ENGINE AND PROPELLER DIRECTORATE ACTION PLAN

REGARDING SPECIAL CERTIFICATION REVIEW RECOMMENDATIONS

A. RECOMMENDATION No. 1: "Revise Airworthiness Directive (AD) 92-08-03, dated, April 27, 1992, which requires a 900 hour repetitive inspection of the servo ballscrew internal spline to extend its applicability to include all models of the 14RF, 14SF, and 6/5500/F propellers"

ACTION: The Engine and Propeller Directorate has initiated action to revise AD 92-08-03 to include all models of the 14RF, 14SF, and 6/5500/F propellers.

B. RECOMMENDATION No. 2: "Issue an AD to require repetitive 1200 hour disassembly and inspection of the propeller and control system."

ACTION: The Directorate together with Hamilton Standard is in the process of identifying all critical propeller components and appropriate inspection procedures. It is planned to have this process completed during July 1992. An AD will be issued mandating propeller disassembly and inspection of all critical items with consideration given to the recommended 1200 hour inspection interval.

C. RECOMMENDATION NO. 3: Assure that the propeller build standard for the 14RF, 14SF and 6/5500/F propellers conforms to the certificated configuration in place prior to incorporation of the titanium-nitride oil transfer tubes in production

ACTION: The titanium-nitrided oil transfer tube was deleted from the propeller build standard on May 13, 1991, by Hamilton Standard. The Directorate will revise AD T 91-11-51, to have all titanium-nitrided oil transfer tubes removed from service and may no longer be used. In addition a review will be made of all design changes to critical components since January 1987.

D. RECOMMENDATION NO. 4: Assure that all future design changes to the 14RF, 14SF, and 6/5500/F propellers are classified as "major" changes pending incorporation of the provisions of Recommendations 5.

ACTION: The Directorate is presently treating all design changes as "major". The Directorate and Hamilton Standard are in the process of modifying the design change procedures. These procedures are to give a clear definition of major and minor changes and this will be included in the Hamilton Standard Engineering System Manual and the Quality Manual. Hamilton Standard will classify all future design changes which affect a critical function as major changes.

E. RECOMMENDATION NO. 5: Require that Hamilton Standard develop changes to the design of 14RF, 14SF, and 6/5500/F propellers to incorporate fail-safe features. The design should be certificated and available within two years with incorporation in all in-service propeller units within three years thereafter. Incorporation of the fail-safe design features should be terminating action for the actions specified in Recommendations 1,2,3, and 4.

ACTION: The Directorate will advise Hamilton Standard before June 30, 1992, to incorporate "fail-safe" features into the design of Model 14RF, 14SF and 6/5500/F-1 propellers in accordance with the implementation schedule identified in Recommendation No. 5.

F. RECOMMENDATION NO. 6: Initiate rulemaking action to change FAR 35 to require all propeller control systems to be fail-safe or damage tolerant. The damage for the damage tolerant design must be easily detected without disassembly before catastrophic failure.

ACTION: The Directorate is in the process of initiating a project to propose new regulations. These regulations when adopted, will insure that all propeller control systems will be fail-safe.

HAMILTON STANDARD

14RF PROPELLER

SPECIAL CERTIFICATION REVIEW REPORT

FEDERAL AVIATION ADMINISTRATION

ENGINE AND PROPELLER DIRECTORATE

AIRCRAFT CERTIFICATION SERVICE

NEW ENGLAND REGION

JUNE 11, 1992

INTRODUCTION

As a result of the accident of an Atlantic Southeast Airlines Embraer, EMB-120, on April 5, 1991, near Brunswick, Georgia, the Federal Aviation Administration (FAA) Engine and Propeller Directorate, Aircraft Certification Service, formed a Special Certification Review (SCR) team to examine the design and certification process used to approve the Hamilton Standard 14RF series propellers. The Hamilton Standard 14SF, and 6/5500/F series propellers were also reviewed at the same time due to their similarity to the 14RF series propellers. The SCR was conducted in accordance with FAA Order 8110.4, "Type Certification", paragraph 21, "Special Certification Review", and is responsive to National Transportation Safety Board (NTSB) recommendations A-92-25 through 27.

The SCR team was formed to review the Hamilton Standard 14RF series propellers and systems to determine if the original design complied with Title 14, Code of Federal Regulations (CFR) Part 35, Airworthiness Standards: Propellers. Specific review was conducted pertaining to the provisions of Section 35.21, Reversible Propellers, to determine if subsequent propeller design changes created any unsafe conditions, to determine if the 14RF series propellers are fail-safe, to recommend corrective actions for any unsafe conditions found, and to recommend appropriate changes or revisions to the propeller airworthiness standards.

The NTSB investigated the accident and concluded that the probable cause of the accident was an in-flight loss of control of the airplane due to a malfunction of the left engine propeller control unit (PCU) which allowed the propeller blade angles to go below the flight idle position.

The five person SCR team consisted of a team leader, Mr. Thomas Moreland, Propulsion Branch Manager, Seattle Aircraft Certification Office (ACO), Mr. Robert Alpiser, Aerospace Engineer, Small Airplane Directorate, Mr. Kent Valentino, Manufacturing Inspection Specialist, Atlanta ACO, Mr. Martin Buckman, Aerospace Engineer, Engine and Propeller Directorate and Mr. Frank Walsh, Aerospace Engineer, Boston ACO.

The SCR team visited Hamilton Standard, Windsor Locks, CT, on June 2, 3 and 4, 1992, to review the propeller type design and type certification data. The team met with the following Hamilton Standard personnel: James Baum, Manager, Regional Aircraft Products, Project Engineering, Bernard Gatzen, Vice President, Regional Aircraft Products, Robert Perkinson, Manager, Propeller Actuators and Control, Design and Development, William Bymers, Senior Design Engineer, Michael Stewart, Project Manager, FAA-DER ANE-236, Jorge Laires, Senior Experimental Engineer, Bruce Twambly, Chief Reliability Engineer for Mechanical Products, Robert Walters, Project Engineer, FAA-DER ANE-242, and Peter Dowd, Design Engineer.

The SCR team, with the exception of Mr. Kent Valentino, met again at the Burlington, Massachusetts, New England Regional Office, on June 5 through 11, 1992, to document the results of their investigation and to develop recommended corrective actions.

14RF, 14SF, and 6/5500/F PROPELLER CERTIFICATION

Hamilton Standard's original application for the new design concept, hydromechanical double acting pitch control propeller, designated 14RF was submitted on October 9, 1979. The Preliminary Type Certification Board Meeting for this application was held on November 14, 1979, jointly by FAA offices of the New England and Great Lakes Regions. During the original certification development program, Hamilton Standard elected to make various design changes and improvements. This delayed the certification process and resulted in re-application for the 14RF on June 24, 1982. The Preliminary Type Certification Board meeting for this re-application was held on July 15, 1982, with the New England Directorate designated as the responsible FAA propeller certification office. FAA certification basis for the 14RF series was established as Federal Aviation Regulations (FAR) Part 35, Amendments 1-5, which includes Instructions for Continued Airworthiness.

The Special Certification Review team conducted a detailed and extensive review of the following special tests, analysis and requirements for all sections of FAR 35: Blade retention test, blade fatigue test, hub fatigue test, endurance test, functional test, blade pitch control and component test, Failure Mode Effects and Analysis (FMEA), pitchlock functional test, pitchlock load test, dome and retention test, dome anti-torque arm test, bird strike capability, lightning protection, blade corrosion protection, environmental consideration, hub quality report, and blade pitch change pin and its retention structural integrity.

In addition to the certification tests and analysis noted above the following system and development test data and analysis were reviewed for the 14RF, 14SF, and 6/5500/F series propeller systems:

TEST CELL - stress survey, compatibility/functional test, oil pressure survey, and test club synchrophaser compatibility.

TEST STAND - stress survey, compatibility/functional test, and synchrophaser compatibility.

FLYING TEST BED - vibration evaluations and stress survey, compatibility/functional test, oil temperature and pressure survey.

WHIRL TESTING - complete whirl tests for all models, however for the 6/5500/F a special test of 50,000 pitch change cycles were conducted for the entire control system throughout the full operating range.

The SCR team concluded that the propeller system had met the regulations and was certificated correctly. The propeller system was also considered fail-safe for any mechanical control or hydraulic failure at the time of certification, based on the results of tests conducted in a test cell and on an aircraft. The aircraft tests consisted of high speed taxi and ground maneuvers. These tests showed the propeller system would pitchlock or travel toward high pitch (feather) by internal bearing and friction loads when critical parts were failed.

Recent flight tests were conducted which showed that if the transfer tube is decoupled, the blade angle may go to either flat pitch or high pitch at random with certain failed components. These flight tests demonstrated that the system design is not fail-safe.

ADDITIONAL INFORMATION OBTAINED FROM ACCIDENT FINDINGS

Investigation of the accident found that in the propeller control system, the attachment of the quill shaft to the oil transfer tube, had failed. This was caused by extreme wear of the PCU quill shaft teeth that normally engage the splines of the propeller oil transfer tube. This apparently resulted in a decoupling of the oil transfer tube from the driving ballscrew which eliminated governor and power lever control of the propeller pitch setting.

The failure occurred after the finish on the spline of the oil transfer tube was changed from an A-1, Nitrided surface finish to a Titanium - Nitrided surface finish. This was done to improve manufacturing efficiency and was processed as a minor change.

The failure occurred within 800 hours of service. It was caused by the harder surface of the Titanium - Nitrided surface finish splines which were incompatible with the internal quill teeth. With the A-1, Nitrided surface finish splines there never has been a reported problem with the oil transfer tube spline-quill teeth connection in approximately 8 million hours of service.

Examination of the left propeller components indicated a propeller blade angle of about 3 degrees at impact while the left PCU ballscrew position was consistent with a blade angle of 79.2 degrees. The discrepancy between the ballscrew position and the position of the pitchlock acmescrew is a strong indication that a disconnect between these two components occurred prior to impact and that the left propeller had achieved a blade angle below the normal flight range.

After the accident, aircraft flight and ground tests were conducted in an Embraer-120 aircraft. For these tests the oil transfer tube was decoupled from the driving ballscrew at the quill shaft to oil transfer tube connection. This was accomplished by removing the quill shaft teeth.

Two test articles were installed into the propeller system for flight testing to facilitate safe operation. They were a low blade angle stop, and a hydraulic shutoff control valve to manually shutoff hydraulic control of the propeller.

Two ground run tests to 90 knots were conducted and the blades went to increase pitch (68 degrees).

Two flight tests were then conducted. In these tests the blades drifted toward both high and low pitch at random. In both flight tests the blade angle ended at the 22° stop.

This demonstrated that the blades can go to low pitch and the propeller control system was not fail-safe.

RELATED SERVICE PROBLEM

A related service problem has been found at the engagement of the ballscrew spline teeth with the gear teeth of the quill. Four cases of extreme wear at the ballscrew spline teeth were found, on the Embraer-120, such that they would not fully engage the gear teeth on the quill.

Airworthiness Directive (AD) 92-08-03, dated, April 27, 1992, was issued to require inspection of this joint every 900 hours of service for propeller installations on the Embraer-120 only because inspections conducted on all model installations indicates that extreme wear is isolated to the Embraer-120. On-going research and testing has not found the cause of the extreme wear of these parts.

The SCR team has reviewed this service problem and believes the AD should be extended to include all propeller models.

RECOMMENDATIONS

Based on the above review, the SCR Team recommends that the Engine & Propeller Directorate take the actions listed below. (The SCR Team has reviewed Hamilton Standard's June 2, 1992, Petition to the NTSB for Reconsideration or Modification of Aviation Accident Report dated April 28, 1992. The SCR Team believes that the recommendations listed below are applicable irrespective of any action which may be taken by the NTSB with respect to this petition.)

1. Revise AD 92-08-03, dated April 27, 1992, which requires a 900 hour repetitive inspection of the servo ballscrew internal spline, to extend its applicability to include all models of the 14RF, 14SF, and 6/5500/F propellers.

2. Issue an AD to require repetitive 1200 hour disassembly and inspection of the propeller and control system.

3. Assure that the propeller build standard for the 14RF, 14SF, and 6/5500/F propellers conforms to the certificated configuration in place prior to incorporation of the titanium-nitride oil transfer tubes in production.

4. Assure that all future design changes to the 14RF, 14SF, and 6/5500/F propellers are classified as "major" changes pending incorporation of the provisions of Recommendation 5.

5. Require that Hamilton Standard develop changes to the design of 14RF, 14SF, and 6/5500/F propellers to incorporate fail-safe features. The design should be certificated and available within two years with incorporation in all in-service propeller units within three years thereafter. Incorporation of the fail-safe design features would be terminating action for the actions specified in Recommendations 1, 2, 3, and 4.

6. Initiate rulemaking action to change FAR 35 to require all propeller control systems to be fail-safe or damage tolerant. The damage for the damage tolerant design must be easily detected without disassembly before catastrophic failure.

The chairman Moreland and members Buckman, Walsh, Alpiser and Valentino concurred in these recommendations.

Thomas D. Moreland
Chairman