Memorandum

U.S. Department of Transportation
Federal Aviation Administration

Subject:	ACTION: Durability Substantiation of Reciprocating Engine Redesigned Parts (PMA, STC, Type Design Change)	Date:	November 29, 1999
From:	Manager, Engine and Propeller Directorate, ANE-100	Reply to Attn. of:	Mark Rumizen Tel: (781)238-7113 Fax: (781)238-7199
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1. INTRODUCTION

A review of certification data submitted for type design changes, Parts Manufacturing Approval (PMA), and Supplemental Type Certificate (STC) projects for reciprocating engine critical, highly stressed, or complex parts has revealed a wide disparity in the application of the durability requirements of Part 33 of the Federal

Aviation Regulations (14 CFR Part 33), specifically §33.19, or Civil Air Regulation (CAR) §13.104. In many cases, accomplishment of the endurance test of §33.49 or CAR §13.254 was considered sufficient substantiation of durability, while in other cases, extensive testing and analysis was performed in addition to the endurance test. This policy memo will provide information to explain the requirements for durability, and clarify the relationship between durability and manufacturers recommended overhaul intervals.

2. BACKGROUND

The initial models of today's horizontally opposed piston engines were certified in the late 1940's and 1950's. These engines initially entered service with recommended time between overhaul (TBO) intervals of 500 hours to 750 hours. These TBO's were recommended by the engine designer and accepted by the FAA based on the results of the certification block testing. Successful performance of the block testing was sufficient to substantiate safe operation over the recommended TBO because of the short duration of those initial TBOs, thus meeting the durability requirement of CAR §13.104. However, over the last 50 years engine manufacturers have gradually increased their recommended TBOs for existing engine designs to intervals as long as 2000 hours. FAA acceptance of these TBO increases was based on successful service, engineering design, and test experience. New engine designs, however, are still introduced with relatively short TBOs, in the range of 600 hours to 1000 hours.

Over the life of an engine, redesigned parts are approved for incorporation into existing engine designs through type design changes, Parts Manufacturer Approvals (PMA), or Supplemental Type Certificates (STC). Redesigns can involve material changes, material process changes, geometry changes, or any combination of these. What may initially appear to be a relatively benign design change, such as a material process change, can actually have a significant affect on material strength or stress and on the ability of the part to operate safely for the recommended engine TBO.

The current regulations applicable to these design changes all include a durability requirement that requires engine parts be designed to operate safely for the duration of the applicable overhaul interval. The applicable overhaul interval is either the recommended TBO for the engine on which the part will be installed, or a unique TBO if established specifically for the redesigned part. In some cases, where applicants have recognized the effect of the lengthy TBOs on durability, they have performed tests and analyses specifically to meet the durability regulatory requirement. However, in other cases the endurance test of § 33.49 and CAR §13.254 was still considered adequate to substantiate the durability requirement despite the lengthy TBOs.

3. APPLICABLE REGULATIONS

The certification procedures specified in Part 21 (14 CFR Part 21) require that redesigned parts must meet the applicable airworthiness standards. The specific regulations are:

- For PMA (test & computation), §21.303(c)(4) requires the applicant to "substantiate the design meets the applicable airworthiness standards".

- For STC parts, §21.115(a) requires that "Each applicant for a supplemental type certificate must show that the altered product meets applicable airworthiness requirements…".

- For type design changes, §21.101(a) requires that "…an applicant for a change to a type certificate must comply with either- (1) The regulations incorporated by reference in the type certificate, or". For engine parts, the applicable regulations or airworthiness standards are contained in either Part 33 or CAR Part 13. The above stated Part 21 regulations require that an applicant review the applicable airworthiness standards and make a determination as to which specific sections require re-evaluation, based on the part's

redesign and the extent of that redesign. Critical, highly-stressed, or complex reciprocating engine parts, by their very nature, require re-evaluation of durability when redesigned.

Civil Air Regulations §13.104, entitled "Durability", was included in Part 13 at least as early as 1956 (see, 21 FR 4305, June 20, 1956). Because this was prior to the introduction of turbine engines to commercial aviation, it is obvious that this regulation was intended for reciprocating engines. It requires that "all parts of the engine shall be designed and constructed to minimize the development of an unsafe condition of the engine between overhaul periods". That durability requirement appeared as a section of Subpart B, dealing with the design and construction of reciprocating engines. As such it is "…applicable to the engine when it is installed, operated, and maintained in accordance with the instruction manual…" CAR §13.100 (b). This requires that the limits specified in the service instructions, including the TBO, be consistent with the substantiated engine design. The intent of CAR §13.104 was carried over to §33.19 when Part 33 was issued in 1965.

4. CONCLUSION

For PMA (test & computation), STC, or type design change certification projects involving critical, highly stressed, or complex reciprocating engine parts, the following must be considered when substantiating compliance with §33.19 or CAR §13.104:

- The substantiation scope must be based on the extent of the redesign.

- The substantiation scope must be based on the TBO applicable to the engine on which the part will be installed, unless the applicant chooses to specify a separate inspection or replacement interval for the part. In general, the longer the TBO, or the greater the extent of the redesign, the more testing and/or analysis required.

- Elements of the substantiation scope may include material analyses and testing, finished part analysis and testing, and engine block testing, depending on the criticality of the component and the differences with the original type certificated part.

- The substantiation test methods must be designed to simulate the duty cycle per flight of the applicable engine, extrapolated to the recommended TBO or inspection interval. The different phases of the duty cycle, such as takeoff, climb, or cruise, should be expressed in terms of the typical engine parameter values experienced, such as manifold pressures, horsepower, cylinder head temperature, exhaust gas temperature, and RPM.

Questions regarding this policy memorandum may be directed to Mark Rumizen, ANE-110, at (781) 238-7113.

Original Signed by T. Boudreau for
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dated November 29, 1999