



National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Log 2586

Date: March 20, 1996

In reply refer to: A-96-6

Honorable David R. Hinson
Administrator
Federal Aviation Administration
Washington, D.C. 20594

On August 18, 1995, a McDonnell Douglas Helicopter Company (MDHC)¹ 369D helicopter, serial number 0118D, D-HMEN, experienced separation of one of the five main rotor blades before takeoff near Leipzig, Germany. The occupants of the helicopter were not injured, but the helicopter sustained severe damage. Preliminary inspection of the helicopter by the FUS² revealed that the separated main rotor blade part number 369D-21100-516A, serial number E821, fractured chordwise near the inboard end of the blade and crossed the most outboard bolt hole of the upper and lower root fitting. This was in an area where the upper and lower fitting is adhesively bonded to a doubler located at the root end of the blade, and the doubler is bonded to the skin of the blade. The root fittings are also attached to the blade by five attachment bolts and nuts. Upon removing these attachment bolts and nuts, investigators found a bonding separation between the lower root fitting and the doubler.

At the Safety Board's request, the FUS sent the inboard portion of the separation from the main rotor blade, along with five attachment nuts and bolts and separated lower root fitting, to the Board's metallurgical laboratory. The FUS allowed the outboard separation portion to be sent to the manufacturer in Mesa, Arizona. A Safety Board materials engineer participated in both examinations. These examinations revealed that about 75 percent of the blade fracture contained a preexisting fatigue crack. Scanning electron microscope examination of the outboard fracture revealed that the fatigue cracks stemmed from opposite sides of the most outboard attachment bolt hole at the bottom side of the blade. On the aft side of the hole, fatigue crack propagation was in the aft direction through the doubler, skin, and spar with termination near the trailing edge of

¹ Formerly Hughes Helicopter, Incorporated.

² Flugunfalluntersuchungsstelle beim Luftfahrt-Bundesamt (FUS) is the accident investigation bureau that conducts aviation accidents in Germany.

the blade. The fatigue crack on the forward side of the bolt hole propagated forward through the doubler, skin, and spar with extension through the leading edge and around the top side of the blade, then aft up to the top side of the same attachment bolt hole. No metallurgical anomalies were noted at the origin areas.

Examination of the exposed adhesive bond surface between the lower root fitting and the doubler disclosed evidence of adhesive debonding, between the trailing edge of the root fitting and the doubler, that extended from the inboard to the outboard end of the fitting. About 30 percent of the debonded area occupied the lower root fitting bonding surface area and appeared to have been in existence since the manufacture of the blade. Another 35 percent of the adhesive bond area appeared to have separated during service prior to the incident, whereas the remaining percent of the bond appeared to have separated at the time the main rotor blade completely separated from the helicopter. Although the upper root fitting had not separated as a result of the accident, it was forcefully separated from the doubler in the laboratory to expose the bond line. This examination of the bond revealed nearly the same ratio of debonded, separated-in-service, and intact bonded surface area as that found for the lower root fitting except that the debonded area in the upper root fitting was located at the leading edge instead of the trailing edge.

The manufacturing process was reviewed because debonding appeared to have occurred, in part, at the time of blade manufacture. It was found that during manufacture, opposing arms in a fixture are used to apply pressure and heat to the upper and lower root fitting area while the adhesive is curing. If the arms do not apply uniform pressure across the root fittings, the adhesive may improperly cure or debond. The debonded area found on diametrically opposite sides of the blade indicated that the blade was not properly aligned in the fixture. Differential scanning calorimeter analysis of adhesive samples removed from the debonded area of the upper and lower root fitting of the incident blade produced spectra containing an exotherm indicative of an improperly cured adhesive.

Review of the manufacturing process also disclosed that when proper pressure is applied to the root fittings during the bonding process, excess adhesive will be squeezed out of the joint, forming a fillet at the edges of the root fitting. If excess adhesive is not squeezed out of the joint, either an inadequate amount of adhesive was used and/or proper pressure was not applied to the root fitting during the bonding process. The investigation of the failed blade disclosed that about 6 inches of the leading edge, extending lengthwise between the upper root fitting and the blade, was filled with sealant instead of adhesive to form a fillet, which indicates there was missing adhesive in the area. A metallurgical section made through this area revealed that the sealant was coated with primer and black paint applied by the manufacturer. The review also disclosed a common practice in the manufacturing process: personnel doing the adhesive bonding would apply sealant to close a gap between the root fitting and the blade.

Bonding separation between the lower fitting and the doubler at the inboard end of the main rotor blade, including cracking of the doubler and skin of the blade, was the subject of manufacturer Service Information Notices (SINs) DN-188, EN-81, FN-67, HN-239, and NN-008, dated October 27, 1995. The SINs advised operators of model 369 and 500N helicopters

to perform a one-time visual inspection of the main rotor blade root end for chordwise cracks and paint/sealant cracking between the lower end fitting and doubler with specific concentration on the most outboard attachment bolt of the root fitting. The visual inspection is to be performed within the next 10 hours of helicopter operation with the main rotor blade lifted off of the droop stop. Any missing or cracked adhesive/paint in the root end fitting to doubler bond line prompts a 100-hour repetitive inspection with the main rotor blades removed from the helicopter. Each SIN advises operators to visually inspect, at 100-hour intervals and using a 10X magnifying glass, the root end of the blade area for chordwise cracks emitting from the root fitting edge on the blade doubler and skin; each SIN also advises operators to insert a 0.004-inch-thick piece of Mylar (plastic) sheet between the root fitting and the main rotor blade after the five attachment bolts are loosened to detect adhesive bond separation. As indicated in the SINs, if a Mylar sheet can be inserted 0.1 inch or more into the bond line of the blade, the blade must be removed from service, and any cracks detected in the inspection areas of the blade assembly are considered unserviceable. However, the SINs do not specify inspection for bonding separation between the upper root fitting and the doubler.

The Safety Board is aware that within the last 10 years, eight main rotor blades have been found with chordwise cracks in the doubler and/or skin on model 369 helicopters. Cracking of the blades reportedly was associated with helicopters involved in sling load operations. The most recent crack was detected in January 1996. All of these cracks reportedly stemmed from the most outboard bolt hole of the lower root fitting. A manufacturer representative indicated that the blade part number on several of these helicopters is different from the one installed on the D-HMEN helicopter even though identical root fittings, doubler, and bonding process are used in manufacturing the blades. The blade with the earliest detected crack had been operated 1,750 hours before the defect was noted, compared to the blade retirement life of 3,530 hours. The separated blade in the Leipzig accident had been operated 3,464 hours, just short of its scheduled retirement.

The MDHC reported that nearly 500 model 369H series, 700 model 369D series, 700 model 369E series, and 150 model 369F series helicopters were manufactured and are subject to the SIN. The SIN also applies to OH-6A (military version of the 369A) series and about 80 model 500N helicopters because they are installed with the same root fitting blade part number as in the model 369 helicopters.

The Safety Board is aware that the FAA issued Airworthiness Directive (AD) 95-03-13, effective March 21, 1995, advising operators of model 369 and OH-6A helicopters to visually inspect the attachment lugs and lead-lag links for cracks and the lug bushings for looseness. The AD also contains a statement specifying a visual inspection for cracking in the skin and doubler adjacent to the root fitting. The AD inspections are to be performed with the main rotor blades removed from the helicopter within 25 hours time-in-service after the effective date of the AD and at 100-hour intervals thereafter. However, the AD contains no requirement to perform an inspection for or mention of how to detect a bonding separation between the root fitting and doubler.

The Safety Board believes that improper bonding during manufacturing probably resulted in initiation of the fatigue cracking in the main rotor blade of the D-HMEN helicopter and that bonding separations are likely to occur in other blades similarly manufactured. The SINS are not mandatory, and the present AD is not specific to bonding inspections. Consequently, bond separations could remain undetected and lead to fatigue cracking of the main rotor blades in other helicopters.

Additional mandatory action is needed to minimize the potential for separation of the main rotor blade that could result in loss of control of the helicopter and loss of property, serious injury, or death. Therefore, the National Transportation Safety Board recommends that the Federal Aviation Administration:

Issue an airworthiness directive for McDonnell Douglas helicopter models 369D, 369E, 369F, 369H, OH-6A (military version of the 369A), and 500N to require inspection of the root end of the main rotor blades for cracking and bond separation of the lower root fitting according to McDonnell Douglas Service Information Notices DN-188, EN-81, FN-67, HN-239, and NN-008, dated October 27, 1995. In addition, the airworthiness directive should include inspection for bond separation between the upper root fitting and the doubler, as well as for cracking in this area. (Class I, Urgent Action) (A-96-06)

Chairman HALL, Vice Chairman FRANCIS, and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in this recommendation.

By 
Jim Hall
Chairman