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LAND SEA AIR SPACE

AEROSPACE RECOMMENDED PRACTICE

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ARP 1061

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Revised

ALTITUDE ALERTING DEVICES AND SYSTEMS

1. PURPOSE

This Aerospace Recommended Practice (ARP) establishes an industry recommended practice for altitude warning devices and systems, when used as an alerting device related to altitude information normally used for aircraft height control, but not including the remote sources of such information.

2. SCOPE

2.1 This ARP provides performance criteria for Altitude Alerting Devices and Systems. These devices can be self-contained or receive remote altitude information and can have integral or remote barometric corrections. Only the generation of the alerting signals is covered by this recommended practice and not the details of the visual or audio alerts operated by these signals. It is recommended that the system's operational correspondence between the selected altitude settings of the Altitude Alerting Device and the Altitude Level Indication normally used to control the aircraft should not exceed ±250 ft RSS throughout the operating range of the device.

2.2 Range of Altitude: This recommended practice provides for operational performance up to 80,000 ft of altitude based on pressure altitude, radar altitude or radio altitude in any combination or singular inputs.

2.3 This device should contain or accept inputs of altitude, equal to that information displayed and used by the pilot for height control of his aircraft, in increments of not greater than 100 ft of indicated altitude. This device should provide for audio/visual warning signals when the flight altitude deviates from the preselect altitude or height level and for approaching and/or departing a preselect altitude level.

2.4 Other Parameters: The following is a listing of other parameter inputs which can augment and modify the altitude alerting system in its operation at various levels of flight altitude and landing approach altitudes.

a. Altitude Rate of Change
b. Angle of Attack
c. Radio Altitude
d. Airspeed Min./Max..
e. Mach Number Min./Max.
f. Flap position
g. Landing Gear Position
h. Minimum Decision Height
    1. Cat. II Series
    2. Cat. III Series
i. Auto Land System

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j. Automatic Flight Control and Stability Augmentation Systems

k. Altitude Function Inputs via a C.A.D.C. System

l. Altitude Rate of Change via INS System

2.5 Documents Referred to Herein:

Altitude Reference - U. S. Standard Atmosphere 1962.
Airspeed Reference - NASA TN-D822 Tables.

Both of the above references are available from the Superintendent of Documents, U. S. Government Printing Office.

Environmental Conditions and Test Procedures - RTCA Document No. DO-138, June 27, 1968, by Radio Technical Commission for Aeronautics, 2000 K Street, N.W., Washington, D.C. 20006.

3. GENERAL REQUIREMENTS

3.1 Acceptance Criteria: These are test requirements related to aircraft instruments and are used to establish the individual acceptability of each instrument. Reference to paragraph 6.

3.2 Qualification Criteria: These are test requirements related to aircraft instruments and are used to generally establish the quality of the design and manufacture of aircraft instruments. Reference to paragraph 7.

3.3 Materials and Workmanship:

3.3.1 Materials: Materials should be of a quality which experience and/or tests have demonstrated to be suitable and reliable for use in aircraft instruments.

3.3.2 Workmanship: Workmanship should be consistent with high grade aircraft instrument manufacturing practice.

3.4 Identification: The following information should be legibly and permanently marked on the instrument or nameplate attached thereto:

a. Name of instrument

b. SAE ARP - (show number and revision letter)

c. Manufacturer's part number

d. Manufacturer's serial number or date of manufacture

e. Manufacturer's name and address

f. Altitude Range, operational signal levels and other input parameters (if applicable)

g. Rating (electrical, vacuum, etc., if applicable)

h. Aircraft identification (if applicable)

i. Environment Category - See code in RTCA DO-138, Appendix B

j. Weight

3.5 Compatibility of Components: Both self contained and remote components of an Altitude Alerting Device or System are covered by this ARP. Components that are individually acceptable but require matching for proper operation shall be identified in a manner that will assure performance to the requirements of this recommended practice.

3.6 Interchangeability: Instruments and components which are identified by the same part number in accordance with 3.4 shall be directly and completely interchangeable, as defined by 3.5.

3.7 Environmental Conditions: The following conditions have been established as design requirements. Tests should be conducted as specified in paragraphs 6 and 7 to insure compliance with this ARP. The instrument should be capable of its intended function throughout the environmental conditions set forth, and the conditions selected should be declared as operating limitations.

3.8 Interaction Provisions: Operation of the instrument shall not adversely affect interconnected instruments or systems.

3.9 Self Generated Signals: The generated signals should be capable of operating alert signals in accord with ARP 450C, Flight Deck Visual, Audible and Tactual Signals.

3.10 Test Provisions: As installed on the aircraft the device or system shall have the capability of being tested, without the usage of special test equipment, to assure that the essential alerting signals are properly operating.

3.11 Explosion Category: The instrument component, when intended for installation either in uninhabited areas of non-pressurized aircraft or in non-pressurized areas of pressurized aircraft, should not cause an explosion when operated in an explosive atmosphere. Instruments intended for mounting in a pressurized area only need not be tested for this category.

3.12 Fire Hazard: The instrument should be so designed as to safeguard against hazards to the aircraft in the event of malfunction or failure, and the maximum operating temperature or surfaces of any instrument component contacted by combustible fuel or vapor should not exceed 200 C due to self-heating. All materials should be non-combustible and should not liberate gases or fumes which can result in such corrosion as to cause malfunction of equipment or discoloration of dials or indicia, nor should toxic gases or fumes that are detrimental to performance of the aircraft, or health of personnel, be liberated under the operating conditions specified herein.

3.13 Radio Interference: The instrument shall not be a source of objectionable interference under operating conditions at any frequencies used on the aircraft, either by radiation, conduction, or feedback in any electronic equipment installed in the same aircraft as the instruments, and capable of performing as required when tested per the procedures of RTCA Document DO-138, paragraphs:

11. Audio-Frequency Conducted Susceptibility Test.
12. Audio-Frequency Conducted Susceptibility Test.
13. Radio-Frequency Susceptibility Test.

Appendix A Standards on Emission of Spurious Radio Frequency Energy (Conducted and Radiated Interference) and Associated Test Procedures.

3.14 Magnetic Effect: The magnetic effect of the instrument shall not adversely affect the performance of other instruments installed in the same aircraft.

3.15 Dielectric: Each instrument shall be capable of meeting the dielectric requirements of 6.1. This requirement is for electrical isolation only and shall not be impressed on circuits where the potential will appear across elements such as windings, resistors, capacitors, etc.

3.16 Power Loss: Means shall be incorporated in the instrument to alert the user of loss of power essential to the operation of the instrument or the effect thereof.

4. DETAIL REQUIREMENTS

4.1 Instrument Markings:

4.1.1 Dial Finish: Matte white or other approved color material which is applied to graduations, numerals, pointers, indices, or other means from which quantitative information is to be read should be conspicous. The background for all surfaces from which operating information is read (dials, drums, tapes, etc.) should be non-reflecting contrasting color.

4.1.2 Visibility: The indicating means (indices, pointers, counters, etc.) used for altitude preselect and baro set if required, should be clearly identifiable from all points within a space defined by a surface generated by lines making angles of at least 30 degrees with a perpendicular to the display surface and diverging from the perimeter of the instrument window aperture. The distance between the indicating means and its cover glass should be a practical minimum.

4.1.3 Graduations and Numerals: Incremental markings should be provided at intervals of not greater than 100 ft for setability and for devices with a self-contained baro setting, incremental marking of not greater than .01 in. Hg and/or 0.5 millibars are required. The display should include sufficient numerals to permit quick and positive setting of discrete altitude levels, and baro setting if required.

4.1.4 Preselected Altitude Setting: Incremental numerals or markings shall be displayed at intervals of not greater than 1000 ft of indicated altitude; with a setability of 100 ft of indicated altitude.

4.1.5 Instruments with Self Contained Barometric Setting: Incremental marking or numerals of the barometric setting shall be displayed at intervals not greater than .02 in. of Hg and/or 1 millibar with a setability of .010 in. of Hg and/or .5 millibar.

4.1.6 Selected Altitude Display: Where mechanical means are used to display the select altitude setting, relative motion of the index with respect to the scale (either the index or the scale may be the moving element) should be clockwise, up or to the right for increasing function except that the relative motion of counters with respect to the window should be downward for increasing value. The display of the preselected altitude setting should be barometrically corrected altitude.

4.1.7 Barometric Setting Display (If Present): Rotation and/or setting of the barometric inputs, where required, should not cause the altitude setting to change its indicated value, nor should the setting of the selected altitude cause the barometric settings, when present, to change its value.

4.1.8 Flag Warning: When warning flags are used they should be a minimum of 1/16 of a square inch in area and should be visible for warning within the requirements of 4.5.

4.1.9 Integral Lighting (When Present): White internal lighting should be in accordance with ARP 798, Design Criteria for White Incandescent Lighted Aerospace Instruments.

Red integral lighting should be in accordance with ARP 582A, Lighting, Integral, for Aircraft Instruments: Criteria for Design of Red Lighted Instruments.

4.1.10 Instrument Title: The instrument title, when used, should be the same approximate size but not larger than the numerals. The title may be of the same finish as the numerals.

4.1.11 Multiple Mode Indications: Where an instrument has more than one mode of operation, means should be provided to indicate the mode of operation being used.

4.1.12 Relative Motion Counter (When Used): Relative motion counters with respect to the window shall be downward for increasing value.

4.2 Knobs: Rotation of knobs should be clockwise for increasing function.

4.3 Barometric System:

4.3.1 For devices with self-contained pressure altitude information, a barometric setting means should be provided which will permit the device to be set to any ambient barometric pressure throughout a minimum range of 28.1 to 31.0 in. of Hg and/or 951.5 to 1050.0 millibars. A safety feature should be provided which will prevent an incorrect operating of the altitude alerting system when the baro setting mechanism exceeds its barometric pressure setting limits.

4.3.2 For devices receiving remote pressure altitude information, a barometric setting means should be provided as detailed in 4.3.1 when the remotely supplied pressure altitude information has not been compensated for barometric setting and is referenced solely to a pressure of 29.921 in. of Hg and/or 1013.2 MB for zero feet pressure altitude.

4.3.3 For devices or systems receiving remotely supplied altitude information which is already corrected for barometric setting, or in the case of radio altitude or radar, no additional baro setting system should be provided.

4.3.4 Interaction: Means should be incorporated to prevent the barometric setting system adjustment as defined in 4.3.1 and 4.3.2 from causing an additional requirement for adjustment of the altitude preselect level.

4.4 Case Over Pressure: (For devices or systems containing pressure altitude sensing members.) The case should withstand a positive external differential pressure of 26 in. Hg.

4.5 Failure Monitoring: When remote altitude and or barometric signal sources have failure monitoring of these signals, the Altitude Alerting Device should indicate in a positive manner that such signal source are no longer valid for proper operation of the altitude alerts.

4.6 Fail-Safe Provisions: No single failure or malfunction of the device should introduce unsafe transients to associated interconnected instruments or systems.

4.7 Synchro Requirements: The synchros if used should be in accordance with the characteristics specified in ARP 461B, Synchros.

4.8 Solid State Detection and Logic: The use of Solid State Detection and Logic is advocated. Attention is called to the manufacturers to assure that solid state detection and logic is designed and tested in such a manner that failure of component sections is detectable and provide for a fail operational alerting system.

4.8.1 Derating of Components: When solid state components are in use adequate derating of active elements should be applied to assure long life and minimum heat rise. Special attention should be given to components which remain on at periods when no alerting signals are generated.

4.9 Digital Altitude Information: Digital altitude information shall have a minimum resolution of 100 ft per bit.

4.10 Relays and Switches: The use of electro-mechanical relays and switches should be kept to an absolute minimum and should be used primarily for terminal outputs or operational mode switching when high current requirements dictate.

4.11 Alerting Signals Operating Requirements: The instrument shall generate signal to operate alerts relative to the preselected barometrically corrected altitude level as specified in 6.6.

4.12 Minimum Operating Rate: The instrument shall be capable of generating the required signals for operation in accordance with 4.11 when the altitude signal input is changing at a rate of 10,000 ft per minute.

4.13 Radio Altimeter Altitude Signals (If Used): The Altitude Alerting System should accept signals from the Radio Altimeter below 3,000 ft AGL. These signals shall be used to limit the operation of the Altitude Alerting Device based on pressure altitude input. Signals generated via the Radio Altimeter should control the output signals of the Altitude Alerting System below 3,000 AGL.

4.14 Remotely Supplied Altitude Signals: Remotely supplied altitude information shall be any of the following:

a) Indicated altitude (barometrically corrected).

b) Pressure altitude (zero feet datum at 29.921 inches Hg. abs.).

c) Radio altitude (for altitudes below 3,000 feet AGL).

4.15 Servo Supplied Information:

4.15.1 Altitude Changes: The servo supplying the altitude information shall be capable of following input altitude change of at least 10,000 ft per min. with a maximum lag of 50 ft at the output altitude signal.

4.15.2 Servo Performance (Electrical Instruments): The damping ratio specified shall be indicative of adequate response and stable operation of linear servos. Where performance requirements dictate use of non-linear servos, the damping ratio may vary from that specified, provided comparable response and stability is maintained.

4.15.3 Threshold and Resolution: The servo supplying altitude information shall respond to sinusoidal changes as specified in 6.10 and 6.11 from -1000 to 50,000 ft, and a change in altitude output signal shall be apparent.

4.15.4 Remote Barometric Setting Information: Information supplied to the instrument from a remote barometric setting means shall be considered part of the Altitude Alerting System and shall be included in the alerting signal operating requirements where applicable.

4.16 Prevention of Alert Signals (If Present):

4.16.1 Visual Alert Signal: The visual alert signal should not be capable of being inhibited prior to generation of such signal and the operation of the visual alert. If such an inhibit signal is present, it should automatically be removed when the visual alert signal is normally released by attainment of the preselected altitude level or by selection of a new altitude level or when departure alerting signals are generated.

4.16.2 Audio Alert Signal: The audio alert signal shall not be capable of being inhibited prior to the generation of such signal and the operation of the audio sound generator.

4.16.3 Radio Altitude Alert Signal (If Present): If a radio altitude alert signal is present it should inhibit the operation of the pressure altitude alert signals below 3,000 ft AGL and be capable of operating at least one type, either visual or audio alert before or at the attainment of the minimum decision altitude setting in accordance with the approved operating procedure for the subject altitude alerting system.

4.17 Select Altitude Reset: When means are included in the select altitude set knob operation to inhibit the generation of alerting signals during the setting of a preselected altitude reference, this inhibit signal shall be automatically removed when the altitude set knob is at rest at any altitude value.

4.18 Digital Altitude Information: Digital altitude information shall have a minimum resolution of 100 ft per bit.

5. TEST CONDITIONS

5.1 Atmospheric Conditions: Unless otherwise specified herein, all tests required herein should be made at an atmospheric pressure of approximately 29.92 in. of Hg and/or 1013.2 millibars at an ambient temperature of approximately 25 C and a relative humidity of not greater than 85%. When tests are conducted with atmospheric pressure or temperature substantially different from these values, allowance shall be made for the variation from the specified conditions.

5.2 Power Conditions: Unless otherwise specified herein, all tests should be conducted at the power levels recommended by the manufacturer.

5.3 Attitude: Unless otherwise specified herein, all tests should be conducted with the device in its normal operating attitude.

5.4 Standard Pressures: (For devices and systems containing pressure altitude sensing members and/or differential pressure sensing members.)

5.4.1 Altitude pressure values shall be in accordance with "U.S. Standard Atmosphere, 1962."

5.4.2 Differential pressure values shall be in accordance with NASA Technical Note D-822 "Tables of Airspeed, Altitude, and Mach Number based on latest International Values for Atmospheric Properties."

5.4.3 Pressure Reference Standard: The reference standard for atmospheric pressure shall be a mercury barometer or equivalent. The barometer should be maintained in such a manner so as to assure that the barometer will have repeatability to its calibration standard and to its calibration data to within ±.002 Hg. The readability and setability should be within .001 inch Hg. The user should maintain records and data to show that the above conditions have been complied with within intervals of 3 months or less dependent on usage. The usage of a manometer or equal should exhibit the same characteristics as for the atmospheric standard and should be accordingly maintained.

5.5 Linear Motion Vibration: Vibration equipment should be such as to allow vibration to be applied along each of three mutually perpendicular axis of the instrument.

5.6 Vibration During Performance Tests: Unless otherwise specified, external vibration should not be allowed while accomplishing the performance tests. When this instrument has an integral vibrator, it should be tested in accordance with 6.8.

5.7 Barometric Setting Scale: When adjusting the barometric pressure scale to 29.92 in. Hg prior to starting a performance test, the 29.92 setting should always be approached from the low value end of the baro-scale.

6. INDIVIDUAL PERFORMANCE TESTS

All devices should be tested in accordance with the following recommended test procedures to show specific compliance with this recommended practice and any additional tests recommended by the manufacturer.

6.1 Electrical Insulation: Each device should be tested by the method of inspection listed herein.

6.1.1 Insulation Resistance: The insulation resistance measured at 200 volts DC for 5 seconds between all ungrounded electrical connector terminals connected together and the metallic case should not be less than 20 megohms. Insulation resistance measurements shall not be made to circuits where the potential will appear across elements such as windings, resistors, capacitors, semi-conductors, etc., since this measurement is intended only to determine adequacy of insulation.

6.1.2 Overpotential: The instrument should not be damaged by the application of a test potential between isolated electrical circuits and between isolated electrical circuits and the metallic case. The test potential should be a sinusoidal voltage of a commercial frequency with an R.M.S. value of five times the maximum circuit voltage, or per 6.1.2.1 or 6.1.2.2, whichever applies. The potential should start from zero and to increased at a uniform rate not to exceed 100 volts per second to its test value. It should be maintained at this value for 5 seconds and then reduced at a uniform rate not to exceed 100 volts per second to zero. Since these tests are intended to insure proper electrical isolation of the circuit components in question, these tests shall not be applied to circuits where the potential will appear across elements such as windings, resistors, capacitors, semi-conductors, etc.

6.1.2.1 Hermetically sealed instruments should be tested at five times the maximum circuit voltage up to a maximum of 200 volts R.M.S.

6.1.2.2 Circuits that operate at potentials below 15 volts should not be subjected to overpotential tests.

6.1.2.3 Individual output signal leads may be specified by the manufacturer to be deleted from the above overpotential test when such a signal output will be subject to destruction by the test (i.e., solid state circuits).

6.2 Leak Test: (For device or systems with self-contained pressure sensing elements.)

6.2.1 Static Pressure: The Pitot and/or static pressure ports should be tee connected to the master test equipment and to a source of vacuum. The total volume including the instrument under test shall be 100 ±10 cubic inches. An absolute pressure shall be applied to the pressure connections in accordance with Table I. The source should then be sealed off for a period of one minute during which time the difference between the readings of the master test equipment should not change by more than the tolerance specified in Table I.

NOTE: Thermal equilibrium should be maintained while performing this test.

6.2.2 Total Pressure (If Applicable): The Pitot pressure port should be connected to the master test equipment and to a source of pressure. The total volume including the instrument under test should be 100 ±10 cubic inch. A pressure approximating the maximum total pressure to be sensed should then be sealed off for a period of one minute during which time the master test equipment should not change by more than 0.03 inch.

6.3 Hermetically Sealed Components (If Applicable): Hermetically sealed components should be tested for leaks by a mass spectrometer leak detector of the helium type or equivalent. The leak rate should not exceed 0.0434 micron cubic foot per hour per cubic inch of filling gas at a pressure differential of one atmosphere.

NOTE: A micron cubic foot/hour leak rate is defined as that gas leakage which would change the pressure of a one cubic foot volume by the amount of one micron one millionth of a meter of mercury in one hour at a pressure differential of one atmosphere.

6.4 Power Loss: Means should be incorporated in the instrument to indicate when adequate electronic power is not available for proper operation. Such means should indicate this loss in a positive manner according to the importance of the loss, i.e., if performance is degraded but usable a flag shall be adequate. If the instrument is unusable, readability should be noticeably impaired by the warning device.

6.5 Balance Error: The instrument should be subjected to tests in each of the following attitudes, with inputs as required for the specific device:

1. Normal operating position.
2. Instrument positioned clockwise around its X (longitudinal) axis, 90 degrees from its normal position.
3. Instrument positioned clockwise around its X (longitudinal) axis, 180 degrees from its normal position.
4. Instrument positioned counterclockwise around its X (longitudinal) axis, 90 degrees from its normal position.
5. Instrument positioned about its Y (lateral) axis, 90 degrees from its normal operating position so that its dial is up.
6. Instrument positioned about its Y (lateral) axis, 90 degrees from its normal operating position so that its dial is down.

A change in alerting signal levels from those obtained when tested in the normal position (item 1 above) should be considered "balance error." The maximum deviation should not exceed the equivalent 10 feet of altitude change at levels below 10,000 ft, 30 feet of altitude change, at levels from 11,000 ft through 40,000 ft, and 50 feet at levels from 41,000 ft to 80,000 feet.

6.6 Alert Signal Performance:

6.6.1 The instrument should be capable of generating the required signals for operation as specified herein when the altitude signal input is changing at a rate of 10,000 ft per minute.

6.6.2 The actual generation of alerting signals relative to the selected altitude level should be within the requirements of section, and should not occur closer to the selected altitude level than 150 ft plus the system's operational correspondence as defined by the user of the system.

6.6.3 Several preselect altitude settings within the altitude range of the instrument should be tested. The alerting signal operating points should be those set forth on the identification plate (reference paragraph 3.4.f) relative to the preselect altitude level of the device. The instrument should generate signals to operate alerts relative to the preselected barometrically corrected altitude levels within the parameters specified herein (paragraphs 6.6.2 thru 6.6.5) when an ideal altitude input is presented to the instrument. The operation of the generated on/off signals should be within 100 ft or 10%, whichever is greater, of the alerting signal operating points specified by the approved procedure. This tolerance (100 ft or 10%) includes switch point hysteresis, at a maximum 30 feet, repeatability, and self contained barometric settings means at a maximum of plus or minus 25 ft (if present), when the instrument is mounted and is used in the environment specified by manufacturer and as defined in RTCA DO-138. When ideal pressure values are applied to a self-contained Altitude Alerting Device relative to the preselect altitude setting, it should meet the same accuracy plus the approved tolerances for the self-contained pressure sensing means.

6.6.4 Approaching the Preselected Altitude Level:

6.6.4.1 A signal should be generated, to operate a visual alert not further than 2,500 ft nor closer than 550 ft before the attainment of the preselected altitude level, for both ascending and descending towards the selected altitude level. The generated signal for the visual alert should remain on for at least 400 ft as the aircraft approaches the preselected altitude level.

6.6.4.2 A signal should be generated to operate an audio alert not further than 2,500 ft nor closer than 150 ft before the attainment of the preselected altitude level, for both ascending and descending towards the preselected altitude level.