Department of Transportation
Federal Aviation Administration
Aircraft Certification Service
Washington, DC

TSO-C46a

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Technical Standard Order

Subject: TSO-C46a, MAXIMUM ALLOWABLE AIRSPEED INDICATOR SYSTEMS

§ 37.145 Maximum allowable airspeed indicator systems —TSO-C46a.

(a) *Applicability.* This technical standard order prescribes the minimum performance standards that maximum allowable airspeed indicator systems must meet in order to be identified with the applicable TSO marking. New models of the instrument that are to be so identified, and that are manufactured on or after the effective date of this TSO, must meet the requirements of the "Federal Aviation Administration Standard, Maximum Allowable Airspeed Indicator Systems", set forth at the end of this section.

(b) *Marking.* In addition to the markings required by § 37.7, the instrument must be marked to indicate its range in knots, and, if applicable, to identify the calibration employed to control the movement of the maximum allowable airspeed pointer in the V_{MO} and M_{MO} ranges, or to identify the particular aircraft type design on which the instrument is intended to be used.

(c) *Data requirements.* In accordance with §37.5, the manufacturer must furnish the Chief, Engineering and Manufacturing Branch, Flight Standards Division, Federal Aviation Administration, in the region in which the manufacturer is located, the following technical data:

(1) Seven copies of the manufacturer's operating instruction, equipment limitations, and installation procedures.

(2) One copy of the test report of the manufacturer.

(d) *Previously approved equipment.* Maximum allowable airspeed indicator models approved prior to the effective date of this section may continue to be manufactured under the provisions of their original approval.

FEDERAL AVIATION ADMINISTRATION STANDARD
MAXIMUM ALLOWABLE AIRSPEED INDICATOR SYSTEMS

1. *Purpose.* This document specifies minimum performance standards for pitot-static type, maximum allowable airspeed indicator systems which indicate continuously both indicated airspeed and maximum allowable airspeed.

2. *Performance requirements.*

2.1 *General.*

(a) *Materials.* Materials must be of a quality demonstrated to be suitable and dependable for use in aircraft instruments.

(b) *Environmental conditions.* The instrument must be capable of performing its intended function and not be adversely affected during or following prolonged exposure to the environmental conditions stated under section 3. Where optional environmental conditions are set forth, the conditions selected

must be declared as equipment limitations.

2.2 *Detail requirements.*

(a) *Indicating means.* Indicated airspeed and maximum allowable airspeed must be displayed in such a manner that the numerical values on the scale increase in a clockwise, left to right, or bottom to top direction.

(b) *Case markings.* The outlets in the case must be marked with "P" for the pitot pressure connection, and with "S" for the static pressure connection.

2.3 *Design requirements.*

(a) *Adjustable settings.*

(1) *Maximum allowable airspeed pointer.* An adjustable stop may be provided in the instrument for limiting the movement of the maximum allowable airspeed pointer. If included, the design of this adjustment must be such that it will not affect the indication of the pointer when the altitude pressure conditions and Mach Number setting are such that the limiting speed will be lower than that set by the adjustable stop.

(2) *Mach Number.* If a readily accessible means is provided for setting the instrument to any desired Mach Number, the value of the setting must be visible from the front of the instrument. When the instrument does not contain an external Mach Number setting adjustment, the value of the permanent Mach Number setting need not be visible from the front of the instrument.

(b) *Visibility.* The indicating means and all markings must be visible from any point within the frustum of a cone, the side of which makes an angle of at least 30° with the perpendicular to the dial and the small diameter of which is the aperture of the instrument case. The distance between the dial and the cover glass must be a practical minimum.

(c) *Calibration.*

(1) *Indicated airspeed pointer.* The indicated airspeed pointer must indicate airspeed in accordance with the values contained in Table I.

(2) *Maximum allowable airspeed pointer.* The maximum allowable airspeed pointer must indicate maximum allowable airspeed values in the V_{MO} and M_{MO} limit ranges which—

(i) Follow the standard fundamental relationships of subsonic compressible flow gas dynamics which are stated in appendix A; or

(ii) Are adjusted to account for design factors that are characteristic of a particular aircraft type design such as, but not limited to, static source pressure error variations and variable speed limitations with altitude.

(d) *Scale error.*

(1) *Instruments with permanent Mach Number setting.* The indicated airspeed scale error and the maximum allowable airspeed scale error must not exceed the tolerances specified in Tables I and II, respectively, with the instrument set at its permanent Mach Number.

(2) *Instruments with means for external Mach Number setting adjustment.*

(i) The indicated airspeed scale error must not exceed the tolerances specified in Table I with the instrument set at the lowest Mach Number.

(ii) The maximum allowable airspeed scale error must not exceed the tolerances specified in Table II with the instrument set at the lowest Mach Number and at increasing Mach Number setting of not more than 0.10 to and including the maximum Mach Number.

(e) *Hysteresis.* The reading of the maximum allowable airspeed pointer first at 30,000 feet altitude and then at 10,000 feet altitude must not differ by more than 2 to assure the instrument complies with the scale error requirements of section 2.3(d)(2) knots from the corresponding readings obtained for increasing altitudes during tests (ii) of this TSO.

(f) *After effect.* To assure the instrument complies with the scale error requirements of section 2.3(d)(2)(ii) of this TSO, the maximum allowable airspeed pointer must return to its original readings, cor-

rected for any change in atmospheric pressure, within 3 knots, after not less than 1 or more than 5 minutes have elapsed following completion of performance tests.

(g) *Friction.*

(1) *Maximum allowable airspeed pointer.* The friction of the pointer must not produce an error exceeding 4 knots at each point indicated by an asterisk in Table II.

(2) *Indicated airspeed pointer.* The friction of the pointer must not produce an error exceeding 3 knots at each point indicated by an asterisk in Table I.

(h) *Leak.*

(1) *Case leak.* When subjected to a static pressure differential of 15 inches of mercury between the inside and outside of the case, the internal pressure must not increase because of case leaks more than 0.05 inches of mercury at the end of 1 minute time following first application of the differential pressure.

(2) *Airspeed diaphragm leak.* There must not be any apparent movement of the indicated airspeed pointer for 1 minute after a sequence of events in which pressure sufficient to produce full scale deflection of the indicated airspeed pointer is applied to the pitot connection (static pressure connection open to atmosphere), the pressure source is stopped, and the connection tubing pinched.

3. *Environmental conditions.*

3.1 *Temperature.* The instrument must perform its intended function over the range of ambient temperature from –30° to 50° C. With the instrument temperature stabilized at the limits of the range, the scale error must not exceed by more than 4.5 knots the tolerances specified in Tables I and II at the points marked with an asterisk. The instrument must not be adversely affected by exposure to the range of ambient temperature from –65° to 70° C.

3.2 *Altitude.* The instrument must perform its intended function and must not be adversely affected when operating in the pressure range from –1,000 feet and the maximum altitude of intended operation. The instrument must withstand an external case pressure of 50" Hg. absolute when installed properly and vented to an atmospheric pressure of approximately 29.92" Hg. absolute.

3.3 *Vibration.* The instrument must perform its intended function and must not be adversely affected when subjected to vibrations of the following characteristics:

Instrument panel mounted (vibration isolated)	Frequency cycles per second	Maximum double amplitude (inches)	Maximum acceleration
Reciprocating engine powered aircraft --	5-50	0.020	1.5g
Turbine engine powered aircraft ---	5-55 55-1000	0.020 ----------	--------- 0.25g

3.4 *Humidity.* The instrument must perform its intended function and must not be adversely affected following exposure to the extreme condition of relative humidity in the range from 0 to 95 percent at a temperature of approximately 70° C for a period of 10 hours.

4. *Compliance tests.* As evidence of compliance with this standard, the manufacturer must perform evaluation tests on prototype instruments to demonstrate proper design, reliability in performance of its intended functions, and conformity with the performance standards of section 2. Tests must also be performed to demonstrate compliance with the environmental condition requirements specified in section 3.

5. *Individual performance tests.* The manufacturer must conduct such tests as may be necessary on each instrument to assure that it will meet the minimum performance requirements of sections 2.3(b) through 2.3(h).

TABLE I

Speed knots	Impact pressure (qc) inches Hg at 25° C	Tolerance knots
50	0.1198	±4.0
*60	.1727	2.0
80	.3075	2.0
*100	.4814	2.0
120	.6950	2.0

*150	1.091	2.5
180	1.580	3.0
*200	1.959	3.0
230	2.610	3.0
*250	3.100	3.0
280	3.924	3.5
*300	4.534	3.5
320	5.195	3.5
*350	6.286	4.0
370	7.082	4.5
*400	8.385	5.0
430	9.826	5.5
*450	10.87	6.0
480	12.56	7.0
*500	13.78	7.0
520	15.07	7.0
*550	17.16	8.5
570	18.66	8.5
*600	21.07	9.0
630	23.71	9.5
*650	25.59	10.0

TABLE II

Altitude feet	Pressure inches mercury	Maximum speed pointer tolerance ±knots
0	29.921	**4
*5,000	24.896	
10,000	20.577	
*15,000	16.886	
20,000	13.750	
*25,000	11.104	
30,000	8.885	
*35,000	7.041	
40,000	5.538	
*45,000	4.355	
50,000	3.425	**4

**From indicated airspeed corresponding to maximum equivalent airspeed or maximum mach whichever is the limiting factor.

Appendix A
Relationships for calibrating maximum allowable airspeed pointer

(1) For altitudes from sea level to altitude where $V_{MO} = M_{MO}$:

$$V_{MO} = Cso\sqrt{\frac{2}{k-1}\left\{\left\{1+\frac{P}{Po}\left[\left(\frac{V^2{}_M}{5C^2{}_{80\sigma}}+1\right)\frac{k}{k-1}-1\right]\right\}\frac{k-1}{k}-1\right\}}$$

(2) For altitudes where M_{MO} is limiting factor:

$$V_{MO} = Cso\sqrt{\frac{2}{k-1}\left\{\left\{\frac{P}{Po}\left[\left(1+\frac{k-1}{2}\cdot M^2{}_{MO}\right)\frac{k}{k-1}-1\right]+1\right\}\frac{k-1}{k}-1\right\}}$$

Where:

V_{MO} = Maximum allowable indicated airspeed in knots.

M_{MO} = Maximum allowable mach.

k = Ratio of specific heats = 1.40 for air.

Po = Pressure at sea level in inches of Hg.

P = Ambient static pressure in inches of Hg.

Cso = Speed of sound at sea level = 661.48 knots.

s = Density ratio at altitude.

V_M = Maximum equivalent airspeed in knots.