



U.S. Department
of Transportation
**Federal Aviation
Administration**

Memorandum

Subject: **ACTION:** Requesting Review of and Concurrence with,
Equivalent Level of Safety (ELOS), Raytheon Aircraft
Company Model 3000, FAR 23.1305(c)(5) and
23.1549(b), Digital Propeller Tachometer and Markings;
Finding No. ACE-99-10.

Date: July 27, 1999

From: Manager Wichita Aircraft Certification Office,
ACE-115W

Reply to: Tina L. Miller
Attn. of: 316-946-4168

To: Manager Small Airplane Directorate, ACE-100

This memorandum is to document concurrence with an equivalent level of safety for the digital propeller tachometer and markings and the requirements of 14 CFR, Part 23, Sections 23.1305(c)(5) and 23.1549(b).

Background: The Raytheon Aircraft Company (RAC) Model 3000 propeller tachometer uses a direct-reading, digital display that does not have a trend monitoring capability. FAR 23.1305(c)(5) states that a tachometer indicator must be provided for the engine and policy in the past has been that an indicator should have the ability for trend monitoring. Also, the indicator displays in white digits with the propeller normal range indicated by a black background (the background turns red when propeller speed is in a restricted range). FAR 23.1549(b) and Advisory Circular (AC) 20-88A, paragraph 6.c require direct-reading, digital instruments to have a green color-code to indicate normal regions. AC 20-88A, paragraph 6.d states that if all abnormal conditions are adequately indicated, green markings are unnecessary based on a finding of equivalency.

The Raytheon Model 3000 is a single engine, turboprop aircraft with an electronic integrated engine/propeller control system which uses input from a single power control lever (PCL) to control power. Propeller pitch and speed are controlled automatically through the PCL (no separate propeller control is provided), with the propeller governed at 100% Np in flight above 140 KIAS. With the pilot not having direct input on propeller speed and the propeller governed to 100% Np in flight, trend monitoring of the propeller speed is not deemed as necessary by Raytheon. Therefore, the propeller tachometer provided is a direct-reading, digital instrument with no trend monitoring capability. When propeller speed is in the normal range, the background of the tachometer is black with white digits. This is to provide maximum contrast of the digits for ease of reading.

Applicable Regulations: 14 CFR, Part 23, Sections 23.1305(c)(5) and 23.1549(b).

Applicant's Position: Raytheon's position was provided in RAC's letter 940-98-01-345, dated January 15, 1998. The conclusion only is included here:

The digital tachometer is found to provide an equivalent level of safety to §23.1305(c)(5) because:

1. A tachometer is provided which indicates the speed of the propeller and highlights the displayed digits with a red background at the established limiting speeds.
2. Governed N_p in flight is 100%, even with a control system failure. There is no need, or capability, to set RPM in order to set power and therefore no need for trending or rate-of-change information.
3. A latent failure of the secondary N_p governor is addressed by a preflight check of the secondary governor before each flight.

Rate of change or trend information for the N_p tachometer is not required since it is not a pilot controllable feature. The following list discusses typical operations and the corresponding propeller RPM range and shows that propeller RPM trend or rate of change information is not required. The only time the propeller RPM can enter a restricted range is during ground operations unless there have been multiple failure in the engine control system.

1. The only restriction below 100% N_p in flight is in spins. The control system automatically governs this, also spins are prohibited with the engine control system inoperative.
2. Typical ground idle N_p is 46 to 48%, well clear of the sustained ground operation range.
3. Idle N_p provides enough thrust for sustained taxi operations. Additional thrust required for nonsustained taxi operation (i.e., initiating taxi, taxiing uphill, taxiing through snow, slush, etc.) will cue the pilot to observe the N_p indicator and adjust power as needed to eliminate sustained operations in this range.
4. Engine runup does not require any sustained operation in or near the restricted range.
5. The indicator highlights the displayed digits with a red background to alert the pilot of operation in the restricted range or above rated max RPM as per AC-20-88A. The system is intuitive since it is based on 0% to 100% and pilot training will provide the pilot with this knowledge.

The digital tachometer is found to provide an equivalent level of safety to §23.1549(b) because although the Model 3000 digital tachometer displays the background color as black vs the 23.1549(b) green AC20-88A, paragraph 6d states "If all abnormal conditions are adequately indicated by specific design features, green markings are unnecessary based on a finding of equivalency". All abnormal conditions are indicated by a red background as shown by the table in the System Description section and restated below.

1. The tachometer highlights the displayed digits with a red background to alert the pilot to operation above maximum rated propeller RPM.
2. The only restriction below 100% N_p in flight is in spins. The control system automatically governs this, also spins are prohibited with the engine control system inoperative.
3. During ground operation the tachometer highlights displayed digits with a red background in the restricted range from 62 to 80%.

The following discussion addresses items (a) through (d) listed in the FAA letter to RAC dated December 10, 1997.

Item (a) FARs 23.1311 and 23.1321

FARs 23.1311 and 23.1321 are specific findings for the Model 3000 and will be evaluated during certification testing. FAA Preliminary Cockpit Evaluation has already been completed with subsequent changes recommended (ref FAA letter to RAC dated July 22, 1997). RAC has made changes to the cockpit based on this evaluation. This item is considered a separate issue from the equivalent level of safety finding on FARs 23.1305(c)(5) and 23.1549(b).

Item (b) The ability to assess necessary trend or rate information quickly, including if and when this information may be needed during inflight engine restarts.

The ability to assess trend or rate of change information from the propeller tachometer on the Model 3000 is not necessary and is discussed in the conclusions section. In addition, this information is not needed during inflight restarts since the PT6A-68 is a free turbine. Engine starting RPM is based on gas generator speed N_G and not propeller speed N_p .

Item (c) The ability to assess how close the indicated parameter is relative to the redline limit.

In flight the only red line restriction is above 100% N_p . This should be intuitive to the pilot and will also be reinforced by pilot aircraft familiarization. Since the engine control system governs the propeller to 100%, which is just below red line, the pilot does not need to assess how close the propeller is to the redline limit. The engine will not exceed redline unless multiple failures have occurred. In addition, the propeller speed is not directly controllable by the pilot. During ground operations, additional thrust required for nonsustained taxi operation (i.e., initiating taxi, taxiing uphill, taxiing through snow, slush, etc.) or engine checks will cue the pilot to observe the N_p indicator. The ability to assess how close the propeller is to the redline is not necessary since these are transient operations and not sustained. The pilot will watch for a red indication of the tachometer and adjust power as needed to avoid sustained operation in the restricted range. Furthermore, the propeller restricted operation range is above the normally required N_p range for ground operations.

Item (d) Compensating engine design features or characteristics that would forewarn the crew prior to the parameter reaching redline limit.

The compensating engine and software design features which keep the propeller from reaching redline are discussed in the Propeller Operation Restrictions section. These features do not allow the propeller into the restricted range in flight.

It is our conclusion that the propeller RPM indicator and system have been analyzed and provide an equivalent level of safety to FAR §23.1305(c)(5) and §23.1549(b) through Amendment 23-47.

FAA's Position: In addition to the requirements of FARs 23.1305 and 23.1549 using the guidelines provided in AC 20-88A, to certify the direct-reading, digital format of the tachometer for the Model 3000, the following issues need to be addressed:

(a) FARs 23.1311 and 23.1321 need to be considered. The visibility and relative location of the indicated parameter should be stringently reviewed, including appropriate conditions of lighting and instrument panel vibration. Sometimes parameters are proposed for a direct-reading, digital display when inadequate display space is available for both an analog and digital annunciation. This situation may result in a cluttered, hard to read (i.e., small digits) display which minimizes use to the crew.

(b) The ability to assess necessary trend or rate information quickly, including if and when this information may be needed during inflight engine restarts.

(c) The ability to assess how close the indicated parameter is relative to the redline limit.

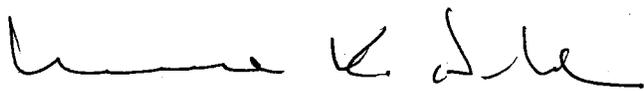
(d) Compensating engine design features or characteristics that would forewarn the crew prior to the parameter reaching redline limit.

Recommendation: The FAA's concerns were addressed in Raytheon's response which is summarized in the Applicant's Position. In FAA letter dated March 25, 1998, the FAA stated that "FARs 23.1311 and 23.1321, which are Specific Findings for the propeller tachometer, are areas that should be satisfactorily addressed for an Equivalent Level of Safety Finding to FARs 23.1305(c)(5) and 23.1549(b).....we cannot provide concurrence to subject findings [Model 3000 Equivalent Level of Safety to FARs 23.1305(c)(5) and 23.1549(b)] until the Specific Findings to FARs 23.1311 and 23.1321 for the tachometer are completed." The specific finding to FAR 23.1311 was closed by FAA letter dated May 27, 1999. The specific finding to FAR 23.1321 was closed by FAA letter dated July 22, 1999. The FAA concurs with the applicant's position and agrees that the propeller RPM indicator and system have been analyzed and provide an equivalent level of safety to FAR §23.1305(c) and §23.1549(b) through Amendment 23-47. The certification basis for the Model 3000 will include an Equivalent Level of Safety finding for FARs §23.1305(c) and §23.1549(b).

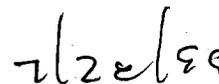


Everett W. Pittman, ACE-115W
Manager, Wichita Aircraft Certification Office

Concurrence:



Manager, Standards Office, ACE-110



Date



Manager, Small Airplane Directorate, ACE-100



Date