



# Federal Aviation Administration

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## Memorandum

Date: October 8, 2008

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

To: Manager, Small Airplane Directorate, ACE-100

Prepared by: Grant Youngdahl, Flight Test and Program Management, ACE-117W

Subject: ELOS for 14 CFR, part 23, §§ 23.207(c), 23.1419(b) – Cessna 208B Stall Warning, ACE-08-19

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### **Background:**

The Cessna 208B equipped with the TKS Ice Protection System (IPS) cannot attain the required 5 KCAS stall warning margin with thin rough ice accretions utilizing the current production stall warning system. Cessna is proposing to utilize a Low Airspeed Awareness (LAA) System to provide an equivalent means of stall warning for operations in icing conditions.

A TKS IPS was recently certified for the Cessna Model 208B. During certification of the TKS IPS the aircraft was never tested with the stall warning system in the final production configuration. Instead, a combination of test data for different configurations and analysis was utilized to show compliance with this regulation.

During initial production acceptance of the first TKS equipped 208B, an issue arose that highlighted a concern with the configuration of the stall warning system. It was decided that the aircraft would be evaluated with critical ice accretions in the final production configuration. The critical ice accretions consisted of thin rough ice accretions simulating a delayed/pre-activation ice shape, and the normal operating 45 minute hold ice shape. Test results indicated the following:

1. For the delayed/pre-activation ice shape the current production stall warning system was not capable of satisfying the requirements of 14 CFR part 23, § 23.207(c) without causing nuisance indications.
2. For the normal operating 45 minute hold ice shapes the current production stall warning system meets all the requirements of 14 CFR part 23, § 23.207.

Due to test result number 1, new production Cessna 208B aircraft equipped with the TKS IPS are prohibited from flight into known or forecast icing conditions until this condition is rectified. Because of this Cessna Aircraft Company is proposing to utilize a Low Airspeed Awareness System similar to that certified on the pneumatic deiced Cessna 208B to provide an equivalent level of safety to the stall warning requirement of 14 CFR part 23, § 23.207(c).

This request was coordinated within the FAA by Issue Paper F-1.

**Applicable regulations:**

The installed TKS system was required to meet 14 CFR part 23, § 23.1419 at amendment 14. Subparagraph (b) of this regulation requires the following:

“An analysis must be performed to establish, on the basis of the airplane's operational needs, the adequacy of the ice protection system for the various components of the airplane. In addition, tests of the ice protection system must be conducted to demonstrate that the airplane is capable of operating safely in continuous maximum and intermittent maximum icing conditions as described in Appendix C of part 25 of this chapter.”

Current and past FAA policy has indicated that one of the requirements to demonstrating that an aircraft is capable of operating safely in the icing conditions described in Appendix C is that the aircraft demonstrate compliance to 14 CFR part 23, § 23.207 for stall warning margin. The applicable amendment to 14 CFR part 23, § 23.207 for the Cessna 208B requires the following:

*“The stall warning must begin at a speed exceeding the stalling speed by a margin not less than 5 knots, but not more than the greater of 10 knots or 15 percent of the stalling speed, and must continue until the stall occurs.”*

**Regulation Requiring an ELOS:**

The 14 CFR Part 23 regulation applicable to this ELOS: 23.207(c)(Amd 7) Stall Warning.

**Compensating features which allow the granting of the ELOS:**

The Low Airspeed Awareness System activates the Stall Warning System when the airspeed drops below 97.5 knots  $\pm$ 2 knots provide adequate stall warning in icing conditions.

**Explanation of how these features provide an ELOS:**

The following memo contains Cessna Aircraft Company information and justification to support a request for an Equivalent Level of Safety (ELOS) finding for the Cessna Caravan Model 208B when equipped with a TKS anti-icing system and a Low Airspeed Awareness (LAA) system.

The 14 CFR part 23 regulation applicable to this ELOS: § 23.207 (Amendment 7) Stall Warning.

**Low Airspeed Awareness (LAA):**

The Model 208B equipped with TKS will incorporate a Low Airspeed Awareness system similar to that which is installed in the Model 208/208B pneumatically deiced aircraft. This Low Airspeed Awareness system met the requirements as outlined in FAA Airworthiness Directive 2007-10-15.

**Issue:**

On TKS equipped aircraft with simulated, inadvertent ice shapes (40-grit sandpaper) on the full span of leading edge of the wings and horizontal stabilizer (tail) and flaps UP, stall warning has not been achieved without producing nuisance warnings in the clean wing configuration. This condition simulates “delayed turn on” of the TKS anti-ice system or potentially incorrect mode operation, when entering actual icing conditions.

**Description:**

Turning the PITOT/ STATIC HEAT switch ON enables the LAA system. The pilot is instructed per the POH/AFM to turn the PITOT/ STATIC HEAT switch ON anytime the airplane is being operated at an outside air temperature of 5°C (41°F) or below regardless of visible moisture. The Low Airspeed Awareness system (LAA) provides a low airspeed warning (both aural and visual) when indicated airspeed decreases to 97.5±2.2 knots or below. System functionality is independent of flap position and due to the possibility of nuisance aural warnings during approach and landing; a pilot cancelable annunciator has been installed.

The annunciator is bi-color with a white or amber background and black letters, which reads ‘BELOW ICING MIN SPD’. This annunciator is mounted in the instrument panel directly in front of the pilot, and is activated by an airspeed switch plumbed off the pitot/static lines. A remote mounted relay box provides logic for both the annunciator, and the stall warning horn, (which provides the aural warning). Power is supplied by both the LEFT and RIGHT PITOT HEAT circuit breakers isolated by diodes and electrically controlled by the PITOT/STATIC HEAT switch. The pilot is instructed per the POH/AFM to turn the PITOT/ STATIC HEAT switch ON anytime the airplane is being operated at an outside air temperature of 5°C (41°F) or below regardless of visible moisture.

When the PITOT/STATIC HEAT is turned ON, the annunciator will illuminate white if the indicated airspeed is less than 97.5±2.2 knots. Once the airspeed exceeds 97.5±2.2 knots, the annunciator will extinguish. If the airspeed subsequently decreases below 97.5±2.2 knots, the annunciator will alternate between amber and white at a rate of once per second and the stall warning horn will sound while the amber portion of the flashing annunciator is illuminated. When the airspeed is increased above 97.5±2.2 knots threshold, the annunciator extinguishes and aural warning ceases.

Pressing the flashing annunciator, which incorporates a momentary switch, silences the aural warning, causes the annunciator to stop flashing and remain solid white as long as the airspeed is below 97.5±2.2 knots.

Additionally, the LAA warning will automatically disconnect the autopilot (if engaged – G1000 equipped aircraft only). LAA installations on non-G1000 equipped aircraft will require the pilot to disconnect the autopilot. Following an LAA warning, pressing the flashing annunciator will allow re-engagement of the autopilot.

**Low Airspeed Awareness System as an Aero Performance Monitor:**

During conditions of high workload, the Low Airspeed Awareness system will assist the pilot in monitoring aircraft airspeed by warning of any airspeed at or below the minimum airspeed for safe flight in icing conditions and at which flaps MUST be extended (10° minimum) if the minimum airspeed cannot be maintained.

The proposed minimum icing speed schedule after installation of the new LAA system is:

- 95 KIAS – Flaps UP
- 85 KIAS – Flaps 10 - 20°

**Description of the Low Airspeed Awareness System as an equivalent of Stall Warning Bias:**

Certification flight tests will validate the actual stall speed of the Model 208B with simulated ice shapes on wing and tail. These ice shapes include simulated inadvertent (40-grit sandpaper) on the protected areas. The unprotected areas were previously evaluated during flight tests and because of the complete coverage of the TKS system on wing and tail leading edges, the stall speeds with the TKS system operating produced values lower than those currently published in the POH/AFM (by approximately 1 knot). Therefore, the stall warning vane provides adequate stall warning with the TKS system operating and ice on the unprotected areas.

Recent development flight tests were conducted to determine the actual stall speeds of the Model 208B with simulated ice shapes on the wing and tail resulting in the following data:

**Stall speeds with simulated ice shapes (wings level stall):**

Ice Shape	Flaps	Stall Speed KCAS	LAA Warning KCAS	Warning Interval KCAS
Unprotected Areas Only 45 min exposure	0	78	97.5±2.2	19.5±2.2
Unprotected Areas Only 45 min exposure	20	64	97.5±2.2	33.5±2.2
Inadvertent	0	81	97.5±2.2	16.5±2.2

40 Grit Sandpaper				
Inadvertent 40 Grit Sandpaper	20	65	97.5±2.2	32.5±2.2

Due to the lower stall speeds associated with a TKS anti-ice system, relative to the pneumatically deiced 208, the activation point for the (TKS) LAA will be lowered to 97.5±2.2 knots. The following stall warning margins will result during maneuvering with the LAA enabled:

**Stall warning margins with simulated ice shapes (30° bank angle):**

Ice Shape	Flaps	Stall Speed KCAS	LAA Warning KCAS	Warning Interval KCAS
Unprotected Areas Only 45 min exposure	0	84	97.5±2.2	13.5±2.2
Unprotected Areas Only 45 min exposure	20	69	97.5±2.2	28.5±2.2
Inadvertent 40 Grit Sandpaper	0	88	97.5±2.2	9.5±2.2
Inadvertent 40 Grit Sandpaper	20	70	97.5±2.2	27.5±2.2

Based on the data above, the LAA system would provide adequate stall warning for an inadvertent encounter with bank angles up to 30°. In addition, recent flight tests show adequate stall warning margin (greater than 5 KCAS) from the stall warning vane with 20 degrees flap setting.

The basis for ice shapes used during the TKS development and certification efforts are described in Cessna Aircraft Company Report AI-208B-200 “Ice Shape Definition – FAA Project ST4513WI-A.”

**Four notes to consider:**

1. Ice shape testing is limited to stall speed and stall margin effects and focuses on simulated wing and horizontal stabilizer inadvertent shapes and represents the most conservative scenario.
2. The wing and tail inadvertent shapes are conservative assessments of potential accretion areas. The simulated, inadvertent ice shapes extend beyond observed accretion areas.

3. The sandpaper extents represent accretions that may result from a delayed activation. The 22- $\mu$ m conditions are considered critical due to the higher water content and thicker accumulations. The sandpaper limits conservatively approximate all impingement areas on the wing with local collection efficiency greater than 10%. The sandpaper representation provides a conservative assessment of the icing roughness during initial recognition of the conditions (up to two minutes) and subsequent clearing of the protected areas (approximately five minutes).

**ACO Recommendation:**

The FAA agrees with Cessna's position as of September 11, 2008. In accordance with the provisions of § 21.21(b)(1), the FAA finds that an Equivalent Level of Safety can be granted for § 23.207(c) upon successful completion of the requirements contained in this Issue Paper because the low airspeed awareness system (LAAS) provides adequate stall warning for any inadvertent encounters with icing conditions. During all other flight conditions, when the LAAS is active, the system acts an indicator to inform the pilot that they have dropped below the minimum speed in icing conditions. In both of the cases, either the inadvertent encounter or dropping below the minimum speed in icing, the pilot action would be the same to disconnect the autopilot, increase airspeed and monitor the TKS system until the LAAS light extinguishes.

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