Designation: F3233/F3233M – 17

Standard Specification for Instrumentation in Small 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 international standards for the instrumentation aspects of airworthiness and design for "small" aircraft.

1.2 The applicant for a design approval must 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.

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 may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

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 and health practices and determine the applicability of regulatory limitations prior to use.*

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 Small Aircraft

F3082/F3082M Specification for Flight for General Aviation Aeroplanes

F3116/F3116M Specification for Design Loads and Conditions

F3117 Specification for Crew Interface in Aircraft

F3120/F3120M Specification for Ice Protection for General Aviation Aircraft

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

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

3. Terminology

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

3.2 *Definitions:*

3.2.1 *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 Specification F3061/F3061M.

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

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

3.2.4 *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).

3.2.5 *low speed, n*—an aircraft's performance level is considered low speed if V_{NE} 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.

3.2.6 *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.

[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.

4. Instrumentation

NOTE 1—Table 1 provides correlation between various Aircraft Type Codes and the individual requirements contained within this section; refer to 3.2.1. 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 must 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 must be provided.

4.1.2 A means to determine altitude must be provided.

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

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

4.1.6 A speed warning device must be provided for aircraft for which V_{MO}/M_{MO} and V_D/M_D are established under Specification F3116/F3116M and Specification F3082/F3082M 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 must 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 may 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 must be set to minimize nuisance warnings.

4.1.10 If an attitude display is installed, the instrument design must 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 must have a maximum allowable airspeed indicator showing the variation of V_{MO} with altitude.

4.1.12 The altimeter must be a sensitive type.

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

4.1.13.1 In showing compliance with 4.1.13, the instrument must be powered from a source independent of the electrical generating system.

4.1.13.2 In showing compliance with 4.1.13, the instrument must continue reliable operation for a minimum of 30 min after total failure of the electrical generating system.

4.1.13.3 In showing compliance with 4.1.13, the instrument must operate independently of any other attitude indicating system.

4.1.13.4 In showing compliance with 4.1.13, the instrument must be operative without selection after total failure of the electrical generating system.

4.1.13.5 In showing compliance with 4.1.13, the instrument must 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 In showing compliance with 4.1.13, the instrument must 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 must 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 must meet the arrangement and visibility requirements of Specification F3117.

4.2.2 Electronic display indicators must 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 must 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 must 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, but must be located where they meet the pilot's visibility requirements of Specification F3117.

4.2.6 Electronic display indicators must 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, must 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 must 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.

TABLE 1 ATC Compliance Matrix, Section 4

Section	Airworthiness 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																				
4.3.3																				
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														×	×					

4.3.2 Each airspeed system must 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, may 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} to V_{MO}/M_{MO} or V_{NE}, whichever is appropriate with flaps retracted; and, 1.3 V_{S1} to V_{FE} with flaps extended.

4.3.4 The design and installation of each airspeed indicating system must 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 must have a heated pitot tube or an equivalent means of preventing malfunction due to icing; refer to Specification F3120/F3120M.

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

4.3.6.1 In showing compliance with 4.3.6, the ground run calibration must 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 In showing compliance with 4.3.6, the ground run calibration must be determined assuming an engine failure at the minimum value of V_1.

4.3.7 Aircraft with high speed performance levels (refer to 3.2.3) must 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 must 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 must 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 must be such that positive drainage of moisture is provided.

4.4.3 The design and installation of a static pressure system must 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 must 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 must 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 must 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 must 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 pressure source, the means for selecting one or the other source must be designed in accordance with 4.4.8.1 and 4.4.8.2.

4.4.8.1 In showing compliance with 4.4.8, when either source is selected, the other is blocked off.

4.4.8.2 In showing compliance with 4.4.8, both sources cannot be blocked off simultaneously.

4.4.9 For unpressurized aircraft, 4.4.8.1 does not apply if it can be demonstrated that the static pressure system calibration, when either static pressure source is selected, is not changed by the other static pressure source being open or blocked.

4.4.10 Each static pressure system must be calibrated in accordance with Practice F3229/F3229M.

4.5 *Direction Indicator:*

4.5.1 If a magnetic direction indicator is used to satisfy the requirements of 4.1.3, the following requirements must be met.

4.5.1.1 Except as provided in 4.5.1.3 or 4.5.1.4, each magnetic direction indicator must be installed so that its accuracy is not excessively affected by the aircraft's vibration or magnetic fields.

4.5.1.2 Except as provided in 4.5.1.3 or 4.5.1.4, the compensated installation of the magnetic direction indicator may not have a deviation in level flight greater than 10° on any heading.

4.5.1.3 The compensated installation of the magnetic direction indicator may deviate more than 10° when a radio is transmitting, but must not exceed 15°.

4.5.1.4 A magnetic nonstabilized direction indicator may deviate more than 10° due to the operation of electrically powered systems such as electrically heated windshields if either a magnetic stabilized direction indicator, which does not have a deviation in level flight greater than 10° on any heading, or a gyroscopic direction indicator, is installed.

4.5.1.5 Deviations of a magnetic nonstabilized direction indicator of more than 10° must be placarded in accordance with Specification F3117.

4.6 *Instruments Using a Power Source:*

4.6.1 Each instrument that uses a power source must have a means to indicate to the crew if power is not adequate to sustain proper instrument performance.

4.6.1.1 In showing compliance with 4.6.1, the power must be sensed at the instrument, not at the power source only.

4.6.1.2 In showing compliance with 4.6.1, for electric and vacuum/pressure instruments, the power is considered to be adequate when the voltage or the vacuum/pressure, respectively, is within approved limits.

4.6.1.3 If a separate indicator is used to meet the requirements of 4.6.1, it must be located so that the pilot using the instruments can monitor the indicator with minimum head and eye movement.

4.6.2 The installation and power supply systems for instruments that use a power source must be designed so that the failure of one instrument will not interfere with the proper supply of energy to the remaining instruments.

4.6.3 The installation and power supply systems for instruments that use a power source must be designed so that the

failure of the energy supply from one source will not interfere with the proper supply of energy from any other source.

4.6.4 For certification for Instrument Flight Rules (IFR) operations, the heading, altitude, airspeed, and attitude instruments must meet the requirements of either 4.6.4.1 or 4.6.4.2.

4.6.4.1 In showing compliance with 4.6.4, there must be two independent sources of power (not driven by the same engine on multiengine aircraft), and a manual or an automatic means to select each power source.

4.6.4.2 As an alternative to the requirements of 4.6.4.1, there must be a separate display of parameters for heading, altitude, airspeed, and attitude that has a power source independent from the aircraft's primary electrical power system.

5. Keywords

5.1 electronic display; indication; instrumentation; instruments