국토해양부

Report No: ARAIB/AAR1103

Aircraft Accident Report

Crash While Transporting Cargo

Kim's Solution Co., Ltd.

Ka-32T, HL9400

Machasan (Mt.), Yangwon-ri, Jeongok-eup,

Yeoncheon-gun, Gyeonggi-do

April 4, 2011

October 25, 2012

AVIATION AND RAILWAY ACCIDENT INVESTIGATION BOARD

MINISTRY OF LAND, TRANSPORT AND MARITIME AFFAIRS

REPUBLIC OF KOREA

According to the provisions of the Article 30 of the Aviation and Railway Accident Investigation Act of the Republic of Korea, it is stipulated;

The accident investigation shall be conducted separately from any judicial, administrative disposition or administrative lawsuit proceedings associated with civil or criminal liability.

And in the Annex 13 to the Convention on International Civil Aviation, Paragraphs 3.1 and 5.4.1, it is stipulated as follows:

The sole objective of the investigation of an accident or incident shall be the prevention of accidents and incidents. It is not the purpose of the activity to apportion blame or liability. Any investigation conducted in accordance with the provision of this Annex shall be separate from any judicial or administrative proceedings to apportion blame or liability.

Thus, this investigation report issued as the result of the investigation on the basis of the Aviation and Railway Accident Investigation Act of the Republic of Korea and the Annex 13 to the Convention on International Civil Aviation, shall not be used for any other purpose than to improve aviation safety.

In case of divergent interpretation of this report between the Korean and English languages, the Korean text shall prevail.

Aircraft Accident Report

Aviation and Railway Accident Investigation Board. ***Crash into Machasan (Mt.) While Air-transporting Construction Materials for Power-line Towers, Kim's Solution Co., Ltd., Ka-32T Helicopter, HL9400, Yangwon-ri, Jeongok-eup, Yeoncheon-gun, Gyeonggi-do, April 4, 2011.*** **Aircraft Accident Report ARAIB/AAR1103. Seoul, Republic of Korea.**

The Aviation and Railway Accident Investigation Board (ARAIB), Republic of Korea, is a government organization established for independent investigation of aviation and railway accident, and the ARAIB conducts accident investigation in accordance with the provisions of the Aviation and Railway Accident Investigation Act of the Republic of Korea and Annex 13 to the Convention on International Civil Aviation.

The objective of the investigation by the ARAIB is not to apportion blame or liability but to prevent accidents and incidents.

The main office is located near the Gimpo International Airport.

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Crash While Transporting Cargo

- Operator: Kim's Solution Co., Ltd.
- Manufacturer: KumAPE Kumertau Aviation Production Enterprise
- Type: Ka-32T[1)]
- Registration Mark: HL9400
- Place: Yangwon-ri, Jeongok-eup, Yeoncheon-gun, Gyeonggi-do
  (37˚58'29"N 127˚02'39"E, Elevation 221m)
- Date & Time: April 4, 2011 at 18:05 (Korean Standard Time[2)])

Synopsis

On April 4, 2011, about 18:05, a Ka-32T helicopter, HL9400, operated by Kim's Solution Co., Ltd. crashed into Machasan (Mt.) at about 70 percent of the mountain's height[3)] in Yangwon-ri, Jeongok-eup, Yeoncheon-gun, Gyeonggi-do while transporting building materials for power-line towers to a construction site. The two pilots were killed, and the aircraft was destroyed.

The Korea Aviation and Railway Accident Investigation Board (ARAIB) determines that the probable cause of the accident was 「the engines' shutdown due to fuel depletion from both tanks No.2 that supply fuel directly to the engines because a violation of fueling procedures hindered fuel of tanks No.1 and No.3+4 from transferring to tanks No.2 although fuel remained in the tanks.」

As a result of this accident investigation, the ARAIB makes one safety recommendation to Kim's Solution Co., Ltd. and the Russian KumAPE, respectively.

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1) Engine Type: TB3-117BMA
2) Unless otherwise indicated, all times in this report are Korean Standard Time, based on 24-hour clock.
3) Elevation of Machasan: 585 m, Elevation of the Crash Site: 221 m

1. Factual Information

1.1 History of Flight

On April 4, 2011, at 17:22:30, a Ka-32T helicopter, HL9400, operated by Kim's Solution Co., Ltd. (hereinafter referred to as "HL9400") crashed into Machasan (Mt.) at about 70 percent of the mountain's height about 0.4 km in the direction from tower No.33 to the helipad while ferrying (about 2.2 km section) between the helipad (landing point in [Figure 1]) beside a power-line construction site office in Habongam-ri, Dongducheon-si, Gyeonggi-do and tower No.33 in Machasan, Yangwon-ri, Jeongok-eup, Yeoncheon-gun, Gyeonggi-do as shown in [Figure 1]. HL9400's mission was to transport building materials between the above sites.

At April 4, about 10:00, HL9400 departed from the Gimpo International Airport and landed at the helipad beside the construction site office in Dongducheon at 11:25. Then, an aircraft mechanic carried out a ground inspection on the aircraft. At 13:30, HL9400 started transporting cargo and shuttled 19 times between the helipad and tower No.33. At 15:25, it landed at the helipad, and the engines were shut down.

After the engine shutdown, the aircraft mechanic filled 720 liters of fuel into RH and LH tanks No.5 and conducted a transit check.

At 16:00, HL9400 resumed transporting cargo and shuttled 11 times. Then, it landed at the helipad to be refueled about 17:25.

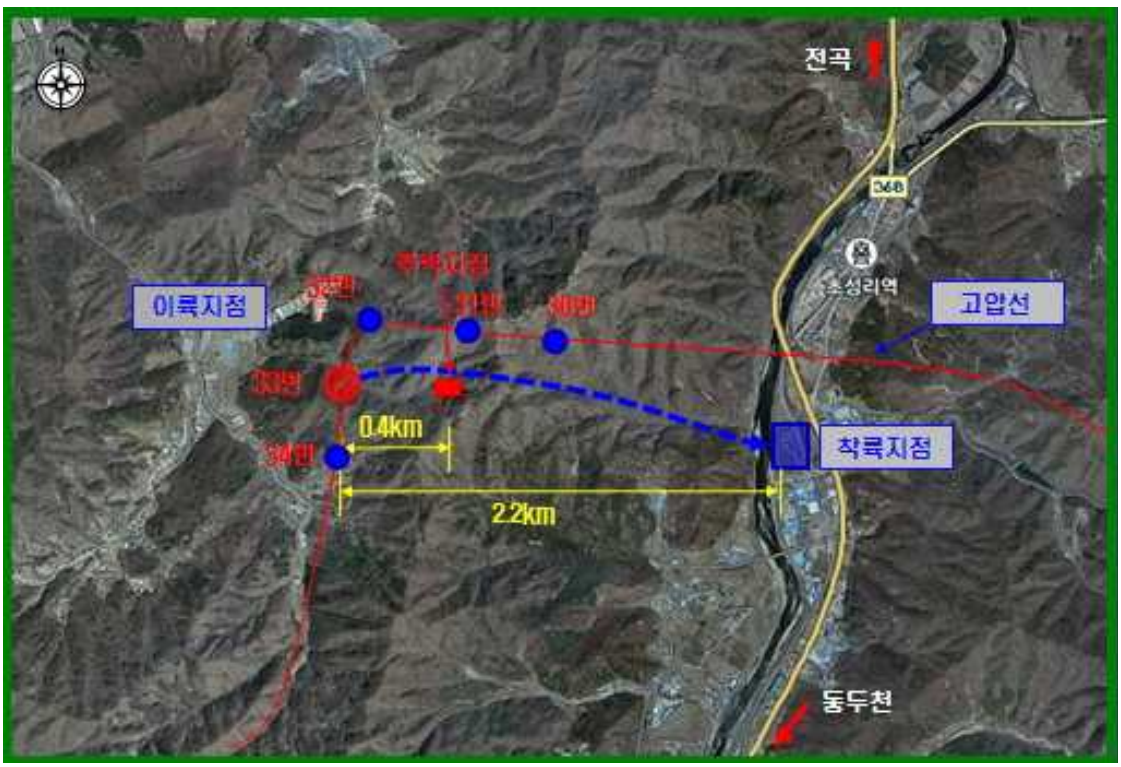
RH tank fuel shortage warning[4] was detected when the aircraft was flying to the helipad for landing. After landing, the aircraft mechanic filled 650

4) A warning light in the cockpit illuminates when the fuel quantity is 125 liters and less.

liters of fuel into RH tank No.1 and LH tanks No.3+4 while the engines were in operation.

In principle, when the aircraft is refueled, the pilot must give the mechanic a signal to stop refueling while monitoring the fuel quantity, but he failed to do so and thus, tanks No.3+4 overflowed with fuel.

After refueling, HL9400 resumed transporting cargo, and from take-off to the crash, RH tank fuel shortage warning continued. Without landing, HL9400 made its shuttle flight three times, and during the fourth shuttle flight, crashed after two engines almost simultaneously shut down while returning to the helipad from the tower.



[Figure 1] Accident Site and Flight Path

1.2 Injuries to Persons

Injuries	Crew	Passengers	Other
Fatal	2	0	0
Serious	0	0	0
Minor/None	0	0	

1.3 Damage to Aircraft

When HL9400 crashed, its propellers were hit against tree branches and severed. The aircraft crashed with its right side facing the ground, and the fuel tanks mounted under the fuselage got stuck in the ground. During the crash, the engines damaged the upper portion of the cockpit with their own weight, and the rotor blades were hit against tree branches and severed. The aircraft was destroyed.

1.4 Other Damage

About 20 trees in the mountain sustained damage.

1.5 Personnel Information

1.5.1 The Captain

The captain (male, age 61) held a valid commercial pilot license[5] and an aircraft radio operator license[6].

He had accumulated 6,392.3 total flight hours, including 358.9 hours in the same type aircraft. He had flown 0 and 24.1 hours in the 24 hours and 90

5) Qualification No.: 1385 (Initially issued on Jul. 6, 1989, Reissued on Nov. 26, 2009)
6) Certificate No.: 830158 (Issued on Sep. 20, 1983)

days, respectively.

For the last 72 hours before the accident, the captain went to work and left the office as usual on April 1, 2011 (Fri) and on Saturday and Sunday, took a rest at home in Suwon-si, Gyeonggi-do.

1.5.2 The Co-pilot

The co-pilot (male, age 49) held a valid commercial pilot license[7], an airman medial certificate[8], and an aircraft radio operator license[9].

The co-pilot had accumulated 3,703.3 total flight hours, including 23.6 hours in the same type aircraft. He had flown 0 and 23.6 hours in the 24 hours and 90 days, respectively.

For the last 72 hours before the accident, the co-pilot took a rest from April 1, 2011 (Fri) until the day before the accident and on April 2 and 3, went to visit his wife's parents in Andong-si, Gyeongsangbuk-do and came back.

1.5.3 Aircraft Mechanic

The aircraft mechanic (male, age 29) held Aircraft Maintenance Mechanic Type Ⅱ[10] needed to perform maintenance of rotorcraft. He has worked for Kim's Solution Co., Ltd. since March 11, 2009 and on July 21, 2010, obtained a Ka-32 rating issued by the company after completion of its own training program.

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7) Certificate No.: 6502 (Passed on Apr. 24, 2007, Issued on Jan. 28, 2008)
8) Certificate No.: 062-7489 (Valid until Dec. 31, 2010)
9) Certificate No.: 07-34-2-0114
10) Certificate No.: 9550 (issued on Dec. 10, 2007)

1.6 Aircraft Information

1.6.1 Aircraft General

HL9400, a Ka-32T helicopter manufactured[11] by the Russian KumAPE on November 24, 1992, was delivered to Kim's Solution Co., Ltd. from Poland and registered[12] in the Ministry of Land, Transport and Maritime Affairs on May 27, 2008. It held a valid airworthiness certificate[13].

Early models of Ka-32T were Ka-8 and Ka-14 designed to station at a navy vessel, and search and attack enemy submarines. By improving the two models, Ka-27 was designed. From 1990 when the former Soviet Union was opened, Ka-32T was produced by improving Ka-27's engine thrust and airframe strength.

Ka-32T is a co-axial rotor helicopter mainly used to transport cargo and known for its strong climbing power that enables it to be operated even in the bad weather. Especially in the Republic of Korea, Ka-32T as a fire-fighting helicopter is famous for transporting 3,400 liters of water, much more water than other aircraft. A total of 33 Ka-32Ts are registered in the nation, and the Korea Forest Service is operating it as its main aircraft.

1.6.2 History of the Aircraft

HL9400 had accumulated 1,254:07 total flight hours and 1,053 total cycles on the day of the accident, and the engines had been served for 702:21 total hours. When the aircraft was overhauled on January 25, 2008, port and starboard engines were replaced. At the time of the replacement, the airframe

11) Manufacture No.: 8910
12) Registration No.: 2009-057
13) Certificate No.: AB10007

and the engines had been served for 1111:23 and 559:15 hours, respectively.

HL9400 is overhauled when one of either 1,500 hour or 10 year service time is reached first, and overhaul was carried out by SPARC, the Russian maintenance company, on February 18, 2008. The history of the aircraft and main equipment is shown in [Table 1] and [Table 2].

Nationality & Registration Mark	HL9400	Type Certificate No.	N/A
Type	Rotorcraft/Multi Engine Land	Manufacturer	KumAPE
Airworthiness Category	Rotorcraft (TB)	Serial No.	8910
Airworthiness Certificate No.	AB10007	Manufacture Date	Nov. 24, 1992
Registration No.	2009-057	Engine Type	TB3-117BMA
Registration Date	May 27, 2008	Aircraft Type	Ka-32T

[Table 1] History of the Aircraft

Category	Model	Serial No.	Installation Date	Airframe SVC Hrs. When Installed	SVC Hrs. When Installed
Left Engine	TB3-117BMA	7087894000199	2008-1-25	1111:23	559:15
Right Engine	TB3-117BMA	7087894000198	2008-1-25	1111:23	559:15
Rotor	N/A (Upper Rotor)	4280УГ	2008-2-20	1111:23	0
		4282УГ	2008-2-20	1111:23	0
		4284УГ	2008-2-20	1111:23	0
	N/A (Lower Rotor)	4705УГ	2008-2-20	1111:23	0
		4707УГ	2008-2-20	1111:23	0
		4709УГ	2008-2-20	1111:23	0
APU	АИ-9	Н98540037	2008-1-25	1111:23	103.23
Gear Box	ВР-252	л0304018к	2008-1-25	1111:23	820:12

[Table 2] History of the Main Equipment

1.6.3 Weight and Balance

Weight and balance data of HL9400 is as follows:

- Own Weight ····· 6610 kg
- Pilot Weight ····· 160 kg
- Oil Weight ····· 90 kg
- External Load Weight ····· 2,000 kg
- Fuel Weight ····· 622 kg
- Max. Takeoff Weight ····· 11,000 kg

HL9400 weighed 9,482 kg in total[14] at the time of the accident, and accordingly, it had a margin of 1,518 kg in comparison to the Max. Takeoff Weight, 11,000 kg.

1.6.4 Aircraft System

1.6.4.1 Fuel System

The fuel system consists of fuel tanks, refueling system, engine fuel supply and transfer system, tank drainage system, tank vent system, and the instruments and devices for controlling the fuel system operation.

The fuel tanks are arranged along the fuselage LH and RH sides and in the cargo compartment as shown in [Figure 2]. The tanks located along the fuselage LH side and the forward external tank installed in the cargo compartment make up the left tank group, whereas the tanks arranged along the fuselage RH side and the aft external tank in the cargo compartment constitute the right tank group.

14) Own Weight + Pilot Weight + Oil Weight + External Load Weight + Fuel Weight

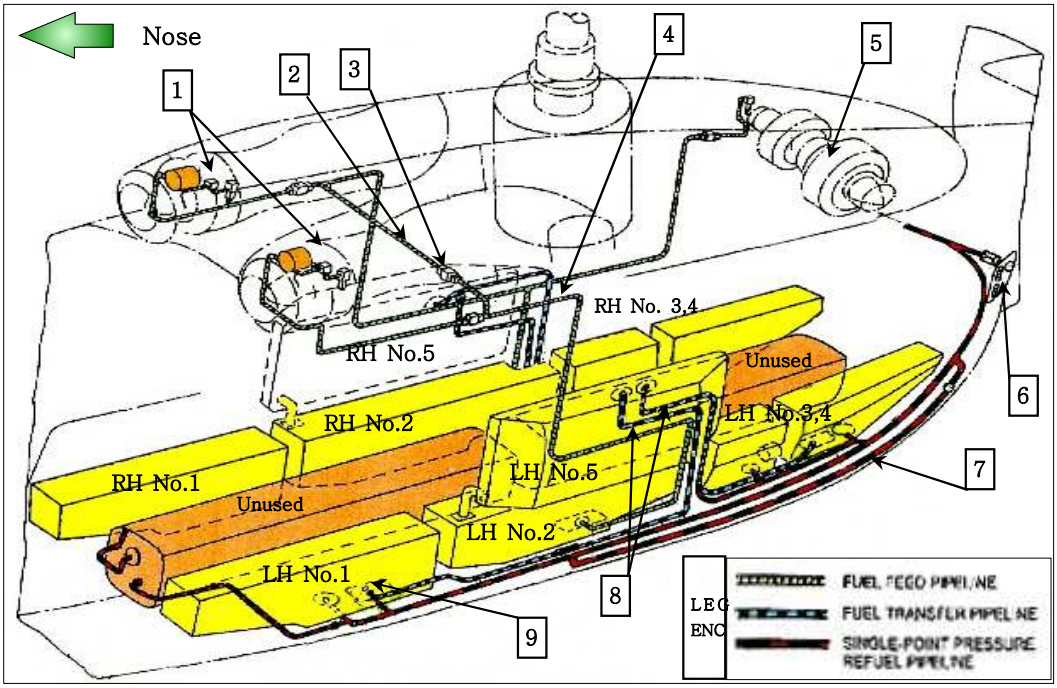
Each group includes tanks No.1, 2, 3, 4, 5 and 6. Tanks No. 1, 2, 3, and 4 are arranged under the cargo compartment, whereas tanks No.5 and No.6 are installed in the containers mounted on the fuselage outer sides and in the cargo compartment, respectively. Yet, tanks No.6 were not installed on HL9400. LH tanks No. 3 and 4 along with RH tanks No. 3 and 4 are connected to each other like one tank, and thus, they are called tanks No.3+4.

Fuel flows from tanks No.5 by gravity to tanks No.2 below since tanks No.5 are mounted over tanks No.2. Tanks No.2 and 5 make up the service tank group since fuel is supplied from tanks No.2 directly to the engines. This supply process is done by two fuel boost pumps mounted in each boost pump units.

As fuel is consumed from the service tank groups, tanks No.5 are replenished with fuel delivered from fuel tanks No.1, 3, and 4 by the fuel transfer pumps. Each transfer pump unit installed in tanks No.1 and 4 is provided with one transfer pump. The fuel transfer pumps stop their operation 300 seconds after fuel depletion so that damage to the pumps due to overheating can be prevented.

The fuel tanks are refueled either with the use of the single-point pressure refuel system through connection or through filler necks. The former can refuel all the tanks simultaneously, whereas the latter can refuel only the applicable tank.

During single-point pressure refueling, each tank is filled with the accurate quantity of fuel by the fuel level control float valves installed in every fuel tank except for tanks No.2. The quantity of fuel to be filled into each fuel tank in the course of the single-point pressure refueling is specified in [Table 3].



1	Engines	**2**	Cross feed valve
3	Fuel feed pipeline	**4**	Fuel supply pipeline
5	Auxiliary engine	**6**	Single-point pressure fueling connection
7	Single-point pressure fueling pipeline	**8**	Fuel transfer pipeline
9	Fuel transfer pumping unit		

[Figure 2] Fuel Tanks and Pipelines

Tank No.	Fuel Quantity for Single-point Pressure Refueling of Tank Group, L (gal)	
	Right	Left
1	260 (67.6)	260 (67.6)
2	280 (72.8)	280 (72.8)
3+4	330 (85.8)	330 (85.8)
5	220 (57.2)	220 (57.2)
6	450 (117)	450 (117)
Total	1,540 (400.4)	1,540 (400.4)

[Table 3] Fuel Quantity for Single-point Pressure Refueling of Tank Group

The fuel usage sequence is as follows: 1) forward tank No.6 and aft tank No.6; 2) LH tank No.1 and RH tanks No.3+4; 3) LH tanks No.3+4 and RH tank No.1; 4) LH tank No.5 and RH tank No.5; and 5) LH tank No.2 and

RH tank No.2.

The selected sequence of fuel usage from the tanks is provided by the fuel level control float valves installed in LH tank No.1 (one valve), RH tank No.4 (one valve) and tanks No.5 (two valves in each tank).

To increase the fuel quantity, it is allowed to fuel the tanks with an additional amount of fuel above that provided through the use of the single point refueling by refilling the tanks through filler necks. In so doing, the total quantity of fuel may amount up to 270 L (70.2 gal) and, with extra fuel tanks No.6 installed, up to 370 L (96.2 gal), which is to be filled in the following tanks as shown in [Table 4].

Tank No.	Left Tank Group	Right Tank Group
1	25 L (6.5 gal)	25 L (6.5 gal)
3+4	80 L (20.8 gal)	80 L (20.8 gal)
5	30 L (7.8 gal)	30 L (7.8 gal)
6	50 L (13 gal)	50 L (13 gal)
Total	185 L (48.1 gal)	185 L (48.1 gal)

[Table 4] Additional Fuel Quantity

All the fuel boost and transfer pumps are energized manually before starting the engines. The fuel boost pumps are started automatically after fuel depletion from a tank in response to the signal given by the fuel quantity transmitter limit switch. The boost pumps are energized only manually. If need arises, any pump may be stopped manually with the aid of the pump switches located on the central control pedestal.

The ability of the fuel system to ensure normal operation of the engines is achieved through the use of the following arrangements: 1) Installation of two pumps operating in parallel into the fuel boost pump units of the fuel consumed

tanks; 2) Connection of the fuel boost and transfer pumps to the power supply system emergency bus to provide electric power supply to pumps from storage batteries in case of the main electric power system failure; and 3) Ability of the engine pumps to pump fuel from the fuel consumed tanks through the by-pass non-return valve if both pumps fail in operation.

Should all the fuel boost and transfer pumps fail to operate, the engine may use fuel from tanks No.2 and 5. In the event of malfunction of the boost pumps and normal operation of the fuel transfer pumps, the fuel may be totally used up from the tanks.

Drain of fuel is effected through drain valves fitted on the tanks or through single-point engine fuel system preservation filler. The fuel tanks venting is accomplished via the vent pipelines that are coupled to the vent air outlets.

1.6.4.2 Fuel Distribution

Fuel distribution is an essential feature of the helicopter fuel system, which incorporates accessories and pipelines of the fuel tanks refueling, venting, engine fuel feeding and tank-to-tank fuel transfer sub-systems. In the course of the single-point pressure refueling, the fuel is supplied simultaneously to the left and right group of tanks. Each group of tanks ensures fuel feeding to one main engine. Fuel supply to the APU engine is provided from the right group of tanks. The tank groups are connected with each other with the aid of the fuel cross-feed pipeline equipped with a fuel cross-feed valve.

In case of malfunction of one group of tanks or one of the main engines, the fuel is supplied through the cross-feed pipeline, with the fuel cross-feed valve open, from one fuel feeding pipeline to another to ensure thereby fuel supply to two engines from one group of tanks or to one main engine from

both tank groups.

For feeding fuel to two main engines from one group of tanks, it is necessary to stop all the pumps of the failed group and to open the fuel cross-feed valve. For feeding fuel to one main engine from both groups of tanks, it is required to close the shut-off valve of the failed engine fuel feeding line and to open the fuel cross-feed valve.

The tanks are filled with fuel by the use of the single-point pressure refuel system or through filler necks of the tanks. The single-point refueling is the basic method in which the fuel is supplied under pressure by the refueler pumps to the tanks. The single-point pressure refuel system consists of refuel connection, refuel valve, fueling control panel, and pipelines. The system also incorporates the fuel level control float valves, fuel quantity transmitters, shut-off valves, and non-return valves.

Electronically-driven refuel valve, connection, and fueling control panel are arranged along the fuselage LH side at frame 16. The fueling control panel carried circuit breakers to provide protection for the circuits of the refuel valve, indication/warning system, left and right tank groups indicator lights, refuel valve control selector switch, and the VLV OPEN, REFUEL ON, STOP indicator lights, as well as the circuits of the test buttons of indicator lights and warning circuits of pressure switches.

1.7 Meteorological Information

Weather observations made by the Korea Meteorological Administration in Dongducheon-si, Gyeonggi-do when HL9400 was operated are as follows: ceiling and visibility O.K; northwest wind at 3.0 m/s; and temperature 9℃.

1.8 Aids to Navigation

HL9400 did not use navigation aids for the flight operation.

1.9 Communications

The communication equipment of HL9400 did not affect this accident.

1.10 Aerodrome Information

On the day of the accident, HL9400 took off from the ultralight aircraft parking lamp at the Gimpo International Airport and then used, as a temporary helipad, open space in front of a power-line construction site office in Habongam-ri, Dongducheon-si, Gyeonggi-do.

1.11 Flight Recorders

1.11.1 Flight Data Recorder

The flight data recorder (FDR, Part No.:BUR-1-2B, Serial No.: 10186) mounted on HL9400 was manufactured by the Russian NPO Pribor using a metal tape for recording. The FDR was recovered from the accident site and transferred to the analysis lab of the ARAIB on April 4, 2011. On the exterior, the device was not seriously damaged.

The ARAIB retrieved from the FDR the final 25 hours of data before the engine shutdown and from this raw data, came up with all the 58 parameter values for the four-hour flight leg before the accident.

1.11.2 Cockpit Voice Recorder

The cockpit voice recorder (CVR, Part No.: MC-61, Serial No.: 675228) mounted on HL9400 was manufactured by the Russian NPO Pribor using a metal string for recording. The CVR was recovered from the accident site and transferred to the analysis lab of the ARAIB on April 4, 2011.

On the exterior, a part of the recorder body was damaged by impact forces at the time of the accident, and one of the two reels was separated from the recorder with a metal string severed. The tape was found wound almost to the end of the reel. The ARAIB successfully retrieved the data from the CVR and made it a WAVE file. The playtime of the WAVE file is 3:39:37.

The data in the retrieved file was recorded several days before the accident, and the flight on the day of the accident was not recorded.

1.12 Wreckage and Impact Information

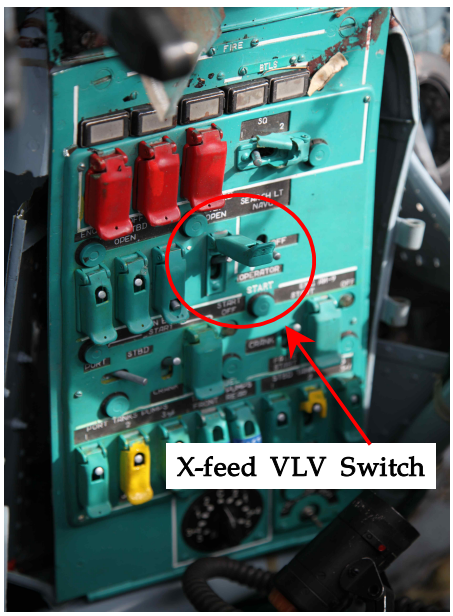
HL9400 crashed in the valley about 15 m below the mountain ridge, and the damaged trees at the accident site were within a radius of rotation of the propeller. It is determined based on the direction in which the trees were broken that the aircraft crashed vertically at a low speed of advance.

The fuel quantity indicator selector switch in the cockpit indicated "C[15)]" as shown in [Figure 3], and the fuel quantity indicator showed about 900 liters of fuel.

15) C indicates the aggregate total of fuel in all the fuel tanks.

[Figure 3] Fuel Quantity Indicator & Fuel Quantity Indicator Selector Switch

The fuel cross-feed (X-feed) valve switch was in the open[16] position as shown in [Figure 4]. When the switch is open, the fuel in LH and RH service tanks can be cross-fed so that, in case of a level flight, the fuel quantity of LH and RH service tank can get eventually similar to each other.



[Figure 4] Fuel X- feed Valve Switch

16) It means that the switch guard is open and that the switch is lifted up. This causes the fuel cross-feed valve to open so that the fuel of LH and RH tanks supplying fuel separately to the engines can be cross-fed, thereby making both tanks work like one.

1.13 Medical and Pathological Information

The captain had taken prescribe drugs[17] such as antidiabetics[18], depressants[19], and fenofibrate[20] everyday. His term of validity of the aviation physical examination was expired on January 31, 2011, but he failed to take the examination.

1.14 Fire

No fire occurred after the crash of HL9400.

1.15 Survival Aspects

1.15.1 General

Four-point seat belts were installed in two pilot seats, and they were in good condition. The upper portion of the captain seat-back was bent backward, and the bottom right portion of it was deformed. The left and right portions of the cushion were damaged. The bracket for the cushion was deformed, but the seat was not separated from the fuselage floor.

The seat-back of the co-pilot seat was bent forward and damaged. The left, right and bottom portions of the seat cushion bracket were deformed, but the seat was not separated from the fuselage floor.

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17) Prescribed by "Seo Minjeong Clinic (General Medicine)" in 1296-1, Kwonseon-dong, Suwon-si (Tel: 031-214-0399)
18) Amaryl-Mex Tab. 2/500 mg, Glucodaun OR Tab. 5 mg
19) Rovadipin Tab. 2.5 mg, Losartam Tab. 50 mg, Dichlozid 1/2 Tab.
20) Lipidil Supra Tab.

1.15.2 Emergency Response

On April 4, 2011, the Dongducheon Fire Station[21] situation room notified of the HL9400 crash at 18:08 relayed the situation to the Yeoncheon Fire Station situation room and at 18:17, gave a dispatch order. At 18:25, the Dongducheon Fire Station situation room ordered a mountain rescue vehicle to be dispatched and at 18:27, gave a dispatch order to Bulhyeon 119 Safety Center, which was returning from its mission and within the jurisdiction of Dongducheon Fire Station. At 19:17, Bulhyeon 119 Safety Center joined the rescue team at the accident site and performed a rescue mission.

After the situation room of Yeoncheon Fire Station[22] was notified of the accident by Dongducheon Fire Station at 18:08, it started assessing the situation. Amid the assessment, it received a report about the HL9400 crash from another witness[23] at 18:34, and directed National 119 Rescue Service within the Yeoncheon Fire Station jurisdiction, and Eundae and Jeongok 119 Safety Centers to dispatch rescue teams to the accident site. The command car of Yeoncheon Fire Station departed for the site at 18:46.

At 19:03, the National 119 Rescue Service team arrived at the site and at 19:05, found two pilots dead[24] in the HL9400 aircraft. The aircraft sustained a severe compression damage due to impact forces in that the engines on the upper part of the fuselage and the lower part of the fuselage were heavily compressed inboard, thereby causing difficulty with the rescue mission. Under the circumstances, however, at 19:17, recovering the bodies was initiated, and at 20:40, two recovered bodies were loaded separately onto two ambulances of

21) Mobilized Resources: 2 pumps, 1 tank, 1 command vehicle, 2 rescue vehicles, 2 ambulances, and 2 other vehicles. Mobilized Personnel: 21 persons.
22) Mobilized Resources: 2 pumps, 1 tank, 1 command vehicle, 2 rescue vehicles, 1 survey vehicle, and 1 ambulance. Mobilized Personnel: 15 persons.
23) Tower assembly technician who witnessed the crash of HL9400, went to the accident site, and called 119 and reported the accident at the site about 17:34.
24) The cause of death was multiple organ failure (MOF).

Eudae and Jeongok 119 Safety Centers and sent to the nearby hospital at 21:08.

1.16 Tests and Research

The ARAIB used the equipment of the electronic test lab at the National Forest Service and tested the insulation status of the five fuel tanks (fuel boost pumps of LH and RH tanks No.2, fuel transfer pump of RH tanks No.3+4, and fuel transfer pumps of LH and RH tanks No.1) and the operation status of the motor. The test showed that all of them were within normal range.

In addition, the Interstate Aviation Committee (IAC) examined the parts of the fuel system, and the result of the examination is as follows: 1) Due to the impact loads at the moment of collision, the emergency annunciation pilot lights "125 LTR STBD TNKS" and "125 LTR PORT TNKS" were "ON" and "OFF", respectively; 2) The fuel quantity transmitter of the LH tank No.2 failed before the crash. Due to the malfunction of the fuel quantity transmitter, "125 LTR PORT TNKS" warning light in the cockpit did not come on, and "LEFT TANKS ASSEMBLY EMERGENCY FUEL" was not recorded by the FDR; and 3) The fuel quantity transmitter of the RH service fuel tank did not show any evidence of defect and functioned normally at the last flight of HL9400.

As a result, as the two engines shut down almost simultaneously, HL9400 descended rapidly and collided with the ground.

The engines' shutdown was caused by fuel depletion from the both service fuel tanks No.2. The fuel of RH tank No.1 and LH tanks No.3+4 was not transferred to the service fuel tanks No.2 because the fuel supply procedures were violated during the last refueling.

After take-off until the collision with the ground, "RIGHT TANKS' ASSEMBLY EMERGENCY FUEL" was recorded by the FDR. During the last

flight, there was no event or defect in the aircraft or system. “LEFT TANKS' ASSEMBLY EMERGENCY FUEL” was not recorded by the FDR.

1.17 Organization and Management Information

The organizational and management factors did not affect this accident.

1.18 Additional Information

Not applicable.

1.19 Useful or Effective Investigation Technics

Not applicable.

2. Analysis

2.1 General

It is prescribed[25] that, during fueling, starting or warming up the engines of the HL9400 aircraft should not be allowed for safety, but the airline personnel fueled the aircraft while the engines were in operation.

Fuel is used as a collant for the pump motor. Without fuel, therefore, the protection circuit shut down the operation of the pump motor to prevent a fire.

In case of fueling with engines running, the protection circuit shuts down the fuel transfer pumps. The pumps are designed to operate again only after the power supply temporarily turns on and off (reset procedure), but this procedure was not specified in the flight manual since fueling with engines running was prohibited in principle.

2.2 Fuel Transfer Pump

2.2.1 Function and Operation of the Fuel Transfer Pump

The fuel transfer pumps are installed to transfer fuel from tanks No.1 and No.3+4 to tanks No.5. Fuel flows from tanks No.5 by gravity to tanks No.2 since tanks No.5 are mounted over and connected to tanks No.2. The fuel boost pumps are installed in tanks No.2 to supply fuel directly to the engines.

During refueling, the fuel transfer pumps of tanks No.1 and No.3+4 were already inoperative to protect themselves due to fuel depletion in the

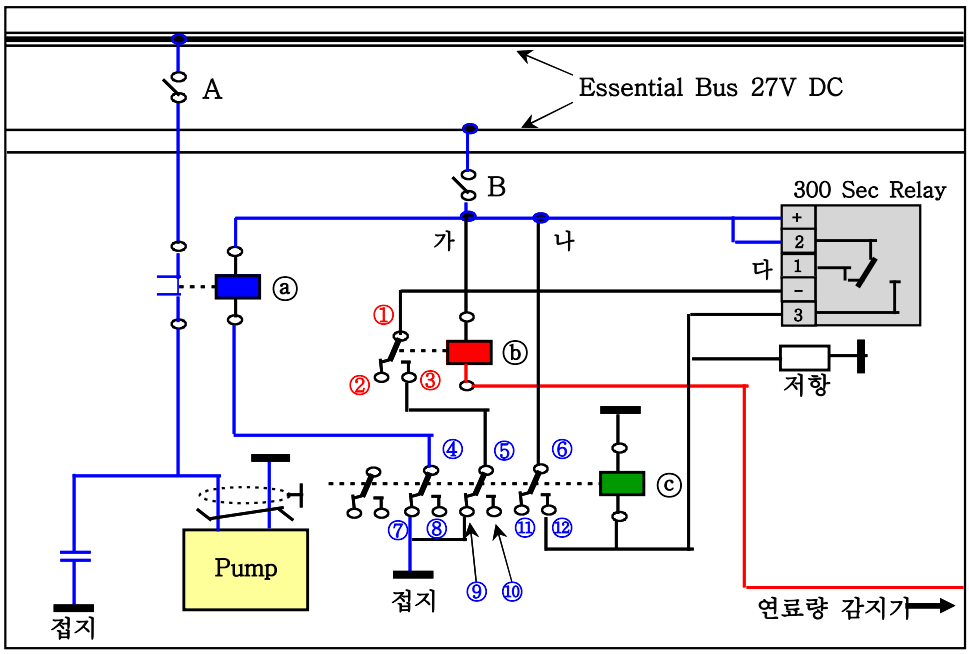
25) Ka-32 Flight Manual 9.1.2. Safety Precautions during Fueling, 9.1.2.4

previous flight. Thus, HL9400 started its last flight with the fuel transfer pumps inoperative since the power supply on/off procedure (reset procedure) could not be performed because, with the engines running, the transfer pumps are constantly energized.

2.2.2 Analysis of the Fuel Transfer Pump Protection Circuit

Each transfer pump protection circuit consists of 28V DC power supply circuit breaker, 300 sec relay, and relay using the fuel quantity transmitter signal as shown in [Figure 5].

In case that the pump continues to operate without fuel, the pump will be failed since its motor cannot be cooled down. It is designed, therefore, that 300 sec relay is activated to stop the pump 300 seconds after fuel depletion, thereby preventing a pump failure.



[Figure 5] Diagram of the Fuel Transfer Pump Protection Circuit

When the fuel pump switch B is "ON" with the circuit breaker switch A "ON", ⓐ relay gets magnetized, thereby activating the transfer pump. When fuel depletion activates ⓑ relay, terminal ① in ⓑ relay is shorted, thereby activating 「300 sec relay」.

When the terminals ② and ③ in 「300 sec relay」 are shorted after 300 seconds, thereby magnetizing ⓒ relay, power is not supplied to neither ⓐ relay nor the transfer pump, thereby deactivating the pump.

Although fuel is resupplied, ⓒ relay, to which power is supplied from 2, remains magnetized and thus, ⓐ relay is not magnetized, thereby deactivating the transfer pump.

When the power supply is cut off to initialize ⓒ relay by turning the fuel pump switch "B" "OFF", ⓐ relay is on standby. The fuel pump switch "B" should be turned "ON" to activate the transfer pump.

In case that the fuel transfer pumps shut down due to duel depletion, the fuel pump "B" switch should be turned off and on (reset procedure) to reactivate the transfer pumps, thereby transferring fuel to the service tanks because, during refueling fuel with the engines running, power is constantly supplied.

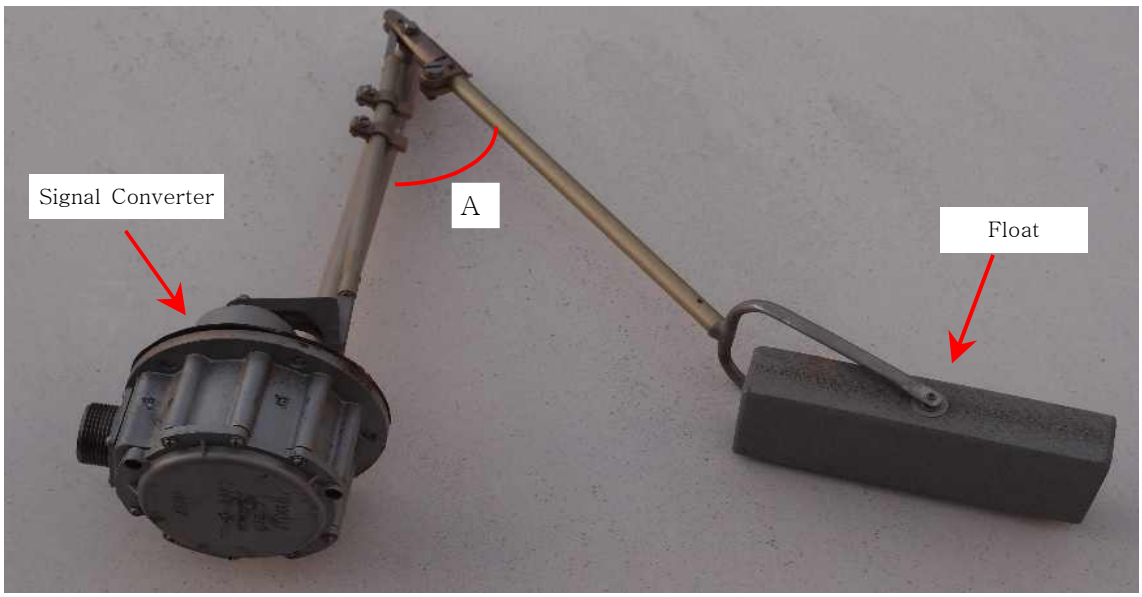
This accident has occurred because, during fueling with the engines running, the fuel pump switch was not turned off and on (reset procedure), thereby deactivating the fuel transfer pumps. As a result, fuel of the service tanks was depleted, and the engines shut down because fuel remaining in other tanks was not supplied to the service tanks.

2.3. Fuel Quantity Transmitter

By using a float as shown in [Figure 3], the fuel quantity transmitter is designed to convert the fuel level into electric resistance signal in proportion to

angle "A" changing in accordance with the fuel level. The signal converter carries out this function. During the flight on the day of the accident, the fuel quantity transmitter of the LH tank No.2 had a malfunction.

A fuel shortage of the left tank was not detected due to the fuel quantity transmitter's malfunction, and thus, "125 LTR PORT TNKS" warning light in the cockpit did not come on, and "LEFT TANKS' ASSEMBLY EMERGENCY FUEL" was not recorded by the FDR.



[Figure 6] Fuel Quantity Transmitter

2.4 Pilot Factors

It is prescribed in the HL9400 flight manual that when the fuel low-level warning lights of the left and right service tanks illuminate, the pilots should check the total quantity of fuel and open the X-feed valve, and that if the total quantity of fuel is 250 liters and less, the pilots should land the aircraft. On the other hand, it is prescribed that when the warning light of only one service tank illuminates, the pilots should continue to operate the aircraft only after they check the total quantity of fuel, open the X-feed valve, and

estimate possible flight time.

When the fuel of both service tanks of HL9400 was depleted, the fuel low-level warning light of the left service tank failed to illuminate due to the malfunction of the left service tank fuel quantity transmitter, and thus, only the right service tank's warning light illuminated.

After the crash, the fuel quantity indicator selector switch indicated "C," the aggregate total of fuel, and the fuel quantity indicator showed about 900 liters of fuel. Therefore, it is assumed that after checking the total quantity of fuel, the pilots continued to fly with a false belief that the fuel low-level warning light of only one service tank illuminated, but this assumption could not be verified.

During flight, the pilots could have checked the fuel quantity of tanks No.2 by using the fuel quantity indicator selector switch, but it is assumed that they failed to do so given that they had continued to fly.

The pilots may have forgotten to check the fuel quantity due to negligence in flight preparation, and to put it more specifically, they may have been ignorant of the fuel transfer pump's protective circuit or though they knew, they may have neglected to monitor the fueling procedures, thereby causing fuel to overflow. The latter is highly possible in that most pilots of the same type aircraft are fairly familiar with the protective circuit.

3. Conclusions

3.1 Findings

1. HL9400, a Ka-32T helicopter manufactured by the Russian KumAPE on November 24, 1992, was delivered to Kim's Solution Co., Ltd. from Poland and registered in the Ministry of Land, Transport and Maritime Affairs on May 27, 2008. It held a valid airworthiness certificate.

2. The captain held an invalid airman medical certificate.

3. On April 4, 2011, HL9400 departed from the Gimpo International Airport and arrived at the helipad beside the construction site office, and at 13:30, started transporting cargo. During the mission, with its engines shut down at 15:25, HL9400 was refueled with 720 liters of fuel for the first time and with the engines running about 17:25, was refueled with 650 liters of fuel for the second time.

4. Before HL9400 landed for the second refueling, RH tank fuel shortage warning was detected, and the operation of the fuel transfer pumps was shut down to prevent a fire.

5. During refueling before the last flight, the fuel transfer pumps of tanks No.1 and No.3+4 were already inoperative to protect themselves due to fuel depletion in the previous flight. Thus, HL9400 started its last flight with the fuel transfer pumps inoperative since the power supply on/off procedure (reset procedure) could not be performed because, with the engines running, the transfer pumps are constantly energized.

6. The fuel was not transferred to the both service tanks No.2 supplying fuel

directly to the engines although fuel remained in tanks No.1 and No.3+4 because the fuel transfer pumps were inoperative. Even with fuel depletion of the service tanks, the fuel low-level warning light of the left service tank failed to illuminate due to the left service tank fuel quantity transmitter's malfunction, whereas the right service tank's warning light illuminated.

7. The pilots continued to operate the flight with a false belief that fuel remained in the left service tank, and eventually as the engines shut down due to fuel depletion, the aircraft crashed.

3.2 Probable Causes

The ARAIB determines the probable cause of the accident as follows:

「The engines of HL9400 shut down, and the aircraft crashed as fuel of tanks No.2 that supply fuel directly to the engines was depleted because a violation of fueling procedures hindered fuel of tanks No.1 and No. 3+4 from transferring to tanks No.2 although fuel remained in the tanks.」

4. Safety Recommendations

As a result of the investigation of the accident that occurred to HL9400 on April 4, 2011, about 18:00 in Yeoncheon-gun, Gyeonggi-do, the ARAIB makes the following safety recommendations.

To Kim's Solution Co., Ltd.

Revise operating regulations for the pilots to manually monitor fuel of the service tanks during flight (AAR1103-1)

To KumAPE Kumertau Aviation Production Enterprise

Review the possibility of altering a Ka-32T helicopter to introduce central fueling procedures in which fuel is filled into the service tanks with the engines running (AAR1103-2)