

Report

CX010-0/98

March 2000

This translation of the official German report is to serve for information only. In case of any queries the German issue is to be used.

Facts

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|--------------------------|-------------------------|
| Event: | Accident |
| Date: | September 4, 1998 |
| Location: | near Hindelang |
| Aircraft Type: | Helicopter |
| Manufacturer/Model: | Kaman K-1200 |
| Injury to Persons:: | Pilot in Command Killed |
| Damage to the Aircraft:: | Helicopter Destroyed |
| Third Party Damage:: | None |

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According to the Convention on International Civil Aviation (ICAO Annex 13) , the sole objective of the investigation of an accident shall be the prevention of future accidents. It is not the purpose of this activity to apportion blame or liability.

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List of Abbreviations Used in the Report

| | |
|------|---|
| BFU | German Federal Bureau of Aircraft Accidents Investigation |
| FCU | Fuel Control Unit |
| ft | Feet |
| MTOW | Maximum Take Off Weight |
| SHP | Shaft Horsepower |
| FOD | Foreign Object Damage |
| LBA | Luftfahrt-Bundesamt |
| STC | Supplemental Type Certificate |
| SAR | Search and Rescue |
| FAR | Federal Aviation Requirements |

Synopsis

On 09/04/98 at 11:30 a.m. the Search and Rescue Service (SAR) informed the German Federal Bureau of Aircraft Accidents Investigation (BFU) that a helicopter accident had occurred near Hindelang. The BFU dispatched 2 investigators to the site of the accident, who began the investigation on the same day.

The helicopter was used for external load flights to transport tree trunks from a treacherous terrain to a loading place in the valley. Attaching and detaching the load was carried out while hovering.

After several flights had already been uneventfully carried out, an engine malfunction with complete loss of power occurred while picking up load. The helicopter started to move forward and entered a steep descend. After about 150 meters, it crashed almost inverted into a moor on the ground, without prior release of the external load.

The pilot in command suffered fatal injuries from the accident. The helicopter was destroyed.

The accident can be attributed to the fact that a sudden engine failure occurred after both drive shafts of the double-flow (for redundancy reasons) engine-driven fuel pump failed due to wear on two splined shaft connections. The accident was unavoidable as the helicopter was hovering over a terrain unsuitable for a successful autorotation landing. The following facts contributed to the development of the accident:

- A pressure monitoring device for the two pump segments that could have enabled the pilot to determine the failure of one pump segment before the engine failure occurred, was not installed on the Kaman K-1200 contrary to other helicopter models equipped with the same type of engine.
- The pilot in command did not jettison the external load. It could not be determined whether this was omitted accidentally or with the purpose not to endanger persons on the ground. Whilst an accident could not be avoided after the power loss the still attached external load contributed to the severity of the event.

1. Factual Information:

1.1 History of the flight

On the morning of the day of the accident, flight operation with the helicopter was started at about 9:30 a. m. The scheduled flights served the transportation of log from a logging site that was located at the Sonnenkopf at an elevation of about 5000 ft in a terrain not accessible to vehicles to a loading place in the Rettenschwang valley.

On site were flight assistants who attached wire cable loops to the tree trunks and then latched them to the cargo hook at the end of a 50-meter long load cable, while the helicopter remained in a hovering position. Initially, the helicopter erected the tree trunks into a vertical position while climbing up, lifted them a few meters from the ground and then flew down to the valley following the steeply declining terrain. Deploying the load at the loading place was carried out without external help by opening the electrically actuated cargo hook. The time from picking up one load to the next one was about 3 minutes.

Before commencing the flights, the load cable was attached at the loading place and a release test of the cargo hook at the end of the cable was performed. The pilot in command, who flew this particular Kaman K- 1200 for the first time, initially pushed a wrong button. After respective instructions from one employee of the company, he used the correct switch and the release mechanism opened properly.

After already several flights had been carried out uneventfull, one of the forestry workers attached another load that consisted of a longer and shorter trunk. The helicopter pilot erected the load vertically but did not lift it up as usual. Then the tree slipped about 1 to 2 meters downwards and stood for a moment on its cutting surface in vertical position. At the same time, the sound of the helicopter changed, the load cable slagged and the helicopter actuated the warning siren. The tree trunk fell downwards and the helicopter began a steep descend towards the valley and crashed almost in upside-down position about 150 meters underneath the location where the load was picked up with the cable still attached.

1.2 Injuries to persons

At the accident, the pilot in command was fatally injured.

1.3 Damage to aircraft

The helicopter was destroyed by the crash.

1.4 Third Party Damage

None.

1.5 Personnel Information

The pilot in command held a valid Austrian commercial helicopter pilot licence, with a first issue date of 05/08/1990, issued by the Bundesamt für Zivilluftfahrt (Federal Office for Civil Aviation) in Vienna with German and Swiss acceptance. He was employed with a German helicopter company and was leased to the Swiss company that operated the helicopter. The flights on the day of the accident constituted his first work with their aircraft.

The entire flight time with helicopters was about 2,200 hours; about 200 hours of those were on type.

1.6 Aircraft information

The Kaman K-1200 is a single-engine, single-seater helicopter in full-metal design that has specifically been developed for the transportation of exterior loads. The rotor system consists of two intermeshing, semirigid counter-rotating blade rotors that are driven by rotor shafts, offset by 12,5°. Because of this design, there is no need for a tail rotor. The control is achieved by one Flettner flap on each rotor blade, where both the cyclical and the collective changes in the pitch angle are carried out through the torsion of the blades.

The drive is accomplished via a 2- shaft turbine engine with free-running turbine coupled to the main gearbox via a fixed coupling.

| | |
|------------------------------|---------------------------------------|
| Manufacturer: | Kaman Aerospace Corp., Bloomfield USA |
| Model: | K-1200 |
| Empty Mass: | 2178 kg |
| MTOW without exterior load: | 2948 kg |
| Maximum external load: | 2721 kg |
| Manufacturer of theEngine: | Allied Signal. USA |
| Model No.: | T53 17 A-1 |
| Max. Continuous Performance: | 1350 SHP |

The helicopter was properly approved for operation. The respective documents were available. All prescribed maintenance events had been performed. Flight mass and center of gravity were within allowable limits.

1.7 Meteorological information

According to reports from witnesses, the weather was sunny with a light wind. The request for a professional opinion of the weather was waived, because the influence of the weather played no role in the development of the accident.

1.8 Aids to navigation

No concern.

1.9 Communications

No concern.

1.10 Aerodrome information

No concern.

1.11 Flight recorders

Flight data recording devices are not stipulated for aircraft in this category. A flight recorder was not installed.

1.12 Wreckage and impact information

The accident site was near the Sonnenkopf in the region of a moor at an elevation of about 5000 ft, at the foot of a steeply ascending logged area that changed towards the valley into a hilly, descending meadowy terrain. While a portion of the forest further up was cut already, a dense area of spruce trees about 25 to 30 meters in height was still standing between the meadowy terrain and the logged area.

The wreckage of the helicopter was found in an upside-down position with the front of the body pointing upwards on the slope. The 50 meter long load cable was still attached to the cargo hook and was draped

loosely over the above mentioned trees. The end with the release mechanism was lying on the mountain-side of the tree row on the ground of the forest. A 5 meter long wire cable was hooked to the latch that was looped around a tree trunk with an diameter of about 20 cm that was broken apart in the area of the loop under great pull effects. Other pieces of the trunk were found in the immediate vicinity of the accident.

Three of the four main rotor blades were broken off and the broken pieces of them were found in the scatter range of the accident site. The fourth blade was still attached to the helicopter. At first contact with the ground, the main rotor left behind considerable marks in the soft grassy ground that point toward a very steep impact almost in an upside-down position. This corresponds to another deep mark in front of the front part of the body, which confirms this fact.

The cockpit region of the helicopter was heavily damaged during the impact. The front struts were bent and partially broken off, the roof of the cockpit was greatly deformed. The region in front of the cockpit showed a dull, massive indentation which documented strongly that the contact with the ground occurred upside down with the front of the body and the cockpit. Accordingly, the back part of the body suffered comparatively minor damage only. The main gearbox was partially removed from its anchors; however, it was still in its place. The fuel tank, located in the central region of the body, was not damaged. Therefore, only small amounts of fuel leaked out.

The suspensions of the engine were partially torn off. The coupling between the engine and the gearbox was forcibly separated during the accident by a shifting of the drive assembly.

Because it was not possible to carry out extensive useful examinations at the accident site, the wreckage was first turned to its normal position using a helicopter and then transported to a hangar within an army complex. Here, the drive mechanism was examined first. Aside from damage caused by the impact, there were no findings that pointed toward a possible cause of the accident.

The main gearbox could be turned without problems; the external condition of the turbine was inconspicuous. After taking samples of all operating fluids, the engine was removed for further examination.

The entire wreckage remained secured until the findings obtained during the examination of the engine made it clear that additional technical examinations were no longer required. It was then released to the company operating the helicopter.

1.13 Medical and pathological information

An autopsy was performed on the corpse of the pilot in command. In addition, toxicological and histological examinations were carried out. According to the expert opinion of the Department for Flight Accidents of the Institute for Flight Medicine of the German Air Force, the death occurred as consequence of two different injuries, each by itself being fatal. They are a dull head/brain trauma in the region of the right, rear head and a rupture of the heart muscle with rupture of the main artery by a force acting from behind. This force lead to the fracture of the thoracic spinal column. In addition, various fractures at the extremities and a liver injury were detected. However, these were not immediately fatal.

There were no indications of limitations to action or perception due to alcohol or medication. Influences on the development of the accident due to acute or past illness were not detected as well.

1.14 Fire

There was no fire.

1.15 Survival aspects

At the time of the accident, the pilot was secured with a 5-point belt system and wore a safety helmet with an integrated head set. The restrain system is equipped with a roll-up device for the shoulder harness which can be locked with a handle located at the left side of the seat. In the locked position the harness is capable of spring loaded spooling in only. When unlocked it can spool in and out for a better movability of the pilot. The body harnesses and fixed. The locking device was found in the unlocked position.

As already mentioned, two different injuries caused the death. The severe head injury was with high probability caused by the deformation of the fuselage in the cockpit area. The cabin roof as well as the on top of it mounted aggregates (lubricant tank, lubricant cooler) entered the seating region due to the deformation which lead to a massive impact on the right rear head. It was so strong that it crushed the safety helmet.

The crushing of the thoracic spinal column and of the heart was caused by a massive impact from behind. The impact site corresponds with a bar running crosswise at the upper end of the backrest of the seat. It forms the end of the backrest, protrudes chord-like from the remaining shell of the backrest and is only covered by a cushion. With view to the length of the backrest the bar is located far above the spinal column when the pilot is normally seated. Thus it can be assumed that during the last portion of the flight the pilot was lifted that far from his seat by negative g-forces that the a.m. contact between the seat's crossbar and the spinal column in the area of the heart was possible.

During external load operation it is necessary for the pilot to look down vertically during load pick-up to control the load cable. Therefore he needs to bend forward and turn his body to the side while both hands and feet operate the controls. This can hardly be achieved when the safety belts are fastened and secured in a way necessary for appropriate protection in case of an accident.

Naturally, it is hardly possible to make a definitive statement concerning the survivability of an accident situation. However, in this case it can be viewed as probable that at least the spine injury would not have occurred in the same manner if the helicopter was fitted with a self fastening restrain system as known from the automobile field and the seat of the pilot in command had a different ergonomic shape offering better protection in the back area.

The head injury was probably a direct result of the almost total destruction of the cockpit region. The destruction could possibly have been reduced to a survivable extent through special design measures (roll bar). Anyhow it is necessary to point out that such a heavy impact in an upside-down position occurs so rarely in helicopter accidents that also the airworthiness requirements (FAR27) do not contain values for the stiffness of the fuselage for this direction of deformation. The major number of accidents lead to an impact in a normal attitude with usually high negative g-loads in the direction of the spinal column.

1.16 Tests and research

1.16.1 Investigation of the Engine

The investigation of the engine was carried out on the 23rd and 24th of September, 1998 at the company BMW Rolls Royce in Oberursel.

Total operating time: 2197:30 hours (from Flight & Maint. Report dated 09/03/98 plus the flight time of 0:35 hours on the day of the accident.)

External Damage

The drive coupling was broken with typical signs of an overstress failure. Traces on the drive shaft clearly pointed towards the effects of force from the front onto the engine. Traces of other external influences of the accident on the engine were not detected.

The right rear suspension of the engine (a welded structure at the diffuser) was broken. Traces at the breaking point indicated that the metal sheets were tacked to one another by spot welding. The actual connection was brazed. It cannot be ruled out that the solder joint was not connected at the entire surface. Further investigation was waived, because the breaking can be explained by the impact and the reason for the failure of the engine was not associated with the break of the suspension.

In the same diffuser, a control air line was torn out of a welded stud. Here, a faulty soldering point was clearly recognizable. Although an escape of control air could not be ruled out, a relevant influence on the performance of the engine was doubtful.

The air controller for the bleed air operated without trouble.

The chip detector was free of chips and the oil filter was clean. An oil sample has already been taken at the accident site.

Findings of the Dismantling

Damage on the drive shaft in the reduction gear confirmed that forces acted upon the engine from the front. Among other things, the carbon gasket ring and the inner ring of the front ball bearings were damaged.

The front region of the flanks of the teeth of the planet wheel showed clear indications of wear although the wheel had been replaced only 141 hours before at BMW Rolls Royce. The wear did not yet have any influence on the run behavior.

No indication of friction or damage was found in the entire compression and turbine region, except for minimal FOD traces at the turbine blades. A clear correlation to the accident was not observable. Small metal chips distributed throughout the entire turbine region and in the burner chamber were noticeable. Additionally, there were large areas of the turbine were oily. These traces would allow the conclusion that the turbine was cold during or immediately after the accident while the engine was slowing down.

The oil pump showed no defects. The drive was present.

The drive of the fuel controller was operational and had no defects that could have caused a malfunction.

According to the nameplate, the designation of the main fuel controller was :

Chandler Evans FCU, Mod. Ta-7, SN: 9ADS1701, PL: 106500A2.

A sticker on the housing said: OVERHAUL.CECO, West Hartford. A handwritten date could not be deciphered clearly, however it could read „6-13-94“ in agreement with the test records.

Since the controller already showed no reaction on a test bench at BMW, an examination was carried out subsequent to the engine examination at the company PLU, Pierburg in Neuss.

Examination of the Main Fuel Controller

The examination was carried out on 09/25/98 at the company PLU

Findings:

The controller was still filled with fuel.

It became apparent that both drives of the fuel pumps failed due to extensive wear at the respective spline shaft connections. The drive spline wear pattern were different. The primary drive spline was excessively worn and had smooth polished appearance, while the secondary drive spline wear surfaces were rough and unpolished. Upon further examination with magnification, scoring marks could be seen about the circumference of the primary spline. The rotational scoring and differing appearance of the spline wear patterns strongly suggest that the primary drive spline had failed at some point prior to the secondary drive spline, and the primary pump element was not rotating while the secondary pump element was still being driven by the engine

The drive leading from the pump to the controller was intact. A slim pin transferring the force was unharmed.

There was a large number of small metal chips in the controller housing that could not be assigned directly (some were magnetic). It could not be ruled out that the chips stemmed from the mounting of the housing of the fuel pump in the controller housing. A correlation to the drive failure was not apparent.

1.16.2 Metallurgical Investigation

The impaired components from the main fuel controller underwent a material science examination to gain information about the material composition, machining and possible reasons for the component failure.

In his expertise, the expert came to the conclusion that the materials used corresponded to the specifications in their chemical composition and hardness.

Concerning surface finishing, he stated that the chrome plating, supposedly present according to the specifications, was missing from the primary splined shaft. He attributed the failure of the gearing to swing

breaks in almost all teeth, caused by the pulsating sheering forces in the direction of the circumference due to flight- related load changes at the controller drive.

Contrary to that the manufacturer of the fuel control unit concluded after having studied the expertise and carrying out specific tests that the crack surfaces showed no significant sign of fatigue but point towards a failure due to wear. To sort this out the manufacturer's and BFU's experts held a discussion of the findings during a meeting and duly agreed that the failure of the splined shafts was caused by wear-out.

1.17 Organizational and management information

The accident was investigated according to the law concerning the investigation of accidents and incidents during the operation of civil aircraft (FLUUG). Representatives of the manufacturer, the operator as well as the widow of the killed helicopter pilot were informed and had the possibility of commenting as part of the investigative process. Drafts of the final report were submitted to the a.m. parties. Their comments were implemented in the report as far as factual information was concerned and taken to the BFU's file for further reference.

1.18 Additional Information

1.18.1 Hook Load at Time of the Accident

To determine the hook load at the time of the accident, during the process of the investigation the transported wood pieces except one smaller piece which could no more be found after the accident were weighed with an electronic scale under another helicopter. According to the measurement, the weight of the load was 2170 kg. According to the flight assistants the missing piece was a thin and small tree trunk. It thus can be assumed that the hook load was within the permissible range.

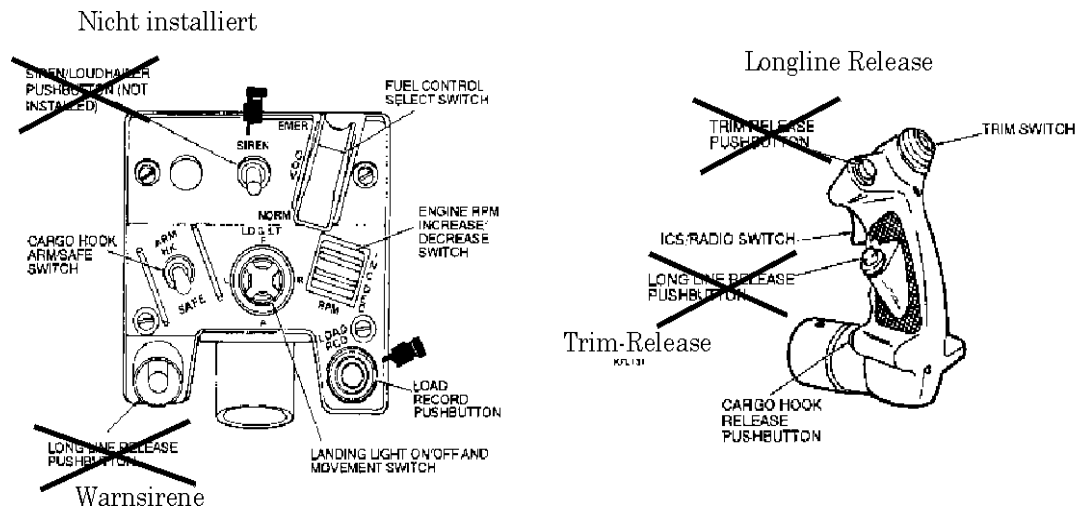
1.18.2 Operation of the External Load Hook

In the course of the investigation, it was apparent that the helicopter pilot did not release the external load upon the occurrence of the engine failure. The assistants stated that they heard the helicopter's warning siren immediately before the crash. In addition, on the morning of the day of the accident during the routine release test a problem occurred in that the helicopter pilot first pressed a wrong button on the control stick and only pressed the correct button after respective instructions.

With this model, the release of the external load is possible in various ways. During normal flight operations, it is carried out by opening the electro-magnetically-actuated hook at the end of the load cable. The control elements for this are designated as „Longline Release“. In addition, the load hook at the helicopter can be opened electro-magnetically or mechanically. This leads to a separation on the entire external load, including the load cable. The control elements in the cockpit carry the designation „Cargo-Hook-Release“ and are affixed at the lower end of the stick handle to be operated with the little finger and at the collective lever, similar to the hand brake lever on a bicycle.

According to the flight manual of the K-1200, the Longline-Release is either operated by a button that is located central on the left side of the control stick handle, or by a key on the left side of the operating panel of the lever for the collective blade adjustment.

In this regard, this particular K-1200 was modified on the request of the operator without appropriate notification in the flight manual. On the stickhandle, the key of the Longline-Release was switched with the Trim-Release button, which is normally at the head of the handle on the left side. Appropriately altered labels were affixed to the stick. The Longline-Release button at the collective lever was missing entirely. The siren was activated with the button installed in this place. According to the operator this button was labeled accordingly. Anyhow the label was no more evident after the accident.



The operator explained as reason for the modification that the entire fleet of the company, with the exception of the K-1200, consist of helicopters of a French design. The layout of the switches was taken from these helicopters and applied to the K-1200 to facilitate the helicopter pilots.

The pilot who had the accident flew this K-1200 for the first time in a work application on the day of the accident. The helicopter that he flew normally was equipped according to the flight manual. This explains both the difficulty during the pre-flight tests and probably the actuation of the warning siren. However, the possibility of mechanically or electrically activating the cargo release and such drop the entire load assembly was available to him. Before the flight application, he was familiarized with the specialties of this helicopter by another pilot and was advised of the altered switch wiring.

1.18.3 Function and Monitoring of the Pump in the Fuel Controller

The fuel pump in the main fuel controller is designed as a double-flow gear pump where both halves have a separate drive. The pumping performance is designed such that even if one drive fails the remaining part of the pump delivers enough fuel to supply the engine without restrictions.

In an installed condition, a direct testing of the mechanical function is not possible and was not mandatory with view to the manufacturer's maintenance manual at the time of the accident. For this reason, another helicopter model family with the same engine is equipped with a pressure monitoring device that activates a respective warning in the cockpit when one of the two halves of the pump fails. The helicopter pilot than has the possibility of making a safety landing before a malfunction of the engine occurs. Such damages have reportedly occurred in the armed forces of Germany several times without a resultant accident.

The above mentioned monitor was not provided in the design of the version that had the accident.

1.18.4 Emergency procedures in case of power loss

The flight operation manual of the K-1200 contains the following advices for an engine failure during hover out of ground effect:

External load - jettison

Airspeed - Try to pick up an airspeed of 45 kIAS.

at 50 to 75 ft AGL - flare

at 10 to 15 ft AGL - level aircraft and land

In the context it is recommended to use the cargo hook to jettison the load.

Furthermore it contains a note, titled „warning“ that points out that the safety of persons on the ground is critical when deciding to jettison the load.

1.19 Useful of effective investigation techniques

Techniques that go beyond regular means of air accident investigations were not employed for these investigations.

2. Analysis

As the findings of the investigation document without a doubt, the initiating event in the accident sequence was a sudden and for the pilot not foreseeable loss of engine power. At this time, the helicopter was hovering outside of the ground effect at a height of about 250 ft above ground. This height is calculated from the length of the cable of 50 meters and the length of the already upright tree trunk of 25 meters. The inclination of the hill was 23°. This leads to a difference in height between the position at the time of the load pick-up and the 150 m distant crash-site which also was the only suitable emergency landing field of 435 ft. In front of this, however, was an obstacle in the shape of a row of trees that had a height of approx. 90 ft. According to the flight manual of the K-1200 the flight path angle in an autorotation at an airspeed of 50 kts. is 18°. The manufacturer stated that the height loss when entering autorotation from the hover until reaching 50 kts. is approx. 150 ft.

From this data it can be taken that the helicopter could have entered a steady autorotation if the pilot had immediately dropped the external load and reacted without any delay. It could theoretically also have cleared the row of trees. With view to the downslope and the surface of the emergency landing field it can be excluded that with an autorotational landing an accident could have been avoided.

It can be assumed that even after an immediate dropping of the load and an undelayed reaction of the pilot an accident would have occurred. Anyhow the crash would have been less severe if the helicopter had touched the ground in a normal attitude. Incidents where rotorcraft roll over after an autorotation or contact obstacles are known and usually do not lead to fatal injuries among the crew. The attached external load that was pulled along the surface during the last portion of the flight led to the roll-over of the helicopter and thus to the impact in an uncontrolled attitude. This is strongly documented from the marks of high forces on the part of log that was still attached to the longline by means of a cable sling.

As described above, on the request of the customer, the control elements on the control stick handle and lever for the collective of the long line release were modified at this K-1200, while the Cargo Hook Release control remained unchanged. The flight manual, chapter emergency measures, states that at a power loss the external load is to be released, recommended using the Cargo Hook Release. However, it also contains the note that the decision to drop the load in an emergency situation is a critical one, when there are persons underneath the helicopter, which was the case here.

It was not possible to clarify conclusively, whether the helicopter pilot made a deliberate decision not to drop the load so as not to endanger the workers on the ground and instead actuated the warning siren, or if he actuated the button for the siren, which in the helicopter he flew previously activated the longline release, by mistake in an attempt to separate the load. In case the desire was to jettison the load the better decision would have been to use the cargo hook release. According to the manufacturer this is how it is being trained during their type familiarization courses.

The total failure of the double-flow (for redundancy reasons) fuel pump, which is driven by the engine, as a result of the failure of two independent multiple spline shaft connections, that each drive one of the two pump halves due to wear was determined to be the cause of the engine failure. It can be ruled out with high probability that the progress of the breaks was so uniform that this happened simultaneously. Rather, it is to be assumed that initially one of the two pump halves failed through the failure of the drive shaft and that, undetected by the pilot, the engine was supplied by the remaining pump, before the drive of this pump failed as well. Such instances have reportedly occurred several times already.

An important criteria of designs according to the redundancy principle is the mandatory requirement to be able to recognize the failure of one component leading to the loss of redundancy. In this situation at hand, this was not the case, because the possibility to monitor the pressure provided for the engine was not

utilized with this helicopter model. Thus, the failure of one fuel pump half could not be recognized either during flight or during routine maintenance.

The type certification of the helicopter was done on the basis of FAR 27, and that of the engine according to FAR 33. According to these requirements, a redundancy is not required for the engine-driven fuel pump. The existing double-flow design of the pump undoubtedly serves the purpose of increasing the operational safety, however, it was not a prerequisite for the certification according to FAR 33. Utilizing the existing capability for monitoring the pressure naturally is to be viewed as useful. However, it was not to be a requirement for the type certification of the helicopter according to the current airworthiness requirements.

According to the engine manufacturer the double flow design of the pump was utilized only to comply with a requirement of the US military forces. With view to technical reasons neither the double drive nor the pressure monitoring device was necessary. Furthermore the design safety of the splined shafts was so high that a failure was not to be expected during the normal operation time of 3000 hours between two overhauls. Contrary to this statement are, anyhow, the failures in the past that have been reported to the BFU in the course of the investigation as well as the subject accident.

From the viewpoint of aviation safety it is unsatisfying that a system that was designed for redundancy cannot be utilized as the necessary monitoring devices were not incorporated.

When a total power loss occurs, there is with a single engine helicopter generally only one possibility of a successful emergency landing, and that is to initiate autorotation immediately and to land. This requires that the rotorcraft is operated within the respective range of the height/speed diagram and that a suitable emergency landing field is within reach. With helicopters used for external load transport, this is not a reality most of the time.

Picking up and releasing loads is done while hovering outside the ground effect. Due to the lack of forward speed and height, it is more difficult to initiate autorotation than in forward flight. Additionally, the operation is often over difficult terrain or terrain with trees, which rarely offers emergency landing spots.

In addition, these operations have significant risks for other reasons. In the past, accidents occurred through entanglement of the load on the ground, through swinging of the external load and through contact with obstructions. Thus, the protection of the occupants should have a high priority in helicopters that are specifically designed for such operations.

As a result of the data obtained from the Flight Medicine Institute of the German Air Force it can be deduced that a better design of the seat for the helicopter pilot as well as a self fastening restraint system could have contributed to the improvement of the passive safety, which would have improved the chance of survival at this accident.

The seat is designed to reduce the negative g-forces in the accident that is most common for rotorcraft, the impact in a normal attitude with a high rate of descend. The origin for any considerations with view to seat design is of course that the pilot occupies his seat in a normal position and is securely fastened. The severe back injury was in this case caused by a part of the backrest which is not located in the back area but far above in a normal seating position. This documents that the pilot was lifted from his seat and thus his seatbelts were not fastened and pulled tight. The reason for this is that during external load operation it is necessary to look down vertically during load pick up which requires to bend forward and to the side. This is impossible especially for smaller pilots if the seatbelts are pulled tight. In order to bring the pilot into a safe seating position and fix him there a belt fastening system which is known from the automobile field could be used.

3. Conclusions

3.1 Findings

- The helicopter was properly certified to fly. The respective documents were available.
- Flight mass and center of gravity were within admissible limits.
- The pilot in command held the required license and rating and was authorized to conduct the flight.
- In the course of picking up a load, an engine failure occurred due to a dual failure of the engine-driven fuel pump.
- The external load was not jettisoned
- The external load led to an impact of the helicopter in an inverted attitude.
- The button for dropping the external load from the end of the load cable was moved to a place different from the original condition. The location of the actuators for opening the cargo hook release the use of which is recommended in the emergency procedures was unchanged.
- It could not be determined whether the pilot in command did not jettison the load in order not to endanger the persons on the ground, accidentally pushed a wrong button or activated the warning siren on purpose.
- A fuel pressure warning system which would detect the failure of one of the dual pump elements, which is used on other T53 engine installations, was not installed on this model helicopter.
- The airworthiness requirements applicable for the type certification of the engine did not require redundancy for the engine driven fuel pump.
- The area within reach in autorotation was unsuitable for an emergency landing.

3.2 Causes

The accident can be attributed to the fact that a sudden engine failure occurred after both drive shafts of the double-flow (for redundancy reasons) engine-driven fuel pump failed due to wear on two splined shaft connections. The accident was unavoidable as the helicopter was hovering over a terrain unsuitable for a successful autorotation landing.

The following facts contributed to the development of the accident:

- A pressure monitoring device for the two pump segments that could have enabled the pilot to determine the failure of one pump segment before the engine failure occurred, was not installed on the Kaman K-1200 contrary to other helicopter models equipped with the same type of engine.
- The pilot in command did not jettison the external load. It could not be determined whether this was omitted accidentally or with the purpose not to endanger persons on the ground. Whilst an accident could not be avoided after the power loss the still attached external load contributed to the severity of the event.

4. Safety recommendations

As a result of the investigation, the German Federal Bureau of Aircraft Accidents Investigation (BFU) issued the following safety recommendation:

4/98 The cockpit of the helicopter Kaman K-1200 should be retrofitted with pressure monitoring for the two separately operating fuel pumps a feature already available at the main fuel controller.

In addition a letter was directed to the Luftfahrt-Bundesamt in which the BFU asked to consider the following modifications:

- The seat of the pilot of the helicopter Kaman K-1200 should be fitted with a restraint system which allows for the pilot even when correctly fastened the freedom of movement necessary for external load flight with vertical reference.
- The ergonomical design of the seat should be improved.

Until now this led to the following reactions:

The manufacturer of the helicopter issued on Aug. 27, 1999 the service bulletin No. 075, requiring all operators to install a visual warning device for a pressure loss in one of the pump segments.

The operator of another K-1200 is momentarily negotiating with the helicopter manufacturer, a German manufacturer of aircraft seats and restraint systems and the Luftfahrt-Bundesamt (LBA) in order to get a Supplemental Type Certificate for an improved seat and a modified restraint system. A representative of the BFU participates in the discussions with the LBA in an advisory manner.

5. Appendix

none

Braunschweig, 10.03.00

German Federal Bureau of Aircraft Accidents Investigation

Stefan Hasenfuss

Investigator in charge

The following investigators participated in the investigation:

Dipl.-Ing. Jürgen Dorner-Müller (Engine investigation)