

# Investigation Report

3X182-0/07  
March 2009

## Identification

Type of incident:	Accident
Date:	14 November 2007
Place:	Hanover
Aircraft:	Helicopter
Manufacturer / type:	MD Helicopters, Inc. / MD 900
Injuries to persons:	three slightly injured persons
Damage to property:	Aircraft seriously damaged
Other damage:	None
Source of information:	Investigation by BFU

## Factual information

### History of the flight

During an emergency landing, the helicopter left the concrete runway and came to rest on its left side. It was severely damaged; the three occupants were slightly injured.

The crew, consisting of the pilot, a technician and a system operator, started for a tracing operation from the Hanover Airport at 9:03 a.m.<sup>1</sup> After the operation had been terminated, the Hanover Airport was approached via the reporting point ECHO. After the landing clearance at 10:42 a.m, a direct approach to helipad No. 2 was planned. According to the statement of the pilot, the engine power and the airspeed were reduced. During flare in a height of 40-60 ft with 20-30 kt, the power was increased. During this, the helicopter

turned to the right around the vertical axis. The helicopter pilot tried to compensate this rotation by pushing the left pedal, however without success. He then decided to regain airspeed and initiated a go-around.

After the attitude had been stabilized an emergency call was reported to Hanover Tower on 10:45 a.m.. Circling in the south of the Hanover Airport, the crew tried to analyze the existing problem. Each time when airspeed was reduced below approximately 90 kt, the helicopter yawed to the right in spite of the left pedal being fully pushed. Additionally, a strong vibration could be felt coming from the tail. The on-board flight technician performed several system tests; none of these showed any conspicuities. The crew assumed a control failure within the torque compensation system as the cause for the unintended rotation and decided to proceed according to the flight manual.

Several approaches were performed in order to attempt to land the helicopter in a controlled way. After 5-6 approaches the helicopter touched down at 11:13 a.m. skidding on the northerly runway 09L first the left skid after approximately 170 m with both skids. After a skidding distance of approximately 380 m, the helicopter turned sideways and left the runway to the right. The left skid broke, the helicopter tilted and the main rotor hit the ground. The helicopter came to a rest 13.7 m south of the runway, lying on its left side. The crew manually switched off the still running engines and were able to rescue themselves from the wreckage without any injuries.

### Personnel information

The 33 year old pilot held a valid commercial pilot license CPL(H) according to the regulations of JAR-FCL 2, issued first on 09 November 2006, with the type rating as pilot in command on MD 900/902, valid

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<sup>1</sup> Unless otherwise specified, all times are indicated in local time

until 06 November 2008. He also held a valid medical certification of class 1 according to JAR-FCL 3 without limitations. His overall flight experience as pilot was 298 hours, of these 165 hours on the accident type. In the last 90 days he had flown 26 hours.

#### Aircraft information

The two-engine helicopter MD 900 of the manufacturer MD Helicopters Inc. is a light multipurpose helicopter for a maximum of eight occupants. It was built in 1999 and has the serial number 900-00061. It had two engines PW 206E, a five-blade main rotor, a skid landing gear; for torque compensation around the vertical axis a NOTAR system (NO TAIL ROTOR) was used. The helicopter was equipped for police operation.

Since the issue of a German certificate of registration and certificate of airworthiness in September 1999, the helicopter had been operated by the police. The maximum take-off mass was 2 835 kg. The last annual technical examination had been performed on 06 November 2007 after 3 994 operating hours. At the time of the accident, the helicopter had an overall operating time of 4 008 hours.

The NOTAR system for the torque compensation control of the helicopter consists of variable-pitch fan, a tail boom with air exhaust slots on the right side as well as a rotatable thruster. The fan produces a big air volume and continuously produces a slight overpressure in the tail boom. For direction control, the fan blades as well as the rotatable thruster are connected to pedals.

The air unilaterally exhausted on the right side of the tail boom causes a boundary layer effect on the circulating air (Coanda effect). The result is that the tail boom acts like a wing in the air stream of the main-rotor, thus almost compensating the torque around the vertical axis in hovering flight. For this, direction control is performed via the rotation of the thruster. In forward flight, the gyro controlled vertical surfaces on the tail boom supply the required torque compensation.

Service Bulletin (SB) 900-099 modified the type design of the helicopter with the addition of a thruster extension and vortex generator installation. An approved service center of MD helicopters performed this SB on the helicopter on 19 December 2006 after an overall operating time of 3 822 hours. For this, the tail boom was prolonged behind the tail unit, which caused among other things the installation of a push rod prolonged by 53 cm, in the mechanism of the rotatable thruster.

#### Meteorological information

According to the Meteorological Aviation Report (METAR) the following flight conditions prevailed at the Hanover Airport at the time of the accident:

The wind came from 360 degrees with 10 kt. Visibility at ground level was more than 10 km. The lowest ceiling of the clouds was 1 to 2 octa at 1,900 ft above ground. Temperature was 2 °C (dew point 0 °C). Air pressure (QNH) was 1 010 hPa.

#### Communications

When entering the control zone, the helicopter crew had radio contact to Hanover Tower. Furthermore, radio contact was established to the local police helicopter squadron in order to solve the existing problem and to obtain support.

#### Aerodrome information

The Hanover Airport has three runways with the direction 09/27. The concrete runway 09L used for approach has a length of 3,800 m and a width of 45 m. The airport elevation is 183 ft.

#### Flight recorders

The helicopter was neither equipped with a flight data recorder (FDR) nor a cockpit voice recorder (CVR). These recording devices were not obligatory according to the valid aviation regulations.

The helicopter was equipped with an on-board computer. This computer recorded various system parameters in intervals (speeds, temperatures, pressures, stresses, positions). These records showed a pedal actuation (-31 %) to the left during the approaches.

One of the approach attempts as well as the accident landing were recorded on video and were available to the BFU for investigation purposes.

#### Wreckage and impact information

The helicopter lay 858 m past the threshold of runway 09L, between the taxiways Juliet and Kilo, 13.7 m to the right (in southerly direction) of the runway, on its left side.

The tail boom was severed at the level of the registration mark. The only remaining connection between tail boom and fuselage were two electric power cables. All five main rotor blades were severed at the rotor head. The linkages of the blade to the swash plate were torn off. The left skid of the landing gear was broken. The right windscreen presented a big hole.



Accident side

photo: BFU

There was debris and dirt at the aspiration protection grille of the NOTAR fan. The pull push cable for the control of the thruster was found outside of the tail boom, in the grass in northern direction of the wreckage. It was possible to turn the thruster by hand without any abnormalities.

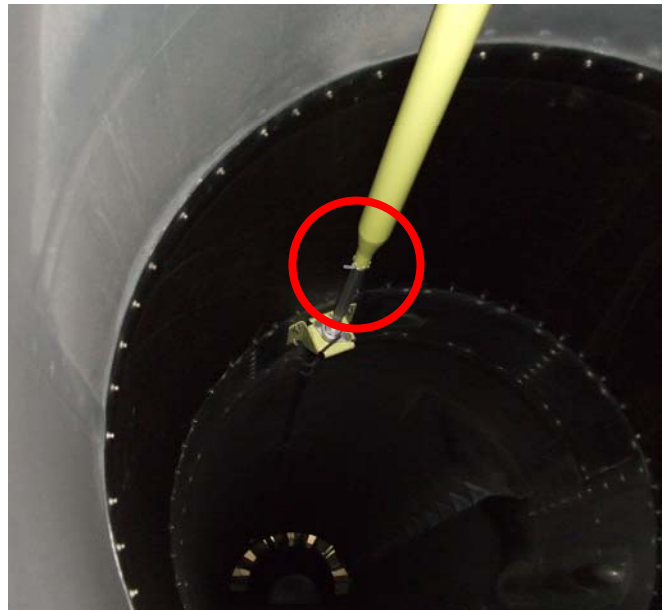
The following findings were found at the torque compensation control of the helicopter:

- There was a connection in the torque control system from the pedals of the pilot to the fan blade adjustment mechanism in the NOTAR fan.
- Furthermore there was a connection from the pedals to the fuselage-side mechanism of the pull push cable for the adjustment of the thruster.
- The push-pull cable leading to the rear side was torn out at this point. The front and the rear support of the push-pull cable were destroyed.
- There was a connection from the transition point between the push-pull cable and the linkage of the thruster, by means of control rod, deflection lever, wire ropes and deflection pulley. Damages were not apparent.
- The connection was interrupted at the connection point between the push-pull cable and the push rod. A remaining piece of the threaded rod of the push-pull cable was found in the threaded bush of the control rod.
- This remaining piece of the threaded rod had a groove in longitudinal direction. A locking plate engages in this groove in order to prevent the rotation of the threaded rod with respect to the pushing sleeve and the push rod. The locking plate and the pushing sleeve were missing and could not be found at the accident site, even though metal detectors were used.



Image of the damage at the accident helicopter, view from the front to the rear towards the control rod for thruster adjustment

photo: BFU



Connection between bowden cable and push rod in a helicopter of same type, view from the rear to the front

photo: BFU

The BFU ordered an expert from the Materials Science Institute of the Technical University of Braunschweig to determine the fracture cause. The expert delivered the following comprehensive result:

- *The point of fracture is located – as expected – directly at the exit of the threaded stud from the threaded bush of the control rod*
- *The macroscopic appearance of fracture clearly points to a vibration fracture (also designated endurance or fatigue fracture)*
- *These findings were confirmed without any doubt with the scanning electronic microscope*
- *The forced final fracture is limited to a very small border surface*
- *A small final fracture surface principally indicates a low (oscillating) stress level*
- *Vice versa, the start of a local fatigue fracture requires a high local stress concentration, for example due to a sharp notch, possibly in conjunction with a peak load*

Fire

There was no fire.

Tests and research

Two approaches to the used runway were performed with a helicopter of the same type. The first approach was performed as overflight in low height with the airspeed required for emergency landing. For the second approach, the helicopter changed to hovering flight in low height above the runway.

These approaches were to give evidence about the position of the thruster as well as about the usage of the pedals in these flight phases in order to compare these to the circumstances during the emergency landing. During the overflight as well as during hovering flight, the thruster aperture pointed downwards and slightly to the left (07:00 position). The pedals almost remained in neutral position.

Organizational and management information

For the case of a failed torque compensation control system, the flight manual of the MD 900 indicated an emergency procedure for fan drive failure and for blocked pedals, respectively.

As the pedals were able to be moved freely, however a direction control of the helicopter was not possible with the pedals, the pilot applied the following emergency procedure:

#### ANTI-TORQUE FAILURE - FIXED THRUSTER SETTING

Conditions: Right pedal applied

Procedures:

- Adjust airspeed and power for level flight at an airspeed that produces the least amount of right yaw, usually between 80 and 100 KIAS.
- Perform a shallow approach and running landing to a hard surface or other suitable area. If possible, select an approach direction that offers a left quartering headwind to reduce the touchdown ground speed and the amount of right yaw.

**NOTE:** Touchdowns made into the wind between 20 and 30 KIAS, may provide good directional control at reduced power (collective) settings.

- An aggressive reduction in power (collective) as the aircraft is decelerated during the final approach should yaw the aircraft to the left.
- As the ground is neared, adjust collective as necessary to align the aircraft with the touchdown direction and cushion the landing.

- During ground run out adjust collective to maintain directional control. If necessary, during touchdown and ground run out, reduce rotor RPM by rotating both twist grips simultaneously towards IDLE to assist in maintaining directional control.

**NOTE:** Use of the twist grips to change RPM is generally not recommended due to the complexity of manipulating both twist grips simultaneously and now having both engines in the manual mode. If needed, it is recommended that they be used only to reduce RPM just prior to or at the moment of touchdown.

Excerpt from flight manual MD 900

## Analysis

During the approach to the airport, the pilot was confronted with a malfunction of the torque compensation control system in a height of 40-60 ft. Indications for this were the fact that the helicopter rotated to the right and did not react to pedal movements. Thus, preparations for an emergency landing were made on the basis of the emergency procedure given in the flight manual.

The manufacturer determines in the emergency procedure for the NOTAR system how to operate the helicopter in case of a drive or control failure. For this, it was necessary to check, during the flight, whether the NOTAR fan had failed (drive failure) or whether the NOTAR control was blocked (control failure). Basing on the indication of freely movable pedals without any correcting influence on the rotating movement on the helicopter, it was initially understandable to use the procedure for a drive failure.

After several system tests during the landing attempts the crew noticed that the NOTAR fan had not failed. Due to the behavior of the helicopter, despite the movable pedals, they chose to apply the emergency procedure for a fixed thruster setting.

According to the statements of the crew and according to the existing video recordings, in all landing attempts in the low speed range the helicopter behaved completely differently than described in the emergency procedure. Below 85 kt it kept rotating uncontrollably to the right; thus, it was impossible to touch down with the recommended airspeed of 20 to 30 kt in the subsequent landing.

According to his own statements, the pilot intended to counteract the constant rotation to the right by pedal actuation to the left, during the flight phase and during the skidding phase on the ground. During this he noticed that the entire helicopter vibrated with unusual intensity. The technical investigation of the helicopter revealed that the fan power increased with pedal actuation, via the preserved adjustment of the fan blades in the NOTAR fan increased also the vibrations. With increased fan power, the interfering effect of the thruster increased due to the position of the thruster to the right. This resulted in the detected deviations from the applied emergency procedure.

In case of a failed NOTAR fan, an actuation of the pedals would have had no effect, and in case of a blocking of the pedals an adjustment of the fan would have been impossible. There weren't any indications at all from the manufacturer for the present case of possible pedal actuation having even negative influence on the emergency procedure due to a continuously working fan. According to the principle "The operation and servicing of an aircraft must be performed according to manufacturer specifications" and due to the essential consequences of this, such correlations should at least be pointed out in the existing emergency procedures.

The recording of a landing attempt showed the thruster in 05:00 position. Due to the consisting problems it must be assumed that the fracture in the mechanism had already occurred during the flight and that the mechanism remained in this position during all landing attempts. With the fan still working, the position of the thruster has important significance for the controllability of the helicopter. Due to these serious effects it is assumed necessary that the thruster takes a predetermined position in case of a fracture of the mechanism. The expected behavior of the helicopter would then be predictable and should be described in the emergency procedures.

The fracture in the mechanism of the thruster occurred in a threaded stud at the transition from a push-pull cable to a control rod. The determined fracture type – oscillation (fatigue) fracture – was caused by a high local stress concentration. The crack had started in the area of a milled recess. Depending on the position of the milled recess in relation to the oscillation direction, a different stress level already results from the installation position.

On the occasion of a prolongation of the tail boom by 53 cm, the broken component had been screwed into a prolonged push rod 172 operation hours before the accident. Principally, a change of the distances of the cell-side attachment points causes a change of the stiffness of the design. The unfavorable influence of the milling recess in the section of the threaded rod, as

well as the actuation forces to be transmitted, have not changed. Thus, it cannot be excluded that the changed oscillation behavior, in conjunction with a perhaps changed installation position of the milled recess, has led to the fracture.

The stress concentration in the threaded rod and thus the risk of a fracture could be essentially reduced if it was possible to avoid the milled recess in the section. The pushing sleeve secures the connection of the push rod to the threaded rod and fixes these parts to each other. A tightening torque and a locking wire ensure that this connection cannot loosen. It should be checked whether an additional rotary protection for the threaded rod is absolutely necessary.

## Conclusions

### Immediate causes:

- A fatigue fracture during flight caused the breaking of the control mechanism of the rotatable thruster.
- After fracture, the thruster remained in a position which was due to full left pedal applied unfavorable for directional control in forward flight below 80 kt, and for landing.
- The instructions and notes in the RFM's emergency procedures for the NOTAR system do not have the condition where pedals can move and change the fan pitch, yet the thruster is at a fixed setting.

### Systemic causes:

- The point of fracture was located at the exit from the threaded bush of a control rod. The control rod screwed into the defective part had been prolonged by 53 cm in December 2006. This extension of the control rod resulted in a change of the design stiffness, which surely had effects on the stress magnitudes in the breaking point area.
- The undamaged control system of the fan blades influenced on the pedal-controlled directional stability of the helicopter in a problematical way. After the fracture, the thruster did not take a position where a fan power increase would have no or few effects. Such a device is so far not obligatory for a NOTAR system; thus, it was not constructively provided.

- The remaining possibility to influence the direction of the helicopter by pedal actuation did not fit any of the emergency procedures for the NOTAR system. The indications of the flight would lead to the emergency procedure for fixed thruster setting. In this emergency procedure there is no information given to the possible effects of pedal actuation (depending on the thruster position).

## Safety recommendations

Action of the manufacturer:

MD Helicopters Inc. released the Service Bulletin 900-0108 on 12. August 2008 which lead to the emergency AD 2008-17-51 of the FAA, issued 14. August 2008. These publications require an inspection of the control system of the rotatable thruster and a change of the lock device.

Because of these actions the BFU refrained from issuing a corresponding safety recommendation.

- 09/2009: The Federal Aviation Administration (FAA) should induce the helicopter manufacturer of the MD 900 to integrate an emergency procedure for a fracture within the control system for the rotatable thruster of the NOTAR system into the flight manual, or to extend the existing emergency procedures by a note to this type of malfunction.
- 10/2009 The Federal Aviation Administration (FAA) should induce the helicopter manufacturer of the MD 900 to implement a defined position of the rotatable thruster, to be engaged in case of a mechanical interruption within the control system.

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The investigation has been conducted in compliance with the law relating to the Investigation of Accidents and Incidents associated with the Operation of Civil Aircraft (Flugunfall-Untersuchungsgesetz - FIUUG) dated 26 August 1998. According to the law the sole objective of the investigation shall be the prevention of future accidents and incidents. It is not the purpose of this activity to assign blame or liability or to establish claims.

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