



National Transportation Safety Board

Washington, DC 20594

Safety Recommendation

Date: February 13, 2013

In reply refer to: A-13-04 through -06

Mr. Robert S. (Steve) Miller
Chief Executive Officer
Hawker Beechcraft Corporation
10511 East Central
Wichita, KS 67206

The National Transportation Safety Board (NTSB) is an independent federal agency charged by Congress with investigating every civil aviation accident in the United States and significant accidents in other modes of transportation—railroad, highway, marine, and pipeline. The NTSB determines the probable cause of the accidents it investigates and issues safety recommendations aimed at preventing future accidents. In addition, the NTSB carries out special studies concerning transportation safety and coordinates the resources of the federal government and other organizations to provide assistance to victims and their family members affected by major transportation disasters. We are providing the following information to urge your organization to take action on the safety recommendations issued in this letter.

These recommendations address fatigue cracks of nose landing gear (NLG) end caps on Beechcraft 1900D airplanes. The recommendations are derived from the NTSB's investigation of several recent incidents and are consistent with the evidence we found and the analysis we performed. As a result of these investigations, the NTSB has issued three safety recommendations addressed to Hawker Beechcraft Corporation. Information supporting these recommendations is discussed below.

On May 17, 2011, about 0645 mountain daylight time, a Beechcraft 1900D, N218YV (UE-218), sustained minor damage when the left main landing gear (MLG) collapsed during the landing roll on runway 35L at Denver International Airport (DEN), Denver, Colorado. The airline transport-rated captain, commercial-rated first officer, and nine passengers were not injured. The airplane was registered to Raytheon Aircraft Credit Corporation and operated by Great Lakes Airlines under the provisions of 14 *Code of Federal Regulations* Part 121 as a scheduled passenger flight. Visual meteorological conditions prevailed for the flight, which operated on an instrument flight rules flight plan. The flight originated from Pueblo Memorial Airport, Pueblo, Colorado, about 0607 and was destined for DEN. The NTSB determined that the probable cause of the incident was the fatigue failure of the NLG end cap, which resulted in insufficient hydraulic pressure to secure the left MLG into the down-and-locked position.

Contributing to the fatigue failure was the NLG end cap's nonoptimum grain direction and the inadequate inspection procedure performed during overhaul.¹

The fractured NLG end cap from the incident airplane was examined by the NTSB's materials laboratory along with another fractured end cap supplied by Hawker Beechcraft.² Examination revealed that both end caps failed due to fatigue from multiple origins that initiated in the machined inner diameter and propagated outward toward the cap's exterior. The NLG end caps were machined from wrought aluminum alloy 7075-T73 plate. The primary cyclic tension stresses in the NLG end cap result from hydraulic pressure and occur along the longitudinal axis of the actuator when the NLG is extended once per flight. Examinations in the NTSB's materials laboratory of the microstructure of each end cap revealed that the longitudinal grain direction was oriented perpendicular to the longitudinal axis of the NLG on both end caps. According to the *Metals Handbook Desk Edition*,³ wrought aluminum products (such as the end cap) generally exhibit differences in tensile properties and in resistance to fatigue stresses in the three orthogonal grain directions (longitudinal, long-transverse, and short-transverse)⁴ with the longitudinal direction being superior. In general, a component will be stronger and more resistant to fatigue if the longitudinal grain direction is aligned with the principal tension stresses. At the time that these end caps were machined, the end cap manufacturer, APPH, Inc., did not specify a metallurgical grain direction for NLG end caps. However, in February 2010, APPH, Inc., revised its end cap drawing to specify that the longitudinal grain direction in the raw material be aligned (parallel) along the longitudinal axis of the NLG actuator for manufacturing the end caps.

The incident NLG end cap had accumulated a total of 29,533 cycles since manufacture and was last overhauled in 2008 with 24,948 total cycles by APPH, Inc. The overhaul paperwork indicated that the end cap was inspected for cracks using dye penetrant with no discrepancies reported (4,585 cycles before the failure). An analysis of fatigue striations on the NLG end cap fracture surface performed by the NTSB's materials laboratory indicated that the crack was likely present for at least 16,397 cycles.⁵

As a result of previous NLG end cap fractures⁶ and the preliminary findings from the incident investigation, Hawker Beechcraft changed its recommended maintenance practices for the NLG actuator on August 1, 2010, May 1, 2011, and November 1, 2011, so that the Model 1900D Airliner Maintenance Manual now recommends that the NLG actuator undergo a repetitive ultrasonic inspection every 1,200 cycles once it has accumulated 8,000 total cycles and that it is overhauled every 10,000 cycles.

¹ The report for this incident, NTSB case number CEN11IA341, can be found online at <http://www.nts.gov/aviationquery/index.aspx>.

² The end cap supplied by Hawker Beechcraft was a cracked end cap that had been returned to the manufacturer, but no cycle or overhaul information was made available.

³ J. R. Davis, *Metals Handbook Desk Edition*, 2nd Edition (Metals Park, OH: ASM International, 1998).

⁴ The longitudinal grain direction is defined as being parallel to the rolling direction of the wrought material, the long-transverse grain direction is across the width, and the short-transverse grain direction is normally through the thickness.

⁵ Landing gear extension cycles typically happen once per flight. The total landing gear extension cycles are likely higher than the airplane cycles due to landing gear extension performed during ground maintenance.

⁶ In an August 10, 2011, meeting with the NTSB, Hawker Beechcraft informed the NTSB of five previous NLG end cap failures.

The NTSB is presently investigating two additional instances of fatigue cracks of NLG end caps on Beechcraft 1900D airplanes that occurred after the May 17, 2011, incident and after the effective date of the maintenance manual changes. On December 3, 2011, the pilot of a Great Lakes Airlines Beechcraft 1900D airplane, N247GL, found a hydraulic leak on the NLG during a postflight inspection.⁷ Inspection of the NLG revealed a crack in the NLG end cap, which had accumulated 38,831 total cycles since manufacture. Great Lakes Airlines had performed the ultrasonic inspection recommended by Hawker Beechcraft with no discrepancies noted 485 cycles before the identification of the cracked end cap. An analysis of fatigue striations on the NLG end cap fracture surface performed by the NTSB's materials laboratory indicated that the crack had been present for at least 14,898 cycles.

On February 17, 2012, the pilot of another Great Lakes Airlines Beechcraft 1900D airplane, N210GL, found a hydraulic leak on the NLG during a postflight inspection.⁸ Inspection of the NLG revealed a crack in the NLG end cap, which had accumulated 39,655 total cycles since manufacture. Great Lakes Airlines had performed the ultrasonic inspection recommended by Hawker Beechcraft with no discrepancies noted 337 cycles before the identification of the cracked end cap. An analysis of fatigue striations on the NLG end cap fracture surface performed by the NTSB's materials laboratory indicated that the crack had been present for at least 15,305 cycles.

Preliminary NTSB materials laboratory examination of the NLG end caps from these two airplanes revealed that the end caps failed due to fatigue that initiated from multiple origins in the machined inner diameter and propagated outward toward the cap's exterior, similar to the end cap from N218YV. Examination of the microstructure of each end cap also revealed that the longitudinal grain direction was perpendicular to the longitudinal axis of the NLG on both end caps.

All of the failed NLG end caps examined to date failed in fatigue that initiated at the machined inner diameter and propagated outward, and all were manufactured with the longitudinal grain direction perpendicular to the longitudinal axis of the NLG. The NTSB notes that APPH, Inc., revised its NLG end cap drawing to specify the grain direction for manufacturing. However, the NTSB is concerned that APPH, Inc., has not provided engineering data to validate an improved fatigue life for end caps with the longitudinal grain direction aligned with the longitudinal axis of the NLG. Typically, fatigue loading in the longitudinal grain direction can provide a 5 to 10 percent improvement in fatigue strength.⁹ The NTSB concludes that there is insufficient data to determine if the NLG end cap design revised in February 2010 with the longitudinal grain direction aligned with the longitudinal axis of the NLG is sufficiently resistant to fatigue to ensure continued airworthiness. Additionally, the manufacturer did not know how many end caps were manufactured with the unspecified grain direction before the change was implemented. The NTSB concludes that the unspecified grain direction could increase the likelihood of a fatigue fracture of the NLG end cap, which may cause a landing gear

⁷ Preliminary information about this incident, NTSB case number ENG12IA013, can be found online at <http://www.nts.gov/aviationquery/index.aspx>.

⁸ Preliminary information about this incident, NTSB case number ENG12IA014, can be found online at <http://www.nts.gov/aviationquery/index.aspx>.

⁹ T. Lyman, *Metals Handbook*, 8th Edition, Volume 1 (Properties and Selection of Metals) (Metals Park, OH: American Society for Metals, 1961), 881.

collapse that could damage the airplane and injure passengers. Therefore, the NTSB recommends that Hawker Beechcraft Corporation determine the fatigue life (life limit) of the Beechcraft 1900D NLG end cap with the longitudinal grain direction both aligned and not aligned with the longitudinal axis of the NLG. Further, the NTSB recommends that Hawker Beechcraft Corporation develop and implement a replacement program for all Beechcraft 1900D NLG end caps based on the fatigue life determined in Safety Recommendation A-13-04.

Further, the NLG end caps from the December 3, 2011, and February 17, 2012, incidents underwent the ultrasonic inspection recommended by Hawker Beechcraft a relatively short time before the cracks were discovered in service. Additionally, crack growth studies established that cracks in both NLG end caps existed at the time of the inspections. The NTSB concludes that the repetitive inspections using the current Hawker Beechcraft-developed and -approved method are not capable of detecting subcritical fatigue cracks in the NLG end caps. Without an effective inspection method, the 1,200-cycle inspection interval is not adequate to ensure that cracks are detected before failure occurs in service. Therefore, the NTSB recommends that Hawker Beechcraft Corporation revise the Beechcraft 1900D NLG end cap repetitive inspection procedure and time interval to ensure that fatigue cracks are detected prior to failure and issue updated guidance to operators regarding the inspections.

Therefore the National Transportation Safety Board makes the following recommendations to Hawker Beechcraft Corporation:

Determine the fatigue life (life limit) of the Beechcraft 1900D nose landing gear (NLG) end cap with the longitudinal grain direction both aligned and not aligned with the longitudinal axis of the NLG. (A-13-04)

Develop and implement a replacement program for all Beechcraft 1900D nose landing gear end caps based on the fatigue life determined in Safety Recommendation A-13-04. (A-13-05)

Revise the Beechcraft 1900D nose landing gear end cap repetitive inspection procedure and time interval to ensure that fatigue cracks are detected prior to failure and issue updated guidance to operators regarding the inspections. (A-13-06)

Chairman HERSMAN, Vice Chairman HART, and Members SUMWALT, ROSEKIND, and WEENER concurred in these recommendations.

The NTSB is vitally interested in these recommendations because they are designed to prevent accidents and save lives. We would appreciate receiving a response from you within 90 days detailing the actions you have taken or intend to take to implement them. When replying, please refer to the safety recommendations by number. We encourage you to submit your response electronically to correspondence@ntsb.gov. If your response exceeds 10 megabytes, including attachments, please e-mail us at the same address for instructions. To avoid confusion, please do not submit both an electronic copy and a hard copy of the same response.

By: *[Original Signed]*
Deborah A.P. Hersman, Chairman