Federal Aviation Administration

Memorandum

Date: April 10, 2008

To: Manager, Small Airplane Directorate, ACE-100

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

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Subject: Equivalent Level of Safety for 14 CFR Part 23, §§ 23.1305(c)(2), (c)(5), and § 23.1549(a)(b)(c) for Electronic Engine Instrument Display of Digital Only Fuel Flow and Propeller RPM for the Cessna Model 208 and 208B, Finding No. ACE-08-06

This memorandum requests your office to review and provide concurrence with the proposed Equivalent Level of Safety to the requirements of 14 CFR part 23, § 23.1305(c)(2) and (c)(5) at Amendment 23-52 and § 23.1549(a)(b)(c) at Amendment 23-45 for electronic engine instrument display of digital only fuel flow and propeller RPM.

BACKGROUND:

The original type certified configuration of the Cessna 208 and 208B (hereafter, Model 208) used 2-inch, round dial, analog cockpit instruments to display engine information (see below). The following instruments were located just below the glare shield, on center from left to right as: torque, propeller RPM, inter-turbine temperature (ITT), gas generator speed (Ng), oil pressure / temperature, fuel flow, and left and right fuel quantity indicators.

Cessna is now amending the type certificate and installing the Garmin G1000 avionics suite in the Block Point Change 2008 airplanes (see below). The G1000 suite includes a primary flight display (PFD) located directly in front of the pilot, and a multi-function display centrally located on the instrument panel, both just below the glare shield. The MFD includes an electronic engine indicating system column which occupies the left hand side of the MFD. In the engine indicating system column there resides the following parameters and format from the top down: torque analog/digital, ITT analog/digital, gas generator speed (Ng) analog/digital, and propeller

RPM digital only, oil pressure / temperature analog/digital, fuel quantity analog/digital, fuel flow digital only. The MFD presents these engine parameters, full-time on the ENGINE page.

(Ref. FIGURE I and II). Early digital displays did not have the ability to indicate red, yellow, and green limitation range markings. However, the proposed new digital display values (numbers) can change color as the sensor signal changes the digital display in the appropriate operating ranges. Propeller RPM is proposed to be presented in a digital only format. This indication requires that an Equivalent Level of Safety (ELOS) be established.

This request was coordinated within the Federal Aviation Administration by Issue Paper P-1.

The following figures are presented for reference in evaluating the position herein.

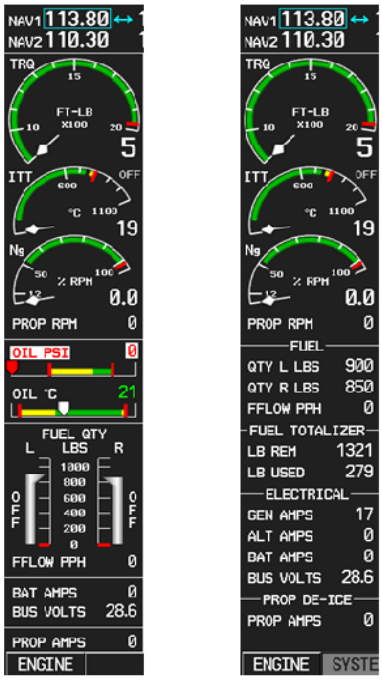

FIGURE I

The far left section of the G1000 MFD is presented above in two formats:.

1. The full-time ENGINE page is on the left
2. The selectable SYSTEMS page is on the right

Digital only propeller RPM is just below the Ng (gas generator speed) presentation and digital only fuel flow is presented just below the fuel quantity gauges on the full time ENGINE page.

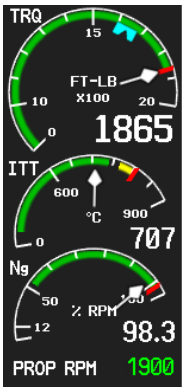

FIGURE II

Digital only propeller RPM presentation on the G1000 MFD
ENGINE and SYSTEMS pages
[Maximum propeller RPM; 1900 presented]

APPLICABLE REGULATIONS:

§ 21.21(b)(1)
§ 21.261
§ 23.1305 at Amendment 23-52
§ 23.1311 at Amendment 23-49
§ 23.1549 at Amendment 23-45
AC 23.1311-1B

REGULATIONS REQUIRING AN ELOS:

For Engine Fuel Flow; § 23.1305(c)(2) at Amendment 23-52;

Sec. 23.1305 Powerplant instruments.

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.

For Propeller RPM; § 23.1305(c)(5) at Amendment 23-52;

Sec. 23.1305 Powerplant instruments.

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:

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

For Electronic Display Instrument Systems; § 23.1311 at Amendment 23-49

Sec. 23.1311 Electronic display instrument systems.

[(a) Electronic display indicators, including those with features that make isolation and independence between powerplant instrument systems impractical, must:

(1) Meet the arrangement and visibility requirements of Sec. 23.1321.

(2) Be easily legible under all lighting conditions encountered in the cockpit, including direct sunlight, considering the expected electronic display brightness level at the end of an electronic display indicator's useful life. Specific limitations on display system useful life must be contained in the Instructions for Continued Airworthiness required by Sec. 23.1529.

(3) Not inhibit the primary display of attitude, airspeed, altitude, or powerplant parameters needed by any pilot to set power within established limitations, in any normal mode of operation.

(4) Not inhibit the primary display of engine parameters needed by any pilot to properly set or monitor powerplant limitations during the engine starting mode of operation.

(5) Have an independent magnetic direction indicator and either an independent secondary mechanical altimeter, airspeed indicator, and attitude instrument or individual electronic display indicators for the altitude, airspeed, and attitude that are independent from the airplane's primary electrical power system. These secondary instruments may be installed in panel positions that are displaced from the primary positions specified by Sec. 23.1321(d), but must be located where they meet the pilot's visibility requirements of Sec. 23.1321(a).

(6) Incorporate sensory cues for the pilot that are equivalent to those in the instrument being replaced by the electronic display indicators.

(7) Incorporate visual displays of instrument markings, required by Secs. 23.1541 through 23.1553, or visual displays that alert the pilot to abnormal operational values or approaches to established limitation values, for each parameter required to be displayed by this part.

(b) The electronic display indicators, including their systems and installations, and considering other airplane systems, must be designed so that one display of information essential for continued safe flight and landing will remain available to the crew, without need for immediate action by any pilot for continued safe operation, after any single failure or probable combination of failures.

(c) As used in this section, "instrument" includes devices that are physically contained in one unit, and devices that are composed of two or more physically separate units or components connected together (such as a remote indicating gyroscopic direction indicator that includes a magnetic sensing element, a gyroscopic unit, an amplifier, and an indicator connected together). As used in this section, "primary" display refers to the display of a parameter that is located in the instrument panel such that the pilot looks at it first when wanting to view that parameter.**]**

For the Applicable Guidance Material; AC 23.1311-1B, Installation of Electronic Displays in Part 23 Airplanes; Section 9.0 Powerplant Instruments; 9.4, Direct-Reading Alphanumeric-Only Displays

9.4 Direct-reading alphanumeric-only displays are most valuable when integrated with an analog display by adding a precise, quantitative indication to compliment an analog display’s qualitative indication. Direct-reading alphanumeric powerplant displays should not be used in place of analog instruments to indicate values of engine parameters where trend or rate-of-change information is important. Direct-reading alphanumeric displays limit the flight crew’s ability to assess trend information and result in reduced crew awareness. Direct-reading alphanumeric displays are also limited in their ability to provide a comparison of parameters from multiple engines or to check the general proximity of differing parameters against their individual limits. While these shortcomings can be compensated for with additional design provisions, the use of direct-reading alphanumeric displays should be made with care and evaluated for each airframe, engine, and airframe/engine integration. The required § 23.1305 powerplant instruments referred to as “indicators” should have the ability to provide trend or rate-of-change information, if appropriate to the specific engine parameter. If using direct-reading alphanumeric displays, consider the following factors. These are subject to evaluation on a case-by-case basis.

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 a multiengine aircraft.
e. Compensating engine design features or characteristics that would forewarn the crew before the parameter reaching the operating limit (for example, redline).

NOTE: Item 9.4 (d) above is not applicable to the Model 208, as it is a single engine airplane.

9.5 Mark powerplant parameters on electronic displays following § 23.1549. AC 20-88A provides alternate methods of marking electronic powerplant displays. Alternate methods of marking the displays may be performed. However, evaluate this on a case-by-case basis, depending on each airframe, engine, integration, and appropriate human factors considerations

For Powerplant Instruments; § 23.1549(a)(b)(c) at Amendment 23-45;

Sec. 23.1549 Powerplant [and auxiliary power unit instruments.]

[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;

(c) Each takeoff and precautionary range must be marked with a yellow arc or a yellow line; and

DESCRIPTION OF COMPENSATING FEATURES:

Digital Fuel Flow Indication

Regulation: § 23.1305(c)(2)
See the Regulation(s) Requiring an ELOS and the Applicable Guidance section above for text of the regulation.

Compensating Feature
The regulation specifies an indicator. The FAA has concluded that, where trend information is needed, the word "indicator" should be retained. The indicator has been replaced by a digital only indication with white letters on a black background. The associated trend information provided by a round analog indicator is no longer present. However, a limited amount of trend and rate-of-change information is available by observing the fuel flow digits. The fuel flow does not have a maximum or minimum limit, or a cautionary fuel flow range as defined by the engine manufacturer. Therefore, there is no corresponding change in digit color. The trend information available is adequate for the operational requirement. With no established limits or cautionary range, the compensating feature is that the digits are displayed full-time in white on a black background, which corresponds to the normal operating range.

Guidance Material: AC 23.1311-1B
See the Regulation(s) Requiring an ELOS and the Applicable Guidance section above for text of the regulation.

Compensating Feature
AC 23.1311-1B, paragraph 9.4(a), addresses visibility and relative location of the indicated parameter. The electronic engine indicating system column, which includes fuel flow indication on the full-time ENGINE page of the G1000 MFD, is located just below the fuel quantity information on the centrally located MFD. This has been evaluated during DOA or FAA flight testing and found to be acceptable.

AC 23.1311-1B, paragraph 9.4(b), addresses the ability to assess trend or rate-of-change information quickly including in-flight airstarts. Trend or rate-of-change information is indicated by the change of the white digits only. This has been evaluated during DOA or FAA flight testing and found to be acceptable.

AC 23.1311-1B, paragraph 9.4(c), addresses the ability to assess how close the indicated parameter is relative to a limit. As there are no limits for fuel flow defined by the engine manufacturer, this aspect is not applicable.

AC 23.1311-1B, paragraph 9(e), addresses the compensating engine design features or characteristics that would forewarn the crew before the parameter reaching the operating limit (for example, redline). As there are not limits for fuel flow defined by the engine manufacturer, this aspect is not applicable.

Regulation: § 23.1549(a)(b)(c)
See the Regulation(s) Requiring an ELOS and the Applicable Guidance section above for text of the regulation.

Compensating Feature
(a) The fuel flow does not have a maximum or minimum flow limit as defined by the engine manufacturer. The digits are displayed in white on a black background.
(b) Normal operating ranges cannot be marked with the required green arc or green line on a digital only indication. The compensating feature is that the digits are displayed in white, which corresponds to the normal operating range.
(c) The cautionary range(s) cannot be marked with the required yellow arc on a digital only indication. As fuel flow does not have a defined cautionary range, no corresponding yellow digit color is displayed.
This has been evaluated during DOA or FAA flight testing and found to be acceptable.

Digital Propeller RPM Indication

Regulation: § 23.1305(c)(5)

See the Regulation(s) Requiring an ELOS and the Applicable Guidance section above for text of the regulation.

Compensating Feature

✷Digital Only Propeller RPM Presentation:
The regulation specifies an indicator. The FAA has concluded that, where trend information is needed, the word "indicator" should be retained. The indicator has been replaced by a digital only indication and the associated direct trend information provided by a round analog indicator is no longer present. However, trend and rate-of-change information is now available by observing the PROP RPM area of the electronic engine indicating system on the left side of the MFD (Ref. FIGURE I & II). This area is identified by a white “PROP RPM” directly below the percent Ng analog and digital display on the full-time ENGINE page of the MFD. Propeller RPM resolution is to the nearest 10 RPM from 0-2100. The display provides a white digital display against a black background for values from 0-1599 RPM, a green digital display against a black background for values from 1600-1900 RPM (normal; prop governing range), and a white digital display against a red background with flashing and alternating colors for values greater than 1900 RPM (1910). “PROP RPM” also flashes for values greater than 1900 RPM in the same manner. There are no takeoff or precautionary ranges for propeller RPM defined by the propeller manufacturer.

✷Propeller RPM Control (Governing) and Overspeed Protection:
The Model 208 has redundant propeller overspeed protection systems, they include the primary propeller governor, the propeller overspeed governor, and a power turbine governor (also known as the Nf governor or the fuel topping system). The propeller overspeed governor acts as a safeguard against propeller overspeed should the primary propeller governor fail. The power turbine governor functions to protect the engine against a possible propeller overspeed if a failure of both the primary propeller governor and overspeed governor occurs. If both of the governors were to fail, this system will ensure that engine installation limits are not exceeded. The Model 208 also includes a feedback ring, which is used for all operations off the governor and reverse thrust. While off the primary governor in beta, the pilot directly controls blade angle with the power control lever. Due to this direct control, the pilot does not need either rate of change or trend information to properly control the propeller off the governor.

For propeller overspeed monitoring and protection, the pilot has an essential role in setting and monitoring propeller RPM although, on this airplane, RPM is set at 1900 RPM and basically left there for all required power settings, and phases of flight. For approach and landing, the propeller RPM is set at 1900 RPM to ensure full power is available for a missed approach, balked landing, and go-around. The pilot also plays an essential role in setting required takeoff and approach power by adjusting the power control lever (torque/ITT) within limits, as required to maintain the desired flight path. The pilot does not need rate of change or trend information for propeller RPM to operate the engine and propeller within established limits.

✷Engine Power Setting (Torque), Propeller RPM and Flight Operations:
The required method of setting power is by reference to the applicable power setting tables in the AFM. At a desired engine rating, the torque to be set depends on propeller speed, altitude, airspeed, air temperature, air bleed and power extraction. The Model 208 AFM presents Limitations and Normal Procedures for takeoff, max climb, and max cruise torque such that propeller RPM must be set so as not to exceed 675 SHP with torque above 1865 ft-lbs. The full 675 SHP rating is only available at RPM settings of 1800 RPM or greater. Note that for all FAA Approved engine performance limitations, 1900 RPM is the required propeller speed to be set by the pilot.

When setting power in the Model 208, torque is the primary parameter monitored while propeller RPM is secondary. Rate of change, or trend, of the propeller RPM is not required for the pilot to be able to correctly set engine power. Before engine start, the Model 208 AFM instructs the pilot to position the propeller speed control lever in the full forward, max RPM position (1900). The AFM does not instruct the pilot to change the propeller RPM during engine start, taxi, or takeoff. By setting the propeller speed control lever in the max position, this will ensure that 1900 RPM will be set and controlled by the primary propeller governor.

Engine torque is presented in the top left corner of the MFD on the full time ENGINE page (Ref. FIGURE I, II & III). The redline on the torque display is a dynamic limit, which is based on the maximum allowed power extraction of 675 SHP and the current propeller RPM, subject to a maximum value of 1970 ft-lb. This results in a redline at a constant torque limit of 1970 ft-lbs for propeller RPM below 1800, and a dynamic redline that is SHP limited for propeller RPM between 1800 and 1900. This redline changes position as required for engine conditions and is always at the top of the green arc. The pilot will then ensure that 675 SHP is not exceeded by setting the engine to the appropriate torque value (per Section 5 of the AFM) by use of the power control lever. The pilot must observe this limit during all phases of operation. Additionally, the pilot must observe the altitude and OAT limitations for takeoff torque, as stated in Section 5 of the AFM. Again, due to this power setting method torque is the primary parameter monitored while propeller RPM is secondary. Finally, if the pilot has not moved the propeller speed control lever forward, as required by the AFM, and does not achieve 1900 RPM, this will be indicated by the redline being above the takeoff torque setting of 1865 ft-lb, which the pilot must confirm during the takeoff roll.

For climb operation, the AFM allows the pilot to set the propeller between 1600-1900 RPM, with a notation that full 675 SHP is only available at propeller RPM greater than 1800. The pilot is to fly the aircraft to the torque gauge redline, to the AFM limitations for ITT and Ng, and to the Section 5 climb torque limits based on altitude and OAT, by use of the power control lever.

For cruise operation, the AFM allows the pilot to set the propeller between 1600-1900 RPM. For this condition, the pilot may now fly the aircraft to the cruise torque bug indication by use of the power control lever. The cruise torque bug is for reference only (or advisory) and does not alleviate the pilot’s responsibility to consult the tables in Section 5 of the AFM.

The propeller RPM is required to be set at maximum RPM (1900) for takeoff, maximum continuous, maximum climb, and maximum cruise power, all of which are limitations in the FAA approved AFM. These power setting limitations are defined by a torque and ITT at 1900 RPM only. In addition, takeoff distance, rate of climb, climb gradient, maximum rate of climb, and other performance information such as fuel and time required, range and endurance are also established and defined in the AFM at 1900 RPM only. For approach and landing, the propeller speed control lever is again set to the full forward position in order to maintain 1900 RPM. Approach power settings are made only by adjusting the power control lever as required to maintain the desired flight path. The AFM also requires propeller RPM be set at 1900 RPM for Instrument Landing System (ILS) approaches to preclude interference on the approach path. Additionally, the AFM also contains normal procedures that require 1900 RPM to be set by the pilot to achieve the above noted performance.

✷Power and Propeller Controls System Design and Installation:
The propeller speed control lever is tightly grouped with the power control lever on the pedestal. During one airplane evaluation, someone noted that for a an incorrect pilot selection of 1800 RPM for Takeoff on the propeller speed control lever, the lever itself was displaced approximately one full knob length aft of the required 1900 RPM position. This tactile queue should obviate the need to push the propeller speed control lever up to the maximum position to achieve full power. Additionally, there is less than a half inch between the top of the propeller speed control lever (when it is set at minimum) and the power control lever. If pilots were to have the power control lever at min, they would notice that it was not set correctly when they advanced the power control lever forward to demand full power.

These issues have been evaluated during DOA or FAA flight testing and found to be acceptable.

Guidance Material: AC 23.1311-1B

See the Regulation(s) Requiring an ELOS and the Applicable Guidance section above for text of the regulation.

Compensating Feature

AC 23.1311-1B, paragraph 9.4(a), addresses visibility and relative location of the indicated parameter. The G1000 suite includes a 10.4” multi-function display (MFD) centrally located on the instrument panel, just below the glare shield. The MFD includes an electronic engine indicating system column, which occupies the left hand side of the MFD on the full-time ENGINE page. The presentation size, fonts, general format, general location, etc. of the engine indicating system column is similar to other FAA approved 10.4” G1000 MFD installations. The MFD does not transfer the left to right engine instruments of the original analog gauge type certificated airplane into a vertical column format. Cessna elected to change the hierarchy of propeller RPM by relocating it in the instrument stack and chose to depict it in digital only format. The following parameters and format reside in the engine indicating system column from the top down: torque analog/digital, ITT analog/digital, percent Ng analog/digital, and propeller RPM digital only, oil pressure / temperature analog/digital, fuel quantity analog/digital, fuel flow digital only (Ref. FIGURE I). Propeller RPM is identified by a white “PROP RPM” and digital window directly below the percent Ng analog and digital display on the full time ENGINE page of the MFD. Resolution is to the nearest 10 RPM from 0-2100. Propeller RPM presentation is included in the same region of the MFD as the other primary sources of engine information (torque, ITT, and percent Ng). There is a white line demarcation to isolate torque, ITT, percent Ng and propeller RPM from the engine oil system parameters. During normal operations, there is color, size, and format isolation of the propeller RPM parameter from that of the digital percent Ng. This is accomplished by presenting the digital Ng percentage in decimal format, in white on black background in a larger scale font versus the smaller font presented in thousands in a green on black

background for propeller RPM. This has been evaluated during DOA or FAA flight testing and found to be acceptable.

AC 23.1311-1B, paragraph 9.4(b), addresses the ability to assess trend or rate-of-change information quickly including in-flight air starts. Trend or rate-of-change information is indicated primarily by the change of the digits on the display and further by a color change if the propeller proceeds towards an overspeed condition. On the Model 208, Cessna has chosen to change the hierarchy of the propeller RPM information and thus the need for trend or rate-of-change information. Torque and ITT are now the top two prominent instruments on the MFD, which are to be used for engine power setting. Both are presented in an analog arc format with corresponding digital window for the specific value of the parameter. Per the AFM limitations, propeller RPM is required to be set at maximum RPM (1900) for takeoff, maximum continuous, maximum climb, and maximum cruise power. These power setting limitations are defined by a torque and ITT at 1900 RPM only. In addition, engine torque, takeoff distance, rate of climb, climb gradient, maximum rate of climb, and other performance information such as fuel and time required, range, and endurance are also established and defined in the AFM at 1900 RPM only. The AFM also contains normal procedures that require 1900 RPM to be set by the pilot to achieve the above noted performance. As there is no precautionary range for the Model 208 propeller, there is no need to present that type of information to the pilot. For normal operations, propeller RPM is pilot selected and set. Thereafter, the pilot may scan the display for a specific propeller RPM to be sure the demanded RPM has been achieved. This is more likely to occur during the cruise phase of flight or when carrying passengers where RPM reduction is permitted and advantageous to cabin noise management. However, the pilots need to assess trend in these conditions after a selection is made is minimal. During normal operations on or off the governor, the digital display presents increasing or decreasing propeller RPM in the form of a digit change on a constant color background, either white on black or, for all governed operation, green on black. Trends toward overspeed are presented only by the increasing digital value. With redundant overspeed protection systems, the need for rate-of-change information for normal operations is also minimized. Primary engine start information is provided by the ITT, and percent Ng with supplementary information from the engine torque and propeller RPM displays. This has been evaluated during DOA or FAA flight testing and found to be acceptable.

AC 23.1311-1B, paragraph 9.4(c), addresses the ability to assess how close the indicated parameter is relative to a limit. The display provides a white digital display against a black background for values from 0-1599 RPM, a green digital display against a black background for values from 1600-1900 RPM (normal governing) and a white digital display against a red background with flashing and alternating colors for values greater than 1900 RPM. “PROP RPM” also flashes for values greater than 1900 RPM (1910) in the same manner. This has been evaluated during DOA or FAA flight testing and found to be acceptable.

AC 23.1311-1B, paragraph 9(e), addresses the compensating engine design features or characteristics that would forewarn the crew before the parameter reaching the operating limit (for example, redline). If the primary propeller governor were to fail, there is an engine installed propeller overspeed governor to limit propeller RPM. Additionally, there is a power turbine governing section incorporated into the primary propeller governor (engine component) that will limit gas generator speed in the event of a primary and overspeed governor failure.

Regulation: § 23.1549(a)(b)(c)

See the Regulation(s) Requiring an ELOS and the Applicable Guidance section above for text of the regulation.

Compensating Feature
(a)There are no takeoff or precautionary ranges for propeller RPM defined by the propeller manufacturer. When the propeller speed is not governed, the display provides a white digital display against a black background for values from 0-1599 RPM. When the propeller is being governed, the maximum propeller speed is 1900 RPM. At any RPM greater than 1900, a white digital display against a red background with flashing and alternating colors will appear. "PROP RPM" also flashes for values greater than 1900 RPM in the same manner.
(b)Normal operating ranges cannot be marked with the required green arc or green line on a digital only indication. The compensating feature is that the display provides a white digital display against a black background for values from 0-1599 RPM, and a green digital display against a black background for values from 1600-1900 RPM (propeller governing range) displayed in green, which correspond to the normal operating range of the propeller on and off the governor.
(c)The cautionary range(s) cannot be marked with the required yellow arc on a digital only indication. There are no takeoff or precautionary ranges for propeller RPM defined by the propeller manufacturer, and, therefore, no corresponding yellow digit color is provided.

This has been evaluated during DOA or FAA flight testing and found to be acceptable.

EXPLANTION OF COMPENSATING FEATURES:

Digital Fuel Flow Indication

Regulation: § 23.1305(c)(2)

See the Regulation(s) Requiring an ELOS and the Applicable Guidance section above for text of the regulation.

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 DOA or FAA flight testing and found to be acceptable.

Guidance Material: AC 23.1311-1B

See the Regulation(s) Requiring an ELOS and the Applicable Guidance section above for text of the regulation.

Explanation of Equivalent Level of Safety

AC 23.1311-1B, paragraph 9.4(a), addresses visibility and relative location of the indicated parameter. The electronic engine indicating system column, which includes fuel flow indication on the full-time ENGINE page of the G1000 MFD, is located just below the fuel quantity information on the centrally located MFD. This has been evaluated during DOA or FAA flight testing and found to be acceptable.

AC23.1311-1B, paragraph 9.4(b), addresses the ability to assess trend or rate-of-change information quickly including in-flight airstarts. Trend or rate-of-change information is indicated by the change of the digits. In-flight starts are primarily controlled with ITT and gas generator speed (Ng), with fuel

flow as supplementary information. This has been evaluated during DOA or FAA flight testing and found to be acceptable.

AC 23.1311-1B, paragraph 9.4(c) and (e), addresses the indicated parameters proximity to a limit and any compensating engine design features that would forewarn that the parameter is reaching a limit. 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.

Regulation: § 23.1549(a)(b)(c)

See the Regulation(s) Requiring an ELOS and the Applicable Guidance section above for text of the regulation.

Explanation of Equivalent Level of Safety

Fuel flow caution and limit markings do not exist and are not required by the engine manufacturer. The display of digits in white is considered equivalent to marking a green arc on an analog indication for parameters that are in the normal range. This has been evaluated during DOA or FAA flight testing and found to be acceptable.

Digital Propeller RPM

Regulation: § 23.1305(c)(5)

See the Regulation(s) Requiring an ELOS and the Applicable Guidance section above for text of the regulation.

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 DOA or FAA flight testing and found to be acceptable.

Guidance Material: AC 23.1311-1B

See the Regulation(s) Requiring an ELOS and the Applicable Guidance section above for text of the regulation.

Explanation of Equivalent Level of Safety

AC 23.1311-1B, paragraph 9.4(a), addresses visibility and relative location of the indicated parameter. The electronic engine indicating system for propeller RPM is identified by a white “PROP RPM” directly below the percent Ng display on the full-time ENGINE page of the MFD. This has been evaluated during DOA or FAA flight testing and found to be acceptable.

AC 23.1311-1B, paragraph 9.4(b), addresses the ability to assess trend or rate-of-change information quickly including in-flight air starts. Trend or rate-of-change information is indicated by the change of the digital value and change of color of the digital display. This has been evaluated during DOA or FAA flight testing and found to be acceptable.

AC 23.1311-1B, paragraph 9.4(c), addresses the ability to assess how close the indicated parameter is relative to a limit. The display provides a white digital display against a black background for operations off the governor and a green digital display against a black background for operations on the governor. A white digital display against a red background with flashing and alternating colors is provided during any propeller RPM limit exceedance. This has been evaluated during DOA or FAA flight testing and found to be acceptable.

AC 23.1311-1B, paragraph 9(e), addresses the compensating engine design features or characteristics that would forewarn the crew before the parameter reaches the operating limit (for example, redline). The Model 208 incorporates separate and isolated automatically available redundant propeller overspeed protection systems.

Regulation: § 23.1549 (a)(b)(c)

See the Regulation(s) Requiring an ELOS and the Applicable Guidance section above for text of the regulation.

Explanation of Equivalent Level of Safety

The digit colors correspond to the normal and limit markings for operations on and off the propeller governor. There are no takeoff or precautionary ranges for propeller RPM defined by the propeller manufacturer. This has been evaluated during DOA or FAA flight testing and found to be acceptable.

ACO RECOMMENDATION:

The FAA concurs with the applicant, Cessna Aircraft Company, position on the Model 208 airplane equipped with the Garmin G1000 avionics suite, which includes an MFD with electronic engine indicating system, as defined in the Model 208 type design data to be granted an equivalent level of safety for the following:

Digital Only Indication	ELOS Provided for 14 CFR Part 23
Engine Fuel Flow	§ 23.1305(c)(2) and § 23.1549(a)(b)(c)
Propeller RPM	§ 23.1305(c)(5) and § 23.1549(a)(b)(c)

The compensating features noted in this memo will provide an equivalent level of safety to the requirements of 14 CFR part 23, § 23.1305(c)(2) and (c)(5) at Amendment 23-52 and § 23.1549(a)(b)(c) at Amendment 23-45 for electronic engine instrument display of digital only fuel flow and propeller RPM, upon successful completion of required tests and compliance substantiation documentation.

Concurrence:

Margaret Kline, Manager,	*04/01/08*
Manager, Wichita Aircraft Certification Office, ACE-115W	Date

Patrick R. Mullen, Acting	*04/10/08*
Manager, Standards Office, ACE-110	Date

James E. Jackson, Acting	*4/10/08*
Manager, Small Airplane Directorate Aircraft Certification Service, ACE-100	Date