This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

Designation: F3233/F3233M – 23b

Standard Specification for Flight and Navigation Instrumentation in Aircraft[1]

This standard is issued under the fixed designation F3233/F3233M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This specification covers flight and navigation instrumentation aspects of airworthiness and design. The material was developed through open consensus of international experts in general aviation. This information was created by focusing on Level 1, 2, 3, and 4 Normal Category aeroplanes; however, the content may be more broadly applicable, and should not be unduly limited. The topics covered within this specification are flight and navigation instruments including those for airspeed, altitude, attitude, heading, free air temperature, and speed warning.

1.2 The applicant for a design approval shall seek the individual guidance of their respective CAA body concerning the use of this specification as part of a certification plan. For information on which CAA regulatory bodies have accepted this specification (in whole or in part) as a means of compliance to their Small Aircraft Airworthiness regulations (hereinafter referred to as "the Rules"), refer to ASTM F44 webpage (www.ASTM.org/COMMITTEE/F44.htm), which includes CAA website links. Annex A1 maps the means of compliance described in this specification to EASA CS 23, amendment 5 or later, and FAA 14 CFR 23, amendment 64 or later.

1.3 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 Following is a list of external standards reference throughout this specification; the earliest revision acceptable for use is indicated. In all cases, later document revisions are acceptable if shown to be equivalent to the listed revision, or if otherwise formally accepted by the governing civil aviation authority; earlier revisions are not acceptable.

2.2 *ASTM Standards:*[2]

F3060 Terminology for Aircraft

F3061/F3061M Specification for Systems and Equipment in Aircraft

F3116/F3116M Specification for Design Loads and Conditions

F3117/F3117M Specification for Crew Interface in Aircraft

F3120/F3120M Specification for Ice Protection for General Aviation Aircraft

F3174/F3174M Specification for Establishing Operating Limitations and Information for Aeroplanes

F3179/F3179M Specification for Performance of Aircraft

F3229/F3229M Practice for Static Pressure System Tests in Small Aircraft

F3230 Practice for Safety Assessment of Systems and Equipment in Small Aircraft

2.3 *CARs Standard:*[3]

CAR 523 Normal, utility, aerobatic and commuter category aeroplanes and Airworthiness manual chapter 523 – Normal, utility, aerobatic and commuter category aeroplanes

2.4 *EASA Standard:*[4]

CS-23 Certification Specifications for Normal-Category Aeroplanes

[1] This specification is under the jurisdiction of ASTM Committee F44 on General Aviation Aircraft and is the direct responsibility of Subcommittee F44.50 on Systems and Equipment.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from Transport Canada, 330 Sparks St., Ottawa, ON K1A 0N5, https://tc.canada.ca/en.

[4] Available from European Union Aviation Safety Agency (EASA), Konrad-Adenauer-Ufer 3, D-50668 Cologne, Germany, https://www.easa.europa.eu.

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2.5 *FAA Technical Standard Orders:*
TSO-C10 Pressure Altimeter Systems
TSO-C209 Electronic Flight Instrument System (EFIS) Display
2.6 *Federal Standard:*[5]
14 CFR 23 Code of Federal Regulations Title 14 Part 23—Airworthiness Standards: Normal Category Airplanes

3. Terminology

3.1 Terminology specific to this specification is provided below. For general terminology, refer to Terminology F3060.

3.2 Where reference is made to V_S (V_{SR}), use V_S or V_{SR} as appropriate for the stall speed basis established for the aeroplane in accordance with F3179/F3179M.

3.3 *Definitions:*

3.3.1 *aircraft type code, n*—an Aircraft Type Code (ATC) is defined by considering both the technical considerations regarding the design of the aircraft and the airworthiness level established based upon risk-based criteria; the method of defining an ATC applicable to this specification is defined in Practice F3230.

3.3.2 *continued safe flight and landing, n*—continued safe flight and landing as applicable to this specification is defined in Specification F3061/F3061M.

3.3.3 *high speed, n*—an aircraft's performance level is considered high speed if V_{MO} or V_{NO} is greater than 463 km/h [250 knots], or M_{MO} is greater than M0.6.

3.3.4 *instrument, n*—the term instrument includes devices that are physically contained in one unit or component, 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).

3.3.5 *low speed, n*—an aircraft's performance level is considered low speed if V_{MO} or V_{NO} is less than or equal to 463 km/h [250 knots], or M_{MO} is less than or equal to M0.6.

3.3.6 *primary display, n*—primary display refers to the display of a parameter that is located such that the pilot looks at it first when wanting to view that parameter.

3.3.7 *sensitive altimeter, n*—an instrument that measures altitude as a function of atmospheric pressure typically with an adjustable barometric scale that allows the reference pressure to be set to a range of predefined atmospheric pressure references. The "sensitive" element of the altimeter relates to the sensitivity of the instrument's displayed change in altitude over the total range of display. (For some examples of sensitive altimeter implementations, see TSO-C10( ) or TSO-C209( )).

4. Instrumentation

NOTE 1—Table 1 provides correlation between various Aircraft Type Codes and the individual requirements contained within this section; refer to 3.3.1. For each subsection, an indicator can be found under each ATC character field; three indicators are used:

An empty cell ( ) in all applicable ATC character field columns indicates that an aircraft shall meet the requirements of that subsection.

A white circle (○) in multiple columns indicates that the requirements of that subsection are not applicable to an aircraft *only* if all such ATC character fields are applicable.

A mark-out (×) in any of the applicable ATC character field columns indicates that the requirements of that subsection are not applicable to an aircraft if that ATC character field is applicable.

Example—An aircraft with an ATC of 1SRLLDLN is being considered. Since all applicable columns are empty for 4.1.3, that subsection is applicable to the aircraft. Since both the "R" engine type column and the "L" cruise speed column for 4.1.4 contain white circles, then that subsection is not applicable; however, for an aircraft with an ATC of 1SRLHDLN, 4.1.4 would be applicable since the "H" cruise speed column does not contain a white circle. 4.1.5 would not be applicable to either aircraft, since it contains an × in the "R" engine type column.

4.1 *Flight and Navigation Instruments:*

4.1.1 A means to determine airspeed shall be provided.

4.1.2 A means to determine altitude shall be provided.

4.1.3 A means to determine aircraft heading or direction of flight shall be provided.

NOTE 2—The choice of technology to meet this requirement may be mandated by some governing aviation authorities due to external requirements; for example, a magnetic direction indicator.

4.1.4 A means to determine free air temperature shall be provided.

4.1.5 A speed warning device shall be provided for turbine-engine-powered aircraft.

4.1.6 A speed warning device shall be provided for aircraft for which V_{MO}/M_{MO} and V_D/M_D are established under Specification F3116/F3116M "Design Airspeeds" and Specification F3174/F3174M "Establishing Operating Limitations" if V_{MO}/M_{MO} is greater than 0.8 V_D/M_D.

4.1.7 Any speed warning device required by 4.1.5 or 4.1.6 shall give effective aural warning (differing distinctively from aural warnings used for other purposes) to the pilots whenever the speed exceeds V_{MO} plus 11.11 km/h [6 knots] or M_{MO} + 0.01.

4.1.8 The upper limit of the production tolerance for any speed warning device required by 4.1.5 or 4.1.6 shall not exceed the prescribed warning speed.

4.1.9 The lower limit of any speed warning device required by 4.1.5 or 4.1.6 shall be set to minimize nuisance warnings.

4.1.10 If an attitude display is installed, the instrument design shall not provide any means, accessible to the flight crew, of adjusting the relative positions of the attitude reference symbol and the horizon line beyond that necessary for parallax correction.

4.1.11 If airspeed limitations vary with altitude, the airspeed indicator shall have a maximum allowable airspeed indicator showing the variation of V_{MO} with altitude.

4.1.12 The altimeter shall be a sensitive type.

4.1.13 A third attitude instrument shall be provided that meets the requirements of 4.1.13.1 – 4.1.13.6.

4.1.13.1 The third attitude instrument shall be powered from a source independent of the electrical generating system.

4.1.13.2 The third attitude instrument shall continue reliable operation for a minimum of 30 min after total failure of the electrical generating system.

[5] Available from U.S. Government Publishing Office (GPO), 732 N. Capitol St., NW, Washington, DC 20401, http://www.gpo.gov.

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TABLE 1 ATC Compliance Matrix, Section 4

Section	Certification Level				Number of Engines		Type of Engine(s)		Stall Speed			Cruise Speed		Meteorological Conditions			Altitude		Maneuvers	
	1	2	3	4	S	M	R	T	L	M	H	L	H	D	N	I	L	H	N	A
4																				
4.1																				
4.1.1																				
4.1.2																				
4.1.3																				
4.1.4							○					○								
4.1.5							×													
4.1.6																				
4.1.7																				
4.1.8																				
4.1.9																				
4.1.10																				
4.1.11	×	×	×																	
4.1.12	×	×	×																	
4.1.13	×	×	×											×	×					
4.1.13.1	×	×	×											×	×					
4.1.13.2	×	×	×											×	×					
4.1.13.3	×	×	×											×	×					
4.1.13.4	×	×	×											×	×					
4.1.13.5	×	×	×											×	×					
4.1.13.6	×	×	×											×	×					
4.1.14																				
4.1.15																				
4.2																				
4.2.1																				
4.2.2																				
4.2.3																				
4.2.4														×	×					
4.2.5														×	×					
4.2.6																				
4.2.7	○								○					○						
4.3																				
4.3.1																				
4.3.2																				
4.3.4																				
4.3.5																				
4.3.6	×	×	×																	
4.3.6.1	×	×	×																	
4.3.6.2	×	×	×																	
4.3.7												×								
4.3.8	×	×	×																	
4.4																				
4.4.1																				
4.4.2																				
4.4.3																				
4.4.4																				
4.4.5	○								○					○						
4.4.6																				
4.4.7																				
4.4.8																				
4.4.8.1																				
4.4.8.2																				
4.4.9																				
4.4.10	○								○					○						
4.5																				
4.5.1																				
4.5.1.1																				
4.5.1.2																				
4.5.1.3		×	×	×									×		×	×				
4.5.1.4	○											○		○						
4.5.1.5	○											○		○						
4.6																				
4.6.1																				
4.6.1.1																				
4.6.1.2																				
4.6.1.3																				
4.6.2	○								○					○						
4.6.3	○								○					○						
4.6.4														×	×					
4.6.4.1														×	×					
4.6.4.2														×	×					

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4.1.13.3 The third attitude instrument shall operate independently of any other attitude indicating system.

4.1.13.4 The third attitude instrument shall be operative without selection after total failure of the electrical generating system.

4.1.13.5 The third attitude instrument shall be located in a position acceptable to the governing civil aviation authority that will make it plainly visible to and usable by any pilot at the pilot's station.

4.1.13.6 The third attitude instrument shall be appropriately lighted during all phases of operation.

4.1.14 Instrument panel vibration may not damage, or impair the accuracy of, any instrument.

4.1.15 The instrument lights shall have enough distance or insulating material between current-carrying parts and the housing so that vibration in flight will not cause shorting.

4.2 *Electronic Display Instrument Systems:*

4.2.1 Electronic display indicators shall meet the arrangement and visibility requirements of Specification F3117/F3117M.

4.2.2 Electronic display indicators shall 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.

4.2.3 Electronic display indicators shall not inhibit the primary display of powerplant parameters needed by any pilot to properly set or monitor powerplant limitations during the engine starting mode of operation.

4.2.4 Electronic display indicators shall have an independent magnetic direction indicator and either an independent secondary mechanical altimeter, airspeed indicator, and attitude instrument or electronic display of parameters for altitude, airspeed, and attitude that are independent from the aircraft's primary electrical power system.

4.2.5 If secondary instruments are installed to comply with 4.2.4, they may be installed in panel positions that are displaced from the primary positions specified by Specification F3117/F3117M, but shall be located where they meet the pilot's visibility requirements of Specification F3117/F3117M.

4.2.6 Electronic display indicators shall provide, where appropriate, direction and rate of change of the parameter being displayed to the pilot.

4.2.7 The electronic display indicators, including their systems and installations, and considering other aircraft systems, shall be designed so that one display of information essential for continued safe flight and landing will be available within 1 s to the crew by a single pilot action or by automatic means for continued safe operation, after any single failure or probable combination of failures (refer to Practice F3230).

4.3 *Airspeed Indicating System:*

4.3.1 Each airspeed indicating instrument shall be calibrated to indicate true airspeed (at sea level with a standard atmosphere) with a minimum practicable instrument calibration error when the corresponding pitot and static pressures are applied.

4.3.2 Each airspeed system shall be calibrated in flight to determine the system error.

4.3.3 The system error, including position error, but excluding the airspeed indicator instrument calibration error, shall not exceed 3 % of the calibrated airspeed or 9.3 km/h [5 knots], whichever is greater, throughout the following speed ranges: 1.3 V_{S1} (1.23 V_{SR1}) to V_{MO}/M_{MO} or V_{NE}, whichever is appropriate with flaps retracted; and, 1.3 V_{S1} (1.23 V_{SR1}) to V_{FE} with flaps extended.

4.3.4 The design and installation of each airspeed indicating system shall provide positive drainage of moisture from the pitot static plumbing.

4.3.5 If certification for instrument flight rules or flight in icing conditions is requested, each airspeed system shall have a heated pitot tube or an equivalent means of preventing malfunction due to icing; refer to Specification F3120/F3120M.

4.3.6 Each airspeed system shall be calibrated to determine the system error during the accelerate-takeoff ground run.

4.3.6.1 The airspeed system ground run calibration shall be determined from 0.8 of the minimum value of V_1 to the maximum value of V_2, considering the approved ranges of altitude and weight.

4.3.6.2 The airspeed system ground run calibration shall be determined assuming an engine failure at the minimum value of V_1.

4.3.7 Aircraft with high speed performance levels (refer to 3.3.3) shall meet the requirements of 4.3.6, 4.3.6.1, and 4.3.6.2 regardless of seating capacity.

4.3.8 Where duplicate airspeed indicators are required, their respective pitot tubes shall be far enough apart to avoid damage to both tubes in a collision with a bird.

4.4 *Static Pressure System:*

4.4.1 Each instrument provided with static pressure case connections shall be so vented that the influence of aircraft speed, the opening and closing of windows, airflow variations, moisture, or other foreign matter will least affect the accuracy of the instruments except as noted in Specification F3120/F3120M.

4.4.2 The design and installation of a static pressure system shall be such that positive drainage of moisture is provided.

4.4.3 The design and installation of a static pressure system shall be such that chafing of the tubing, and excessive distortion or restriction at bends in the tubing, is avoided.

4.4.4 The design and installation of a static pressure system shall be such that the materials used are durable, suitable for the purpose intended, and protected against corrosion.

4.4.5 To demonstrate the integrity of the static pressure system, a proof test shall be conducted for unpressurized aircraft in accordance with Practice F3229/F3229M.

4.4.6 To demonstrate the integrity of the static pressure system, a proof test shall be conducted for pressurized aircraft in accordance with Practice F3229/F3229M.

4.4.7 If certification for instrument flight rules or flight in icing conditions is requested and a static pressure system is necessary for the functioning of instruments, systems, or devices, the static pressure system shall comply with the provisions of Specification F3120/F3120M.

4.4.8 Except as provided in 4.4.9, if the static pressure system incorporates both a primary and an alternate static

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