



# Memorandum

U.S. Department  
of Transportation  
Federal Aviation  
Administration

Subject: **ACTION:** Rockwell Collins; Cessna Model 525  
Equivalent Level of Safety; for Use of Digital Only  
Display of Engine High-Pressure Rotor Speed (N<sub>2</sub>) and  
Engine Fuel Flow: ACE-00-01

Date: January 6, 2000

From: Program Manager, ACE-117W,  
Wichita Aircraft Certification Office

Reply to: Bleakney  
Attn. of: 316-946-4135

To: Manager, Project Support Section, ACE-112, Small  
Airplane Directorate

## BACKGROUND:

Rockwell Collins Inc. has requested a finding of Equivalent Level of Safety to the requirements of 14 CFR Part 23, § 23.1305(c)(2), (c)(5) and § 23.1549(a) through (d) as required by 14 CFR Part 21, § 21.21(b) on the Cessna Model 525 for the use of direct reading, digital only displays for high-pressure turbine speed (N<sub>2</sub>), and fuel flow. Rockwell Collins has modified the original airplane to include electronic displays of engine instruments and proposes to display N<sub>2</sub> and fuel flow information in a digital only format.

## DISCUSSION OF APPLICABLE REGULATIONS:

14 CFR Part 23, § 23.1305 with respect to the applicable paragraphs reads as follows:

The following are required powerplant instruments:

(c) *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 reads as follows:

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

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

DISCUSSION OF APPLICABLE REGULATIONS (CONTINUED):

- (b) Each normal operating range must be marked with a green arc or green line, not extending beyond the maximum and minimum safe limits;
- (c) Each takeoff and precautionary range must be marked with a yellow arc or a yellow line; and
- (d) Each engine, auxiliary power unit, or propeller speed range that is restricted because of excessive vibration stresses must be marked with red arcs or red lines.

Other avionics installations in similar airplanes have been granted an Equivalent Level of Safety for direct reading, digital only displays for  $N_2$  and fuel flow. A partial list of these other airplanes are the Cessna Models 550, S550, 552 and 560 airplanes on Type Certificate Data Sheet (TCDS) A22CE, and the Cessna Model 750 on TCDS T00007WI. Although these Cessna Models are Transport Category airplanes, it is noteworthy to state that the regulatory requirements of § 23.1549 and § 25.1549 are identical.

ROCKWELL COLLINS INC. POSITION:

The Model 525 will use electronic displays for those powerplant instruments required by 14 CFR Part 23, § 23.1305 (a)(1), (2), (3), (c)(1), (2), and (5). Both the  $N_2$  and fuel flow are an all digital numeric presentation. These all digital displays will require a request for an Equivalent Level Of Safety to § 23.1549 (a), (b), (c) & (d), with appropriate justification to show equivalency to the requirements of § 23.1305, as well as to address the guidance criteria contained in Paragraph 8.5 of AC 23.1311-1A for electronic digital only engine displays.

The justification for the digital fuel flow display is provided below:

The Model 525 uses the Williams FJ44-1A engine with a hydro-mechanical fuel control. Each engine installation incorporates a Cessna installed temperature compensated fuel flow-measuring device, which provides the signal for the digital fuel flow display. For engine operation, fuel flow may be used as a verification of engine control system operation by providing indication on the initiation of fuel flow to the engine during start (prior to ITT rise), for maintenance, as well as for any requirement for supplemental fuel consumption information. The Williams FJ44-1A Installation Instructions, and FJ44-1A Operating Instructions do not contain any maximum or minimum operating limits, restricted operating ranges, or specific usage instructions including trend requirements for fuel flow or fuel flow indication. Therefore fuel flow is a parameter where limits, trend, or rate-of-change information may not be considered an important requirement.

The fuel flow digital only numeric indication is displayed on the MFD, which is centrally located on the instrument panel. The display provides a green digital readout against a black background, with a range from 0 to 2000 PPH and a resolution of 10 PPH. The indication is

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individually displayed for each engine, and is identified by a white "FUEL FLOW" above the displays.

A white "PPH" is located between the display for each engine. This display is considered to meet the intent of § 23.1305 (c)(2).

Since no engine operating limit is defined or required, the digits remain green during operation. Response of the digital display system is such that fuel flow information is easily discerned for each engine during both transient and steady state operation, and with the logical display location, comparison of engine-to-engine data can be quickly compared. The fuel flow display location has been shown by flight test demonstration to meet the requirements for visibility including appropriate conditions of lighting and panel vibration. Because no redline or red radials are required, an equivalent level of safety to § 23.1549(a) is not required and paragraphs 8.5.6.2, 8.6.5.3, and 8.5.6.5 of AC 23.1311-1A do not apply. The display design features are in agreement with paragraphs 8.5.6.1, 8.5.6.2, and 8.5.6.4 of AC 23.1311-1A.

The green digits of the display during operation meet the intent of a green arc or green radial, thus an equivalent level of safety to § 23.1549 (b) is shown. As previously stated, no takeoff or precautionary range for fuel flow is required by the FJ44-1A Operating Instructions, or by the installation of the engine in the aircraft. Therefore, § 23.1549(c) does not apply. The Model 525 engine installation has no restricted operating range. Therefore, § 23.1549 (d) does not apply.

In summary, the digital numeric display is equivalent in safety to the intent of § 23.1305 (c)(2) for a fuel flowmeter indicator, is equivalent in safety to the requirements of § 23.1549, and is consistent with the guidance material for such displays as defined in AC 23.1311-1A. The use of an analog display would offer no additional safety over the digital fuel flow display based on the above justification, and engine design and aircraft operation. An Equivalent Level of Safety should therefore be extended to the Model 525 for the digital fuel flow presentation.

The justification for the digital N<sub>2</sub> display is provided below:

The Model 525 will use electronic displays for the powerplant instrument required by § 23.1305 (c)(2). This display will incorporate an all digital numeric presentation for N<sub>2</sub>. This presentation requires an Equivalent Level Of Safety accompanied by appropriate justification to show that the Williams FJ44-1A digital only N<sub>2</sub> display has an equivalent level of safety to the requirements of § 23.1549 (a), (b), (c) & (d), meets the intent of § 23.1305(c)(5), and address the guidance material contained in AC 23.1311-1A.

The Model 525 uses the Williams FJ44-1A engine with a hydro-mechanical fuel control. This engine requires the use of N<sub>2</sub>. This parameter is used for engine starting and overspeed

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monitoring. The limits and usage of this parameter are defined by the Williams FJ44-1A Operating Instructions.

Cessna has in the past used a digital only display for this parameter. The Citation 550 and 560 series aircraft have similar limitations and are certified with a digital only  $N_2$  speed display.

The  $N_2$  speed display provides digital readout from 0 to 120% with a resolution of 0.1%. The redline limit for  $N_2$  as established by Williams is 99.3%. The digital display changes from green to red, flashes red for five seconds, and remains red when  $N_2$  exceeds this value plus the display resolution limit. The hydro-mechanical fuel control operates with a flyweight governor system, decreasing fuel flow with increasing  $N_2$  speed. Scheduled speed is limited by a maximum PLA stop. For cold conditions, a maximum fuel flow function is included which will cutback fuel with increasing  $N_2$  speed to limit engine speed.

These features will prevent critical engine overspeed and are considered compensating features. The engine overspeed protection and the overspeed warning given to the pilot provides an equivalent level of safety to the redline or red arc required by § 23.1549(a), and are therefore in agreement with paragraph 8.5.6.3 and 8.5.6.5 of AC 23.1311-1A.

The digital  $N_2$  speed display has green digits against a black background positioned in a central location on the instrument panel with the display for each engine adjacent to each other. This is considered to meet the intent of § 23.1305(c)(5). The location of the  $N_2$  display for each engine is such that trend or rate of change information can be quickly discerned including information needed in-flight engine restarts, and for quickly and accurately comparing engine-to-engine data. This location has been shown by flight test demonstration to meet the requirements for visibility including appropriate conditions of lighting and panel vibration. Normal operation of the engine high pressure turbine speed is displayed by illuminated steady green digits, and no other indication. The display is in agreement with the guidance material contained in paragraphs 8.5.6.1, 8.5.6.2, and 8.5.6.4 of AC23.1311-1A. The green digits meet the intent of a green arc or green radial, thus an equivalent level of safety to § 23.1549 (b) is shown.

No precautionary range is required by the FJ44-1A Operating Instructions, or by the installation of the engine in the aircraft. Engine  $N_2$  is within the normal operating range unless the redline limit is exceeded, at which point the display changes as described above. Therefore, the redline notification constitutes equivalency to the precautionary range and is equivalent in safety to § 23.1549(c).

The Model 525 engine installation has no  $N_2$  restrictions which would require an additional  $N_2$  red arc or red marking other than the defined maximum speed limitation. Therefore, an equivalent level of safety is not required for § 23.1549 (d).

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In summary, the digital numeric display is equivalent in safety to the intent of § 23.1305(c)(5) for the high pressure turbine rotor speed, the requirements of § 23.1549, and meets the guidance material for such displays defined in AC 23.1311-1A. The use of an analog display would offer no additional safety over the N<sub>2</sub> digital display based on the above justification and commonality of engine design and aircraft operation. An Equivalent Level of Safety should be extended to the Model 525.

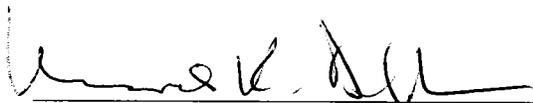
FAA POSITION

In addition to the requirements of 14 CFR part 23, § 23.1305 and § 23.1549 and the guidance provided in Advisory Circulars AC 20-88A, recently released AC 23.1311-1A contains criteria which should be considered when seeking an Equivalent Level of Safety for powerplant displays. AC 23.1311-1A, Section 8.5 "Powerplant Displays", paragraphs 8.5.6 through 8.5.6.5 states the following factors should be considered:

- (a) The ability to assess necessary trend or rate information quickly, including if and when this information may be needed during in-flight engine restarts.
- (b) The ability to assess how close the indicated parameter is relative to the redline limit.
- (c) Value to the crew of quickly and accurately comparing engine to engine data.
- (d) Compensating engine design features or characteristics that would forewarn the crew prior to the parameter reaching the redline limit.

RECOMMENDATION

The FAA concurs with the Rockwell Collins Inc. position. The FAA also finds that an Equivalent Level of Safety to 14 CFR part 23, § 23.1305(c)(2), (c)(5) and § 23.1549(a) through (d) as required by 14CFR Part 21, § 21.21(b) be granted for the use of direct reading, digital only displays for the high-pressure turbine speed (N<sub>2</sub>), and fuel flow indications on the Cessna Model 525.

CONCURRENCE

Mike Dahl, Manager Standards Staff, ACE-110  
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Mike Gallagher, Manager, ACE-100  
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