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**Aircraft Accident Investigation Bureau AAIB**

# Final Report No. 2072 by the Aircraft Accident Investigation Bureau

concerning the accident

to the Kaman K-1200 helicopter K-MAX, registration HB-XQA

on 11 October 2004

"Petit Truyo", Grandvillard/FR

approx. 30 km south of Fribourg

Aéropôle 1, Route de Morens, CH-1530 Payerne

## Ursachen

Der Unfall ist auf ein Versagen der Kupplungseinheit zurückzuführen.

Das Versagen wurde durch eine Überbeanspruchung und Ermüdung der Laufflächen auf der Kupplungswelle des Freilaufs verursacht.

Zum Unfall beigetragen hat mit grosser Wahrscheinlichkeit das verzögerte Ausgleiten der Last aus dem Lasthaken.

# General information on this report

This report contains the conclusions of the Aircraft Accident Investigation Bureau (AAIB) on the circumstances and causes of the accident which is the subject of the investigation.

In accordance with art 3.1 of the 10th edition, applicable from 18 November 2010, of Annex 13 to the Convention on International Civil Aviation (ICAO) of 7 December 1944 and article 24 of the Federal Air Navigation Act, the sole purpose of the investigation of an aircraft accident or serious incident is to prevent accidents or serious incidents. The legal assessment of accident/incident causes and circumstances is expressly no concern of the incident investigation. It is therefore not the purpose of this investigation to determine blame or clarify questions of liability.

If this report is used for purposes other than accident prevention, due consideration shall be given to this circumstance.

The definitive version of this report is the original in the German language.

All times in this report, unless otherwise indicated, are stated in local time (LT). At the time of the accident, Central European Summer Time (CEST) applied as local time in Switzerland. The relation between LT, CEST and UTC is: LT = CEST = UTC + 2 hours.

## Contents

# Final Report

## Summary

| | |
|---|---|
| Owner | Rotex Helicopter AG, Rheinstrasse 2, FL-9496 Balzers |
| Operator | Rotex Helicopter AG, Rheinstrasse 2, FL 9496 Balzers |
| Manufacturer | Kaman Aerospace Corporation, USA |
| Aircraft type | Kaman K-1200 K-MAX |
| Country of registration | Switzerland |
| Registration | HB-XQA |
| Location | "Petit Truyo", Grandvillard/FR, approximately 30 km south of Fribourg |
| Swiss Coordinates | 573 580 / 152 780 |
| Latitude | N 046° 31′ 32.9″ |
| Longitude | E 007° 05′ 39.5″ |
| Elevation | 1040 m AMSL |
| | 3412 ft AMSL |
| Swiss State Map | Sheet Nr. 1245, Sheet Name Château-d'Oex, Scale 1:25 000 |
| Date and time | 11 October 2004, approx. 16:52 LT |

## Investigation

The accident occurred at approximately 16:52 LT. At approximately 17:20 LT, the Rega Swiss Air Rescue Service informed the AAIB stand-by service of the event. Initial statements were taken on that same evening. The investigation at the wreckage location was started the next morning, at 07:00 LT.

The investigation was carried out in cooperation with the Fribourg cantonal police.

## Synopsis

On 11 October 2004, the pilot and ground crew of a helicopter transport company were engaged in logging operations using a Kaman K-1200 K-MAX transport helicopter 1.7 km southeast of the municipality of Grandvillard/FR. After approximately 50 minutes of transport time or 22-23 turns at this location, the pilot informed his ground crew that he intended to refuel in 10 minutes. When lifting the next load of timber, the pilot heard an abnormal noise from his helicopter and experienced a loss of power. After he had managed to tilt the logs in the direction of the valley and away from the ground crew, he made several attempts to release the load mechanically. The longline only disengaged when the helicopter was already in an unrecoverable position, with the nose pointing towards the ground and the rotor turning at reduced speed. The helicopter crashed nose first into the forest.

The pilot was seriously injured by the impact and the helicopter was destroyed.

There was minor damage to the forest.

**Causes**

The accident is attributable to a failure of the clutch assembly.

The failure of the clutch assembly was caused by overloading and fatigue of the bearing surfaces on the free-wheel clutch shaft.

A contributing factor was with high probability the delayed sliding out of the load from the belly cargo hook.

Within the framework of the investigation, two safety recommendations were issued.

Figure 1: Final position of the helicopter

# 1 Factual information

## 1.1 History of the flight

### 1.1.1 General

The statements of the pilot and ground crew were used for the following description of the flight preparations and history of the flight.

The flight was conducted under visual flight rules.

### 1.1.2 Flight preparations

On the morning of Monday 11 October 2004, helicopter HB-XQA was being used for routine logging operations in Feschel, in canton Valais. The two pilots assigned for this day had agreed to hand over the aircraft at 13:30. In order start his shift calmly and to acquire a general overview, the second pilot was, as usual, at the operations area somewhat earlier, at about 11:30. During lunch on site, he watched his colleague logging and monitored his colleagues' work on the radio.

Shortly afterwards, he was asked by the first pilot whether he could take over the aircraft. After a brief discussion about work, the helicopter was handed over. No snags were noted. The second pilot took off in HB-XQA at 12:27 to complete logging in Feschel. At 14:15 the pilot landed and switched off the engine. The work which had been performed was discussed with the ground crew involved.

At the same time, another company ground crew and forestry workers were preparing for their work in Grandvillard in canton Fribourg.

Once this crew had reported that they were ready, the pilot took off at 15:12 to fly to Grandvillard. Due to the cloud cover reported and visible in the direction of the Bernese Alps, he decided on a flight path along the Rhone valley and Bulle. There were also clouds over the new operations area approximately 2 km southeast of Grandvillard. However, the cloud base was rising and , after a brief reconnaissance of the felling area and the unloading area, was assessed by the pilot not to be a hindrance to logging operations. The pilot landed at the refuelling point to refuel with the engine running (hot refuelling).

### 1.1.3 History of the flight

A few minutes after landing, the helicopter had been refuelled with 800 lb of fuel and was ready for logging operations. This quantity of fuel allowed the pilot to fly for approximately 60 minutes and still maintain a 20 minute reserve. The pilot explained that he always landed with at least 200 lb of reserve fuel on board, to be on the safe side.

As usual, the logs were lifted from the slope of the felling area and flown to the *"Polter"* (log pile at the unloading area). On the forest hillside, three assistants (hookers) were working; they fitted a choker to the logs and attached them to the hook. There were also two assistants (loggers), who prepared the timber. At the unloading site, two assistants (riggers) at the stack of timber received the logs and released them from the chokers with the aid of a tractor.

The pilot brought the hook on the 50 m longline to the hooker by flying a left-hand circuit over an upward sloping hill ridge. The suspended logs, with a total mass of 2 – 2.2 t, were lifted up in the direction of the valley and the left-hand circuit was continued along the valley to the stack which was only 500 m away and some 120 m below. Everything was running smoothly; the helicopter and the assistants were constantly in motion. The cloud base was continually changing, without interfering with operations at any time.

The short distance between the felling site and the stacking site resulted in very short round-trip or turn times of approximately 2 minutes. The pilot stated: "The turns were short, it was easy for me, but hard on the ground crew."

Approximately 22-23 turns or a good 50 minutes later, the pilot reported to his ground crew that he had another 10 minutes flying time available until refuelling. The remaining amount of 300 lb of fuel at that time would have been sufficient for another 4-5 turns.

Then, when lifting the next load of 3-4 logs which were ideally positioned, the pilot felt that something unusual was happening: "*…En construisant la puissance, dans la zone supérieure, j'ai senti qu'il y avait quelque chose qui n'allait plus…Tout allait bien jusqu'à 50 PSI de puissance, ensuite j'ai entendu une fluctuation rapide des régimes rotors avec un bruit caractéristique d'un frottement de métal."* [Translation: …When power building up, in the in the higher range, I felt that something was no longer right. Everything was going fine up to 50 PSI power, then I heard a rapid fluctuation in rotor speed, with a characteristic noise of metallic friction.]

As always, before taking up the load, the pilot had observed the position and attachment of the load by looking down the side. If everything was proceeding normally, he would glance at the instruments to check the build-up of power at about 45-50 PSI torque. He would then look outside again at the load and obstacles. The pilot stated: "*…Par contre, en raison du bruit anormal, je n'ai plus regardé en dessous. Je ne me souviens pas avoir vu un témoin d'alarme ni le master s'allumer. …Je précise que lorsque j'ai entendu les bruits de fluctuation, j'ai certainement baissé le collectif et ai laissé le twistgrip à 100 %."* [Translation: …However, because of the abnormal noise, I did not look down again. I don't recall seeing a warning indication or the master light up. …I know that when I heard the fluctuation noises, I shurely lowered the collective and left the twistgrip at 100 %.]

According to the description given by his ground crew, the load was already approximately 1 m above the ground when it began to sink back down again.

The pilot wanted to release the load immediately, but paused because he wanted to not endanger his colleagues on the ground: "*Pendant un court instant, je n'ai pas voulu lâcher trop vite l'élingue car j'ai pensé à mes camarades au sol. Je voulais que le bois tombe vers l'avant et non pas vers mes collègues. Après j'ai voulu relâcher l'élingue avec le crochet mécanique qui se trouve sous le collectif car c'est le plus sûr."* [Translation: For a brief instant, I didn't want to release the longline too quickly because I was thinking about my colleagues on the ground. I wanted the logs to fall forwards, not towards my colleagues. Afterwards, I wanted to release the longline with the mechanical hook, which is located below the collective, as this is the safest way.]

The helicopter moved forwards and a little to the right; the logs tipped forwards.

The initial attempts at an emergency release of the load including the longline were unsuccessful. The pilot stated: *"Au moment où j'ai voulu décrocher l'élingue j'ai bien ressenti qu'elle ne s'est pas décrochée tout de suite, j'ai dû m'y reprendre à quatre fois. La quatrième fois j'ai rajouté un peu de pas collectif afin de relancer la machine vers l'avant ce qui a certainement eu pour conséquence de faire baisser encore les tours. A ce moment-là j'étais trop bas pour redresser* *l'appareil qui avait le nez qui pointait vers les arbres."* [Translation: At the moment when I wanted to release the longline, I felt that it had not released right away, I had to try four times. The fourth time I added a little collective to move the aircraft forwards which undoubtedly caused a further RPM reduction. At that moment I was too low to level the aircraft, whose nose was pointing towards the trees.]

The helicopter's nose was already pointing steeply towards the ground when the longline finally released from the belly hook on the helicopter, after the pilot had once again slightly pulled on the collective.

As the helicopter pulled away, the ground crew heard a change in the rotor noise.

The pilot was able to describe the position of the pointers on the combined engine/rotor speed instrument: *"Je me rappelle d'avoir regardé rapidement le tableau de bord…Une aiguille était à 9 heures, je ne sais plus laquelle, l'autre était à 6 heures."* [Translation: I remember glancing at the instrument panel… One pointer was at 9 o'clock I don't know anymore which one, the other was at 6 o'clock.] He heard the aural warning which is triggered when the rotor speed is too low (low RPM horn).

The helicopter crashed nose first between the trees onto the forest floor.

The pilot was seriously injured by the impact and the helicopter was destroyed.

There was minor damage to the forest.

## 1.2 Injuries to persons

| Injuries | Crew | Passengers | Total number of occupants | Others |
|---|---|---|---|---|
| Fatal | --- | --- | --- | --- |
| Serious | 1 | --- | 1 | --- |
| Minor | --- | --- | --- | --- |
| None | --- | --- | --- | --- |
| Total | 1 | --- | 1 | |

## 1.3 Damage to aircraft

The helicopter was destroyed.

## 1.4 Other damage

There was minor damage to the forest.

## 1.5 Personnel information

### 1.5.1 Pilot

| | |
|---|---|
| Person | Swiss citizen, born 1968 |
| Licence | Commercial helicopter pilot's licence CPL (H) ICAO, first issued by the FOCA on 11.05.1999, valid till 19.01.2005 |
| Ratings | K-1200, HUGHES 300, HUGHES 500, R22, SA 315, EC 120B<br>International radiotelephony for flying |

| | | |
|---|---|---|
| | | under visual flight rules RTI (VFR/IFR)<br>Night flying NIT (H)<br>Mountain landings MOU (H) |
| | Medical certificate | Class 1, without restrictions |
| | Last medical examination | 15.01.2004 |
| 1.5.1.1 | Flying experience | |
| | Total | 4923 hours |
| | on the accident type | 3000 hours |
| | during the last 90 days | more than 90 hours |
| | of which on the accident type | more than 90 hours |
| | during the last 24 hours | 1:35 hours |
| | of which on the accident type | 1:35 hours |
| | Logging longline, total | 3189 hours |
| 1.5.1.2 | Crew duty time | |
| | Flight duty time on the previous day | none |
| | Rest time | more than 8 hours |
| | Flight duty time at the time of the accident | approx. 5 hours |
| | Flying time | 1:35 hours |

## 1.6 Aircraft information

| | |
|---|---|
| Registration | HB-XQA |
| Aircraft type | Kaman K-1200 K-MAX |
| Characteristics | Single-seat turbine-powered transport helicopter with intermesher rotor system<br>The K-1200 has two twin-blade rotors which are mounted laterally on separate masts with a 90° phase difference, powered by a common transmission. Since the counter-rotating rotors cancel out each other's torque, this helicopter does not require a tail rotor. |
| Manufacturer | Kaman Aerospace Corporation, USA |
| Year of manufacture | 1994 |
| Serial number | A94-0008 |
| Owner | Rotex Helicopter AG, Rheinstrasse 2, FL-9496 Balzers, Liechtenstein |
| Operator | Rotex Helicopter AG, Rheinstrasse 2, FL-9496 Balzers, Liechtenstein |

| | |
|---|---|
| Engine | Honeywell (Textron Lycoming) T5317A-1 S/N LE-81011; max. power 1500 SHP |
| Equipment | Belly hook with weighing system. Primary cargo hook K931204-001, serial number W/D-890 mounted on the helicopter airframe.<br>Double hook mounted on a longline approximately 50 m long. The mass of the last load flown was 5260 lb (2390 kg). |
| Operating hours, airframe | TSN: Hobbs Meter (operating hours counter) 11, 030.5 hours<br>Landings: not recorded |
| Operating hours, engine | TSN: 6807 hours<br>gas producer 32 430 cycles<br>compressor 5184 cycles<br>power turbine 4360 cycles |
| Max. permitted take-off mass | without external load: 6500 lb (2948 kg)<br>with jettisonable external load: 12 000 lbs (5443 kg) |
| Mass and centre of gravity | The helicopter's mass at the time of the accident was 10 920 lbs or 4964 kg.<br>Both mass and centre of gravity were within the prescribed limits. |
| Maintenance | On 03.02.04 at Hobbs Meter 10 135 hours: Installation of the main gearbox P/N K974002-101 S/N A18-33<br>On 25.06.04 at Hobbs Meter 10 526 hours: 1200-hour belly hook inspection<br>On 20.09.04 at Hobbs Meter 10 900 hours: Installation of engine S/N LE-081011; TSN 6677 hours<br>Installation of the clutch assembly P/N K974002-701; S/N A 1023; TSN 984.2 hours TSO 0.0 hours<br>Installation of the sprag assembly P/N K974110-003; S/N A 093; TSN 0.0 hours<br>KAflex drive shaft misalignment check performed<br>Engine side: 0.127 inch<br>Transmission side: 0.176 inch<br>On 30.09.04 at Hobbs Meter 10 970 hours: 50/300-hour lubrication performed.<br>100-hour inspection of airframe and engine as well as visual examination of belly |

| | |
|---|---|
| | cargo hook signed-off.<br>On 07.10.04 at Hobbs Meter 11 008 hours: 50-hour lubrication performed. Engine re-adjustment carried out.<br>On 11.10.04, the day of the accident, the AD 2004 – 269 M/R grip inspection SB 109 and AD HB 99-643 clutch inspection AFM 3-7 were signed-off in the logbook. |
| Fuel grade | JET A1 kerosene<br>The freezing point and electrical conductivity were outside the specification. Experience shows that crystal formation when determining the freezing point occurs in the event of minor contamination (e.g. by diesel fuel). |
| Fuel remaining | 266 lb or 150 l. This corresponds to approximately 25 minutes flying time. |
| Certificate of Registration | Issued by the FOCA on 07.04.1997 |
| Certificate of Airworthiness | Issued by the FOCA on 10.04.1997, valid until revoked |
| Scope of Utilization | in non-commercial use:<br>VFR day / VFR night<br>in commercial use:<br>VFR by day |
| Last airworthiness review | Carried out by the FOCA on 13.02.2001. |

1.6.1 Construction characteristics and certification basis of helicopter K-1200

The K-1200 helicopter was developed by the Kaman company as a transport helicopter. In this context, the rotorcraft flight manual (RFM) states: "The K-1200 is built specifically for repetitive lifting operations. The simplified design uses traditional aircraft materials engineered for maximum load bearing strength. The single-seat configuration offers maximum pilot visibility in all directions. Controls and instruments are arranged to be compatible with vertical reference flight requirements. The pilot's seat is a high-energy absorbing unit supported by reinforced structure."

Type certification according to FAR 21 and FAR 27 was granted on 30 August 1994 by the Federal Aviation Administration (FAA).

1.6.2 Engine

1.6.2.1 Description of the system

The K-MAX helicopter is equipped with a Honeywell T5317A-1 twin-shaft turbine engine. The engine consists of a two-stage power turbine (free power turbine N2) and a two-stage gas generator (gas producer turbine N1), which drives a combined axial and centrifugal compressor. A constant N2 speed is achieved by a varying N1 speed depending on the load.

N1 is regulated by the pilot's twist-grip throttle on the collective via various control rods to the fuel control unit (FCU).

The twist-grip throttle has four different detents for the pilot: OFF, GRD IDLE, FLT IDLE and FLY.

From the FLY position, the OFF position of the throttle is reached by simultaneously pulling back and turning right the twist-grip through the other three detent positions.

1.6.3 Clutch assembly

1.6.3.1 Description of the system

The function of the clutch assembly is on the one hand to transfer engine torque to the gearbox and on the other hand the clutch free-wheel is designed to provide separation of the drive and rotor system in the non-driven (power off) flight condition.

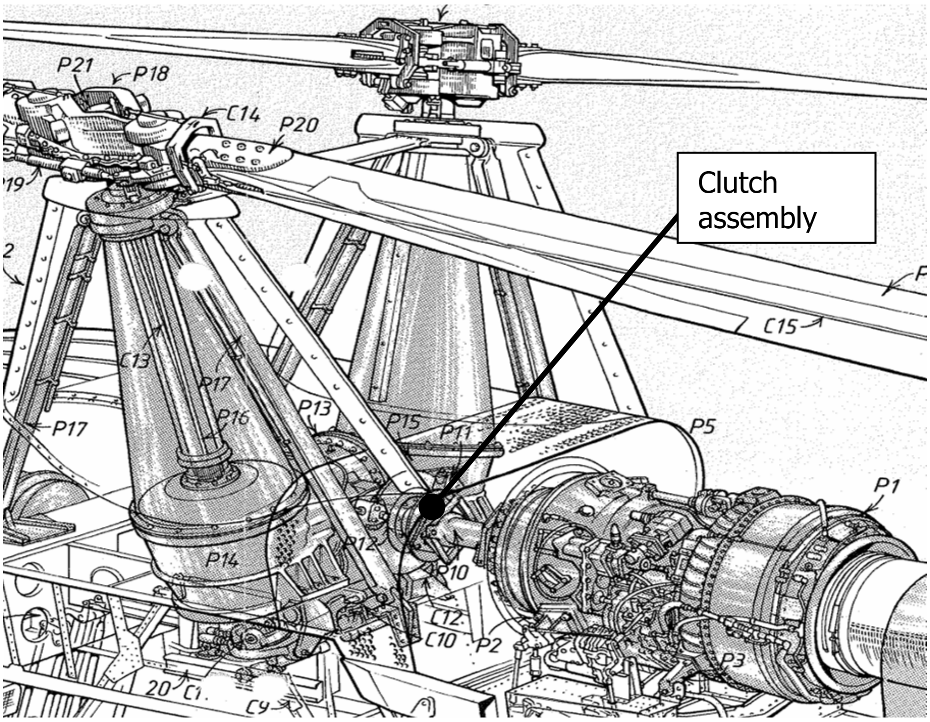



Figure 2: Schematic of the engine, clutch and gearbox assembly and both main rotor units.

The clutch assembly is positioned between the KAflex coupling and the main gearbox input pinion.

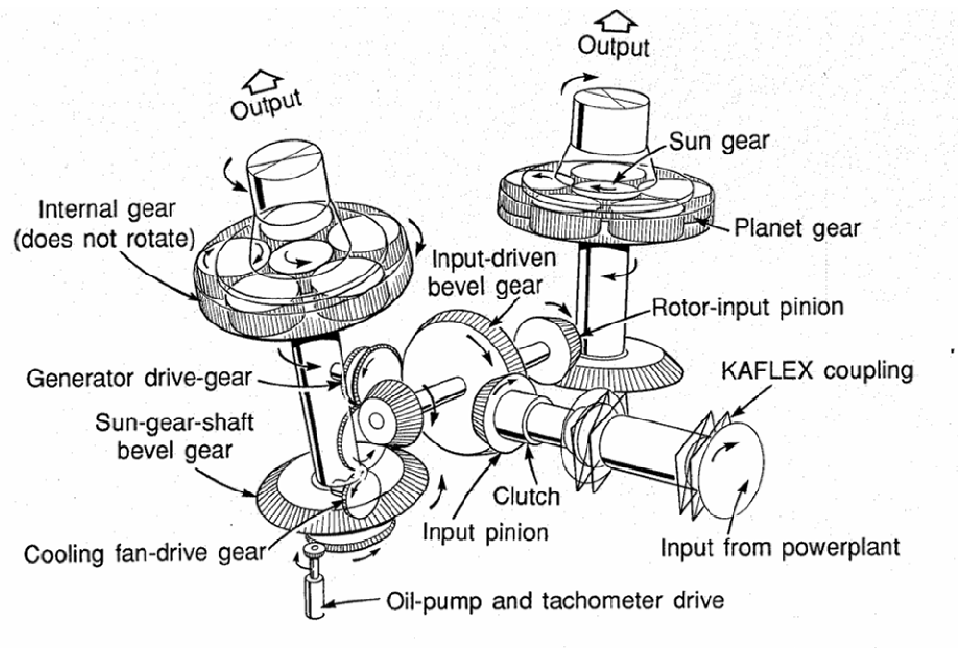



Figure 3: Schematic of the clutch and gear arrangement.

Additional information:

*Input from power plant: 6637 RPM (101 % N2, 21 300 power turbine rpm)*

*Gearbox input: Rigid driveshaft with KAflex flexible couplings at both ends*

*Over-running clutch: Sprag type*

*Rotor shaft input: Bevel cut gears with 24.3: 1 reduction ratio*

*Output main rotor: ca. 270 RPM*

The installed clutch assembly, designed as an overrunning clutch, also known as a free-wheel, is fitted with 33 sprags. These sprags transfer the torque from the drive shaft to the main gear input in only one direction of rotation by friction locking.  Free-wheels are couplings operated by the direction of rotation, i.e. coupling or decoupling takes place automatically, depending on the relative direction of rotation of the input and output sides. The outer race of this coupling is able to rotate freely in one direction in relation to the inner race.


Figure 4: Schematic of the clutch assembly

In the case of rotation in the opposite direction, the sprags wedge between the inner and outer race. This radial wedging ensures non-slip power transmission.

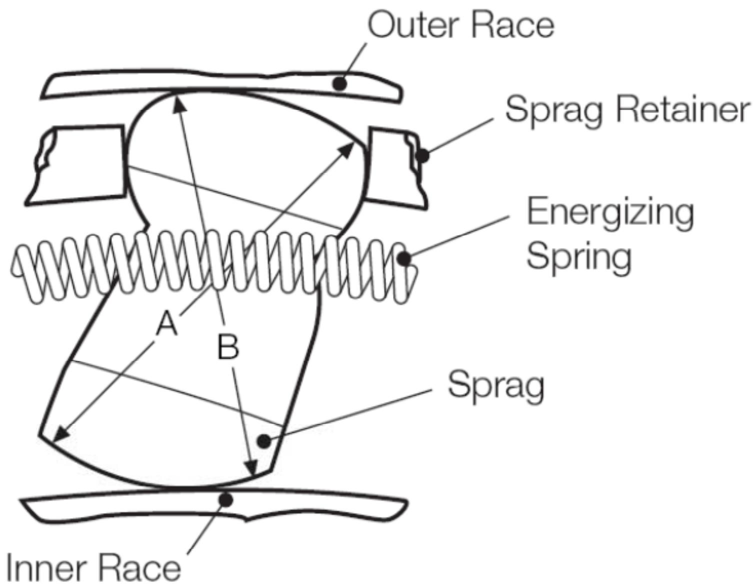



Figure 5: Schematic of the method of operation of the clutch assembly, consisting of the following main components:

Outer race

Inner race

Sprag

Sprag retainer

Energizing spring

The diagonal dimension A is greater than B.

The clutch assembly manufacturer describes its operation as follows:

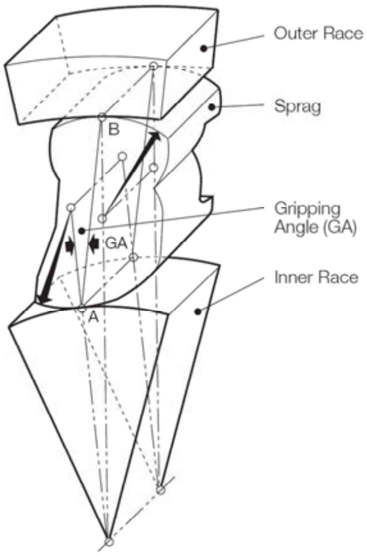



Figure 6: Geometry of the sprags with gripping angle - GA

*"Wedging action depends upon the wedging, or gripping angle of the sprags between the races. The fundamental concept of sprag clutches requires that the coefficient of friction of the sprag, with respect to the inner race at the instant torque is applied in the drive direction, must be greater than the tangent of the gripping angle – GA. If the condition is not satisfied, wedging will not occur.*

*The gripping angle is determined by the construction of figure 6, where points A and B are the points of contact of the sprag with the inner and outer race, respectively. "*

1.6.4 Helicopter manufacturer's additional maintenance and operating instructions

The helicopter was equipped with a clutch assembly P/N K974002-701 S/N A1023 and a sprag assembly P/N K974110-003 S/N 093.

Between 1998 and 2004 the manufacturer and the aviation authorities published, among other things, the following information, bulletins and airworthiness directives in relation to the power transmission/clutch assembly. Extracts from these are reproduced below.

1.6.4.1 KAMAN SERVICE LETTER 98-012

Date of issue: 21 December 1998

*"SUBJECT: K-1200 transmission clutch/free-wheel conservation*

*When carrying an external load and performing a rapid deceleration, or during steep descents with collective approaching full down, we recommend that you add approximately one inch of collective……prior to the large collective input needed to stop the manoeuvre. This graduated procedure should significantly reduce the exposure to clutch/free-wheel damage. Experience shows that failure to make a small initial collective input will result in premature removal of the clutch and freewheeling unit….*

*More specifically, if there is zero load or very close to zero load on the clutch, only a few of the sprag-cams in the free-wheel may remain in functional contact. When the large collective input is applied, these few sprag-cams assume most of the load. This overload will cause some initial slippage before the rest of the sprag-cams grip the shaft. The result of the slippage is damage to the sprags and the free-wheel shaft……*

*Since the clutch/free-wheel currently has a maintenance interval less than 2500 hours, it must be field replaced. This process exposes the transmission to potential internal contamination. It is desirable to eliminate the need for this field action by maintaining the clutch/free-wheel only at overhaul….."*

1.6.4.2 KAMAN SERVICE BULLETIN No. 081 MANDATORY ACTION

Date of issue: 11 November 1999

*"One Time Transmission Clutch Inspection"*

*"A: Effectivity: All K-1200 Aircraft*

*B: Reason for Change: Inspect clutch assembly for integrity*

*C: Description of Change: This inspection involves physically rotating the clutch by hand and checking for ratcheting or roughness, and if necessary removal of the clutch assembly for a visual inspection. …"*

1.6.4.3 BAZL LTA HB 99-643, FAA AD 99-26-04

Effective date: 21 December 1999 Airworthiness Directive AD: URGENT

*"Origin FAA AD 99-26-04 EMERGENCY PRIORITY LETTER"*

*"Model K-1200 with clutch assembly P/N K974002-701 installed …*

*Cause/measure: Clutch assembly: Inspection for Integrity*

*Replacement, if necessary*

*Compliance: Required before the first flight of each day*

*To prevent failure of the engine adapter flange, loss of power to the main rotors, and a subsequent forced landing, accomplish the following:*

*Inspect the integrity of the clutch assembly, in a location where background noise would not hinder evaluation, by firmly and uniformly rotating the KAflex shaft in the anti-rotating direction (…) while maintaining hand contact. The anti-rotation speed should be approximately one-fourth to one-half revolution per second. An unairworthy clutch will feel rough with a continuous dry "raspy" feel and sound, or it may feel as though the clutch has heavy detents or "catches" on the interior surface that impede the free rotary motion. …"*

1.6.4.4 KAMAN SERVICE LETTER 00-001

Date of issue: 15 March 2000

*"SUBJECT: K-MAX External Load Operations"*

*"While operating the K-MAX with an external load, avoid flight regimes that allow the engine torque to drop below 5 psi. Maintaining engine torque pressure above this value will minimize the possibility of disengagement and associated re-engagement of the clutch, which can cause accelerated wear of the clutch assembly. Flight regimes with torque pressure below this value may cause clutch disengagements. Re-engagements loads can be large enough to degrade the working surfaces of the clutch assembly, and repeated cycles of disengagement/re-engagement can produce an unreliable friction surface characterized by slippage, grabbing, and possible loss of drive.*

*…"*

1.6.4.5 KAMAN SERVICE BULLETIN No. 089, MANDATORY RECURRING ACTION

Date of issue: 21 June 2000

*"50 Hour Inspection of Transmission Clutch Assembly"*

*"A. Effectivity: All K-1200 aircraft with K974110-003 and K974110-005 clutch assemblies.*

*B. Reason for Change: Ensure integrity of clutch assembly."*

1.6.4.6 KAMAN SERVICE LETTER 00-002

Date of issue: 21 June 2000

*"SUBJECT: K-MAX External Load Operations-Revised"*

*"Based on flight testing and additional field experience, it has been determined that while operating the K-MAX with an external load, avoid flight regimes that allow the engine torque pressure to drop below 10 psi. …"*

1.6.4.7 KAMAN NOTICE TO K-1200 OPERATORS

Date of issue: 29 June 2000

*"As we advised you by Notice to Operators dated June 15, 2000 Rotex AG of Liechtenstein experienced a forced landing on June 13, 2000. Initial inspection indicated that there was clutch damage.*

*Since June 13, we have issued Notices to Operators dated June 20, 2000, June 21, 2000, and June 22, 2000 as well as Service Letter No. 00-002 dated June 20, 2000 and Service Bulletins No. 088 dated June 21, 2000 and Service Bulletin No. 089 dated June 21, 2000 addressing more sensitive inspections of the clutch and operating procedures when carrying an external load. In addition to these actions, we have agreed to provide the European operators with the K974110-003 clutch as an alternative to the K974110-005 clutch. The operation and inspection requirements listed above will apply to both versions of the clutch assembly and both can be operated safely with adherence to such requirements.*

*Kaman is working on a modified clutch assembly (K974111-001) that is currently being tested here in Bloomfield. Our goal is to have this modified clutch available for a Field Service Experience (FSE) program in the September 2000 time frame with availability for all operators to follow in the first quarter of 2001. …"*

1.6.4.8 KAMAN NOTICE TO K-1200 OPERATORS

Date of issue: 30 June 2000

*"The purpose of this notice is to distribute the attached K-MAX Operator Clutch Inspection Summary Form and request that operators provide Kaman with daily and 50-hour clutch inspection data. This information is necessary to evaluate the clutch inspections and help determine future inspection intervals.*

*It is imperative that each operator completes this form after each inspection and fax it …"*

1.6.4.9 KAMAN SERVICE LETTER 00-003

Date of issue 7 July 2000

*"SUBJECT: Service Bulletin No. 089-50 Hour Clutch Inspection"*

*"In accordance with K-1200 Inspection guidelines contained in the K-MAX Maintenance Manual, the requirements of Service Bulletin Number 089 – Mandatory Recurring Action 50 hour inspection of Transmission Clutch Assembly, must be completed and signed off within 5 hours of its designated interval.*

*This information will be incorporated into a future revision to the K-1200 Maintenance Manual."*

1.6.4.10 KAMAN NOTICE TO K-1200 OPERATORS

Date of issue: 12 July 2000

*"This is to let you know that a mishap occurred in Idaho on July 11, 2000 involving a K-MAX helicopter owned by Superior Helicopter, LLC, N311KA (A94-0017). The aircraft was conducting a logging operation when according to witnesses; it suffered a loss of power. The pilot sustained injuries and has been hospitalized in Spokane, Washington for treatment.*

*The cause of the accident is under investigation."*

1.6.4.11 KAMAN SERVICE BULLETIN No. 090 MANDATORY ACTION

Date of issue: 13 July 2000

*"One Time Transmission Clutch Conversion"*

*"A. Effectivity: All K-1200 Aircraft B. Reason for Change: Precautionary measure.*

*C. Description of Change: Removal of Sprag clutch P/N K974110-005 and installation of Sprag clutch K974110-003 on the K974002-701 clutch assembly.*

*D. Compliance: Mandatory: A one-time clutch conversion is to be completed within 10 hours after receipt of this service bulletin. Clutch assembly K974002-701 with Sprag clutch P/N K974110-005 will have to be removed and returned to Kaman Aerospace. The conversion will be accomplished at Kaman's Bloomfield, …*

*E. Approval: The FAA has approved the technical aspects of this bulletin. …"*

1.6.4.12 KAMAN NOTICE TO K-1200 OPERATORS

Date of issue: 14 July 2000

*"As reported yesterday, Superior Helicopters LLC, aircraft N311KA, had an accident in which there was a reported loss of power. The accident investigation has begun however due to the condition of the aircraft and the investigative processes involved, the definitive cause may take some time to determine.*

*This aircraft was operated with a K974110-005 clutch installed. Kaman continues to believe that operation of this clutch is safe utilizing the operating procedures and inspections recommended by Kaman as the manufacturer. However, as a precautionary measure until a definitive cause of this accident is determined, helicopter operations with the K974110-005 must be suspended.*

*Flight operations with the K974110-001 and K974110-003 clutches continue to be authorized and Kaman is working diligently to provide the -003 clutch to all operators as soon as practicable. We will be in contact with you shortly regarding plans for installation of your -003 clutch."*

1.6.4.13 KAMAN SERVICE LETTER 00-003

Date of issue: 14 July 2000

*"SUBJECT: K-MAX External Load Operations-Revised"*

*"Discussions with K-MAX operators following the issuance of Service Letter 00-002 indicate that there is some confusion regarding the parameters associated with the limitations outlined in that Service Letter, which was issued on June 20, 2000. After further considerations, we are issuing this Service Letter 00-003 which supersedes Service Letter 00-002.*

*Under this Service Letter, operators have the option of conducting flight operations under either of the two following procedures:*

***OPTION 1***

*K-MAX flight operations with an external load may be continued by avoiding flight regimes that allow the engine torque pressure to drop below 5 psi, provided that both of the following two procedures listed below in this section (OPTION 1) are followed:*

*1. Adjust and set rotor autorotational RPM to the lower end of the Autorotational Chart, …*

*2. Adjust collective compensation setting so that in-flight engine N2 RPM does not drop below 104% at low collective settings.*

*Or*

***OPTION 2***

*K-MAX flight operations with an external load may be continued by avoiding flight regimes that allow the engine torque pressure to drop below 10 psi.*

***General Requirements***

*For ALL flight operations (Whether under OPTION 1 or OPTION 2) the following procedures must be used as outlined in the K-1200 Rotorcraft Flight Manual, the K-MAX Maintenance Manual and K-1200 posted placards:*

1. *Verify engine beep range rigging in accordance with …*
2. *Verify collective compensation in accordance with …*
3. *For all external load operations at gross weights greater than 6500 pounds, set and maintain N2 engine speed at 104% in accordance with the cockpit limitations placard, not to exceed 105% N2.*
4. *N2 operations are permitted up to 105% N2.*
5. *Adjust collective compensation setting if engine N2 RPM exceeds 105% at high collective settings.*
6. *Do not adjust N2/Nr below 104% during descents.*
7. *In accordance with Section 3 of the K-1200 Rotorcraft Flight Manual, anticipate possible rotor RPM increases and maintain rotor RPM (Nr) at 104%, not to exceed 105%, through the use of increased collective as necessary during all flight operations.*

*NOTE: The information provided in this letter is not to be considered as contrary to, nor does it replace the need to follow all aspects of the K-1200 Rotorcraft Flight Manual ….*

*BACKGROUND*

*Recent incidents of damage to clutches, input shafts, and output shafts have been attributed to repeated clutch disengagements and re-engagements. During normal helicopter operations, the clutch will remain positively engaged so long as the rotor RPM (Nr) is not permitted to exceed engine (N2) speed. At the point of clutch disengagement, there is near zero torque on the drive train. Each time the clutch is disengaged, wear and the potential for damage during reengagement exists. Repeated disengagement/reengagement of the clutch will cause an increase in wear to the components and may result in an in-flight slippage of the clutch and premature component removal.*

*Therefore, while maneuvering with an external load (turns, banks, descents, flairs, quick stops or aircraft pitch attitude increases), it may be necessary to significantly increase collective position to obtain a torque value required to maintain proper rotor RPM. This collective position may produce a torque value as high as 10 psi or even greater and should be inputted PRIOR TO initiating any flight manoeuvre that could cause an increase in rotor RPM (noted above). The amount of collective required to maintain N2/Nr RPM at 104%, up to 105% will vary according to ambient conditions, the weight of the external load, aircraft operating condition (rotor rigging, collective compensation, density altitude, and other factors noted above), and pilot experience.*

*NOTE – Section 2 of the K-1200 Rotorcraft Flight Manual states that the N2 RPM limitation is 105% N2. However, AlliedSignal Maintenance Manual T5317 Series, 7100-00 provides for transient time limits and torque limits for transient operations. Under the table in paragraph …, transient N2 speeds of up to 106% (K-1200 N2) are permitted at 58 psi torque for a transient time limit of up to 10 seconds. If limits are exceeded, an overspeed inspection must be performed.”*

1.6.4.14 KAMAN NOTICE TO K-1200 OPERATORS

Date of issue: 22 August 2000

*"Several operators have asked for information relative to the -003 and -005 K-MAX clutch configurations and Kaman Aerospace Corporations response to recent K-MAX incidents that have in some manner involved clutch damage. …*

*1. In 1996 the K974110-003 clutch was the first clutch put into widespread service with the K-MAX. Prior to that the …-001 clutch was in limited fleet use. Routine inspection of the …-003 clutch and associated components substantiated the use of this clutch with a 1200 hour overhaul interval but it also revealed two types of accelerated wear.*

*2. The first was an uncharacteristic amount of sprag cam surface wear indicative of both excessive overrunning and multiple reengagement of the clutch under load. Typically for normal operation there would be very little to no sprag cam surface wear expected.*

*3. The second type was excessive amounts of typical surface rubbing wear on the clutch retainer cross bars, again indicative of repeated overrun and reengagement events. The clutch retainer cross bars serve to keep each of the sprags operating in synchronization.*

*4. As a result of its observation, Kaman undertook actions to protect the K-MAX fleet against this accelerated clutch wear via a series of Service Bulletins and field inspections meant to detect accelerated clutch wear. Refer to Service Bulletins 088 and 089.*

*5. Further, in order to avoid operations of the K-MAX wherein repeated reengagement of the clutch are utilized, K-MAX operator pilot briefings and additional Manual revisions and warnings were published. These actions were taken in order to eliminate operations of the K-MAX with an external load where the main rotor RPM exceeds the turbine RPM. If this happens the clutch must overrun. After overrunning, when the K-MAX main rotor again requires power, the clutch must reengage under load. No helicopter drive train clutch is designed for repeated reengagement under load.*

*6. Kaman's activities were driven by safety considerations to detect accelerated clutch wear and to attempt to eliminate the repeated clutch reengagement modes of K-MAX operation.*

*7. Additionally, in an effort to reduce the noted retainer cross bar wear, Kaman modified the -003 clutch retainer configuration. The modification to the retainer was a material nitriding process which provides a hardened wear surface on the retainer. The clutch using the nitrided retainer is the …-005 clutch assembly. The clutch was put into service in 1998 and replaced the -003 clutches in customer aircraft at opportune subsequent overhauls in order to minimize cross bar wear during clutch overrunning and reengagement. At the time of its replacement by the -005 clutch, the -003 clutch had no occurrences where power could not be transmitted to the rotor and continue to overrun during autorotation events. K-MAX configured with -005 clutches were involved in the recent loss of power occurrences.*

*8. The investigations are not yet complete on the recent incidents and final reports have not been issued. Since it will take some time before definitive causes can be determined, if at all, Kaman has taken the precautionary measure of returning the -003 clutch. The -003, in over 30000 flight hours has had no occur-*

*rences where the clutch would not transmit power to the main rotor and continue to overrun during autorotation events.*

*9. Beyond the return of the -003 clutch to service, Kaman continues to aggressively pursue the development of a modified clutch. This clutch is expected to enter into fleetwide K-MAX service during the first quarter of 2001 after a Field Service Experience (FSE) program and FAA approval.*

*10. It must be restressed that the accelerated clutch wear potential subsequent clutch malfunction is caused by operation of the K-MAX outside of the FAA approved K-1200 Flight Manual operational envelope. Operation of the K-MAX within prescribed flight limits does not involve the repeated reengagement of the clutch that causes accelerated wear.*

*11. To ensure that the clutch is not subjected to continued reengagement, external load operations must not be performed where the main rotor RPM exceeding the Engine RPM (needle splits). Refer to Service Letters …"*

1.6.4.15 KAMAN AIRWORTHINESS DIRECTIVE AD 2000-18-10 Amendment 39-11895

*"DATES: Effective September 26, 2000*

*…SUPPLEMENTAL INFORMATION:*

*This amendment adopts a new AD for Kaman Model K-1200 helicopters. This action requires replacing any sprag clutch, part number (P/N) K974110-005, with P/N K…-003. This amendment is prompted by two incidents of sprag clutch, …-005, failure during external load operations. The actions specified in this AD are intended to prevent a malfunctioning transmission clutch. This condition, if not corrected, could result in loss of drive to the main rotor system, and subsequent loss of control of the helicopter.*

*The FAA has reviewed Kaman … Service Bulletin No 90, dated July 13, 2000, which describes procedures for removing the sprag clutch, …-005.*

*We have identified an unsafe condition that is likely to exist or develop on other Kaman Model K-1200 helicopters of the same type design. This AD is being issued to prevent a malfunctioning transmission clutch, loss of drive to the main rotor system, and subsequent loss of control…*

*The short compliance time involved is required because the previously described critical unsafe condition can adversely affect the delivery of power to the main rotor system of the helicopter. Therefore, replacing any sprag clutch …-005 with ...-003 is required within 10 hours time-in-service, and this AD must be issued immediately. …"*

1.6.4.16 KAMAN SERVICE BULLETIN No. 088R1, MANDATORY RECURRING ACTION

Date of issue: 1 November 2001 and 23 July 2002

*"Daily Inspection of Transmission Clutch Assembly"*

*"A. Effectivity: All K-1200 aircraft with K974110-003 clutch assemblies.*

*B. Reason for Change: Ensure integrity of clutch assembly.*

*C. Description of Change: This inspection involves removing the KAflex drive shaft assembly and inspecting the clutch assembly. …*

*D. Compliance:* ***Mandatory for aircraft performing External Load Operations****: prior to next flight after receipt of this Service Bulletin. To be performed by Factory Trained Personnel with K-1200 Advanced Clutch Maintenance Training only. …"*

1.6.4.17 KAMAN SERVICE BULLETIN No. 089R1, MANDATORY RECURRING ACTION

Date of issue: 23 July 2002

*"110 Hour Inspection of Transmission Clutch Assembly"*

*"A. Effectivity: All K-1200 aircraft with K974002-701 clutch assemblies.*

*B. Reason for Change: Ensure integrity of clutch assembly. This revision to the bulletin extends the inspection interval from 50 hours to 110 hours. …"*

1.6.4.18 KAMAN SERVICE BULLETIN No. 103, MANDATORY ACTION

Date of issue: 23 July 2002

*"One Time 600-hour Replacement of the Sprag Assembly"*

*"A. Effectivity: All K-1200 aircraft*

*B. Reason for Change: Precautionary measure."*

1.6.5 Aural warning system

After various incidents concerning the free-wheel clutch on this helicopter, the manufacturer supplemented the existing caution advisory system with the installation of an aural warning system (AWS). The corresponding service bulletins SB 094R1 and SB 102 were implemented on helicopter HB-XQA in May 2003 by technicians from the manufacturer.

The primary purpose of the AWS was to provide an aural indication of speed differences between the engine side and the main gearbox side of the clutch and to record them electronically.

This system generated the following warnings:

1. Fire, Fire, Fire 2. Torque high 3. Torque low

4. Clutch overrun (main gearbox side speed higher than engine side)

5. Slipping clutch (engine side speed higher than gearbox side)

6. High Rotor RPM 7. Low Rotor RPM

Despite various adjustment attempts for warning 3. Torque low and manufacturer support including a replacement unit and an examination of the helicopter's wiring installation, operation of the AWS caused difficulties in operation:

- although manual settings could only be adjusted to a maximum of 10 psi, torque low warnings occurred already at 14-16 psi. This warning was very confusing for pilots during communication with the ground crew during cargo operations.
- Operating the trim button on the cyclic stick generated erroneous messages such as torque high.
- Pressing the weighing counter for the printer on the collective resulted in counting of slippages.
- On the advice of the manufacturer, a test was carried out in combination with the original warning system. In this case, the low RPM warning did not function. The intended speed did not correspond to the red warning light and the aural warning in the pilot's helmet.

The AWS was therefore re-installed, so that at least the warning lights functioned normally. The distracting warnings from the AWS were often deactivated by pulling out the circuit breaker.

According to the operator of HB-XQA, at least one other operator of a K-MAX had retrofitted his warning system to the original standard before the AWS because of similar problems.

## 1.7 Meteorological information

### 1.7.1 General

The information in sections 1.7.2 and 1.7.3 was provided by MeteoSwiss.

### 1.7.2 General meteorological situation

*The weather in Switzerland was being determined by a depression over Brittany. At altitude there is a light south-westerly wind and in layers near the ground there is a light 'Bise' wind, which retains the humidity in the base layer.*

### 1.7.3 Weather at the time and location of the accident

The following information on the weather at the time and location of the accident is based on a spatial and chronological interpolation of the observations of different weather stations.

| | |
|---|---|
| *Weather/clouds* | *1/8 at 2500 ft AMSL,<br>4-6/8 at 5000 ft AMSL, above that AC and CI* |
| *Visibility* | *About 5 km* |
| *Wind* | *North north-east at 4 to 6 knots, gusting to 10 kt; at 5000 ft AMSL south-west at 8 to 10 knots (above inversion)* |
| *Temperature/dewpoint* | *07 °C / 06 °C* |
| *0 °C isotherm* | *8500 ft AMSL* |
| *Atmospheric pressure* | *QNH LSGG 1015 hPa<br>QNH LSZB 1015 hPa<br>QNH LSZH 1017 hPa* |
| *Hazards* | *Some reduced visibility due to low-lying wisps of stratus* |

1.7.4 Astronomical information

| | | |
|---|---|---|
| Position of the sun | Azimuth: 241° | Elevation: 16° |
| Lighting conditions | Daylight | |

## 1.8 Aids to navigation

Not applicable.

## 1.9 Communications

Radiocommunication between the pilot and ground crew took place normally and without difficulties up to the time of the accident.

## 1.10 Aerodrome information

Not applicable.

## 1.11 Flight recorders

The helicopter was neither equipped with a flight data recorder nor a cockpit voice recorder. These were not prescribed.

1.11.1 Analysis of weighing system

From the take-off time at 16:06, the weighing system counted 23 turns with an average turn time of 1:59 minutes and an average weight of 2133 kg. The last recorded load was 2390 kg; the recording was made at 16:51 and the last turn time showed 2:15 min.

Cargo hook indicator: no ball flag visible.

C30 onboard indicator: data indicated maximum weights not exceeded.

1.11.2 Torque indicator analysis

*P/N H1943-1 S/N 120 GS*

*Exceedance Flag: Black (normal), Bit Check: pass*

*Highest Torque sustained for more than 1 second: 58.1 psi*

*Transmission damage fraction: 0.000*

*Ball Flag Code: 0*

*Set Warning light level 58.5 psi*

1.11.3 NG indicator analysis

*P/N 1901 S/N 104 E*

*Exceedance Flag: Black (normal), Bit Check: pass*

*Peak Engine Speed (NG): 100,3*

*Ball Flag Code: 0*

1.11.4 EGT indicator analysis

*P/N H 1900 K-22W S/N 783 D*

*Exceedance Flag: Black (normal)*

*Peak EGT: 574 °C Peak NG Engine Speed: 100.3 % RPM*

*Ball Flag Code: 0*

## 1.12 Wreckage and impact information

### 1.12.1 Site of the accident

| | |
|---|---|
| Accident location | "Petit Truyo", Grandvillard/FR |
| Swiss coordinates | 573 580 / 152 780 |
| Latitude | N 046° 31′ 32.9″ |
| Longitude | E 007° 05′ 39.5″ |
| Elevation | 1040 m AMSL |
| | 3412 ft AMSL |
| Tree felling coordinates | 573 600 / 152 800 |
| Refuelling area coordinates | 574 100 / 152 650 |
| National map of Switzerland | Sheet No. 1245, sheet name Château-d'Oex, scale 1:25 000 |

### 1.12.2 Impact

After initial contact with two trees, the nose of the helicopter crashed onto the forest floor with the airframe in a steep nose-down attitude and with right bank attitude. The impact was cushioned by the contact of the rotating main rotor blades and the airframe with the trees (see figure 1).

### 1.12.3 Wreckage findings

Facts relevant to the accident are listed below:

Belly cargo hook: The investigation after the accident showed no wood or soil residues on the belly cargo hook. It was only possible to mechanically release the hook by applying great force. The nylon choker (type 3 t) was lined with a textile hose for abrasion protection. This hose was abraded in the contact area and displayed rubbing marks (see attached figures L and M). The cargo hook bumper was damaged and the hook could be released only with difficulty (see attached figures L and M).

The location of the circuit breaker for the electrical belly cargo hook release was marked in red. It could not be determined whether the circuit breakers which were sheared off in the accident were pushed or pulled prior to the accident.

Fire warning system: The fire loop was undamaged. No traces of fire were found on the helicopter; the warning system was operational.

Fuel tank: The tank was undamaged; the fuel supply valve and drain breakaway valve were in working order.

Fuel system: The fuel/oil master switch was off, the main fuel valve was open and the fuel pump master circuit breaker was switched off.

Fuel gauge: The remaining quantity was ascertained as approximately 150 l. The fuel pressure and quantity gauges were indicating 0.

Fuel filter and lines: No damage could be found. All rigid and flexible lines were intact; the fuel filter was wet and no contamination was evident.

Main fuel line to the fuel control unit (FCU): Kerosene was found in the line and in the FCU.

Hydraulics: The collective limiter accumulator was intact. Various lines were bent out of shape; no oil leaks were found.

Aural warning system (AWS): This was installed in the rear bulkhead of the cockpit and deactivated.

External instrument panel: This was installed on the right side for bubble vertical reference flying, with the following annunciators: NG gas generator speed, master caution light, fire light, TQ torque, cargo weight and signal conditioner. The annunciator box was slightly damaged.

Landing gear: The nosewheel gear was badly deformed and the main gear was slightly deformed.

Airframe: The cockpit was deformed aft of the pilot station. The tail boom section and the vertical fin were deformed. The central structure was only slightly damaged. The front right gearbox strut had been torn off. The turbine and gearbox were still firmly attached to the airframe.

Rotor system: There was no indication of failure of the controls or of any pre-existing defects.

Flight controls: No pre-existing anomaly in the controls was found. Various control rods had been broken as a result of the deformation of the cockpit.

Rotor speed indicator: This was jammed at 8% speed.

Gearbox: The transmission oil cut-off valve was in the open position. Various rigid lines were deformed; all flexible lines were intact. No abnormality was found on the magnetic plug on the rotor shaft gear or on the transmission oil tank. The oil tank was full and no anomaly was found. Minor wear debris was found in the oil filter; the oil-jet for the clutch lubrication was in working order.

The oil pump and the regulator manifold were intact; the oil cooler and blower were damaged by the impact.

Pronounced crystal formations were found on the gearbox ventilation plug. The oil had a strong burnt smell.

KAflex drive shaft: The connection to the gearbox and engine was intact. Finding after dismantling the KAflex: The engine power output adapter was broken at the location of the smallest cross section.

Clutch: A pronounced grating sound was audible when the KAflex was rotated. When disassembled, burnt oil was found inside the clutch. Metal debris was visible inside the input pinion. The clutch outer race bearing surface exhibited considerable wear and indentations of the sprags; the entire clutch assembly exhibited major damage.

The surfaces of the sprags showed visible pitting and thermal discoloration.

After the clutch assembly was separated from the drive shaft, visible damage was found on the drive shaft surface along with pitting in the material.

Engine: No external defects were found. The compressor and power turbine could be rotated freely. The turbine inlets did not display any visible damage. The connection from the engine to the KAflex was broken at the location of the smallest cross section. No external traces or indications of oil or fuel leaks were found.

Particle separator: No damage was found. The particle separator switch was off.

Engine control: The twist-grip on the collective was in the centre position.

The collective fuel control switch was in the normal position.

The N2 RPM actuator was in the fully extended position.

The N1 and N2 control rods were fitted normally, but deformed at the rear bulkhead as a result of the deformation of the cockpit. The N1 rigging was set to approximately the 50% fuel control position.

Instruments: NG, EGT, torque indicator see 1.11.

Engine oil: The oil tank and the line to the engine were intact. The oil circuit was closed; the engine oil exhibited no anomalies.

Magnetic plug: No wear debris was apparent on the oil tank magnetic plug.

1.12.3.1 Examination of the engine

The engine mounting and suspension points exhibited neither cracks nor deformation. The oil filter pop-out was in the normal position (no filter clogging). The oil lines and fuel lines, as well as electrical connectors, exhibited no anomalies.

Small burnt particles of wood were present in the combustion chamber housing.

The visual inspection of the hot section (combustion chamber housing, power turbine stage and guide stages) produced no abnormal findings. A borescope inspection revealed no damage.

After powershaft disassembly, the gas turbine and the N2 power turbine were able to rotate freely and were undamaged.

1.12.3.2 Examination of the belly cargo hook

The belly cargo hook and in particular the limit stop bumper did not reveal any wood or soil residues and no mechanical deformation of the belly cargo hook.

Due to the restricted movability of the loadbeam and the evident damage to the bumper which is made from synthetic material, the belly cargo hook was examined in more detail. Increased friction forces were evident when opening the cargo hook. Upon disassembly of the sideplates it was discovered that the yellow bumper was held in place between the sideplates of the belly cargo hook by the bent steel pin. The effect of the bent pin was similar to a barbed hook. After the bumper had been pushed inward by some object, the bent pin acted similar to a barrier which prevented the bumper from returning to its original position. The wear on the yellow bumper and its deformation (Figures N, O, Q) make it evident that the bending of the pin was not a result of the accident. It is not possible that the bending was caused by the loadbeam. The contact between the bumper and the loadbeam resulted in increased friction and explains the restricted movability.

The clear friction witness marks similar to a blank polished surface on the load beam indicate that the contact with the bumper could not have been a one-off event (Figure N).

The design is such that there is only a flat surface contact area when the loadbeam is fully open. The opening of the loadbeam must not be restricted (Figure P).

During the investigation the belly cargo hook was reassembled without the bumper. The opening sequence now worked normally.

## 1.13 Medical and pathological information

The pilot suffered serious injuries to his legs.

There are no indications that the pilot suffered any health problems during the flight involved in the accident.

## 1.14 Fire

There was no fire.

## 1.15 Survival aspects

### 1.15.1 General

The strong aluminium cockpit structure and the quality of the pilot's seat with the strong belt system made the accident survivable. The airframe was crushed in at the nose as a result of the steep impact, which caused the serious injury to the pilot's legs.

### 1.15.2 Pilot's seat, belt and helmet

The pilot's seat, tested to high acceleration values (15 g transversal, 26 g vertical, 3.2 g lateral), and the five-point belt withstood the heavy impact.

The helmet protected the pilot from head injuries.

### 1.15.3 Rescue

The pilot was recovered by employees of the helicopter operator. Under the impression that the injuries were not severe they called an ambulance by dialling 144. The ambulance crew had to make its way to the accident scene through the difficult terrain on foot.

The helicopter operator organization reported the accident to the Rega Swiss Air Rescue Service at 17:15 and advised at the same time that the pilot was recovered and on his way to the hospital.

At 18:00 the police man who had arrived at the scene requested a rescue helicopter. The helicopter arrived at 18:24 from the Lausanne base and performed a winch rescue. The patient was flown to the Lausanne university hospital where the helicopter landed at 19:13.

As a result of the misinterpretation of the situation right after the accident and the incorrect information about the recovery of the injured person the entire rescue sequence lasted 2 hours and 21 minutes.

If the rescue helicopter had been requested immediately after the accident then the patient quickly could have been provided with initial medical treatment and could have been flown to the hospital about one hour earlier.

### 1.15.4 Emergency locator transmitter

The aircraft was equipped with an ECB-302 emergency locator transmitter. The unit was deactivated by the assistants after the accident.

## 1.16 Tests and research

A technical examination and analysis was carried out on the materials of various damaged components and of the transmission assembly lubricant.

In addition to the analysis of the damaged components from HB-XQA and of the lubricant, new components and components intended for overhaul from the same helicopter were examined.

### 1.16.1 Examination of the engine power output adapter

Adapter component K974182-011 S/N 0042C and the corresponding bolt were examined. The material quality and tempering condition of both parts were determined. The fracture surfaces of both parts were examined using microfractography.

The fracture surfaces of both components are forced fractures. The fracture surface of the bolt exhibits the pronounced pattern of a torsional fracture.

The grain structure, material composition, hardness and all dimensions of the adapter complied with the specification. The composition of the material and the tempering condition of the bolt correspond to normal values.

### 1.16.2 Examinations and calculation of the free-wheel components

The damaged parts of the free-wheel clutch were measured, and metallurgically and microfractographically examined. For purposes of comparison, new parts of identical construction and used parts destined for overhaul were included in the examination. The load on the free-wheel and its individual components were also calculated.

The following data and observations relate primarily to the sprag assembly and its individual components.

#### 1.16.2.1 Conformity of manufacture

According to Kaman, the manufacturer of the sprags was not willing to make the detailed production drawings with the dimension tolerances available, for reasons of confidentiality. Therefore, it was not possible to assess the sprags for conformity with the production drawings. The dimensions and surface quality of the other examined components complied with the data specified in the manufacturer’s production documentation. Manufacturing tolerances were also complied with. The manufacturing data for these components corresponded to the state of the art.

1.16.2.2 Conformity of the material

All the parts examined complied with the material quality and hardness specifications. Examination of the sprags found that the surfaces subjected to Hertzian stress[1] exhibited a thin layer of chromium carbide (annexed figures H and I). This coating is not mentioned anywhere in the specification. In publications in the public domain, the sprag manufacturer indicates that sprags are coated with such hard materials.

1.16.2.3 Damage

Bearing surface of drive shaft K974047-005

The bearing surface of the shaft (annexed figure A) exhibits very pronounced surface defects. The surface exhibits a pronounced brinelling pattern (annexed figure B) with needle-shaped material displacements. Some of the lubrication bores are constricted or blocked on the bearing surface by plastic deformation of the material (annexed figures C and D).

The needle-shaped swarf which was found loose in the damaged sprag assembly originates from this bearing surface. These have been displaced from shaft K974047-005. The grain structure of the swarf exhibits pronounced plastic deformation. Material transferred from the sprags was found on the bearing surface (annexed figure K).

The bearing surface is also plastically deformed and friction martensite was found (annexed figure E). In addition, microcracks were found (annexed figure F). Friction martensite occurs when the material is subjected to extreme pressure, considerably hardened in the process and locally heated by sliding friction.

Bearing surface of the outer race with pinion K974013-013

The bearing surface of the outer race in the area of the outer race bore also exhibits major surface defects. Material displacement, material transfer from sprags to the bearing surface or microcracks are not evident. Damage to the bearing surface of the outer race is considerably less than to the shaft.

Sprags from the sprag assembly K974110-003

The contact surfaces of the sprags exhibit major damage. Both surfaces exhibit plastic deformation of the material. There is wear with additional flaky, plastic. Microcracking and material displacement is not evident (annexed figure G).

1.16.2.4 Investigation of the mechanical load

The stresses whilst in operation were calculated for the individual components of the free-wheel clutch, consisting of the shaft, outer race and sprags.

The following were used as a basis:

- Manufacturer's production drawings with dimensions and manufacturing tolerances, and material specifications.
- Scientifically recognised theoretical methodology for calculation of the mechanical load.
- Generally recognised permissible load limits derived from practice.

[1] Hertzian stress corresponds to the maximum contact forces between two bodies.

- The demonstrated values correspond to a static loading with a uniform tension distribution and no dynamic or shock influences, i.e. a load factor of 1.0.
- The influence of elastic deformation of the shaft, the sprags and the outer race were not considered.
- A first measurement of the precise dimensions of the contact area of a first sprag using a high-precision measuring machine with an accuracy of better than 0.001 mm and 13 measurement points.
- A second measurement of the precise dimensions of the contact area of a second sprag using a high-precision measuring machine with an accuracy of better than 0.001 mm and more than 240 measurement points.
- The manufacturer's information on power, torque and speed of rotation of the shaft.

Results:

- The calculation of the mechanical load of the free-wheel clutch with the data of the first measurement produces a Hertzian stress between shaft (inner race) and sprag of 3375 MPa. The value calculated from the data of the second measurement is a Hertzian stress of 3155 MPa. Based on experience these values are too high.
- The Hertzian stress between sprag and outer race is lower than the above calculated value and was therefore not considered to be critical.
- The maximum tangential stress of the outer race is calculated at 193 MPa tensile stress and that of the shaft at 278 MPa compressive stress.
- The sizing of the free-wheel seems to be too small for the torque to be transmitted.

According to the manufacturer's strength calculation the free-wheel is adequately dimensioned.

1.16.2.5 Analysis of the gearbox oil

The gearbox oil supplied to the free-wheel of the helicopter involved in the accident was examined and compared with new oil for reference.

The results of the analysis can be summarised as follows:

With reference to the infra-red spectrum and rating, the gearbox oil analysed is identical to the reference oil.

The used gearbox oil contains wear debris from the free-wheel.

The used gearbox oil does not meet the viscosity requirements for a DEXRON III oil. It has a distinctly lower viscosity.

According to the ebullition analysis, the used gearbox oil was not diluted with a component which boils at a lower temperature.

1.16.2.6 Process description for the overhaul of parts of the clutch assembly

No coating process is described in the description of the input shaft overhaul process made available by the manufacturer.

## 1.17 Organisational and management information

Because of its area of deployment, the helicopter was often stationed away from its maintenance base for several days. Consequently, checks and minor maintenance work were often carried out in the field, during available time before or after flight operations. According to the logbook, the helicopter was parked in areas other than airfields for 65 days in the five months from June to October 2004. In these five months the helicopter accumulated approximately 570 flying hours.

## 1.18 Additional information

### 1.18.1 Analysis of accidents and incidents involving the K-1200

Between 1999 and 2004, a total of 17 incidents and accidents reported by operators in connection with the free-wheel clutch on this helicopter were listed in a summary by the manufacturer (see annexe 2).

Two versions of the sprag assembly were involved.

| *sprag assy P/N* | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
|---|---|---|---|---|---|---|
| K974110-003 | 0 | **1** | **4** | **2** | 0 | **1** |
| K974110-005 | **5** | **4** | 0 | 0 | 0 | 0 |

## 1.19 Useful or effective investigation techniques

None.

# 2 Analysis

## 2.1 Technical aspects

### 2.1.1 Engine

From the statements of the persons involved in the accident it was apparent that the engine had been delivering power. The damage (see section 1.12.3) and closer examination of the engine (see section 1.12.3.1), the fuel control unit and the engine system indicate that the engine was operational and was being supplied with fuel. The visible damage to the engine's variable inlet guide vanes very probably occurred during the crash into the tree branches with the engine running.

The abnormal position of the twist grip on the collective-throttle, which was found in a mid-position between FLY and flight idle, must be explained in combination with the jammed, bent and kinked N1 control rods from the mechanical impact forces. The pilot was aware of his available power at the time of the drop in rotor speed; the twist-grip was in the FLY position.

The emergency regulation switch on the collective, provided with a red protective cap, was in the normal position, indicating that the pilot had no problems with the engine speed. The pilot's statements about the moment of the crash were consistent with this. The pilot was able to describe the position of the pointers on the combined engine and rotor speed instrument: "*Je me rappelle d'avoir regardé rapidement le tableau de bord…Une aiguille était à 9 heures, je ne sais plus laquelle, l'autre était à 6 heures".* [Translation: I remember glancing at the instrument panel… One pointer was at 9 o'clock I don't know which one, the other was at 6 o'clock.]


Figure 7: The large pointer with the "R" marking indicates rotor speed and the one with the "E" marking indicates engine speed. The indication is in percent of nominal speeds.

He heard the low RPM horn warning, which signals a rotor speed which is too low.

### 2.1.2 Particle separator

The particle separator was found intact. The operating switch in the cockpit, however, was switched off. The pilot explained this by saying that in ambient conditions free from sand, dust or other contamination he generally kept it switched off. In this type of work, he preferred the effect of a somewhat lower exhaust gas temperature (EGT) and some more available power for high power requirements.

According to the RFM the particle separator must be turned on during flight operations.

### 2.1.3 Free-wheel clutch

The free-wheel clutch exhibited extensive wear and surface damage both on the surface of the shaft and on the sprags. The wear is sliding and rolling wear. It must be assumed that safe operation is no longer ensured given such major damage.

According to the metallurgical examinations, the free-wheel was subjected to such a high load that the material of individual elements suffered plastic deformation. This plastic deformation was very pronounced on the inner contact surfaces of the sprags and shaft.

Microcracking and material displacement were found on the damaged contact surface of the shaft. Such microcracking and material displacement is the result of material fatigue. The strength analysis showed that there was a very high Hertzian stress under load and inadequate long-term strength of the free-wheel in the area of the shaft and sprags.

Since the free-wheel manufacturer was not willing to provide the production drawings of the sprags with the precise shape and manufacturing tolerances, two new sprags were measured on a high-precision measuring machine. The measured values were recorded with a maximum tolerance of 1 micron. The strength analysis was carried out on the basis of these measured values.

According to the manufacturer's strength calculation, the free-wheel is adequately dimensioned. What is striking about this calculation is that the shape of the sprag differs from the one measured very precisely during the examination. The sprag geometry used by the manufacturer favours the result of his calculations.

The elastic deformation of the sprag elements reduces the Hertzian stress but increases the loadfactor. This deformation was not considered because it is unevenly distributed and is difficult to be measured respectively calculated.

### 2.1.4 Overhaul of clutch assembly components

In general, overhaul of component K974047-005 is to be considered questionable, as a dimensional difference to the original condition can be corrected only by coating of the component or an adjustment of the diameter on the sprag side. In the description of the input shaft overhaul procedure provided by the manufacturer, no coating process is mentioned. In addition, overhaul of a material subjected to high Hertzian stress cannot be considered to be appropriate in view of the impossibility to estimate the sub-surface fatigue of the material.

### 2.1.5 Unavailability of sprag specifications

The precise specifications for the sprags are missing from the documentation made available by the manufacturer. On examination of the sprags, a very hard and brittle chromium carbide coating was found on the surfaces subject to Hertzian stress. The layer of chromium carbide exhibits a relatively high surface roughness, with an inappropriate surface quality. The sprags' resistance to wear is considerably increased by a chromium carbide coating.

Since, given a very high Hertzian contact stress, there is a risk that parts of this hard coating can split off and induce wear in its counterpart, this surface treatment must be considered as problematic.

2.1.6 Engine power output adapter

The investigation showed a fracture of the engine power output adapter from torsional overload. The engine power output adapter fractured due to the overload which developed during the failure sequence of the clutch assembly. Consequently this damage is to be considered as secondary damage. This is supported by the pilot's description of the accident sequence.

## 2.2 Human and operational aspects

Utilization of the helicopter with very rapid load changes from low to high torque and vice versa is an above average stress for the sprag clutch. The accident and incident statistics clearly confirm this. Under the topographical conditions in the operations area of HB-XQA, operational requirements regarding excessively low torque conditions and excessively rapid load changes could only be observed by compensating large altitude differences in steep terrain with longer flight distances for each turn. It must remain open whether and to what extent the manufacturer's information in the Kaman Service Letter dated 14 July 2000 was implemented in daily practice. In view of technical difficulties with the slippage counter and the aural warning system, the operator could not implement any supervision or appropriate monitoring.

2.2.1 Aural warning system

According to operator, the aural warning system AWS and slippage counter offered as an option by the manufacturer after recurrent technical problems concerning the clutch was very unreliable and distracting in cargo flight operations, with many false warnings at aeronautically demanding moments. According to the pilot and the operator's maintenance personnel, neither the setting relating to the important torque limit to be observed in descent nor the information from the slippage counter under load was technically mature or serviceable. Individual pilots therefore deactivated the AWS because of safety considerations.

Reports by the manufacturer of problem-free tests on the factory's own helicopters did not improve the unresolved and uncontrolled situation regarding indications of damage to the operator's free-wheel clutch. The conditions under which the manufacturer's system was tested and the helicopters used for the test are not known.

2.2.2 Belly cargo hook

When the pilot had decided to emergency jettison the heavy timber load he could not release it without time delay. It required four attempts in short succession.

The following factors very likely contributed to this circumstance:

- The loop of the longline tightened over the cargo hook under load because it was hooked without the use of an additional shackle. There was increased friction between the abrasion protection hose and the cargo hook.
- The helicopter was moving forward and slightly to the right with respect to the opening direction of the cargo hook which impeded the slipping out of the load. The magnitude and direction of forces possibly acting perpendicularly to the opening direction of the cargo hook could not be determined.
- The opening of the cargo hook was impeded by the dislocated limit stop bumper.

It is not known why the longline loop was not connected to the belly cargo hook with an additional shackle.

It must remain open why there were no snags noted during the opening checks as part of changing the longline.

2.2.3 Conduct of the pilot

At the onset of the technical problems, the pilot intentionally refrained from releasing the cargo immediately. He wanted to not put at risk his ground crew, who were in the area underneath his long load of logs. The pilot therefore demonstrated a high level of situational awareness of risk. It was only thanks to his close attention and good overview of the situation that he was able to make this time-critical decision.

He could not foresee that the chance of a successful immediate cargo jettison is reduced due to the factors described in chapter 2.2.2.

2.2.4 Maintenance

2.2.4.1 Belly cargo hook and cargo-carrying material

The damage to the belly cargo hook bumper and the longline loop was easily detectable (Figures M and N). According to the operator, there were no irregularities noted during the last 100 hour visual inspection of the belly cargo hook on 30 September, 2004. It must remain open how and when the bumper of the belly cargo hook was pushed in. The wear of the abrasion protection hose of the cargo-carrying material was not snagged during the daily visual inspections. It must remain open to what degree the abrasion protection was already worn prior to the accident.

2.2.4.2 Free-wheel clutch

The quality of maintenance and inspection work is primarily dependent on the personnel trained for the tasks. However, for precisely this type of helicopter operation it is common that these tasks have to be performed before and after flying operations on-site in the field, in all kinds of weather, regardless of precipitation, temperature or ambient noise. Delicate inspections such as the manufacturer's instructions below indicate the difficulty of these inspections especially in the field:

- SB No. 081 of 11 November 1999: "*This inspection involves physically rotating the clutch by hand and checking for ratcheting or roughness, and if necessary, removal of the clutch for a visual inspection*".
- "*An unairworthy clutch will feel rough with a continuous dry "raspy" feel and sound, or it may feel as though the clutch has heavy detents or "catches" on the interior surface that impede the free rotary motion. …"*
- SB 088R1 dated 23 July 2002, *daily inspection: "This inspection involves removing the KAflex drive shaft assembly and inspecting the clutch assembly."*

In generally, checks "by ear or feel" are problematic even for specially trained personnel because of subjectively differing comparative experience and because there are no clearly defined criteria.

Although AD 1999/643 clutch inspection AFM 3-7 was signed off on the day of the accident it is obvious that this method did not allow the timely detection of the failure.

2.2.4.3 Gearbox oil

The gearbox oil did not meet the viscosity requirements for a DEXRON III oil. It exhibited a distinctly lower viscosity. One explanation for the low viscosity might be partial degradation of the viscosity index improving agent as a result of high thermal and/or mechanical stress.

The gearbox oil contained wear debris from the clutch assembly.

# 3 Conclusions

## 3.1 Findings

### 3.1.1 Technical aspects

- The helicopter was approved for VFR transport.
- The mass and centre of gravity of the aircraft were within the permitted limits at the time of the accident.
- The mass of the helicopter with its external cargo at the time of the accident was 10 920 lbs or 4964 kg.
- The investigation of the engine produced no indications of any pre-existing technical faults which might have caused or influenced the accident.
- The last 100-hour inspection of the airframe and engine was carried out at 10 970 operating hours, on 30 September 2004.
- On the day of the accident, AD 2004 - 269 M/R grip inspection SB 109 and AD 1999/643 clutch inspection AFM 3-7 were signed off.
- In the final phase of taking up the cargo, the free-wheel could not transmit the engine torque anymore. The main rotor speed dropped as a result of insufficient torque transmission.
- On dismantling the clutch assembly it was found that the free-wheel was severely damaged.
- The fracture of the Engine power output adapter is secondary damage.
- The outer race and drive shaft of the free-wheel were badly damaged on their surface. The damage to the surface of the shaft and the corresponding surfaces of the sprags was greater than the damage to the outer race's clamping surfaces and to the outer clamping surfaces of the sprags.
- All the sprags exhibited severe damage to the contact surfaces.
- All the contact surfaces had suffered plastic deformation.
- Fatigue cracks were found on the surface of the shaft.
- Needle-shaped displaced material was found on the surface of the shaft, indicating fatigue.
- Some of the lubrication bores on the bearing surface were constricted or blocked by plastic deformation of the material.
- The components of the free-wheel complied with the specifications in terms of material quality and thermal treatment.
- The shaft and outer race of the free-wheel complied with the specifications in terms of dimensions.
- It was not possible to check the sprags from helicopter HB-XQA involved in the accident for conformity with reference to dimensions and geometry due to the absence of drawings.
- The gearbox oil complied with the specifications except for its viscosity.
- The calculated tangential stresses in the outer race and in the shaft were high but not critical.

- The surface of the sprag element (DRG No K974110-003) exhibited a thin (3 to 5 microns), brittle and very hard layer of chromium carbide. This coating is neither mentioned nor specified in the production documentation.
- Belly cargo hook: The loadbeam could be opened only with increased force. The bumper was damaged and was dislocated from its intended position.
- The loop of the nylon longline (type 3 t) was lined with a textile hose for abrasion protection. This hose was abraded in the contact area and displayed rubbing marks.
- According to operator, the aural warning system AWS and slippage counter offered as an option by the manufacturer after recurrent technical problems concerning the clutch was very unreliable and distracting in cargo flight operations, with many false warnings at aeronautically demanding moments.
- The pilot deactivated the aural warning system for safety considerations.
- Operating hours for the clutch assembly /N K974002-701, S/N A 1023: TSN 1114.7 h and TSO 130.5 h.
- Operating hours for the sprag assembly P/N K974110-003, S/N 093: TSN 130.5 h.

### 3.1.2 Crew

- The pilot held the necessary licences for the flight.
- There are no indications of the pilot suffering any health problems during the flight involved in the accident.
- The helmet, safety belt and the design of the pilot’s seat helped to protect the pilot.
- The rescue was considerably delayed as a result of misjudgement of the situation.

### 3.1.3 History of the flight

- The pilot was able to describe the position of the pointers on the combined engine and rotor speed instrument. He heard the aural warning which is triggered when the rotor speed is too low (low RPM horn).
- The pilot perceived fluctuations in rotor speed and noise from metallic surfaces rubbing against each other.
- At the onset of the technical problems, the pilot intentionally refrained from releasing the cargo immediately. He wanted to not put at risk his ground crew, who were underneath his long load of logs.
- The attempts to jettison the cargo were successful only at the fourth attempt.
- The low rotor speed and the nose-down attitude of the helicopter inevitably led to the crash.

#### 3.1.4 General conditions

- In a summary the manufacturer listed a total of 17 incidents and accidents reported by operators in connection with the free-wheel clutch on this type of helicopter between 1999 and 2004.
- The helicopter manufacturer published numerous technical publications for the improvement of the airworthiness of the clutch assembly.
- The prevailing weather conditions on the day of the accident had no influence on the circumstances of the accident.

### 3.2 Causes

The accident is attributable to a failure of the clutch assembly.

The failure of the clutch assembly was caused by overloading and fatigue of the bearing surfaces on the free-wheel clutch shaft.

A contributing factor was with high probability the delayed sliding out of the load from the belly cargo hook.

# 4 Safety recommendations and measures taken since the accident

## 4.1 Safety recommendations of 9 March 2005

In a letter dated 9 March 2005 to the Federal Office of Civil Aviation, the AAIB provided information on the current findings of the ongoing investigation and formulated the following safety recommendations:

Safety recommendation No. 406:

In view of the above-mentioned facts, we recommend that the FOCA subject the general operational safety of the K-MAX and its technology to a thorough risk assessment.

Safety recommendation No. 407:

We recommend that operators be advised immediately of the results of your analysis and their consequences.

## 4.2 Measures taken since the accident

Four days after the accident, on 15 October 2004, the manufacturer issued the following Service Bulletin and the following Service Letter:

KAMAN SERVICE BULLETIN No 115, MANDATORY RECURRING ACTION

*"A. Effectivity: All K-1200 aircraft with K974002-701 clutch assemblies.*

*B. Reason for Change: Ensure integrity of transmission clutch assembly.…*

KAMAN SERVICE LETTER No 04-004

*"SUBJECT: Changes to Clutch inspections*

*1. Temporary Revision (TR) 442 …cancelled…effective immediately …TR 445;*

*2. The 220-hour inspection interval for the clutch assembly (974002-701) is reduced to 110 hours; and*

*3. Service Bulletin 115, which mandates a one-time inspection of clutches that have exceeded 110 flight hours since the last clutch inspection, is released."*

The manufacturer issued the following mandatory Service Bulletin on 8 April, 2005:

KAMAN MANDATORY ACTION SERVICE BULLETIN No 117 – Improved Engine Output Adaptor

*„A. Effectivity: All K-1200 KMAX Helicopter*

*B. Reason for Change: Component Improvement…."*

The manufacturer issued the following mandatory Service Bulletin on 31 October, 2005:

KAMAN MANDATORY ACTION SERVICE BULLETIN No 127R1 – New Transmission Installation

*„A. Effectivity: All K-1200 KMAX Helicopter….*

*B. Reason for Change: This new transmission assembly incorporates a new style clutch assembly.*

*C. Description of Change: Install new transmission P/N K974302-001. This deals mainly with modifying existing transmission systems. ….”*

Payerne, 22 June 2010 Aircraft Accident Investigation Bureau

This report contains the conclusions of the AAIB on the circumstances and causes of the accident which is the subject of the investigation.

In accordance with art 3.1 of the 10th edition, applicable from 18 November 2010, of Annex 13 to the Convention on International Civil Aviation (ICAO) of 7 December 1944 and article 24 of the Federal Air Navigation Act, the sole purpose of the investigation of an aircraft accident or serious incident is to prevent accidents or serious incidents. The legal assessment of accident/incident causes and circumstances is expressly no concern of the incident investigation. It is therefore not the purpose of this investigation to determine blame or clarify questions of liability.

If this report is used for purposes other than accident prevention, due consideration shall be given to this circumstance.

## Annex 1 – Documentation of the technical examination of materials

Figure A

K974047-005, S/N 0166B and K974110-003, S/N 093

Event HB-XQA

The clutch shaft bearing surface exhibits a very rough, worn surface.

Figure B

Component K974047-005,S/N 0166B

Event HB-XQA

Detail of bearing surface with pronounced brinelling pattern

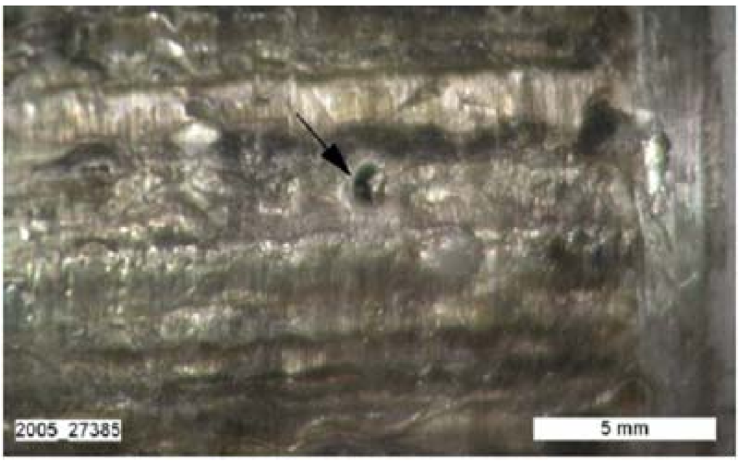
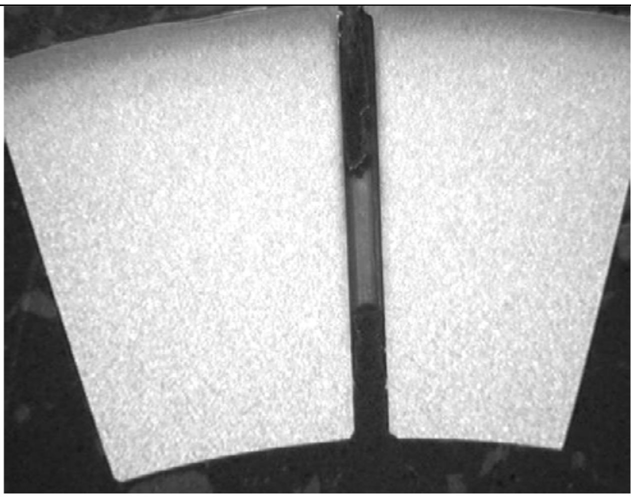
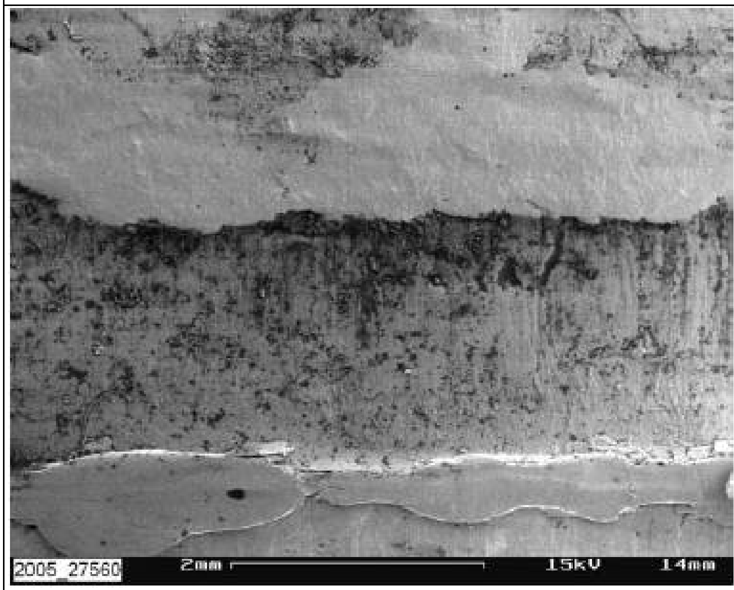
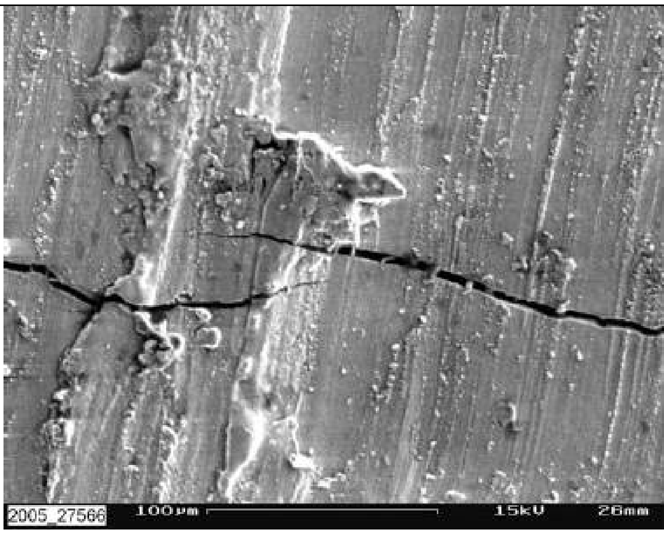



Figure C

Component K974047-005, S/N 0166B

Event HB-XQA

Lubrication bores are partially covered by plastic deformation (arrow).

| | |
|---|---|
|  | Figure D<br><br>Component K974047-005, S/N 0166B<br><br>Event HB-XQA<br><br>Lubrication bores were partially blocked as a result of the deformation of the bearing surface. |
|  | Figure E<br><br>Component K974047-005, S/N 0166B<br><br>Event HB-XQA<br><br>View of clutch bearing surface with distinct traces of plastic deformation. |
|  | Figure F<br><br>Component K974047-005, S/N 0166B<br><br>Event HB-XQA<br><br>Isolated microfissures are visible in the clutch bearing surface. |

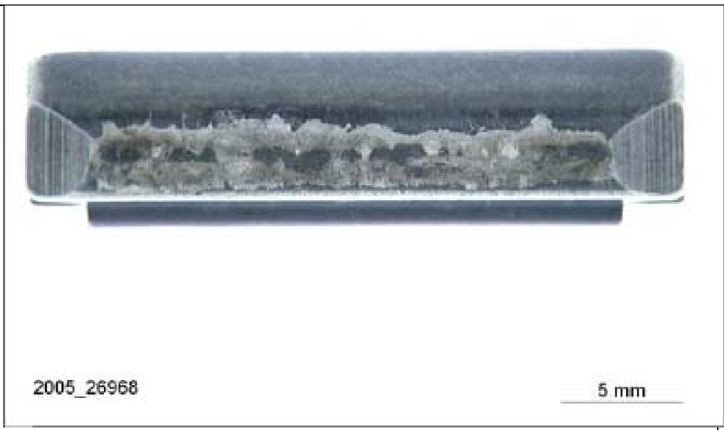



Figure G

Component K974110-003, S/N 093

Event HB-XQA

Surface detail of sprag element with a flaky surface formation (contact surface with K974047-005).

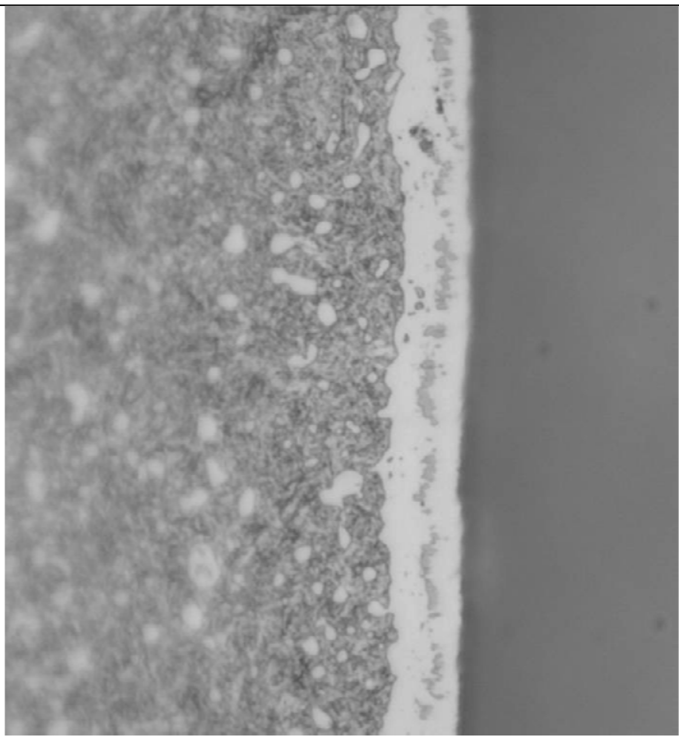


Figure H

Component K974110-003, S/N 093

Event HB-XQA

Peripheral zone of chromium carbides (white)

Etching:

1.5% alcoholic nitric acid

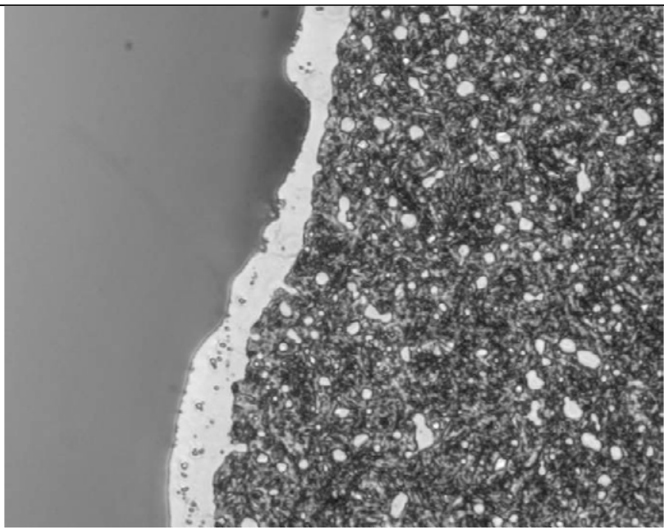


Figure I

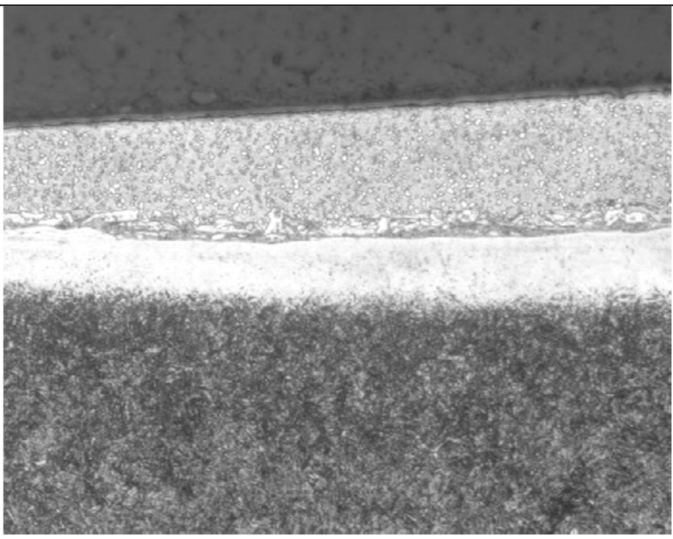
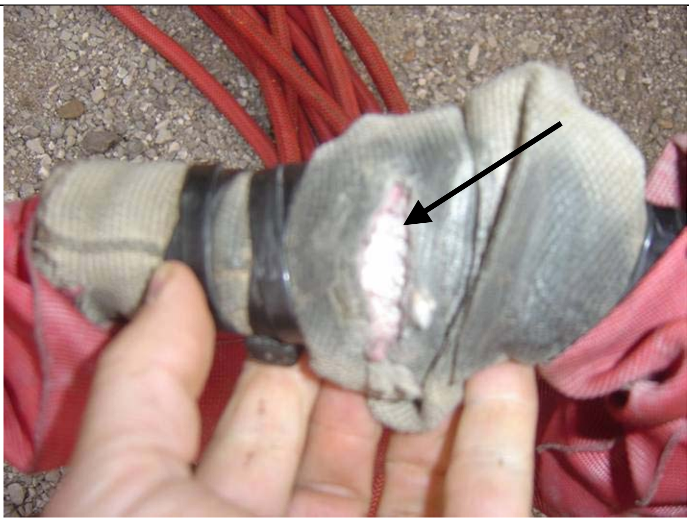
Component K974110-003, S/N 227

Reference part, new

Peripheral zone of chromium carbide (white)

Etching:

1.5% alcoholic nitric acid

| | |
|---|---|
|  | Figure K<br><br>Component K974047-005, S/N 0166B<br><br>Event HB-XQA<br><br>Mechanically deformed bearing surface (friction martensite) with material transferred from the counterpart (sprag element)<br><br>Etching:<br>1.5% alcoholic nitric acid |
|  | Figure L<br><br>Longline loop with protective hose hooked directly into the belly cargo hook.<br><br>Increased friction under tension due to the tight longline loop. |
|  | Figure M<br><br>Friction witness marks on the contact areas.<br><br>Worn through protective hose of the longline loop.<br><br>Event HB-XQA |

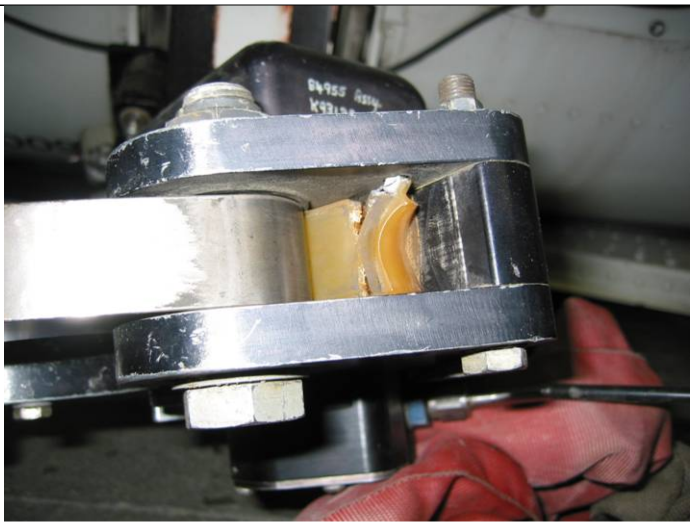


Figure N

Damaged limit stop bumper on the belly cargo hook

No traces of wood or soil were found after the accident.

Indications of the original position of the bumper and clear signs of wear on the load beam.

Event HB-XQA

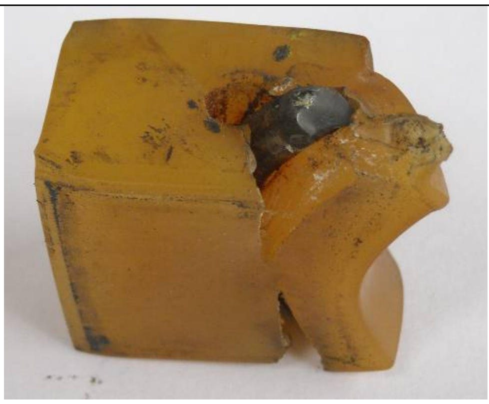


Figure O

Bumper after removal

Direction of shear of the retaining pin

Indications of friction and wear

Event HB-XQA

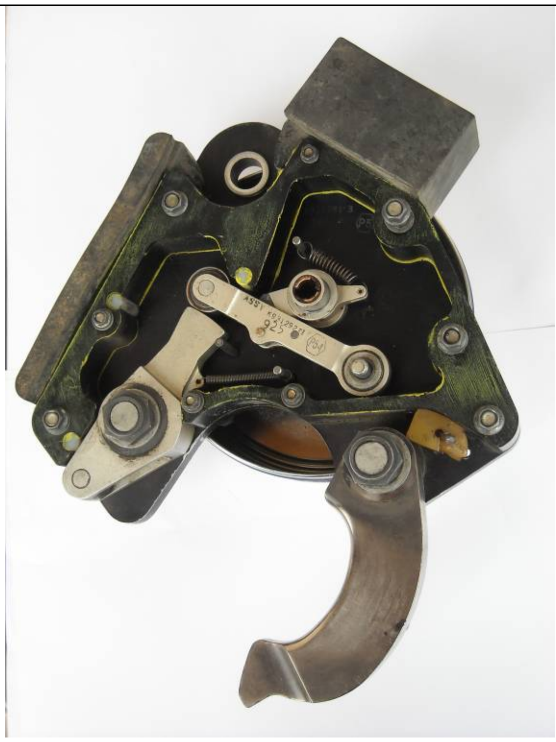


Figure P top

Undamaged cargo hook from the manufacturer

Figure Q left

Event HB-XQA

## Annex 2 – Manufacturer's documentation concerning the accidents and incidents involving K-1200 aircraft in connection with the clutch assembly

### K-1200 K-MAX CLUTCH EVENTS

| Aircraft | Part Number | Time Since New | Date | Description / Reason for Removal | Individual Reporting and Field Service Report # |
|---|---|---|---|---|---|
| A94-0004 Mountain West | K974110-005 | 617.8 | 1/17/99 | Damage to clutch sprags | Pilot reported incident. Mechanic experienced resistance during clutch rotation. Subsequent inspection revealed damage to the clutch sprags and the input gear. |
| A94-0004 Mountain West | K974110-003 | 1061.8 | 11/09/01 | "Rough clutch sprags" | Pilot reported incident. Subsequent inspection revealed a slight rough spot while compressing the clutch sprags and rotating the shaft. |
| A94-0005 Kimberly Clark | K974110-005 | 173.4 | 3/4/99 | Engine overspeed, damaged clutch sprags and Input Housing | Pilot reported incident. Inspection revealed damage to the clutch sprags and the input housing. |
| A94-0006 Woody | K974110-003 | 369.3 | 10/3/00 | Scratch marks on sprag | Discovered during 50-Hour inspection. |
| A94-0006 Woody | K974110-003 | 1120.5 | 5/31/02 | Sprags "hanging-up" | Discovered during Daily inspection. |

December 21, 2004

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## K-1200 K-MAX CLUTCH EVENTS

| Aircraft | Part Number | Time Since New | Date | Description / Reason for Removal | Individual Reporting and Field Service Report # |
|---|---|---|---|---|---|
| A94-0008 Rotex | K974110-005 | 74.9 | 6/13/00 | Loss of power - clutch slip | The pilot reported a "complete loss of power for six seconds" and then returned to normal. The pilot landed the aircraft under power. The clutch was found to be "locked in the freewheel position". Extraordinary effort was required to separate the clutch from the shaft. The clutch had four broken sprag separators and smeared metal was found on the sprag surfaces. The output gear was "heavily scored".<br><br>Twenty-six (26) hours prior to this incident, a different pilot reported a noise "like something went through the engine" and a two-second loss of power while lifting a log. The pilot continued with the load to the landing without any loss of altitude. The engine was inspected and the aircraft returned to logging. The clutch was not inspected at that time. |
| A94-0008 Rotex | K974110-003 | 324.7 | 6/29/01<br>7/3/01 | Suspected clutch slip | Two different pilots reported possible clutch slippages. The first occurred while the aircraft was lifting 4,500 pounds. The clutch was removed, inspected, and reinstalled. The second incident occurred four days later while lifting 5,000 pounds. Again, inspection of the clutch did not reveal any discrepancies but the rivets on the blower drive shaft were sheared. The clutch, blower drive shaft, and engine adapter were replaced. |

December 21, 2004

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# K-1200 K-MAX CLUTCH EVENTS

| Aircraft | Part Number | Time Since New | Date | Description / Reason for Removal | Individual Reporting and Field Service Report # |
|---|---|---|---|---|---|
| A94-0008 Rotex | K974110-003 | 420.0 | 10/4/01 | Clutch slip | The pilot experienced a "low pitch noise and a RPM drop of 4% while lifting a load'. The pilot released the load and experienced a master caution light for engine low level (oil level), and noticed an oil mist cloud. The pilot landed the aircraft with low but acceptable engine oil pressure. The engine area was covered with oil. Rotation of the driveshaft revealed roughness and noise. Removal of the clutch and inspection revealed: roughness when the clutch sprags were compressed and the shaft was rotated; and, "damage" to all of the clutch sprags. Damage to the input gear was also found. |
| A94-0008 Rotex | K974110-003 | 130.0 | 10/11/04 | Under investigation – aircraft accident | |
| A94-0011 Midwest | K974110-003 | 511.8 | 11/4/02 | Clutch slip – untrained pilot | Pilot reported incident. Inspection revealed the clutch was "rough" and the input gear had damage. The engine adapter was damaged, and the reduction gearbox had to be removed from the engine and placed on a workbench to facilitate its removal. |
| A94-0014 Mountain West | K974110-005 | 282.3 | 9/26/99 | Possible clutch slippage | Pilot reported incident. The clutch was removed and inspected. Inspection by Kaman employees did not reveal any clutch or input gear discrepancies, but the clutch was replaced. |
| A94-0014 Mountain West | K974110-005 | 252.8 | 11/4/99 | Clutch slip | The pilot experienced a loss of power while transitioning away from the log landing. The aircraft suffered damage from a hard landing and was removed from service. |
| A94-0017 Superior | K974110-005 | 390.4 | 1/26/00 | Pilot felt clutch slip | Pilot reported incident. Inspection revealed a "rough feeling" when the clutch sprags were compressed and the shaft was rotated. |

December 21, 2004

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## K-1200 K-MAX CLUTCH EVENTS

| Aircraft | Part Number | Time Since New | Date | Description / Reason for Removal | Individual Reporting and Field Service Report # |
|---|---|---|---|---|---|
| A94-0017 Superior | K974110-005 | 129.7 | 3/22/00 | Rough rotation of clutch | Pilot reported incident. Inspection revealed, "a very rough rotation of the clutch". |
| A94-0017 Superior | K974110-005 | 74.6 | 7/11/00 | Clutch slip - accident | Pilot reported incident. Inspection revealed that the clutch assembly was "locked up" and the clutch sprags exhibited severe wear. The input pinion and the center shaft were also heavily damaged. |
| A94-0018 Zagel | K974110-005 | 234.8 | 9/13/99 | Clutch slip - accident | Pilot reported incident. Investigation of the accident revealed a sheared engine adapter, fractured engine adapter bolt, and damage to the clutch assembly and input gear. |

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