



Federal Aviation Administration

Memorandum

Date: August 11, 2006

To: Manager, Small Airplane Directorate, ACE-100

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

Prepared by: Taylor Martin, Aerospace Engineer, ACE-112

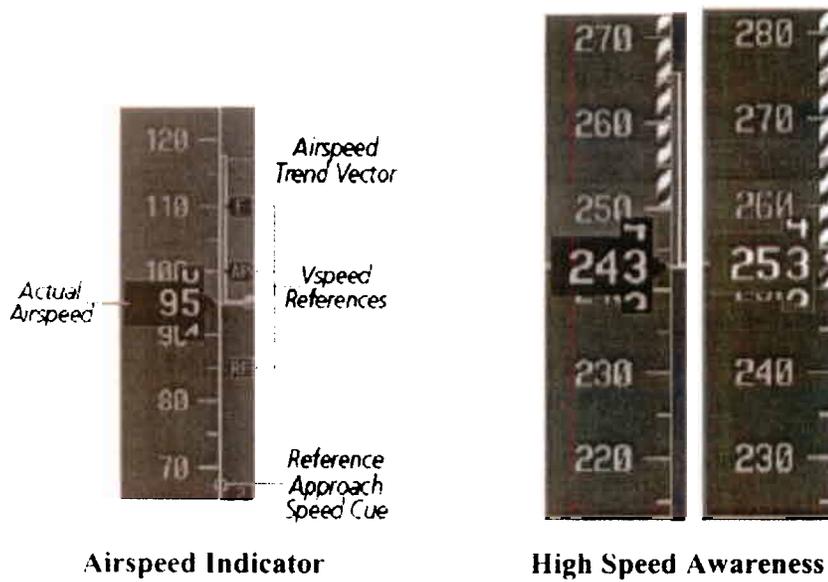
Subject: Review and Concurrence, Equivalent Level of Safety (ELOS) for 14 CFR, part 23, § 23.1545(b)(4), Airspeed Indicator, on Cessna Model 510 Citation Mustang, Project TC3801WI-A, ACE-06-03

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, § 23.1545(b)(4), Amendments 23-1 through 23-54, regarding the Airspeed Indicator. It shows that a digital numeric only airspeed display has an equivalent level of safety to the requirements of § 23.1545(b)(4), Amendment 23-1 through 23-54, and addresses the guidance material contained in Paragraphs 9.3.3 and 9.11 of AC 23.1311-1A for electronic digital only airspeed displays.

BACKGROUND

The Cessna Model 510 Citation Mustang incorporates digital only Airspeed Indicators required by § 23.1545, Amendments 23-1 through 23-54. The Primary Airspeed Indicators are located on the left-hand pilot's and right-hand pilot's left-hand side of the Primary Functional Display (PFD), or on the left-hand side of the Multi-Functional Display (MFD) during reversionary mode, which are all located in the cockpit instrument panel. The Standby Airspeed Indicator is located at the top of the center cockpit instrument panel beneath the Glare Shield.

The Primary Airspeed Indicator displays airspeed on a rolling number gauge using a moving tape. The numeric labels and major tick marks on the moving tape are marked at intervals of 10 knots, while minor tick marks on the moving tape are indicated at intervals of 5 knots. Speed indication starts at 20 knots, with 60 knots of airspeed viewable at any time. The actual airspeed is displayed inside the black pointer. The pointer remains black until reaching the high airspeed limit, at which point it turns red along with the Mach number readout.



Speeds above the maximum operating speed, V_{MO} or M_{MO} depending on airplane altitude, appear in the high speed awareness range, represented on the airspeed tape by red/white “barber pole” coloration. The flap speed references act as the high airspeed limit for altitudes below 18,000 feet. An aural overspeed warning tone is generated if the airspeed exceeds the high airspeed limit.

A red low speed awareness range extends up to the low speed awareness velocity, V_{LSA} . An aural stall warning is generated if the airspeed falls below V_{LSA} and the airspeed pointer changes to red. An open green circle on the airspeed tape represents $1.3 V_{S1}$ when takeoff V_{speeds} are turned off.

The airspeed trend vector is a vertical, magenta line, extending up or down on the airspeed scale, located to the right of the color-coded speed range strip. The end of the trend vector displays approximately what the airspeed will be reached in six seconds, if the current rate of acceleration is maintained. If the trend vector crosses V_{MO}/M_{MO} , the text of the actual airspeed readout and the Mach readout changes to yellow. The trend vector is absent if the speed remains constant, or if any data needed to calculate airspeed is not available due to a system failure.

The Mach number is displayed below the Primary Airspeed Indicator for airspeeds at or above Mach 0.4 or at altitudes exceeding 27,120 feet. The color of the readout corresponds to the color of the actual airspeed pointer.

V_{speeds} can be changed and their flags turned ON/OFF from the Timer/References Window. When active (ON), the V_{speeds} are displayed at their respective locations to the right of the

airspeed scale. By default, all V_{speed} values are reset and all flags turned OFF when power is cycled.

Speed	Value (KCAS)
V_{TA}^*	185
V_{LD}^*	150
V_1	90
V_R	95
V_2	99
V_{ENR}	140
V_{APR}	103
V_{REF}	91

* Flap speeds are not pilot-configurable

Default Reference Speeds

V_{speeds} are categorized as either takeoff or landing. Takeoff V_{speed} flags are automatically turned OFF when airspeed reaches 160 knots. The order in which the categories are displayed is determined by whether the airplane is on the ground or in the air. If the airplane is on the ground, the takeoff V_{speeds} are displayed at the top of the V_{speed} list. If the airplane is in the air, the landing V_{speeds} are displayed at the top.

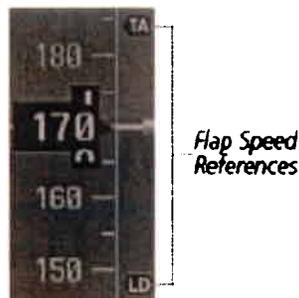
V_{speed} flags can be turned ON or OFF all at once or by category (takeoff and landing). Default values for all or a category of V_{speeds} can also be restored using a menu option (by pressing the MENU Key while the Timer/References Window is displayed):

TAKEDOFF		
V_1	55KT	ON
V_R	59KT	ON
V_2	66KT	ON
V_{ENR}	110KT	ON
LANDING		
V_{APR}	100KT	ON
V_{REF}	91KT	ON

Takeoff and Landing V_{speeds} (Timer/References Window)

Flap extension maximum speed references (for takeoff/approach and landing conditions) are displayed as flags to the right of the Primary Airspeed Indicator for altitudes below 18,000 feet.

These flags cannot be turned off or modified. At altitudes below 18,000 feet, a flap speed reference acts as a high airspeed limit depending on flap deflection. V_{TA} is the limit when deflections exceed 1 degree, and V_{LD} is the limit for deflections exceeding 16 degrees.



Flap Speed References

During normal operation, airspeed digits are white on a black background.

Airspeed digits turn red if indicated airspeed is at least 251 KIAS/0.631M. With the standard hysteresis function applied, this will result in the digits turning red, when the airspeed exceeds 250.7 KIAS/0.6307M and turning back to normal when the airspeed decreases below 250.3 KIAS/0.6303M.

Airspeed digits turn amber if the end of the magenta airspeed trend vector is at least 251 KIAS/0.631M (unless a red condition already exists). With the standard hysteresis function applied, this will result in the digits turning amber when the trend vector exceeds 250.7 KIAS/0.6307M and turning back to normal when the trend vector decreases below 250.3 KIAS/0.6303M.

Below FL180, flap speed bugs also act as high airspeed limits. If flaps are extended beyond 16 degrees, VLD acts as a high speed limit. Airspeed digits turn red or amber if the airspeed or trend vector are above VLD, respectively. VTA acts as a similar limit if flaps are extended beyond 1 degree.

High-Speed Awareness

Maximum operating limit speeds are represented on the airspeed tape by a red and white barber pole. The maximum speed shown is either V_{MO} (250 KIAS) or M_{MO} (.630 M), depending on aircraft altitude. If altitude is above 27,120 feet, all high speed awareness indications are based on mach. Otherwise, all indications are based on airspeed.

Below FL180, flap speed bugs also act as high airspeed limits. If flaps are extended beyond 16 degrees, VLD acts as a high speed limit. Airspeed digits turn red or amber if the airspeed or trend vector are above VLDG, respectively. VTA acts as a similar limit if flaps are extended beyond 1 degree.

There is no aural warning based on flap speed limits.

Airspeed Digit Colors

During normal operation, airspeed digits are white on a black background. Airspeed digits turn red if indicated airspeed is at least 251 KIAS/0.631M. With the standard hysteresis function applied, this will result in the digits turning red when the airspeed exceeds 250.7 KIAS/0.6307M and turning back to normal when the airspeed decreases below 250.3 KIAS/0.6303M.

Airspeed digits turn amber if the end of the magenta airspeed trend vector is at least 251 KIAS/0.631M (unless a red condition already exists). With the standard hysteresis function applied, this will result in the digits turning amber when the trend vector exceeds 250.7 KIAS/0.6307M and turning back to normal when the trend vector decreases below 250.3 KIAS/0.6303M.

Below FL180, flap speed bugs also act as high airspeed limits. If flaps are extended beyond 16 degrees, VLD acts as a high speed limit. Airspeed digits turn red or amber if the airspeed or trend vector are above VLD, respectively. VTA acts as a similar limit if flaps are extended beyond 1 degree.

Aural Warning

Both GIAs trigger a discrete output to the aural warning unit to trip the overspeed aural warning. This output turns on when indicated airspeed is at least 252 KIAS/0.635M. With the standard hysteresis function applied, the warning will trigger at 251.7 KIAS/0.6347M and turn off when the airspeed decreases below 251.3 KIAS/0.6343M. There is no aural warning based on flap speed limits.

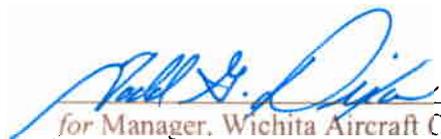
APPLICABLE REGULATION

The electronic displays in the Mustang do not comply with § 23.1545(b)(4), "For the flap operating range, a white arc with the lower limit at V_{SO} at the maximum weight, and the upper limit at the flaps-extended speed V_{FE} established under § 23.1511." Additionally, regulatory guidance contained in § 23.1311(a)(6) states that electronic displays must, "Incorporate sensory cues for the pilot that are equivalent to those in the instrument being replaced by the electronic display indicators." Since the referenced regulations for airspeed were written with analog type electro-mechanical instruments in mind, this design must incorporate additional compensating cues to provide adequate awareness and readability.

RECOMMENDATION

We concur that the proposed design features described as compensating features in the background section above provide an equivalent level of safety to the requirement of 14 CFR, part 23, § 23.1545(b)(4).

Concurred by:

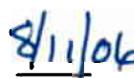

for Manager, Wichita Aircraft Certification Office, ACE-115W


Date


for Manager, Standards Office, ACE-110


Date


for Manager, Small Airplane Directorate, ACE-100


Date