Federal Aviation Administration

Memorandum

Date: JUL 18 2006

To: Manager, Small Airplane Directorate, ACE-100

From: Manager, Fort Worth Aircraft Certification Office, ASW-150

Prepared by: Karl Schletzbaum, Aerospace Engineer, ACE-112

Subject: Review and Concurrence, Equivalent Level of Safety (ELOS) for 14 CFR §23.1323(c), Airspeed Indicating System, on Eclipse Model 500, Project TC3853CH-A (ELOS) ACE-05-36

This memorandum documents concurrence for the subject finding of Equivalent Level of Safety (ELOS). We request your office to review and concur with the proposed ELOS finding to 14 CFR part 23, § 23.1323(c), Airspeed Indicating System. The proposed ELOS will allow for compliance to the regulation by utilizing the heating capabilities of the Pitot/AOA probes on the Eclipse Model 500 to eliminate moisture from the pitot system. The ELOS will also take advantage of the probe's inherent design features which make it resistant to water ingress.

Background

Eclipse Aviation Corporation (EAC) has designed an air data system (ADS) which does not provide literal compliance to 14 CFR § 23.1323(c). This ADS pitot tube has no provisions for water drainage. The lines that connect the pitot tube to the ADS do not have any low points; they run up hill to the ADC. There is one low point in the pitot that could collect water, as mentioned above. There are two mitigating design features:

1) The pitot has heaters (two) internal to it which operate independently. Water that accumulates overnight from condensation will be vaporized within a few minutes after power is turned on to the aircraft.

2) Very little water will ever form or fall into the pitot tube.

The Eclipse Model 500 has three sources of pitot indication: two main probes incorporating AOA located left and right of the nose respectively, and a third probe located on the left side of the nose. The third probe has an electronic sensor located in the base of the probe, inside the fuselage. The two main probes have plumbing lines associated to them, leading to the Air Data Computer (ADC) located in the fuselage. By design, it intended that the two main probes are the

lowest point of the pitot system (the tubing goes down from the ADC to the probe; the tip of the probe is pointed 6.2° up from horizontal; and the mast is pointed 13.4° down from horizontal, making the elbow of the probe the lowest point). The third probe is used in a voting role, not as a primary means. The body of this probe has the same layout and heating element as the main probe. Furthermore, the electronic sensing unit has a water dam at the interface of the probe inner tubes and the unit itself. It is a cross drilled block making it such that water would have to go up to ingress into the sensing unit.

Tests were conducted to demonstrate (1) any trapped water freezing in the probes would not cause damages to the probe internal plumbing, and (2) frozen water could be vaporized in a reasonable amount of time. It was found that within 30 seconds of applying power to the probes heaters, the frozen water in the main pitot tube was melted and pressure readings could be made. A further 18-19 minutes at an ambient -20° C prove that all water could be vaporized as the probe would reach a body temperature over 100° C. After repeatedly freezing water in the probe, it was dismantled and examined under a 30-power microscope. No signs of bulging or other damages were found on the tubes.

The pitot/AOA probes are electrically protected against icing using heaters. The heaters will be commanded on as soon as one engine is running. The probes are self regulating to a set temperature point with the following behavior:

- At the time where the heater is initially commanded on (at engine start), all the probes will heat up to a set point of 250° C for a duration of 4 minutes. This will ensure that any moisture trapped in the probe will be vaporized.
- After that initial 4 minutes, the probes will heat up to a set point of 150° C.
- The probe will revert to a set point of 250° C, if it is detected that it takes a current above a certain threshold to maintain 150° C. This transition will occur below 100 knots of airspeed (due to cooling effect of moving air), ensuring that the probe heats up to a set point of 250° C for the entire flight.

Tests conducted on the system have documented that it is inherently difficult for water to accumulate in the pitot system to an extent that it will cause a malfunction. It was noted that during the tests water had to be inserted with a syringe. The reason for the syringe was that due to the small diameter of the tubes within the probe, surface tension of water made it hardly possible to force water into the tubes. Water being dropped on the probe tends to form droplets that stay atop the holes, but do not necessarily ingress into the tubes. Effectively, a plug forms sealing the tubes thus becoming a closed circuit with a trapped pressure. That pressure will be the same as ambient outside the probe. That in itself prevents water ingress. It is expected that in service any trapped moisture will result mainly from post-flight condensation resulting in a few droplets. The tests used one third of the volume of the tubes filled with water in the test, which represents a quantity of water improbable to collect in service.

Should any moisture collect in the probe, it will be unable to attain a state where surface tension could develop as soon as the heaters are commanded on. Any moisture trapped in the heated area of the probe may be subjected to the dynamic pressure being sensed. If not vaporized outright,

this moisture would be blown back into the tubing system until such point where the dynamic flow of air does not apply pressure on the moisture. This point should be right past the probe, at which point where the aircraft tubing is enlarged to ¼" diameter.

The probe was certified to Technical Standard Order (TSO) C16 in an icing wind tunnel, conclusively demonstrating that water will not be ingested in flight to the extent of having an effect on pressure readings. The ADS monitors the right and left airspeed, altitude and barometric correction. If any differs by more than a set value, a caution advisory system (CAS) message is posted for the crew. Each probe is independently heated and will alert the crew with a CAS message if a heater is failed.

Applicable Regulations

The applicable regulation is 14 CFR § 23.1323(c), which states:

> *Section 23.1323 Airspeed indicating system.*
>
> .....
> *(c) The design and installation of each airspeed indicating system must provide positive drainage of moisture from the pitot static plumbing.*
> .....

Compensating Features

Rather than providing positive drainage as specified in 14 CFR § 23.1323(c), EAC has provided evidence of compensating features that show the system is equivalently safe by eliminating, or preventing water from collecting in the pitot system:

1) The only low point is in the heated pitot probe. Trapped water freezing in the probes will not cause damage to the probe internal plumbing and frozen water could be vaporized in a reasonable amount of time. The system power timing ensures that the system is adequately heated.

2) It has been shown by test that the system is resistant to the ingress of water, and that water in the system will not adversely affect the operation of the pitot system.

Recommendation: We concur that the proposed design features described as compensating features in items (1) through (2), as supplemented by the information from the background in formation, provide an equivalent level of safety to the requirement of 14 CFR § 23.1323(c).

Concurred by:

Michelle M. Owsley — *7-17-06*

Manager, Aircraft Certification Office, ASW-150 — Date

Jean Colony — 7/18/06

Manager, Standards Office, ACE-110 — Date

Daniel Shaw — 7/18/06

for Manager, Small Airplane Directorate, ACE-100 — Date