BY LINDA WERFELMAN

Hydraulic Failings

Citing its investigations of six events since 2002, including two fatal accidents, the U.S. National Transportation Safety Board (NTSB) has identified hydraulic problems that led to "concern regarding the safe operation of Eurocopter AS 350-series helicopters."[1]

In examining the helicopters involved in the six accidents and incidents, NTSB investigators found excessive wear in the splined connection between the hydraulic pump and its pulley assembly. In some cases, the connection failed, and hydraulic power was lost.

A hydraulic power loss makes controlling a helicopter more difficult and increases the risk of a serious accident. Without hydraulic power, a helicopter can be operated in manual mode, "but doing so increases the physical demands on the pilot and can cause a serious accident if the pilot has not maintained familiarity with operation of the helicopter in manual mode or if an uncommanded reversion to manual mode occurs suddenly, especially during a critical maneuver," the NTSB said.

Letters from the NTSB to the European Aviation Safety Agency (EASA) and the U.S. Federal Aviation Administration (FAA) described how the hydraulic pump assembly functions:

"The hydraulic pump assembly is driven by a pulley assembly that contains a coupling sleeve. The coupling sleeve, with internal splines at its forward end, extends forward through the center of the pulley assembly to engage with the external splines on hydraulic pump drive shaft. A lubricant (specified in the maintenance manual as NATO grease G-355) is contained within the coupling sleeve by a plug inserted in the aft end of the sleeve and at the forward end, by contact with an O-ring located in a groove forward of the


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The NTSB's discovery of excessive wear in AS 350 hydraulic connectors has prompted a call for replacement of faulty components.

drive shaft splines. The pump and the coupling sleeve are replaced 'on condition' (that is, when a problem is found during routine maintenance or during operation)."

The NTSB letters also described the six accidents and incidents in which the hydraulic pump assembly did not function as it should have.

The most recent incident, which occurred March 9, 2007, involved a loss of hydraulically powered control and a run-on landing.[2] An investigation found that a bearing had failed in the pulley assembly that drives the hydraulic pump, that the pump's drive shaft splines were worn to a thickness about 25 percent less than the splines' original thickness and that the pulley assembly's coupling sleeve splines were completely worn away, probably because of the bearing failure, the NTSB said.

Hardness testing of all the splines found that the measured hardness was "significantly below the requirements specified in the engineering drawings," the report said. In addition, "lubrication levels were found to be minimal, although 'abundant' was specified in the maintenance work card." Records indicated that the last 100-hour visual inspection had been conducted about 75 operating hours before the incident and the last 1,000-hour wear check had been done 622 operating hours before the incident.

The most recent fatal accident occurred March 8, 2007, at Princeville (Hawaii, U.S.) Airport after the pilot of the Heli-USA Airways air tour helicopter radioed a company dispatcher that he was experiencing "hydraulic problems" and expected to conduct a run-on landing, a preliminary NTSB accident report said. As the conversation continued, the pilot began describing the situation as a "hydraulic failure."[3]

The report said that the dispatcher continued monitoring the frequency and heard the pilot say, as the helicopter approached the ground, "Okay, we're done." Then, the report said, "the sound of the rotor changed pitch, and the helicopter impacted the ground."

The report quoted company employees and other witnesses as saying that the AS 350BA was unusually low during its approach to the airport, "moving slowly in a level attitude, seeming as though it would land in the grass." Then, one witness said, "all of a sudden, the nose went down and [the helicopter] hit the ground."

The pilot and three passengers were killed, and three other passengers received serious injuries in the crash, which caused substantial damage to the helicopter, the report said.

The accident investigation — including a laboratory examination of the hydraulic system — was continuing.

The other fatal accident occurred Sept. 20, 2003, when a Sundance Helicopters AS 350BA struck a canyon wall while maneuvering near Grand Canyon West Airport in Arizona, U.S.[4] The pilot and all six passengers were killed in the crash, which destroyed the helicopter (*ASW*, 1/08, p. 32).

The hydraulic system was not cited as a factor in the crash. The NTSB said in its final report on the accident that the probable cause was the pilot's "disregard of safe flying procedures and misjudgment of the helicopter's proximity to terrain."

An NTSB examination of the helicopter's hydraulic system revealed that about 10 percent of the splines on the hydraulic pump assembly's drive shaft had been worn away, "and their hardness was significantly below engineering drawing requirements." Tests measured hardness at the roots of the splines because case hardening in these areas usually is "pristine," the NTSB said.

The NTSB's examination of the hydraulic pump drive shaft–coupling sleeve assemblies from the six accident/incident helicopters compared those assemblies with a new assembly and two assemblies from other AS 350s and found that in the accident/incident helicopters, "neither the drive shaft splines nor the coupling sleeve splines met the hardness requirements in their respective [engineering] drawings and in some cases were deficient by significant amounts," the recommendation letters said. "In four cases, the coupling sleeve splines were completely worn away, and in the other two

cases, coupling sleeve splines showed excessive wear."

Spline hardness in the assemblies that had been removed from the operating helicopters, as well as the new coupling sleeve provided by the manufacturer, also failed to meet the engineering drawing requirements, the letters said.

The NTSB's inspection also found that all but one of the coupling sleeves contained inadequate lubrication. In addition, in one coupling sleeve, a plug had not been installed; and in another, an O-ring had not been installed. All three conditions — inadequate lubrication and the absence of the plug or O-ring — exacerbate the problem of accelerated wear.

"The Safety Board is concerned because inadequate hardness and inadequate lubrication accelerate the wear in the splined connection, increasing the likelihood of in-flight failure," the letters said. "Potentially catastrophic wear on coupling sleeve splines could occur before the next wear check, which is required by the master servicing recommendations every 1,000 hours."

Eurocopter AS 350 and EC 130 manuals in use at the time of the accidents/incidents did not mention that coupling sleeve splines should be included when hydraulic pump drive shaft splines are visually inspected and lubricated, the letters said. A subsequent service letter added that requirement and reduced the visual inspection interval to 100 hours, down from 500; the requirement later was incorporated into maintenance manuals. The NTSB praised this action, noting that in all of the safety examinations cited in the six accidents/incidents, the coupling sleeve splines displayed more wear than the pump drive shaft splines.

"Although the Safety Board is encouraged by Eurocopter's action in regard to the inspection of the coupling sleeve splines, it remains concerned that the more extensive wear check will be conducted only at 1,000-hour intervals," the NTSB said. "The Safety Board is concerned that once the wear progresses through the casehardened layer on the coupling sleeve splines, the wear rate could accelerate, with the potential for hydraulic failure that could contribute to a serious or fatal accident."

The NTSB issued identical safety recommendations to the EASA and the FAA. The first called on the two agencies to require Eurocopter to "identify the AS 350 and EC 130 helicopter hydraulic pump drive shafts and coupling sleeves with splines that do not meet design specifications and take appropriate action to ensure that these parts (that is, replacement parts and parts to be installed in new helicopters) are expeditiously removed from the supply chain."

The second recommendation said that the EASA and the FAA should require operators of AS 350s and EC 130s to "perform a wear check, visual inspection and lubrication of the hydraulic power assembly splines and coupling sleeve splines in accordance with the latest version of the maintenance manual at the earliest opportunity, and thereafter require operators to repeat the wear check, visual inspection and lubrication of the splined connection at 100-hour intervals, and remove unairworthy parts from service."

Eurocopter AS 350

The Eurocopter AS 350 is a light five/six-seat utility helicopter first produced in October 1977 by Aerospatiale as the AS 350B. The Aerospatiale helicopter division and the MBB (Messerschmitt-Bolkow-Blohm) helicopter division merged to form Eurocopter in 1992.

Several versions have been produced since the first AS 350Bs, which were powered by a 478 kw (641 shp) Turbomeca Arriel 1B turboshaft engine and a rotor system of three fiberglass blades. The next version was the AS 350BA, with larger main rotor blades and an increased takeoff weight.

Current versions include the AS 350B2, certified in 1989, and the AS 350B3, first certified in France in 1997. The AS 350B2 has a 546 kw (732 shp) Turbomeca Arriel 1D1 engine, a maximum cruise speed of 134 kt at sea level and a maximum takeoff weight of 2,250 kg (4,960 lb) or 2,500 kg (5,512 lb) with a slung load. The AS 350B3 has a 632 kw (847 shp) Arriel 2B engine, maximum cruise speed of 140 kt at sea level and a maximum takeoff weight of 2,250 kg, or 2,800 kg (6,173 lb) with a slung load.

Source: *Jane's All the World's Aircraft*

Notes

1. NTSB. Letters accompanying Safety Recommendations A-08-75 and A-08-76, directed to the FAA, and Safety Recommendations A-08-77 and A-08-78, directed to the EASA.
2. A run-on landing, often selected in situations involving a loss of power to the flight controls, is a landing in which the helicopter lands with forward velocity and slides to a stop.
3. NTSB. Accident report no. NYC07MA073.
4. NTSB. *Crash of Sundance Helicopters, Inc. Aerospatiale AS350BA, N270SH, Near Grand Canyon West Airport, Arizona, September 20, 2003*, NTSB/AAB-07/03. Oct. 30, 2007.