Federal Aviation Administration

Memorandum

Date: May 4, 2012

To: Manager, New York ACO, ANE-170

From: Manager, Small Airplane Directorate, ACE-100

Prepared by: James Delisio, Aerospace Engineer, New York Aircraft Certification Office, ANE-173

Subject: Equivalent Level of Safety Finding (ELOS) to 14 CFR, part 23, §§ 23.1305(a)(2), (a)(3), (c)(2) and (c)(5), and 23.1549 for Viking Air Limited's Model DHC-6-400, FAA Project No. AT6129NY-A

ELOS Memo#: ACE-11-17

Regulatory Ref: 14 CFR, part 21, § 21.21(b)(1), 14 CFR, part 23, §§ 23.1305(a)(2), (a)(3), (c)(2) and (c)(5) and 23.1549(a), (b) and (c).

The purpose of this memorandum is to inform the Certificate Management Aircraft Certification Office of an evaluation made by the Small Airplane Directorate on the establishment of an Equivalent Level of Safety (ELOS) finding to the display requirements of 14 CFR, part 23, §§ 23.1305(a)(2), (a)(3), (c)(2) and (c)(5), and 23.1549(a), (b) and (c) for the Viking Air Limited (Viking) Model DHC-6-400.

Background

Viking is requesting an ELOS finding to 14 CFR, part 23, §§ 23.1305(a)(2), (a)(3), (c)(2) and (c)(5), and 23.1549 on the Model DHC-6-400 for the digital, numeric-only display of engine speed (NG), propeller speed (NP), fuel flow, oil pressure and oil temperature.

The DHC-6 Series 400 is a non-pressurized, all-metal, high-wing monoplane with a fixed tricycle landing gear and powered by two Pratt and Whitney Canada Ltd. (PWC) PT6A-34 engines, each of which drives a Hartzell three-bladed propeller. The DHC-6 Series 400 includes a cockpit upgrade with a Honeywell Primus Apex Electronic Flight Instrument System (EFIS). Apex is a fully-integrated four-screen EFIS that provides the following:

a. Primary flight displays (PFD) (left and right sides).
b. Communication and navigation functions.
c. Map display.
d. Safety systems.

e. Flight configuration displays.
f. Engine instruments.
g. Fuel system instruments.
h. Crew alerting system.

The engine instrument display is located in the upper inboard corner of the PFD and is shown in Figure 1. The display for NG, NP, fuel flow, oil pressure, and oil temperature is a digital, numeric-only display. During normal operations, all digital values are displayed in white against a black background. When an engine parameter exceeds its limitation, the integer background changes to amber or red, depending on the severity of the exceedance, and is always accompanied by a caution or warning Crew Alerting System (CAS) message and a single chime (for caution messages) or triple chime (for warning messages). See Figure 2 and Figure 3 for the caution and warning conditions, respectively, for the NG display.

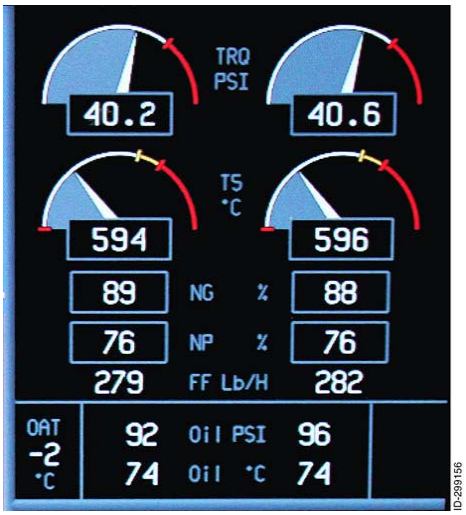

Figure 1
Typical PFD Engine Instrument Display
Normal Operating Range

Figure 2
NG Display – Caution Condition

Figure 3
NG Display – Warning Condition

Historically, it has been considered that digital only powerplant display markings do not provide sufficient trend or rate-of-change information for critical engine parameters. In addition to limiting the flight crew's ability to assess trend information, they also tend to be limited in their ability to provide a comparison of parameters from multiple engines or in their ability to check

the general proximity of differing parameters against their individual limits. Overall, this results in reduced crew awareness. AC 20-88A states "while these shortcomings can be compensated for with additional implementation provisions, the application of digital-only indicators to powerplant displays should be made with care and subject to evaluation on a case-by-case basis."

The following section references the factors from AC 23.1311 1B Chg 1, paragraph 9.4 that must be addressed to provide a rationale for the finding of an equivalent level of safety.

a. *The visibility and relative location of the indicated parameter should be reviewed, including appropriate conditions of lighting and instrument panel vibration.*
b. *The ability to assess necessary trend or rate-of-change information quickly, including when this information may be needed during in-flight engine restarts.*
c. *The ability to assess how close the indicated parameter is relative to a limit.*
d. *The value to the crew of quickly and accurately comparing engine-to-engine data for multiengine aircraft.*
e. *Compensating engine design features or characteristics that would forewarn the crew before the parameter reaching the operating limit (for example, redline).*

ELOS's for digital numeric-only powerplant displays have been granted for numerous turboprop powered Part 23 airplanes. A mitigating feature for the issuance of these ELOS's has been the use of colors specified per 14 CFR, part 23, § 23.1549. The use of these colors is also discussed in AC 23.1311-1B Chg 1, paragraph 22.7:

> *Use red as the warning annunciation for emergency operating conditions when immediate flight crew recognition is required, and immediate correction or compensatory action may be required. Use amber for the cautionary annunciation for abnormal operating conditions when immediate flight crew awareness is required, and subsequent flight crew action may be required. Use white or another unique color for advisory annunciations of operating conditions that require flight crew awareness and, possibly, action. Use green for indication of safe operating conditions.*

Therefore, in accordance with the provisions of § 21.21(b)(1), a type certificate (TC) cannot be issued for the Viking DHC-6-400, unless the airworthiness provision not complied with is compensated for by factors that provide an equivalent level of safety.

Applicable Regulations

14 CFR, part 21, § 21.21(b)(1)
14 CFR, part 23, §§ 23.1305 and 23.1549

Regulations Requiring an ELOS

14 CFR, part 23, § 23.1305:

The following are required powerplant instruments:

(1) *For all airplanes.*

…

(2) An oil pressure indicator for each engine.

(3) An oil temperature indicator for each engine.

© For turbine engine-powered airplanes. In addition to the powerplant instruments required by paragraph (a) of this section, the following powerplant instruments are required:

…

(2) A fuel flowmeter indicator for each engine.

…

(5) A tachometer indicator (to indicate the speed of the rotors with established limiting speeds) for each engine.

…

14 CFR, part 23, § 23.1549:

For each required powerplant and auxiliary power unit instrument, as appropriate to the type of instruments—

(a) Each maximum and, if applicable, minimum safe operating limit must be marked with a red radial or a red line;

(b) Each normal operating range must be marked with a green arc or green line, not extending beyond the maximum and minimum safe limits;

© Each takeoff and precautionary range must be marked with a yellow arc or a yellow line

…

Description of Compensating Design Features

The VAL DHC-6 Series 400 aircraft incorporates the Honeywell Primus Apex™ integrated avionics suite and an "all-glass" cockpit. Primary flight information is indicated to the crew on the pilot's Primary Flight Display (PFD) and the copilot's PFD. Engine displays are indicated on each PFD in a 1/6 display segment that includes semi-arc graphical and digital displays for Torque (TRQ) and turbine temperature (T5), and all-digital displays for engine rpm (NG), propeller rpm (NP), fuel flow (FF), oil pressure and oil temperature. Figure 1 shows the left PFD engine display. Caution and warning ranges are indicated with amber and red, including inverse video background on the graphical displays and inverse video background on digital displays, when in the caution and warning range(s) of each parameter.

Figure 1 Right PFD Engine Display

Engine displays on Apex are required to fit in a 1/6 window. In order to take advantage of the space on window for the parameters that are most pertinent to setting engine power and to ensuring that the engine is operating correctly, TRQ and T5 were identified as appropriate for graphical displays. In addition, these important parameters have windows for digital display of the information. The other parameters are not as important to setting engine power and monitoring engine temperature under dynamic operating conditions and are only presented digitally. However, all of the displays make extensive use of color to ensure that out-of-limit conditions quickly become apparent to the pilot.

The engine displays for the DHC-6 Series 400 were evaluated extensively by ground and flight test, as well as through specification and design review, and system safety assessment. This evaluation included the following:

a. Extensive integration testing of the displays at an engine system sensor level and at an aircraft level.
b. Extensive flight testing evaluating the performance of the displays under a variety of day and night conditions and for all phases of flight.
c. Demonstration of the effectiveness of the displays on the ground and in flight under a variety of normal, abnormal and emergency operating conditions including inflight engine shutdowns and relights, numerous ground cart and battery engine starts, and a variety of failure conditions such as loss of engine sensors and integrity of the graphical displays.
d. Pilot work load assessment.
e. System safety assessment.
f. Consideration of cockpit ergonomics including visibility of the displays under a variety of cockpit lighting and operating conditions.
g. Suitability of display for quick recognition by the pilot of abnormal operating conditions.

In addition to the above evaluations and considerations, the system design also includes a variety of visual and aural alerts when caution or warning conditions occur, including but not restricted to the following:

a. Color change of the graphical and/or digital displays appropriate to the nature of the exceedence (caution or warning).
b. Annunciation on the engine displays of various conditions such as ignition/start and single engine (S/E) operations.
c. Crew alerting system (CAS) messages corresponding to caution (amber) and warning (red) conditions for various engine parameters including TRQ, T5, NG, and NP.
d. Integration of caution and warning conditions with the aircraft's master caution/master warning system.

Based on the evaluation completed to date and the compensating features described above, Viking is of the opinion that the engine display system design implemented on the DHC-6 Series 400 Primus Apex™ system provides an equivalent level of safety to what is required by 14 CFR, part 23, §§ 23.1305(a)(2), (a)(3), (c)(2) and (c)(5), and 23.1549(a), (b) and (c).

Transport Canada (TCCA) concurred with Viking's analysis and stated that the equivalent level of safety for all the displays has been demonstrated.

Explanation of Compensating Design Features

Digital Engine Speed (NG)

Regulation: § 23.1305©(5)

Explanation of Equivalent Level of Safety

The trend information of the indicator required by the regulation can be equivalently provided by the change in digital value and the change in digit color of the digital only indication. This also includes the rate of change information for engine speed for this airplane. This has been evaluated during flight testing and found to be acceptable.

Digital Propeller Speed (NP)

Regulation: § 23.1305©(5)

Explanation of Equivalent Level of Safety

The trend information of the indicator required by the regulation can be equivalently provided by the change in digital value and the change in digit color of the digital only indication. This also includes the rate of change information for propeller RPM for this airplane. This has been evaluated during flight testing and found to be acceptable.

Digital Fuel Flow

Regulation: § 23.1305©(2)

Explanation of Equivalent Level of Safety

The fuel flow parameter does not have a cautionary range or high or low limit values defined by the engine manufacturer. Therefore, no caution or limit markings are required, and there is no associated pilot action. As a result, the limited rate-of-change and trend information available from the changing white digital display is adequate and the available trend information is equivalent to that required of the analog indicator. This has been evaluated during flight testing and found to be acceptable.

Digital Oil Pressure

Regulation: § 23.1305(a)(2)

Explanation of Equivalent Level of Safety

The trend information of the indicator required by the regulation can be equivalently provided by the change in digital value and the change in digit color of the digital only indication. This also includes the rate of change information for oil pressure for this airplane. This has been evaluated during flight testing and found to be acceptable.

Digital Oil Temperature

Regulation: § 23.1305(a)(3)

Explanation of Equivalent Level of Safety

The trend information of the indicator required by the regulation can be equivalently provided by the change in digital value and the change in digit color of the digital only indication. This also includes the rate of change information for oil temperature for this airplane. This has been evaluated during flight testing and found to be acceptable.

After reviewing the submitted data and analysis for this project, the FAA believes the applicant can demonstrate an equivalent level of safety to 14 CFR, part 23, §§ 23.1305(a)(2), (a)(3), (c)(2) and (c)(5), and 23.1549(a), (b) and (c) for the digital, numeric-only display of the following engine parameters: engine speed (NG), propeller speed (NP), fuel flow, oil pressure and oil temperature.

The basis of this ELOS Memorandum was developed from the FAA Issue Paper P-2 at Stage 4, which documented the agreement with Transport Canada and Viking Air Limited.

FAA Approval of the ELOS Finding

The Small Airplane Directorate concurs with the requested ELOS for the Viking Air Limited Model DHC-6-400 finding to 14 CFR part 23, §§ 23.1305(a)(2), (a)(3), (c)(2) and (c)(5), and 23.1549(a), (b) and (c)for the digital, numeric-only display of engine speed (NG), propeller speed (NG), fuel flow, oil pressure and oil temperature.

This ELOS finding does not cover the non-standard color scheme used in the displays.

The displays, as presently configured, use white instead of green to denote the normal operating range, and are not compliant with 14 CFR, part 23, § 23.1549(b). Viking Air has applied for a time-limited exemption to allow the aircraft to be certified with the current color and to operate for up to 15 months in this configuration. As part of this exemption, Viking has committed to revising all of the engine displays to use a color scheme that will comply with 14 CFR, part 23, § 23.1549.

Earl Lawrence	*5-4-12*
Manager, Small Airplane Directorate, Aircraft Certification Service	Date

ELOS Originated by New York ACO: James Delisio	Acting Manager, Aircraft Certification Office, Timothy Hadsall	Routing Symbol: ANE-170