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**MINIMUM OPERATIONAL PERFORMANCE STANDARDS (MOPS)
DRAFTING GUIDE**

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FOREWORD

RTCA, Incorporated, is a not-for-profit corporation formed to advance the art and science of aviation and aviation electronic systems for the benefit of the public. The organization functions as a Federal Advisory Committee and develops consensus-based recommendations on contemporary aviation issues. RTCA's objectives include but are not limited to:

- coalescing aviation system user and provider technical requirements in a manner that helps government and industry meet their mutual objectives and responsibilities;
- analyzing and recommending solutions to the system technical issues that aviation faces as it continues to pursue increased safety, system capacity and efficiency;
- developing consensus on the application of pertinent technology to fulfill user and provider requirements, including development of minimum operational performance standards for electronic systems and equipment that support aviation; and
- assisting in developing the appropriate technical material upon which positions for the International Civil Aviation Organization and the International Telecommunication Union and other appropriate international organizations can be based.

The organization's recommendations are often used as the basis for government and private sector decisions as well as the foundation for many Federal Aviation Administration Technical Standard Orders.

Since RTCA is not an official agency of the United States Government, its recommendations may not be regarded as statements of official government policy unless so enunciated by the U.S. government organization or agency having statutory jurisdiction over any matters to which the recommendations relate.

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1 PURPOSE AND SCOPE

1.1 Introduction

This document contains Minimum Operational Performance Standards for *name of equipment*.¹ These standards specify system characteristics that should be useful to designers, manufacturers, installers and users of the equipment.

Compliance with these standards is recommended as one means of assuring that the equipment will perform its intended function(s) satisfactorily under all conditions normally encountered in routine aeronautical operation. Any regulatory application of this document is the sole responsibility of appropriate governmental agencies.

Section 1 of this document provides information needed to understand the rationale for equipment characteristics and requirements stated in the remaining sections. It describes typical equipment operations and operation goals, as envisioned by the members of Special Committee *TBD*, and establishes the basis for the standards stated in Sections 2 through 3. Definitions and assumptions essential to proper understanding of this document are also provided in this section.

Section 2 contains the Minimum Performance Standards for the equipment. These standards specify the required performance under standard environmental conditions. Also included are recommended bench test procedures necessary to demonstrate equipment compliance with the stated minimum requirements.

Section 3 describes the performance required of installed equipment. Tests for the installed equipment are included when performance cannot be adequately determined through bench testing.

Section 4 describes the operational performance characteristics for equipment installations and defines conditions that will assure the equipment user that operations can be conducted safely and reliably in the expected operational environment.

This document considers an equipment configuration consisting of: *briefly describe the configuration envisioned by the Committee*. Operational performance standards for functions or components that refer to equipment capabilities that exceed the stated minimum requirements are identified as optional features. *Performance requirements and associated test procedures should be developed for these optional features*.

The word “equipment” as used in this document includes all components and units necessary for the system to properly perform its intended function(s). For example, the “equipment” may include *list one possible set of components and/or units making up a complete system*. In the case of this example, all of the foregoing components and units comprise the “equipment.” It should not be inferred from this example that each *name of equipment* design will necessarily include all of the foregoing components or units. This will depend on the specific design chosen by the manufacturer.

If the equipment implementation includes a computer software package, the guidelines contained in RTCA Document No. DO-178B, *Software Consideration in Airborne Systems and Equipment Certification*, should be considered.

1.2 System Overview

Describe the system, in general terms, to establish a basic understanding that will support the information to follow in this section. It is important that the Committee define

¹ Bold-italic text in this Guide pertains to the specific equipment described in the MOPS and provides guidance on what type of text needs to be developed.

the equipment being specified in the context of the overall system. In preparing material for paragraph 1.2, 1.3 and 1.4, the Committee should consider that a system may comprise airborne and ground elements each having hardware, software, procedural, etc., aspects.

1.3 Operational Application(s)

Describe typical system operational application(s).

1.4 Intended Function

Every function that is intended to be performed by the equipment being described in the MOPS should have a paragraph clearly and unambiguously describing the intended function to be performed by the equipment. This section could have several sub-sections devoted to each major function that the Special Committee intends to be addressed by the MOPS.

In addition to the functional description, each function should have a discussion of the effects of the loss or malfunction of this function. This function should be based on the FAR or JAR function hazard categorizations contained in FAR or JAR xx.1309 for FAR compliance, the 231309 and 25.1309-1b Advisory Circulars provide a basis for the evaluation to be performed by the Special Committee.

1.5 Operational Goals

Operational goals dictate the basic requirements that the airborne equipment must satisfy. Wherever possible, the system requirements cited in Section 2 should have their foundation established in this paragraph to answer the question as to why the stated requirements are necessary.

Define these goals, wherever possible, in operational terms. Items to be considered may include the following:

- a. Accuracy*
- b. Sensitivity*
- c. Resolution*
- d. Manual data inputs*
- e. Outputs*
- f. Failure modes, warnings and flags*
- g. Self test*
- h. Data display*
- i. Interface with other airborne equipment/systems*
- j. Etc.*

1.6 Assumptions

Describe the assumptions made, because of inadequate or non-existent information, having a bearing on stated requirements. Where possible, include a statement regarding the sensitivity of each assumption.

1.7 Test Procedures

The test procedures specified in this document are intended to be used as one means of demonstrating compliance with the performance requirement. Although specific test procedures are cited, it is recognized that other methods may be preferred. These alternate procedures may be used if they provided at least equivalent information. In such cases, the

procedures cited herein should be used as one criterion in evaluating the acceptability of the alternate procedures.

The order of tests specified suggests that the equipment be subjected to a succession of tests as it moves from design, and design qualification, into operational use. For example, compliance with the requirements of Section 2 shall have been demonstrated as a precondition to satisfactory completion of the installed system tests of Section 3.

a. Environmental Tests

Environmental test requirements are specified in Subsection 2.3. The procedures and their associated limits are intended to provide a laboratory means of determining the electrical and mechanical performance of the equipment under environmental conditions expected to be encountered in actual operations.

Unless otherwise specified, the environmental conditions and test procedures contained in RTCA Document No. DO-160C, *Environmental Conditions and Test Procedures for Airborne Equipment*, will be used to demonstrate equipment compliance.

b. Bench Tests

Bench test procedures are specified in Subsection 2.4. These tests provide a laboratory means of demonstrating compliance with the requirements of Subsection 2.2. Test results may be used by equipment manufacturers as design guidance, for monitoring manufacturing compliance and, in certain cases, for obtaining formal approval of equipment design.

c. Installed Equipment Tests

The installed equipment test procedures and their associated limits are specified in Section 3. Although bench and environmental test procedures are not included in the installed equipment test, their successful completion is a precondition to completion of the installed test. In certain instances, however, installed equipment test may be used in lieu of bench test simulation of such factors as power supply characteristics, interference from or to other equipment installed on the aircraft, etc. Installed tests are normally performed under two conditions:

1. With the aircraft on the ground and using simulated or operational system inputs.
2. With the aircraft in flight using operational system inputs appropriate to the equipment under test.

Test results may be used to demonstrate functional performance in the intended operational environment.

d. Operational Tests

The operational tests are specified in Section 4. These test procedures and their associated limits are intended to be conducted by operating personnel as one means of ensuring that the equipment is functioning properly and can be reliably used for its intended function(s).

1.8

Definition of Terms

Define those terms used in this document that could have multiple meanings or are not normally used.

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2 EQUIPMENT PERFORMANCE REQUIREMENTS AND TEST PROCEDURES

2.1 General Requirements

General equipment requirements need not be tested in the test procedure subsection. If a requirement needs to be tested, it is not a general requirement and should be included in paragraph 2.2.

2.1.1 Airworthiness

In the design and manufacture of the equipment, the manufacturer shall provide for installation so as not to impair the airworthiness of the aircraft.

2.1.2 Intended Function

The equipment shall perform its intended function(s), as defined by the manufacturer, and its proper use shall not create a hazard to other users of the National Airspace System.

2.1.3 Federal Communications Commission Rules

All equipment shall comply with the applicable rules of the Federal Communication Commission.

2.1.4 Fire Protection

All materials used shall be self-extinguishing except for small parts (such as knobs, fasteners, seals, grommets and small electrical parts) that would not contribute significantly to the propagation of a fire.

Note: One means of showing compliance is contained in Federal Aviation Regulations (FAR), Part 25, Appendix F.

2.1.5 Operation of Controls

The equipment shall be designed so that controls intended for use during flight cannot be operated in any position, combination or sequence that would result in a condition detrimental to the reliability of the equipment or operation of the aircraft.

2.1.6 Accessibility of Controls

Controls that do not require adjustment during flight shall not be readily accessible to flight personnel.

2.1.7 Effects of Test

The equipment shall be designed so that the application of specified test procedures shall not be detrimental to equipment performance following the application of the tests, except as specifically allowed.

2.1.8 Display of Navigation Facility Identification

Note: The following paragraph, or one similar in intent, should be added in MOPS for navigation equipment that may derive navigation guidance from co-located or closely spaced facilities.

The frequency, or paired channel or other identification of the active facility or facilities being used for navigational guidance shall be displayed at all times, or optionally temporarily stored during recall of other navigation facility information. Equipment having the

capability of optionally storing active facility identification shall include the following requirements:

- a. The capability of recalling the active facility at any time for the purpose of identification
- b. Display of facility identification from other than the active facility or facilities shall not interrupt or affect navigation guidance in any way.
- c. An unambiguous indication shall be visible to the pilot when facility identification form other than the active facility or facilities is being displayed.

2.1.9 Design Assurance

This paragraph will discuss the appropriate design assurance level(s) that would be expected as a result of the function definitions and failure categorization(s) contained in Section 1 of the document. This should be based upon the criteria of AC 23.1309 and 25.1309-1b. This paragraph should address both misleading information and the loss of the function. MOPS should point to the latest revision of the RTCA Document No. DO-178() document as a method of establishing the appropriate software levels. A specific software level should not be established in the MOPS since the definitions of the levels could change in RTCA Document DO-178() after the MOPS is issued. The MOPS under development should also point to any hardware or system design assurance standards that are in effect at the time of writing (i.e., SAE ARP-4754).

2.1.10 Continue with other General Requirements as Required

2.2 Equipment Performance – Standard Conditions

- a. *Requirements should be limited to those that are essential to the intended or expected use(s) of the equipment. Further, these requirements should be expressed in minimum terms, i.e., the threshold of performance requirements and values that must be achieved in a prescribed operational environment. When stating these requirements, it is important that they be confined to performance rather than design specifications, thereby permitting maximum freedom of design choice.*
- b. *Equipment classes should be considered where aircraft performance characteristics could result in undue equipment complexity.*
- c. *In general, use one paragraph to express a single requirement.*
- d. *Unless a requirement can be verified solely through visual inspection, it should be expressed in measurable terms so that it can be verified by a test procedure in Subsection 2.4.*
- e. *Particular care must be taken to assure that the requirement statement is compatible with the test procedure to be developed in Subsection 2.4. The Committee should consider multiple test procedures when the requirement could be proven by such methods.*
- f. *Features or functions, in addition to the minimum stated in this paragraph may be envisioned by the Committee as likely to be incorporated in designs providing added capability. The Committee should consider establishing minimum standards for those “optional” features or functions because of their potential effect on operations in the National Airspace System.*
- g. *If an antenna and its transmission line is critical to the equipment performance but it is not an integral part of the equipment, the requirement(s) to prove such performance shall be included in Section 3.*

2.3 Equipment Performance – Environmental Conditions

The environmental tests and performance requirements described in this subsection are intended to provide a laboratory means of determining the overall performance characteristics of the equipment under conditions representative of those that may be encountered in actual aeronautical operation.

Unless otherwise specified, the test procedures applicable to a determination of equipment performance under environmental test conditions are contained in RTCA Document No. DO-160D, *Environmental Conditions and Test Procedures for Airborne Equipment*. General information on the use of RTCA/DO-160D is contained in Sections 1 through 3 of that document. Also, a method of identifying which environmental tests were conducted and other amplifying information on the conduct of the tests is contained in Appendix A of RTCA/DO-160D.

Some of the performance requirements in Subsection 2.2 are not required to be tested to all of the conditions contained in RTCA/DO-160D. Judgement and experience have indicated that these particular parameters are not susceptible to certain environmental conditions and that the level of performance specified in Subsection 2.2 will not be measurably degraded by exposure to these conditions.

In addition to the exceptions above, certain environmental tests contained in this subsection are not required for minimum performance equipment unless the manufacturer wishes to qualify the equipment for additional environmental conditions. If the manufacturer wishes to qualify the equipment to these additional conditions, then these tests shall be performed.

Use only those tests listed below that are necessary to assure proper operation in the aeronautical environments envisioned by the Committee. Paragraph 1.0 of RTCA/DO-160D provides additional information on this subject.

2.3.1 Temperature and Altitude Tests (RTCA/DO-160C, Section 4.0)

RTCA/DO-160D contains several temperature and altitude test procedures that are specified according to equipment category. These categories are included in paragraph 4.3 of RTCA/DO-160D. The following subparagraphs contain the applicable test conditions specified in Section 4.0 of RTCA/DO-160D.

2.3.1.1 Low Operating Temperature Test

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160D, paragraph 4.5.1, and the following requirements of this standard shall be met;

State those performance requirements of subsection 2.2 that should be tested. Care should be exercised to ensure that those test requirements specified can be accomplished within the time allotted in RTCA/DO-160D for each particular test procedure. List the requirements using the format below.

- a. Paragraph 2.__.__(Title)
- b. Paragraph 2.__.__(Title)
- c. Paragraph 2.__.__(Title)
- d. Etc.

2.3.1.2 High Short-Time Operating Temperature Test

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160D, paragraph 4.5.2, and the following requirements of this standard shall be met:

Use the same format as in paragraph 2.3.1.1 above.

2.3.1.3 High Operating Temperature

The equipment shall be subject to the test conditions as specified in RTCA/DO-160D, paragraph 4.5.3, and the following requirements of this standard shall be met:

Use the same format as in paragraph 2.3.1.1 above.

2.3.1.4 In-Flight Loss of Cooling

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160D, paragraph 4.5.4, and the following requirements of this standard shall be met:

Use the same format as in paragraph 2.3.1.1 above.

This test is intended for equipment whose continued operation in the event of loss of cooling is essential to safe flight of the aircraft.

2.3.1.5 Altitude Tests

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160D, paragraph 4.6.1, and the following requirements of this standard shall be met:

Use the same format as in paragraph 2.3.1.1 above.

2.3.1.6 Decompression Test

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160D, paragraph 4.6.2, and the following requirements of this standard shall be met:

Use the same format as in paragraph 2.3.1.1 above.

Care should be taken to specify which requirements should be tested during this test and which should be tested after the test.

2.3.1.7 Overpressure Test

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160D, paragraph 4.6.3, and the following requirements of this standard shall be met:

Use the same format as in paragraph 2.3.1.1 above.

2.3.2 Temperature Variation Test (RTCA/DO-160D, Section 6.0)

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160D, Section 5.0, and the following requirements of this standard shall be met:

Use the same format as in paragraph 2.3.1.1 above.

2.3.3 Humidity Test (RTCA/DO-160D, Section 6.0)

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160D, Section 6.0, and the following requirements of this standard shall be met:

Use the same format as in paragraph 2.3.1.1 above.

2.3.4 Shock Tests (RTCA/DO-160D, Section 7.0)**2.3.4.1 Operational Shocks**

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160D, paragraph 7.2, and the following requirements of this standard shall be met:

Use the same format as in paragraph 2.3.1.1 above.

2.3.4.2 Crash Safety Shocks

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160D, paragraph 7.3, and shall meet the requirements specified therein.

The application of the Crash Safety Shock tests may result in damage to the equipment under test. Therefore this test may be conducted after the other tests have been completed. In this case, paragraph 2.1.7, “Effects of Test” does not apply.

2.3.5 Vibration Tests (RTCA/DO-160D, Section 8.0)

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160D, Section 8.0, and the following requirements of this standard shall be met:

Use the same format as in paragraph 2.3.1.1 above.

2.3.6 Explosion Test (RTCA/DO-160D, Section 9.0)

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160D, Section 9.0. During these tests, the equipment shall not cause detonation of the explosive mixture within the test chamber.

2.3.7 Waterproofness Test

2.3.7.1 Drip Proof Test

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160D, paragraph 10.3.1, and the following requirements of this standard shall be met:

Use the same format as in paragraph 2.3.1.1 above.

2.3.7.2 Spray Proof Test

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160D, paragraph 10.3.2, and the following requirements of this standard shall be met:

Use the same format as in paragraph 2.3.1.1 above.

This test shall be conducted with the spray directed perpendicular to the equipment.

2.3.7.3 Continuous Stream Proof Test

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160D, paragraph 10.3.3, and the following requirements of this standard shall be met:

Use the same format as in paragraph 2.3.1.1 above.

This test shall be conducted with the spray directed perpendicular to the equipment.

2.3.8 Fluids Susceptibility Tests (RTCA/DO-160D, Section 11.0)

The following subparagraphs contain the applicable test conditions specified in Section 11.0 of RTCA/DO-160D.

2.3.8.1 Spray Test

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160D, paragraph 11.4.1, and the following requirements of this standard shall be met:

- a. At the end of the 24-hour operational period, the equipment shall function.
- b. Following the two-hour operational period at ambient temperature, after the 160 hour exposure period at elevated temperature, the following requirements of this standard shall be met:

Use the same formats as in paragraph 2.3.1.1 above.

2.3.8.2 Immersion Test

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160D, paragraph 11.4.2, and the following requirements of this standard shall be met:

- a. At the end of the 24-hour operational period, the equipment shall function.
- b. Following the two-hour operational period at ambient temperature, after the 160 hour exposure period at elevated temperature, the following requirements of this standard shall be met:

Use the same formats as in paragraph 2.3.1.1 above.

2.3.9 Sand and Dust Test (RTCA/DO-160D, Section 12.0)

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160D, Section 12.0, and the following requirements of this standard shall be met:

Use the same format as in paragraph 2.3.1.1 above.

Required exposure to other than the six major axes should be stated.

2.3.10 Fungus Resistance Test (RTCA/DO-160D, Section 13.0)

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160D, Section 13.0, and the following requirements of this standard shall be met:

Use the same format as in paragraph 2.3.1.1 above.

State if an incubation period other than 26 days is required.

2.3.11 Salt Spray Test (RTCA/DO-160D, Section 14.0)

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160D, Section 14.0, and the following requirements of this standard shall be met:

Use the same format as in paragraph 2.3.1.1 above.

Required exposure period other than 48 hours should be specified.

2.3.12 Magnetic Effect Test (RTCA/DO-160D, Section 15.0)

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160D, Section 15.0, and the equipment shall meet the requirements of the appropriate instrument or equipment class specified therein.

2.3.13 Power Input Tests (RTCA/DO-160D, Section 16.0)**2.3.13.1 Normal Operating Conditions**

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160D, paragraphs 16.5.1 and 16.5.2, as appropriate, and the following requirements of this standard shall be met:

Use the same format as in paragraph 2.3.1.1 above.

Performance requirements for each of the two interrupt times identified in RTCA/DO-160D, paragraph 16.5.1.4.c or 16.5.2.3.c should be specified.

Equipment performance requirements different from the defined voltage of frequency modulation conditions should be stated.

2.3.13.2 Abnormal Operating Conditions

The application of the Low Voltage Conditions (DC) (Category B Equipment) test may result in damage to the equipment under test. Therefore, this test may be conducted after the other tests have been completed. Paragraph 2.1.7 “Effect of Test” does not apply,

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160D, paragraphs 16.5.3 and 16.5.4, as appropriate, and the following requirements of this standard shall be met:

Use the same format as in paragraph 2.3.1.1 above.

Equipment performance requirements different from the defined voltage of frequency modulation conditions should be stated.

2.3.14 Voltage Spike Conducted Test (RTCA/DO-160D, Section 17.0)

The following subparagraphs contain the applicable test conditions specified in Section 17.0 of RTCA/DO-160D.

2.3.14.1 Category A Requirements (If Applicable)

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160D, paragraph 17.4, and the following requirements of this standard shall be met:

Use the same format as in paragraph 2.3.1.1 above.

Equipment performance required during application of this test should be stated.

2.3.14.2 Category B Requirements (If Applicable)

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160D, paragraph 17.4, and the following requirements of this standard shall be met:

Use the same format as in paragraph 2.3.1.1 above.

2.3.15 Audio Frequency Conducted Susceptibility Test (RTCA/DO-160D, Section 18.0)

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160D, Section 18.0, and the following requirements of this standard shall be met:

Use the same format as in paragraph 2.3.1.1 above.

2.3.16 Induced Signal Susceptibility Test (RTCA/DO-160D, Section 19.0)

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160D, Section 19.0, and the following requirements of this standard shall be met:

Use the same format as in paragraph 2.3.1.1 above.

2.3.17 Radio Frequency Susceptibility Test (RTCA/DO-160D, Section 20.0)

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160D, Section 20.0, and the following requirements of this standard shall be met:

Use the same format as in paragraph 2.3.1.1 above.

2.3.18 Emission of Radio Frequency Energy Test (RTCA/DO-160D, Section 21.0)

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160D, Section 21.0, and the following requirements of this standard shall be met:

Use the same format as in paragraph 2.3.1.1 above.

2.3.19 Lightning Induced Transient Susceptibility Test (RTCA/DO-160D, Section 22.0)

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160D, Section 22.0, and the following requirements of this standard shall be met:

Use the same format as in paragraph 2.3.1.1 above.

2.4 Equipment Test Procedures**2.4.1 Definitions of Terms and Conditions of Test**

The following are definitions of terms and the conditions under which the tests described in this subsection should be conducted.

- a. Power Input Voltage – Unless otherwise specified, all tests shall be conducted with the power input voltage adjusted to design voltage, plus or minus 2%. The input voltage shall be measured at the input terminals of the equipment under test.
- b. Power Input Frequency
 1. In the case of equipment designed for operation from an AC source of essentially constant frequency (e.g., 400 Hz), the input frequency shall be adjusted to design frequency, plus or minus 2%.
 2. In the case of equipment designed for operation from an AC source of variable frequency (e.g., 300 to 1,000 Hz), unless otherwise specified, tests shall be conducted with the input frequency adjusted to within 5% of a selected frequency and within the range for which the equipment is designed.
- c. Adjustment of Equipment – The circuits of the equipment under test shall be properly aligned and otherwise adjusted in accordance with the manufacturer's recommended practices prior to application of the specified tests.
- d. Test Equipment – All equipment used in the performance of the tests should be identified by make, model and serial number where appropriate, and its latest calibration date. When appropriate, all test equipment calibration standards should be traceable to national and/or international standards.
- e. Test Instrument Precautions – Adequate precautions shall be taken during the test to prevent the introduction of errors resulting from the connection of voltmeters, oscilloscopes and other test instruments across the input and output impedances of the equipment under test.
- f. Ambient Conditions – Unless otherwise specified, all tests shall be made within the following ambient conditions:
 1. Temperature: +15 to +35 degrees C (+59 to +95 degrees F).
 2. Relative Humidity: Not greater than 85%.
 3. Ambient Pressure: 84 to 1-7 kPa (equivalent to +5,000 to -1,500 ft) (+1,525 to -460m).
- g. Connected Loads – Unless otherwise specified, all tests shall be performed with the equipment connected to loads having the impedance values for which it is designed.
- h. Continue as necessary

2.4.2 Required Test Equipment

List all equipment required to perform the test(s). Off-the-shelf test equipment should be identified by commercial model "or equivalent." Essential characteristics must be provided where non-standard test equipment is required.

2.4.3 Detailed Test Procedures

The test procedures set forth below constitute a satisfactory method of determining required performance. Although specific test procedures are cited, it is recognized that other methods may be preferred. Such alternate methods may be used if the manufacturer can show that they provide at least equivalent information. Therefore, the procedures cited herein should be used as one criterion in evaluating the acceptability of the alternate procedures.

2.4.3.1 Title (Paragraph 2.2.X)

Paragraph heading numbers and titles should be the same as the requirement heading numbers and titles, and reference the requirement paragraph number in the title. Insofar as possible, follow the same sequential order in test paragraphs as in requirement paragraphs.

Measurement Procedures

Step 1: ***Brief descriptive title for this test step***

Connect the equipment as shown in Figure 2-X.

Describe the step-by-step procedures to be used in conducting the test. Provide cautionary notes where required. Particular care must be taken to assure that the procedures are compatible with the environmental test procedures required by DO-160D.

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3 INSTALLED EQUIPMENT PERFORMANCE

This section states the minimum acceptable level of performance for the equipment when installed in the aircraft. For the most part, installed performance requirements are the same as those contained in Section 2, which were verified through bench and environmental test. However, certain requirements may be affected by the physical installation (e.g., antenna patterns, receiver sensitivity, etc.) and can only be verified after installation. The installed performance limits stated below take in consideration these situations.

3.1 Equipment Installation

3.1.1 Accessibility

Controls and monitors provided for in-flight operations shall be readily accessible from the pilot's normal seated position. The appropriate operator/crew member(s) shall have an unobstructed view of displayed data when in the normal seated position.

3.1.2 Aircraft Environment

Equipment shall be compatible with the environmental condition present in the specific location in the aircraft where the equipment is installed.

3.1.3 Display Visibility

Display intensity shall be suitable for data interpretation under all cockpit ambient light conditions ranging from total darkness to reflected sunlight.

Note: Visors, glare-shields or filters may be an acceptable means of obtaining daylight visibility.

3.1.4 Dynamic Range

Operation of the equipment shall not be adversely affected by aircraft maneuvering or changes in attitude encountered in normal flight conditions.

3.1.5 Failure Protection

Any probable failure of the equipment shall not degrade the normal operation of equipment or systems connected to it. Likewise, the failure of interfaced equipment or systems shall not degrade normal operation of this equipment.

3.1.6 Interference Effects

The equipment shall not be the source of harmful conducted or radiated interference nor be adversely affected by conducted or radiated interference from other equipment or systems installed in the aircraft.

Note: Electromagnetic compatibility problems noted after installation of this equipment may result from such factors as the design characteristics of previously installed systems or equipment and the physical installation itself. It is not intended that the equipment manufacturer design for all installation environments. The installing facility will be responsible for resolving any incompatibility between this equipment and previously installed equipment in the aircraft. The various factors contributing to the incompatibility shall be considered.

3.1.7 Inadvertent Turnoff

Appropriate protection shall be provided to avert the inadvertent turnoff of the equipment.

3.1.8 Aircraft Power Source

State any requirements for connecting the equipment to the aircraft power source(s) to assure the equipment will perform its intended function(s) in the operational environment.

3.1.9 Other Requirements

Continue with other requirements concerning equipment installation items such as antenna, etc.

3.2 Installed Equipment Performance Requirements

The installed equipment shall meet the requirements of Subsections 2.1 and 2.2 in addition to, or as modified by, the requirements stated below.

State the requirements that the equipment must meet when installed in the aircraft. The following guidelines, although not all inclusive, serve to illustrate some of the more important aspects that should be considered:

- a. Requirements should be strictly limited to those that the Committee considers necessary for all applications and user classes.*
- b. In general, use one paragraph to express a single requirement.*
- c. Requirements should be expressed in a manner that does not constrain design innovation.*
- d. Requirements should not place undue constraints on installation flexibility.*
- e. Care should be taken to define requirements that may be at variance with those stated in Section 2 because of physical or other installation constraints.*
- f. State those requirements that the equipment must meet to perform its intended function(s) but can only be verified after installation.*
- g. Unless a requirement can be verified solely through visual inspection, it should be expressed in measurable terms.*
- h. Particular care must be taken to assure that the requirement statement is compatible with test procedures to be developed for paragraph 3.4.*

3.3 Conditions of Test

The following subparagraphs define conditions under which tests, specified in paragraph 3.4, shall be conducted.

3.3.1 Safety Precautions

State any personnel and/or equipment safety precautions that should be observed because of any unique characteristics of the equipment or installation.

3.3.2 Power Input

Unless otherwise specified, all aircraft electrically operated equipment and systems shall be turned ON before conducting interference testing.

3.3.3 Environment

During testing, the equipment shall not be subjected to environmental conditions that exceed those specified by the equipment manufacturer.

3.3.4 Adjustment of Equipment

Circuits of the equipment under test shall be properly aligned and otherwise adjusted in accordance with the manufacturer's recommended practices prior to application of the specified tests.

3.3.5 Warm-up Period

Unless otherwise specified, tests shall be conducted after a warm-up (stabilization) period of not more than fifteen (15) minutes.

3.3.6 Continue with Other Conditions as Necessary

3.4 Test Procedures for Installed Equipment Performance

The following test procedures provide one means of determining installed equipment performance. Although specific test procedures are cited, it is recognized that other methods may be preferred by the installing activity. These alternate procedures may be used if they provide at least equivalent information. In such cases, the procedures cited herein should be used as one criterion in evaluating the acceptability of the alternate procedures. The equipment shall be tested to determine compliance with the minimum requirements stated in Subsection 2.2. In order to meet this requirement, test results supplied by the equipment manufacturer or other proof of conformity may be accepted in lieu of bench tests performed by the installing activity.

3.4.1 Ground Test Procedures

3.4.1.1 Conformity Inspection

Visually inspect the installed equipment to determine the use of acceptable workmanship and engineering practices. Verify that proper mechanical and electrical connections have been made and that the equipment has been located and installed in accordance with the manufacturer's recommendations.

3.4.1.2 Equipment Function

Vary all controls of the equipment through their full range to determine that the equipment is operating according to the manufacturer's instruction and that each control performs its intended function.

3.4.1.3 Interference Effects

With the equipment energized, individually operate each of the other electrically operated aircraft equipment and systems to determine that significant conducted or radiated interference does not exist. Evaluate all reasonable combinations of control settings and operating modes. Operate communication and navigation equipment on the low, high and at least on, but preferably four, mid-band frequencies. Make note of system or modes of operation that should also be evaluated during flight. If appropriate, repeat tests using emergency power with the aircraft's batteries alone and the inverters operating.

3.4.1.4 Power Supply Fluctuations

Under normal aircraft conditions, cycle the aircraft engine(s) through all normal power settings and verify proper operation of the equipment as specified by the equipment manufacturer.

3.4.1.5 Equipment Accessibility

Determine that all equipment controls and displayed data are readily accessible and easily interpreted.

3.4.1.6 Continue with Other Test Procedures

Continue with other test procedures to verify those installed performance requirements of paragraphs 3.1 and 3.2 that can be demonstrated with the aircraft on the ground.

3.4.2 Flight Test Procedures**3.4.2.1 Displayed Data Readability**

Determine that normal conditions of flight do not significantly affect the readability of displayed data.

3.4.2.2 Interference Effects

For aircraft equipment and systems that can be checked only in flight, determine that operationally significant conducted or radiated interference does not exist. Evaluate all reasonable combinations of control settings and operating modes. Operate communications and navigation equipment on the low, high and at least one, but preferable four, mid-band frequencies.

3.4.2.3 Continue with Other Test Procedures

Continue with other test procedures to verify those installed performance requirements of paragraphs 3.1 and 3.2 that can only, or more conveniently, be demonstrated in flight. Certain cases such as navigation performance, airborne coverage, etc., may require that the aircraft fly paths having specific characteristics. These essential characteristics, including typical flight test paths, should be included together with suggested data acquisition and analysis methods.

4 EQUIPMENT OPERATIONAL PERFORMANCE CHARACTERISTICS

4.1 Required Operational Performance Requirements

To ensure the operator that operations can be conducted safely and reliably in the expected operational environment, there are specific minimum acceptable performance requirements that shall be met. The following paragraphs identify these requirements.

4.1.1 Power Inputs

Prior to flight, verify that the equipment is receiving primary input power necessary for proper conditions.

4.1.2 Equipment Operating Modes

The equipment shall operate in each of its operating modes.

4.1.3 Continue with Other Operational Requirements as Necessary

4.2 Test Procedures for Operational Performance Requirements

Operation equipment tests may be conducted as part of normal pre-flight tests. For those tests that can only be run in flight, procedures should be developed to perform these tests as early during the flight as possible to verify that the equipment is performing its intended function(s).

4.2.1 Power Input

With the aircraft's electrical power generating system operating, energize the equipment and verify that electrical power is available to the equipment.

4.2.2 Equipment Operating Modes

Verify that the equipment performs its intended function(s) for each of the operating modes available to the operator.

4.2.3 Continue with Other Test Procedures

Continue with other test procedures to verify the requirements of paragraph 4.1.

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