



U.S. Department
of Transportation

**Federal Aviation
Administration**

Memorandum

Subject: **ACTION:** Review and Concurrence, Equivalent Level of Safety Finding for Cessna's AMETEK AMLCD Engine Indicator project on a Cessna Model 560XL

Date: Sept. 3, 2002

FAA Project Number TD3274WI-T

Reg. Ref: § 25.1549(a) through (d)

From: Manager, TSS Propulsion/Mechanical Systems Branch, ANM-112

Reply to
Attn. of: Jeff Janusz, ACE-118W
316-946-4148

To: Tina L. Miller, FAA Program Manager, ACE-117W

EIOS TD3274WI-T-P-1
Memo#:

Background

Cessna Aircraft Company has requested an Equivalent Level of Safety to 14 CFR part 25.1549(a) through (d) as required by 14 CFR part 21.21(b)(1). Cessna utilizes electronic displays of engine instruments and proposes to display engine high-pressure turbine speed (N₂) and engine fuel flow indication by digital display. Both indicators are incorporated into an Active Matrix Liquid Crystal Display (AMLCD). This request pertains to the use of a digital display for engine N₂ and fuel flow on the Cessna Model 560XL.

The Model 560XL uses electronic displays for those powerplant instruments required by § 25.1305 (c)(2) and (3). Both the high-pressure turbine rotor speed (N₂), and fuel flow are an all digital numeric presentation.

The primary engine displays on turbine engine powered transport aircraft have traditionally displayed the required engine rotor speeds, oil temperature, oil pressure and fuel flow required by § 25.1305 in an analog-only or an analog and digital format. Standby Engine Indicators (SEI's), when provided, have typically displayed these parameters in either analog-only or digital-only format. An increasing demand to conserve primary display space has led to digital-only primary displays for various engine parameters including those rotor speeds not normally used for power settingⁱ. This situation may result in a small, cluttered, low-resolution primary display.

In addition, it is generally accepted that digital-only displays are often less effective than conventional analog displays at providing the crew with discernible indication of the parameter during a rapid transient, and quick intuitive indication of the parameters approximate level, direction and rate of change, proximity to limits, and relationship to other parameters on the

ⁱN₁ (for EPR engines), N₂ (for N₁ engines), and N₃ (where applicable)

same engine or the same parameter on other engines. This is why AC 20-88A, paragraph 4(c), states that "digital indicators are most valuable when integrated with an analog display."

While an analog format is not required to comply with most of the referenced rules, § 25.1549 requires instrument markings, which presume an analog type display format. Consequently, features of the digital format must at least provide a level of safety equivalent to that intended by compliance with § 25.1549.

Other avionics installations in similar Cessna airplanes have been granted an Equivalent Level of Safety for direct reading, digital only displays for N₂. A partial list of these applications include Cessna Models 550, S550, 552 and 560 airplanes on Type Certificate Data Sheet (TCDS) A22CE, and the Cessna Model 750 on TCDS T00007WI.

This memo contains information concerning the Cessna Model 560XL electronic display, which exceeds that necessary to seek an Equivalent Level of Safety to § 25.1549. It is left intact for the reader's information and understanding of the Cessna show compliance methodology for this electronic display.

Applicable regulations

§§ 21.21(b)(1), 25.901(c), 25.1309(a), (b) and (c), 25.1321(c), 25.1549

Regulation requiring an ELOS

§§ 25.1549 (a) through (d)

Description of compensating design features or alternative standards which allow the granting of the ELOS (include design changes, limitations or equipment need for equivalency)

Section 25.1305(c) requires a fuel flow meter and tachometers be installed for all turbine engine installations. The Cessna AMLCD system contains indications for engine high and low-pressure rotor speeds (N1 & N2) and engine fuel flow. Therefore compliance with the requirements of § 25.1305(c) can be shown by design.

Section 25.1549 defines the markings of the gages meet specific requirements "as appropriate to the type of instrument....". The PW545A engine installation on the Model 560XL has no limitations based on engine fuel flow defined by either the PW545A Installation Manual or the Aircraft Flight Manual. Therefore the gage markings defined by § 25.1549 are deemed not applicable to the fuel flow indication, and a digital only display, similar to the display currently installed in the certified aircraft, is acceptable without need for an Equivalent Level of Safety.

The PW545A engine is controlled by a single channel Electronic Engine Control (EEC) with a hydromechanical backup fuel control unit (FCU). The EEC provides automatic N₂ redline protection during all normal operations and the FCU provides N₂ speed limiting in the event of reversion out of EEC controlled engine operations. The PW545A requires the use of high pressure turbine rotor speed (N₂) indication for engine starting and overspeed monitoring. The PW545A Engine Installation Manual defines the limits and usage of this parameter. Cessna has, in the past, used a digital only display for this parameter.

All Citation 525, 550 and 560 series aircraft, including the original configuration Model 560XL have similar limitations and are certified with a digital only N2 speed display.

The N2 speed display provides a digital readout from 0 to 115% with a resolution of 0.1%. The redline limit for N2 as established by P&WC is 101.8%. The digital display changes from green to red when N2 exceeds the redline limit plus the display resolution limit (i.e. the display changes to red at 101.9% N2). The change in color of the display provides an overspeed warning to the pilot and provides an equivalent level of safety to the redline or red arc required by § 25.1549(a).

Normal operation of the engine high pressure rotor speed is displayed by illuminated steady green digits on a black background and no other indication. The green digits meet the intent of a green arc or green radial; thus an equivalent level of safety to § 25.1549(b) is shown.

No precautionary or takeoff speed range is required by the PW545A Installation Manual, or by the installation of the engine in the aircraft. Engine high pressure rotor speed is within the normal operating range, unless the redline limit is exceeded at which point the display changes as described above. The PW545A Installation Manual allows an overspeed of up to 1.2% for up to 20 seconds before significant engine maintenance action is required. Therefore the redline notification constitutes equivalency to the precautionary range and is equivalent in safety to the yellow arc required by § 25.1549(c).

The Model 560XL engine installation has no high pressure turbine speed restrictions which would require an additional N2 red arc or red marking other than the defined maximum speed limitation of 101.8%. Therefore an equivalent level of safety is not required for § 25.1549 (d), as it is not applicable to the Model 560XL.

Explanation of how design features or alternative standards provide an equivalent level of safety to the level of safety intended by the regulation

The engine manufacturer's election to not define a precautionary speed range for N2, the automatic redline protection feature of the EEC for all normal modes of operation, the N2 speed limiting in manual mode operations, and an N2 display which changes from green to red for any exceedance of the N2 redline limit all provide adequate compensation for the "meager trend and proximity to limits display information" of digital displays by substantially reducing the need for crew awareness and intervention prior to the N2 redline being reached.

The FAA finds that an Equivalent Level of Safety to 14 CFR part 25.1549 (a) through (d) as required by 14 CFR part 21.21(b) may be granted for the use of direct reading, digital only displays for high-pressure turbine speed (N_2), and fuel flow (W_f) for the indicators incorporated into the Active Matrix Liquid Crystal Display (AMLCD).

FAA approval and documentation of the ELOS

The FAA has approved the aforementioned Equivalent Level of Safety Finding in the Cessna 560(XL) issue paper P-1. This memorandum provides standardized documentation of the ELOS that is nonproprietary and can be made available to the public. The Transport Directorate has assigned a unique ELOS Memorandum number (see front page) to facilitate

archiving and retrieval of this ELOS. This ELOS Memorandum number should be listed in the Type Certificate Data Sheet under the Certification Basis, ELOS section.

Note – because the contents of this memorandum will be kept as part of the permanent records of the project files, care should be taken to ensure that any sensitive or proprietary information is kept out of the memo.

/s/

Neil P. Schalekamp
3, 2002

September

Transport Standards Staff
Aircraft Certification Service

Date

Prepared by: Wichita ACO	Name: Jeff Janusz	Routing Symbol: ACE-118W
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