised to issue such a letter.

10TH. FACTS ON THE “NESHER” PLANT CHIMNEYS

(Measurement made on 24 May, 2002, 12:00 p.m.)

Chimney Designation	Height (meters)	Diameter (meters)	Exhaust Temp. (ºC)	Sufficiency (cubic meter/hour)	Gas exhau-tion speed	Oxygen (%)
* Main – 1	65	5.2	100	700,000	20 kts	13
Bypass – 1	40	1.8	98	60,000		19
Main- 2	70	5.5	99	600,000		11.5
Bypass - 2	45	1.98	129	55,000		18.5

* Prior to the engine flameout, the helicopter passed over No. 1 chimney

11TH. ALLISON ENGINE AUTO RE-IGNITION KIT

General Motors, of which the engine manufacturer Allison is a subsidiary, published on 31 December, 1989, a Service Letter concerning the re-ignition of Allison engines. Following is a summary of that letter:

Engine power loss may be experienced in certain situations as a result of flameout. The reasons may vary from extreme maneuvering of the helicopter with low fuel level in its tanks, air leak from the fuel systems tubes, air trapped in the fuel system, flying in snow conditions, or as a result of fuel contamination (especially contaminated by water). In some cases the engine may recover and re-gain its power by means of the employment of a momentary re-ignition action. Allison conducted a research in conjunction with BHT, to develop an auto re-ignition system that will be installed in BHT’s variety of aircraft. When such a system is installed, it provides a momentary automatic ignition as required. The auto re-ignition system senses the drop of compressor pressure (PC), that occurs during engine flameout. The system then automatically provides the ignition system with electrical power without pilot involvement. The system’s reaction time varies according to aircraft type, and it set in the factory to the proper time delay, without enabling the operator to adjust this parameter.

System Activation Switch

The system activation switch comprises three positions as follows:

- Upper position - TEST - Used for momentary system readiness check.
- Center position - ARM - System is ready for auto re-ignition.
- Lower position - OFF/RESET.

After the N2 is stabilized in engine start at 100% rpm, the pilot should set the switch to the ARM position. This will set the system to its ready to auto activation state.

After landing, and during engine shutdown, when the pilot closes the throttle to idle position, he should verify that the switch is set to ARM, and then he may continue and close the throttle to the shutdown position. When done properly, the re-ignition indicator light illuminates to indicate that the system operates properly. After checking, the pilot should set the switch to OFF/RESET position.

Installation of the re-ignition kit in Bell 206 helicopters is optional and it is up to the operator to decide whether to install it in his aircraft.

BHT published on 12 January, 2000, an Information Letter designated 206-00-80, with the heading: "Operating the Helicopter in Snow Conditions". In this letter BHT encouraged Bell 206A and B operators to install the re-ignition kit in their aircraft to provide enhanced safety should their pilots encounter snow storms during its flight.

Summary: Despite the fact the system exists in the industry for 14 years, BHT never issued a letter to its customers ordering them to install the system in their aircraft.

The investigation team discussed the subject with Israeli Air Force (IAF) authorities. It was realized that the IAF had the system installed in the factory in their Bell 206L helicopters, however, because of recurring malfunctions it was removed from all aircraft.

2. ANALYZING

Assessment of the investigation documentation is based on the following two major components:

- Causes of engine flameout.
- Pilot's actions.

12TH. CAUSES OF ENGINE FLAMEOUT

1) Allison 250C20-B Engine – Description & Principle of Operation

The Allison C20-B Engine includes the following two turbines: (a) Gas Turbine – Drives the compressor section, and (b) Power Turbine – Drives the entire drive system and accessory gearbox through the Main Gearbox. No mechanical linkage exists between these two turbines. Hence the name Free Turbine.

Gases expelled from the combustion chamber first pass through the Gas Turbine in order to drive it and after that they pass through the Power Turbine and drive it as well. This configuration creates a "Gas Linkage" between the two turbines. Thus, there is a need for speed monitoring for both turbines.

As helicopter design considerations dictate, the main rotor speed must be constant. However, any variation in the collective pitch angle affects the load applied on the engine/power demand, and as a result it affects the rotor speed as well. How does the rotor maintain its rpm after all? The answer lies in the engine operational method, as described herein: As the collective pitch angle varies, the load applied to the Power Turbine varies in conjunction. This variation tends to accelerate the turbine rpm. In order to control this tendency of the turbine, a mechanism was incorporated to increase the Gas Turbine's rpm, and thus to maintain a constant Power Turbine rpm.

In order to obtain an efficient engine operation throughout its entire range, a fuel control governor was incorporated into the accessory gearbox. The governor is driven at a speed dependent on the Gas Turbine (N1). Various parameters effect the fuel control, including: Throttle setting, compressor intake air pressure, compressor air pressure output, governor's supplied air pressure , and air pressure returned from it

Part of these parameters are utilized to obtain a "relative pressure" that is used for the determination of quantity of fuel supplied to the engine's fuel nozzles – i.e., to generate the proper fuel/air mixture throughout the entire engine operational range.

In order to create a complete fuel control system, a governing unit was added, to maintain a constant Power Turbine's (N2) rpm, by means of adjustment of the fuel control unit. This adjustment determines the Gas Turbine's speed, required to maintain N2 turbine speed. The fuel control governor is situated on the engines accessory gearbox, and is driven at a speed relative to that of the Power Turbine. An efficient rigging of the governor is based on throttle setting and compressor air pressure output.

2) Subject Matter Helicopter's Engine Investigation

- The engine was removed from the helicopter and went through external inspection. No exceptional findings were detected.

- Engine air intake and particle separator were inspected for evidence of damage or clogging. None of these were detected.
- Chip detector plug was removed and checked. No chips were found on the magnetic plug.
- Engine compressor was checked for free rotation and noises. Compressor was found in proper condition.
- Power Turbine was checked for free rotation and noises. The turbine rotated freely. However, exceptional wear noises were audible.
- White grains were found at the engine's exhaust pipe and Power Turbine. They were identified later as residues of the fire extinguishing compound, that was sprayed after the accident in order to prevent fire.
- The engine was delivered to "Bet-Shemesh Engines" plant for further investigation. It was mounted on a run-up cart and was operated for 25 minutes according to a valid run-up procedure. The engine was found running properly throughout its entire operational range, as well as during acceleration and deceleration. Despite its proper operation, the engine was disassembled, in order to inspect each of its parts, and detect a possible failure that may have caused engine failure, and especially to locate the reason for the wear noises heard from the Power Turbine while it was rotating. The engine components inspection did not reveal any defect. The cause for the wear noises was determined as coming from the residues of fire extinguishing compound sprayed on the engine after the accident.

> According to the above analysis, it is obvious that the engine failure has nothing to do with any maintenance/mechanical failure, but resulted from an improper operation of the helicopter.

3) Possible Causes for Engine Failure – Analysis

As the engine was found functioning properly at the test run after the accident, the only option left for the mid-air flameout cause was the fact of flying over an active chimney.

As mentioned above, many accidents have occurred in the world in the past involving helicopter low flight over a variety of smoke generating sources. The investigation team went through many of these accident reports and could not find any documentation concerning the Cause Attributes that eventually led to the engine failures. This regards the following:

A gas turbine/jet engine flameout that occurs in the above mentioned conditions may occur due to several reasons, including:

- High outside air temperature (OAT), that gets into the air intake.
- Low percent of oxygen in the air drawn into the engine.
- Drawing of suspensions from various smoke generated products.
- Formation of rich fuel/air mixture.

Understanding of these Cause Attributes is a must among helicopter operators, as flying in smoke covered vicinity is a routine for helicopter operation, especially when performing fire fighting missions. With the absence of an unequivocal limitation for the performance in an area covered with smoke, it turns this type of flight into a dangerous one!

Based on the above information, the investigation team asked Rolls-Royce, of which Allison, the engine manufacturer, is a subsidiary, to provide their initial response to the occurrence. Before that, the company received the helicopter's flight records prior to the accident, as well as information concerning the chimney, its smoke ingredients, and its smoke expelling speed.

Mr. Jim E Skinmer, an expert from the company referred to the following two issues:

a) High OAT Raising Rate

From the data that were obtained in the company it becomes obvious that, the OAT raising rate was at least five times greater than the design limit (30ºF/sec.). It is acceptable, that such an exceptional rate will cause an engine surge as a result of alteration of fuel/air mixture (i.e., increase of approximately 20% in the air supply). However, in the questioned engine no report was issued concerning a malfunction that occurred prior to the engine failure.

According to the Allison 250 engines recorded history, it is known that, engine surges did cause a momentary engine speed drop (in some occasions without pilot notice), however, there was no recorded case of engine flameout and power loss. (The higher the OAT is, the greater the chances are.)

> It is possible that, an engine surge combined with lack of oxygen, caused by the chimneys burning products, led to the scenario of flameout followed by power loss, as a result of the reduction of air quantity, that its consequences are rich fuel/air mixture.

b) Combustion Chamber

The temperature and oxygen percentage conditions of the air above the chimney may present a problem to the engine's combustion chamber, should it face the above mentioned conditions for a period of only several milliseconds (this parameter is determined during the combustion chamber's design, according to the burning duration). Based on the flight parameters that were delivered to the company, the combustion chamber was placed in the same environmental conditions as presented (i.e., temperature and oxygen percentage) for the duration of 200 millisec. If the airspeed was less than presented, then the duration the combustion chamber was exposed to these conditions would have been longer.

> The conclusions from the above mentioned is that the chances are high to cause a flameout (i.e., flame separation), as a result from the generation of rich fuel/air mixture. The major factor for the generation of the problematic fuel/air mixture level in the combustion chamber is the air which is lean with oxygen expelled out from the chimney.

4) "Beit-Shemesh Engines" plant's Opinion

The "Beit-Shemesh Engines" plant has been involved for years with overhaul and maintenance of the engine involved in the subject matter accident. Because of the vast experience accumulated by the plant, the investigation team approached the plant's Engineering Department in order to get their opinion concerning the reasons that might have caused the engine failure.

Following are the major points brought up by the plant's Engineering Department as part of their assessment, with added facts by the investigation team that emphasize these points.

5) Engine Failure Possible Causes

Based on the nature of the events, the plant's Engineering Department pointed out three possible causes for the engine failure, as follows:

- A temporary fuel clogging.
- Engine surge caused by input distortions.
- Oxygen deficiency.

a) Temporary Fuel Clogging

According to this assumption, the fuel system suffered a clogging that prevented the fuel from being supplied for injection by the nozzles in the combustion chamber. This fuel starvation eventually caused the engine shutdown. As the helicopter impacted the ground, this clogging was released, causing the engine to operate normally without the possibility to reconstruct the event. This option was rejected after a thorough check of the fuel system, and the fact that the fuel filter was found totally clean.

b) Engine surge caused by input distortions

The Input Distortions phenomena that occurs at the engine's air intake is well known in jet fighters. When the aircraft performs sharp maneuvers, the stream of air flowing into the air intake is distorted causing an uneven total air pressure at the air intake. This situation can cause compressor surge that may even develop to an engine failure.

This possibility was rejected due to the fact that, according to the video recording taken from the accident helicopter prior to the engine failure, the helicopter did not perform any sharp maneuver. Nevertheless, it is known that air intake temperature distortion, i.e., an uneven total temperature at the compressor intake, also may cause an engine surge. This condition may in fact occur during flight above chimneys, even if the diluting of oxygen in the air resulted from burning is not significant.

This suggestion was rejected due to the fact that there is a low sensitivity for compressor surges as related to the type installed in the 250C20B Allison engines (configuration of axial compressor with centrifugal compressor behind it) and the nature of such a surge is that it is accompanied with a bang sound, drop of engine speed followed by a recovery to the original rpm. Enforcement for this rejection comes from the pilot's evidence, saying that no bang sounds were audible from the engine, and its shutdown was very smooth.

c) Oxygen Deficiency

The gas mass expelled from the "Nesher" plant chimneys are products of burnout, and as such the percentage of oxygen in them is less than that present in the air (i.e., 21%). If these gases entered the engine air intake during a certain stage of the flight path over the chimneys, the resulted Fuel/Air ratio of the engine, even though maintained properly by the engine fuel control system, failed to maintain the desired Fuel/Oxygen ratio resulting in flameout at the combustion chamber. It is not unlikely that this phenomenon worsened by the fuel control system that sensed the N2 rpm drop (due to the drop of temperature of the gas generator's exhaust gas, caused by the partial combustion). As a result, the fuel control system increased the fuel flow to a level that created too rich fuel/oxygen mixture ratio causing a Rich Flameout.

As mentioned earlier, at the time of flameout the helicopter passed over chimney No. 1. Recorded plant data show that the level of oxygen in the expelled gases is 13%. Should the helicopter pass over the bypass chimneys (18-19% oxygen), the engine would probably continue operating uninterrupted.

6) Accident Flight Analysis

a) Film Recovery

1) During the inspections conducted by the investigation team at the accident site, they found among the debris an unusual camera. It became clear that, the helicopter conducted a photography mission, and thus, it carried three cameras on its bottom. These cameras may have operated during the accident – That is a rare real-time documentation.

2) As the helicopter's bottom was severely damaged, and found resting in a puddle of fuel, the investigation team decided to recover the films as first priority. The helicopter was lifted by means of a forklift from the plant, and three recording devices were found smashed underneath.

3) By the assistance of NRC laboratories in Ottawa, Canada, the film cartridges were recovered from the three recording devices, then they were washed and soaked in mild detergent and other solvents, in order to stop the corrosion process that started on the delicate films.

4) A messenger of the investigation team carried the recovered films in a tank of water with him to the US NTSB laboratories. There, the films were dried out, cleaned, pasted and edited in a manner that enabled investigators to observe the last minutes of the flight prior to the accident.

b) Facts Learned From Films

1) Three cameras were installed each operating at 40 degrees angle apart from each other.

2) The cameras were installed at the bottom in elevation 0 degrees and overlapping 0 degrees. Overall combined panoramic angle was 120 degrees looking forward.

3) The cameras were operating continuously until the impact.

c) Evaluation of Photographed Section

1) Flying from Achisemech village on a general southern heading (190-200 degrees).

2) Prior to arrival to the plant site, the pilot started climbing in order to pass over the plant's facilities and chimneys, scattered in the plant site.

3) The helicopter passed at the proximity to a chimney on its left side, and immediately afterwards it passed precisely over the second chimney, no more than 50 feet above its top. The windshield became blurred due to fogging.

4) Right after it passed over the chimney, the helicopter yawed 30-40 degrees to the left, and its pitch raised slightly accompanied with gaining of altitude.

5) The yawing was a result of the engine failure, caused by the tail rotor due to the torque reduction.

6) The pitch raised due to the air stream expelled from the chimney at approximately 20 knots.

7) According to the film analysis, the pilot did not have many options to perform a successful forced landing (autorotation) at the site, where the helicopter's nose yawed left towards a large container. It might be possible that the pilot pulled the cyclic stick for a second or two, due to his anxiety of the facilities, and only then selected to carry on with the autorotation towards the tall tree. The selection of the tree as landing point was on purpose, coming from his experience and from watching old Vietnam war films that showed how pilots were saved thanks to their landing on trees.

13TH. PILOT'S ACTIONS

If to judge the pilot's actions according to the results, then we should compliment him just for the fact that he and the rest of the helicopter's occupants survived. However more parameters of the accident's process should be considered.

First and foremost: The briefing for the mission apparently was partial, and did not cover all the required details for flight safety, as the obstacles in the site demanded, and especially due to the fact that the flight height was set much lower than the allowed safety height, listed in the Flight Regulations Book as well as in the pilot's company Operational Supplement. After the engine failed, the pilot had only a few seconds to select an appropriate surface to perform the forced landing. From the analysis of the terrain and obstacle structure in the helicopter's vicinity, it is obvious that the pilot could not locate an appropriate landing surface.

As a result of the engine failure, the helicopter's nose yawed as much as 40 degrees to the left. This caused the pilot heading towards a large container and above tall buildings, in a path parallel to his heading. In order to pass over these obstacles the pilot slightly pulled the cyclic stick for a second, and only after that he lowered the collective stick as required for autorotation. Apparently, the stick pull-up caused a drop in main rotor speed.

The pilot's decision to "land" on top of the tall tree was instinctive, and was done because he had too few options. Scanning a variety of technical manuals dealing with forced landings revealed that landing on bushes is concerned a suitable manner to cushion the landing impact. However, none of them related to landing on tree tops (all the more so when tree height is 50 feet). This type of landing is not recommended, because after the forward motion is stopped, the helicopter practically falls down vertically to the ground on its side, and the taller the tree – the harder the impact.

Summary

Based on the flight pattern and the events that occurred in the helicopter after the engine failed, it seems to the investigation team that the manner in which the pilot handled the case was appropriate according to the circumstances. However, due to the quantity of obstacles in the site it should have been appropriate to perform an overview planning path before commencing the actual photography path. This would have given him a chance to evaluate the risks at the site, and accordingly to determine the desired height above the obstacles, based on the allowed height according to the flight regulations, and the company's Operational Supplement. It would have also provided him with clues of the go-around and escape paths for forced landing should he face these circumstances.

3. CONCLUSIONS

FINDINGS

1) The pilot possessed a valid license and carried a valid medical certificate at the date of the accident.

2) The helicopter's airworthiness was appropriate. It was maintained by repair station and went through the entire maintenance schedule as dictated by the IAA.

3) During a photography mission over "Nesher" plant, the helicopter's engine failed in the air. With the absence of an appropriate surface for forced landing, the pilot eventually selected to land on a tree.

4) The helicopter was totally destroyed and its occupants were severely injured.

5) The engine was run-tested after the accident and found serviceable.

ACCIDENT CAUSES

DIRECT FACTORS

1) Too low flight height, below the allowed height, over an active chimney that expels hot air with low oxygen concentrate. As a result, a deviation from the proper fuel/oxygen ratio occurred, a fact that caused a flameout within the combustion chamber.

2) Landing on a tall tree caused a long fall of the helicopter, that impacted the ground with the lower nose section, causing a severe injury to its occupants. Moreover, in these specific falling down circumstances, it is impossible to tell whether falling on the skids could have improved the results.

INDIRECT FACTORS

3) The briefing for the specific mission did not provide the appropriate answers to the safety problems the mission placed, neither did it deal with the emphasis on the required safe flight height as dictated by the specific site conditions (i.e., minimum height for forced landing).

4) Partial control of the operator concerning the mission, briefing, and all safety issues applicable for that certain mission.

5) Despite the fact that similar events occurred in the world in the past, the Flight Manual and Handbook do not include any description or procedures referring to flight above smoke generating sources.

4. RECOMMENDATIONS

RECOMMENDATION 1

It is recommended to define as forbidden flight all flights above smokey chimneys and their vicinity, as well as above gas expelling sources.

Responsibility: IAA

RECOMMENDATION 2

It is recommended to obtain the manufacturer's answers concerning any limitations that should be applied for flights above smoke generating sources, including forest fire.

Responsibility: IAA

RECOMMENDATION 3

As the Automatic Re-Ignition Kit was removed from all IAF Bell 206B helicopters, it is recommended to obtain the manufacturer's answers concerning the reliability of that system. After obtaining the answers, it shall be considered whether to install the Kit in all Bell 206B helicopters operated in Israel.

Responsibility: IAA

RECOMMENDATION 4

It is recommended to dictate that a pre-mission flight shall be conducted at the area prior to a mission subject for flying above an area dense with obstacles, to enable the pilot to evaluate all the risks and define the best recommended solutions before he goes out to perform the actual mission.

Responsibility: IAA

RECOMMENDATION 5

It is recommended to publish the investigation report to all the relevant operators, including armed forces and police, as well as consider to publish it to helicopter operators throughout the world.

Responsibility: IAA

RECOMMENDATION 6

It is recommended to make it clear to all helicopter operators, that obtained on 26 October, 1999 a clearance from adhering to the requirements of regulation 93 (4) b (1) (Operation of Aerial Vehicles and Flight Regulations), that the height values listed in that clearance refer to the principle defined in the regulations, i.e., the cleared height shall be above the tallest obstacle in 600 meters radius from the helicopter (where it represent the circle's center), and in all cases, within the height and airspeed range, that will enable the pilot to perform a safe forced landing.

Responsibility: IAA

5. SUMMARY

The investigation was conducted and the report was written by Accident Investigator, Uri Dayan and Chief Investigator Advocate, Itzhak Raz (Razchik).

Assisted in the investigation's technical aspect Captain Shlomi Conforti of the IAF.

The Report was checked and approved by the Chief Investigator .

Adv. Itzhak Raz (Razchik)

Chief Investigator