

primary attachments) whose requirements are specific in subparts C and D of this part.

[Amdt. 23-41, 55 FR 43309, Oct. 26, 1990; 55 FR 47028, Nov. 8, 1990, as amended by Amdt. 23-49, 61 FR 5168, Feb. 9, 1996]

INSTRUMENTS: INSTALLATION

§ 23.1311 Electronic display instrument systems.

(a) Electronic display indicators, including those with features that make isolation and independence between powerplant instrument systems impractical, must:

(1) Meet the arrangement and visibility requirements of § 23.1321.

(2) Be easily legible under all lighting conditions encountered in the cockpit, including direct sunlight, considering the expected electronic display brightness level at the end of an electronic display indicator's useful life. Specific limitations on display system useful life must be contained in the Instructions for Continued Airworthiness required by § 23.1529.

(3) 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) Not inhibit the primary display of engine parameters needed by any pilot to properly set or monitor powerplant limitations during the engine starting mode of operation.

(5) Have an independent magnetic direction indicator and either an independent secondary mechanical altimeter, airspeed indicator, and attitude instrument or individual electronic display indicators for the altitude, airspeed, and attitude that are independent from the airplane's primary electrical power system. These secondary instruments may be installed in panel positions that are displaced from the primary positions specified by § 23.1321(d), but must be located where they meet the pilot's visibility requirements of § 23.1321(a).

(6) Incorporate sensory cues for the pilot that are equivalent to those in the instrument being replaced by the electronic display indicators.

(7) Incorporate visual displays of instrument markings, required by §§ 23.1541 through 23.1553, or visual displays that alert the pilot to abnormal operational values or approaches to established limitation values, for each parameter required to be displayed by this part.

(b) The electronic display indicators, including their systems and installations, and considering other airplane systems, must be designed so that one display of information essential for continued safe flight and landing will remain available to the crew, without need for immediate action by any pilot for continued safe operation, after any single failure or probable combination of failures.

(c) As used in this section, "instrument" includes devices that are physically contained in one unit, 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). As used in this section, "primary" display refers to the display of a parameter that is located in the instrument panel such that the pilot looks at it first when wanting to view that parameter.

[Doc. No. 27806, 61 FR 5168, Feb. 9, 1996]

§ 23.1321 Arrangement and visibility.

(a) Each flight, navigation, and powerplant instrument for use by any required pilot during takeoff, initial climb, final approach, and landing must be located so that any pilot seated at the controls can monitor the airplane's flight path and these instruments with minimum head and eye movement. The powerplant instruments for these flight conditions are those needed to set power within powerplant limitations.

(b) For each multiengine airplane, identical powerplant instruments must be located so as to prevent confusion as to which engine each instrument relates.

(c) Instrument panel vibration may not damage, or impair the accuracy of, any instrument.

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(d) For each airplane, the flight instruments required by § 23.1303, and, as applicable, by the operating rules of this chapter, must be grouped on the instrument panel and centered as nearly as practicable about the vertical plane of each required pilot's forward vision. In addition:

(1) The instrument that most effectively indicates the attitude must be on the panel in the top center position;

(2) The instrument that most effectively indicates airspeed must be adjacent to and directly to the left of the instrument in the top center position;

(3) The instrument that most effectively indicates altitude must be adjacent to and directly to the right of the instrument in the top center position;

(4) The instrument that most effectively indicates direction of flight, other than the magnetic direction indicator required by § 23.1303(c), must be adjacent to and directly below the instrument in the top center position; and

(5) Electronic display indicators may be used for compliance with paragraphs (d)(1) through (d)(4) of this section when such displays comply with requirements in § 23.1311.

(e) If a visual indicator is provided to indicate malfunction of an instrument, it must be effective under all probable cockpit lighting conditions.

[Doc. No. 4080, 29 FR 17955, Dec. 18, 1964, as amended by Amdt. 23-14, 38 FR 31824, Nov. 19, 1973; Amdt. 23-20, 42 FR 36968, July 18, 1977; Amdt. 23-41, 55 FR 43310, Oct. 26, 1990; 55 FR 46888, Nov. 7, 1990; Amdt. 23-49, 61 FR 5168, Feb. 9, 1996]

§ 23.1322 Warning, caution, and advisory lights.

If warning, caution, or advisory lights are installed in the cockpit, they must, unless otherwise approved by the Administrator, be—

(a) Red, for warning lights (lights indicating a hazard which may require immediate corrective action);

(b) Amber, for caution lights (lights indicating the possible need for future corrective action);

(c) Green, for safe operation lights; and

(d) Any other color, including white, for lights not described in paragraphs (a) through (c) of this section, provided

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the color differs sufficiently from the colors prescribed in paragraphs (a) through (c) of this section to avoid possible confusion.

(e) Effective under all probable cockpit lighting conditions.

[Amdt. 23-17, 41 FR 55465, Dec. 20, 1976, as amended by Amdt. 23-43, 58 FR 18976, Apr. 9, 1993]

§ 23.1323 Airspeed indicating system.

(a) 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.

(b) Each airspeed system must be calibrated in flight to determine the system error. The system error, including position error, but excluding the airspeed indicator instrument calibration error, may not exceed three percent of the calibrated airspeed or five knots, whichever is greater, throughout the following speed ranges:

(1) 1.3 V_{S1} to V_{MO}/M_{MO} or V_{NE} , whichever is appropriate with flaps retracted.

(2) 1.3 V_{S1} to V_{FE} with flaps extended.

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

(d) 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.

(e) In addition, for commuter category airplanes, the airspeed indicating system must be calibrated to determine the system error during the accelerate-takeoff ground run. The ground run calibration must be obtained between 0.8 of the minimum value of V_I , and 1.2 times the maximum value of V_I , considering the approved ranges of altitude and weight. The ground run calibration must be determined assuming an engine failure at the minimum value of V_I .

(f) For commuter category airplanes, 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.

[Amdt. 23-20, 42 FR 36968, July 18, 1977, as amended by Amdt. 23-34, 52 FR 1834, Jan. 15, 1987; 52 FR 34745, Sept. 14, 1987; Amdt. 23-42, 56 FR 354, Jan. 3, 1991; Amdt. 23-49, 61 FR 5168, Feb. 9, 1996]

§ 23.1325 Static pressure system.

(a) Each instrument provided with static pressure case connections must be so vented that the influence of airplane 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 paragraph (b)(3) of this section.

(b) If a static pressure system is necessary for the functioning of instruments, systems, or devices, it must comply with the provisions of paragraphs (b)(1) through (3) of this section.

(1) The design and installation of a static pressure system must be such that—

(i) Positive drainage of moisture is provided;

(ii) Chafing of the tubing, and excessive distortion or restriction at bends in the tubing, is avoided; and

(iii) The materials used are durable, suitable for the purpose intended, and protected against corrosion.

(2) A proof test must be conducted to demonstrate the integrity of the static pressure system in the following manner:

(i) *Unpressurized airplanes.* Evacuate the static pressure system to a pressure differential of approximately 1 inch of mercury or to a reading on the altimeter, 1,000 feet above the aircraft elevation at the time of the test. Without additional pumping for a period of 1 minute, the loss of indicated altitude must not exceed 100 feet on the altimeter.

(ii) *Pressurized airplanes.* Evacuate the static pressure system until a pressure differential equivalent to the maximum cabin pressure differential for which the airplane is type certificated is achieved. Without additional pumping for a period of 1 minute, the loss of indicated altitude must not exceed 2 percent of the equivalent altitude of

the maximum cabin differential pressure or 100 feet, whichever is greater.

(3) If a static pressure system is provided for any instrument, device, or system required by the operating rules of this chapter, each static pressure port must be designed or located in such a manner that the correlation between air pressure in the static pressure system and true ambient atmospheric static pressure is not altered when the airplane encounters icing conditions. An antiicing means or an alternate source of static pressure may be used in showing compliance with this requirement. If the reading of the altimeter, when on the alternate static pressure system differs from the reading of the altimeter when on the primary static system by more than 50 feet, a correction card must be provided for the alternate static system.

(c) Except as provided in paragraph (d) of this section, 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 so that—

(1) When either source is selected, the other is blocked off; and

(2) Both sources cannot be blocked off simultaneously.

(d) For unpressurized airplanes, paragraph (c)(1) of this section 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.

(e) Each static pressure system must be calibrated in flight to determine the system error. The system error, in indicated pressure altitude, at sea-level, with a standard atmosphere, excluding instrument calibration error, may not exceed ± 30 feet per 100 knot speed for the appropriate configuration in the speed range between $1.3 V_{SO}$ with flaps extended, and $1.8 V_{SI}$ with flaps retracted. However, the error need not be less than 30 feet.

(f) [Reserved]

(g) For airplanes prohibited from flight in instrument meteorological or icing conditions, in accordance with

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§ 23.1559(b) of this part, paragraph (b)(3) of this section does not apply.

[Amdt. 23-1, 30 FR 8261, June 29, 1965, as amended by Amdt. 23-6, 32 FR 7586, May 24, 1967; 32 FR 13505, Sept. 27, 1967; 32 FR 13714, Sept. 30, 1967; Amdt. 23-20, 42 FR 36968, July 18, 1977; Amdt. 23-34, 52 FR 1834, Jan. 15, 1987; Amdt. 23-42, 56 FR 354, Jan. 3, 1991; Amdt. 23-49, 61 FR 5169, Feb. 9, 1996; Amdt. 23-50, 61 FR 5192, Feb. 9, 1996]

§ 23.1326 Pitot heat indication systems.

If a flight instrument pitot heating system is installed to meet the requirements specified in § 23.1323(d), an indication system must be provided to indicate to the flight crew when that pitot heating system is not operating. The indication system must comply with the following requirements:

(a) The indication provided must incorporate an amber light that is in clear view of a flightcrew member.

(b) The indication provided must be designed to alert the flight crew if either of the following conditions exist:

(1) The pitot heating system is switched "off."

(2) The pitot heating system is switched "on" and any pitot tube heating element is inoperative.

[Doc. No. 27806, 61 FR 5169, Feb. 9, 1996]

§ 23.1327 Magnetic direction indicator.

(a) Except as provided in paragraph (b) of this section—

(1) Each magnetic direction indicator must be installed so that its accuracy is not excessively affected by the airplane's vibration or magnetic fields; and

(2) The compensated installation may not have a deviation in level flight, greater than ten degrees on any heading.

(b) A magnetic nonstabilized direction indicator may deviate more than ten degrees 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 ten degrees on any heading, or a gyroscopic direction indicator, is installed. Deviations of a magnetic nonstabilized direction indicator of more than 10 de-

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grees must be placarded in accordance with § 23.1547(e).

[Amdt. 23-20, 42 FR 36969, July 18, 1977]

§ 23.1329 Automatic pilot system.

If an automatic pilot system is installed, it must meet the following:

(a) Each system must be designed so that the automatic pilot can—

(1) Be quickly and positively disengaged by the pilots to prevent it from interfering with their control of the airplane; or

(2) Be sufficiently overpowered by one pilot to let him control the airplane.

(b) If the provisions of paragraph (a)(1) of this section are applied, the quick release (emergency) control must be located on the control wheel (both control wheels if the airplane can be operated from either pilot seat) on the side opposite the throttles, or on the stick control, (both stick controls, if the airplane can be operated from either pilot seat) such that it can be operated without moving the hand from its normal position on the control.

(c) Unless there is automatic synchronization, each system must have a means to readily indicate to the pilot the alignment of the actuating device in relation to the control system it operates.

(d) Each manually operated control for the system operation must be readily accessible to the pilot. Each control must operate in the same plane and sense of motion as specified in § 23.779 for cockpit controls. The direction of motion must be plainly indicated on or near each control.

(e) Each system must be designed and adjusted so that, within the range of adjustment available to the pilot, it cannot produce hazardous loads on the airplane or create hazardous deviations in the flight path, under any flight condition appropriate to its use, either during normal operation or in the event of a malfunction, assuming that corrective action begins within a reasonable period of time.

(f) Each system must be designed so that a single malfunction will not produce a hardover signal in more than one control axis. If the automatic pilot integrates signals from auxiliary controls or furnishes signals for operation

of other equipment, positive interlocks and sequencing of engagement to prevent improper operation are required.

(g) There must be protection against adverse interaction of integrated components, resulting from a malfunction.

(h) If the automatic pilot system can be coupled to airborne navigation equipment, means must be provided to indicate to the flight crew the current mode of operation. Selector switch position is not acceptable as a means of indication.

[Doc. No. 4080, 29 FR 17955, Dec. 18, 1964; 30 FR 258, Jan. 9, 1965, as amended by Amdt. 23-23, 43 FR 50593, Oct. 30, 1978; Amdt. 23-43, 58 FR 18976, Apr. 9, 1993; Amdt. 23-49, 61 FR 5169, Feb. 9, 1996]

§ 23.1331 Instruments using a power source.

For each instrument that uses a power source, the following apply:

(a) Each instrument must have an integral visual power annunciator or separate power indicator to indicate when power is not adequate to sustain proper instrument performance. If a separate indicator is used, it must be located so that the pilot using the instruments can monitor the indicator with minimum head and eye movement. The power must be sensed at or near the point where it enters the instrument. 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.

(b) The installation and power supply systems must be designed so that—

(1) The failure of one instrument will not interfere with the proper supply of energy to the remaining instrument; and

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

(c) There must be at least two independent sources of power (not driven by the same engine on multiengine airplanes), and a manual or an automatic means to select each power source.

[Doc. No. 26344, 58 FR 18976, Apr. 9, 1993]

§ 23.1335 Flight director systems.

If a flight director system is installed, means must be provided to in-

dicate to the flight crew its current mode of operation. Selector switch position is not acceptable as a means of indication.

[Amdt. 23-20, 42 FR 36969, July 18, 1977]

§ 23.1337 Powerplant instruments installation.

(a) *Instruments and instrument lines.*

(1) Each powerplant and auxiliary power unit instrument line must meet the requirements of § 23.993.

(2) Each line carrying flammable fluids under pressure must—

(i) Have restricting orifices or other safety devices at the source of pressure to prevent the escape of excessive fluid if the line fails; and

(ii) Be installed and located so that the escape of fluids would not create a hazard.

(3) Each powerplant and auxiliary power unit instrument that utilizes flammable fluids must be installed and located so that the escape of fluid would not create a hazard.

(b) *Fuel quantity indication.* There must be a means to indicate to the flightcrew members the quantity of usable fuel in each tank during flight. An indicator calibrated in appropriate units and clearly marked to indicate those units must be used. In addition:

(1) Each fuel quantity indicator must be calibrated to read “zero” during level flight when the quantity of fuel remaining in the tank is equal to the unusable fuel supply determined under § 23.959(a);

(2) Each exposed sight gauge used as a fuel quantity indicator must be protected against damage;

(3) Each sight gauge that forms a trap in which water can collect and freeze must have means to allow drainage on the ground;

(4) There must be a means to indicate the amount of usable fuel in each tank when the airplane is on the ground (such as by a stick gauge);

(5) Tanks with interconnected outlets and airspaces may be considered as one tank and need not have separate indicators; and

(6) No fuel quantity indicator is required for an auxiliary tank that is used only to transfer fuel to other tanks if the relative size of the tank,

the rate of fuel transfer, and operating instructions are adequate to—

- (i) Guard against overflow; and
- (ii) Give the flight crewmembers prompt warning if transfer is not proceeding as planned.

(c) *Fuel flowmeter system.* If a fuel flowmeter system is installed, each metering component must have a means to by-pass the fuel supply if malfunctioning of that component severely restricts fuel flow.

(d) *Oil quantity indicator.* There must be a means to indicate the quantity of oil in each tank—

(1) On the ground (such as by a stick gauge); and

(2) In flight, to the flight crew members, if there is an oil transfer system or a reserve oil supply system.

[Doc. No. 4080, 29 FR 17955, Dec. 18, 1964, as amended by Amdt. 23–7, 34 FR 13096, Aug. 13, 1969; Amdt. 23–18, 42 FR 15042, Mar. 17, 1977; Amdt. 23–43, 58 FR 18976, Apr. 9, 1993; Amdt. 23–51, 61 FR 5138, Feb. 9, 1996; Amdt. 23–49, 61 FR 5169, Feb. 9, 1996]

ELECTRICAL SYSTEMS AND EQUIPMENT

§ 23.1351 General.

(a) *Electrical system capacity.* Each electrical system must be adequate for the intended use. In addition—

(1) Electric power sources, their transmission cables, and their associated control and protective devices, must be able to furnish the required power at the proper voltage to each load circuit essential for safe operation; and

(2) Compliance with paragraph (a)(1) of this section must be shown as follows—

(i) For normal, utility, and acrobatic category airplanes, by an electrical load analysis or by electrical measurements that account for the electrical loads applied to the electrical system in probable combinations and for probable durations; and

(ii) For commuter category airplanes, by an electrical load analysis that accounts for the electrical loads applied to the electrical system in probable combinations and for probable durations.

(b) *Function.* For each electrical system, the following apply:

(1) Each system, when installed, must be—

(i) Free from hazards in itself, in its method of operation, and in its effects on other parts of the airplane;

(ii) Protected from fuel, oil, water, other detrimental substances, and mechanical damage; and

(iii) So designed that the risk of electrical shock to crew, passengers, and ground personnel is reduced to a minimum.

(2) Electric power sources must function properly when connected in combination or independently.

(3) No failure or malfunction of any electric power source may impair the ability of any remaining source to supply load circuits essential for safe operation.

(4) In addition, for commuter category airplanes, the following apply:

(i) Each system must be designed so that essential load circuits can be supplied in the event of reasonably probable faults or open circuits including faults in heavy current carrying cables;

(ii) A means must be accessible in flight to the flight crewmembers for the individual and collective disconnection of the electrical power sources from the system;

(iii) The system must be designed so that voltage and frequency, if applicable, at the terminals of all essential load equipment can be maintained within the limits for which the equipment is designed during any probable operating conditions;

(iv) If two independent sources of electrical power for particular equipment or systems are required, their electrical energy supply must be ensured by means such as duplicate electrical equipment, throwover switching, or multichannel or loop circuits separately routed; and

(v) For the purpose of complying with paragraph (b)(5) of this section, the distribution system includes the distribution busses, their associated feeders, and each control and protective device.

(c) *Generating system.* There must be at least one generator/alternator if the electrical system supplies power to load circuits essential for safe operation. In addition—

(1) Each generator/alternator must be able to deliver its continuous rated