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Environmental Conditions and Test Procedures for Airborne Equipment

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Prepared by SC-135
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Foreword

This document was prepared by Special Committee 135 (SC-135) and approved by the RTCA Program Management Committee (PMC) on December 8, 2010. It supersedes RTCA DO-160F dated December 6, 2007.

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 Telecommunications 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.

These standards were coordinated by RTCA SC-135 with the European Organisation for Civil Aviation Equipment (EUROCAE). EUROCAE concurs with RTCA on the environmental conditions and test procedures set forth herein. When approved by EUROCAE, this document will be identified jointly as RTCA DO-160G/EUROCAE ED-14G.

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RTCA/DO-160G

**Environmental Conditions and Test
Procedures for Airborne Equipment**

Section 1

Purpose and Applicability

Section 2

Definitions of Terms

Section 3

Conditions of Tests

Important Notice

Information contained in these sections is pertinent to all test procedures described in the other sections of this document. Further, Appendix A is applicable for identifying environmental tests performed.

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1 Purpose and Applicability

This document defines a series of minimum standard environmental test conditions (categories) and applicable test procedures for airborne equipment. The purpose of these tests is to provide a laboratory means of determining the performance characteristics of airborne equipment in environmental conditions representative of those which may be encountered in airborne operation of the equipment.

The standard environmental test conditions and test procedures contained herein may be used in conjunction with applicable equipment performance standards as a minimum specification under environmental conditions, which can ensure a sufficient degree of confidence in performance during operations.

Note: In each of the test procedures contained herein, the following phrase will be seen several times:

DETERMINE COMPLIANCE WITH APPLICABLE EQUIPMENT PERFORMANCE STANDARDS.

The “applicable equipment performance standards” referred to are either:

- a. EUROCAE Minimum Operational Performance Specifications (formerly Requirements) (MOPS/MOPR).
- b. RTCA Minimum Performance Standards (MPS) and/or RTCA Minimum Operational Performance Standards (MOPS).
- c. The manufacturers equipment specification(s), where applicable.

Some of the environmental conditions and test procedures contained in this document are not necessarily applicable to all airborne equipment. The selection of the appropriate and/or additional environmental conditions and test procedures is the responsibility of the writers (authors) of the performance standards for the specific airborne equipment.

Notes:

1. There are several additional environmental conditions (categories), that specific airborne equipment may need to be evaluated against, that have not been included in this document. These include, but are not limited to: hail, acceleration and acoustic vibration.
2. The procedures for testing airborne equipment for special environmental conditions that are usually uniquely related to that specific type of airborne equipment, should be the responsibility of the writer (author) of the performance standard for that specific equipment.

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3. The International System of Units (SI) is usually used throughout this document as the primary values. In certain instances, however, when the primary values were derived in US units, these units are used as the primary values.
4. Subject to the provisions of Subsection 3.2, it is permissible to use more than one test article.

The words airborne equipment, as used within this document, have direct applicability to most airborne equipment. It is the responsibility of those who wish to apply the test conditions and procedures contained in this document to determine the applicability of these test conditions and procedures to a specific equipment intended for installation on, or within, a specific or general class or type of aircraft.

Minimum operational performance standards (MOPS) prepared by RTCA, Inc. for airborne equipment contain requirements that the equipment must meet to ensure reliable operation in actual aeronautical installations. These equipment requirements must be verified in ambient and stressed environmental conditions. The MOPS typically contain recommended bench test procedures for ambient conditions, and refer to RTCA Document DO-160, “Environmental Conditions and Test Procedures for Airborne Equipment,” for the stressed environmental testing. The test categories defined in DO-160 are intended to encompass the full spectrum of environmental conditions that airborne equipment may experience – from benign to very hostile.

The environmental conditions and test procedures defined herein are intended to determine only the performance of the airborne equipment under these environmental conditions and are not intended to be used as a measure of service life of the airborne equipment subjected to these tests.

Any regulatory application of this document is the sole responsibility of appropriate governmental (regulatory) agencies.

1.1 Historical Note, and General Guidance to Users

DO-160 (or its precursor, DO-138) has been used as a standard for environmental qualification testing since 1958. It has been referenced in Minimum Operational Performance Specifications (MOPS) for specific equipment designs, and is referenced in FAA Advisory Circulars as a means of environmental qualification for TSO authorization. It has been subject to a continuous process of upgrade and revision as new needs arose within the aviation community, as improved test techniques have emerged, and as the realities of equipment operation of under actual environmental conditions has become better understood.

Environmental stresses can result from natural forces or man made effects, and may be mitigated by details of the equipment installation. The categories that have been

developed over time reflect a reasonably mature understanding as to the severity of the stresses, the degrees of mitigation achievable in the design of an installation, and the robustness that must be designed into equipment in order to perform under the resultant stress. In order to fully reap the advantages of the maturity of this document, it is incumbent upon the designers of the installed equipment, as well as the designers of the host installation, to consider the categories defined herein as early in their programs as feasible. The categories defined within each environmental test procedure have proved to be a practical set of boundary conditions between the requirements of real world installations and the performance of installed equipment. Effective dialogue between the airframe and equipment designers is essential to ensure that correct categories are utilized.

1.2 DO-160 User Guides

Various sections within this document now contain User Guide material. This material appears at the end of the respective section. The User Guides provide background information for the associated test procedures and requirements in the main body of DO-160. This information includes rationale for requirements, guidance in applying the requirements, commentary, possible trouble shooting techniques and lessons learned from previous laboratory experience. This information is intended to help users understand the intent behind the requirements, and to help users develop detailed test procedures based on the general test procedures in this document. These User Guides are provided for guidance purposes. The User Guides do not contain requirements. Only the procedures in the body of each section are required to be applied to the EUT.

The User Guides follow the same general format as the main body of the section. Main body paragraph numbers are repeated in the User Guide.

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2 Definitions of Terms, General

This section contains the definitions of general terms that are utilized throughout this document. The definition of terms specific to a particular section may be found in the appropriate section.

2.1 Equipment Temperature Stabilization

a. Not Operating

The equipment is considered temperature stabilized when the temperature of the functioning parts of the test item considered to have the longest thermal lag are within three degrees Celsius of the specified test temperature. When temperature measurement of the largest internal mass is not practical, the minimum time considered applicable for temperature stabilization shall be three hours.

b. Operating

The equipment is considered temperature stabilized when the functioning parts of the test item considered to have the longest thermal lag do not vary by more than two degrees Celsius per hour. When temperature measurement of the largest internal mass is not practical, the minimum time considered applicable for temperature stabilization shall be two hours.

2.2 Maximum Duty Cycle

When operation of an equipment is periodic, the maximum duty cycle is the relationship between the maximum length of time for which the equipment is designed to operate at its rated capacity and the length of time during which the equipment is not operating; or when the operating capacity is at a defined minimum. The maximum duty cycle shall be established by the equipment specification.

2.3 Not Operating

Not operating is that condition wherein no power is applied to the equipment unless otherwise defined in the individual equipment specification.

2.4 Controlled or Partially Controlled Temperature Locations

A controlled or partially controlled temperature location is a space within an aircraft in which the temperature of the air is maintained by an environmental control system (see Table 4-1 of applicable category).

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2.5 Total Excursion

Total excursion means the total displacement from positive maximum to negative maximum.

2.6 Equipment

The term “equipment” includes the test items and all of the components or units necessary (as determined by the equipment manufacturer) for the equipment to properly perform its intended function(s). The equipment shall be representative of the production standard that will be utilized in service.

2.7 Altitude

Altitude represents the environmental pressure relative to sea level to which the equipment is exposed during the tests.

2.8 Category of Tests and Declarations

For each environmental condition addressed in this document, the equipment supplier should select, from categories defined within the particular sections, a category which best represents the most severe environment which the equipment is expected to be regularly exposed to during its service life. An exception to this rule is the use of Category X as explained below. The selected categories selections are to be tabulated on the Environmental Qualification Form in accordance with the guidelines presented in Appendix A.

For any category listed on the Environmental Qualification form it can be derived that the equipment would also be able to perform its intended function(s) when exposed to categories that can be assessed as being less severe.

Use of Category X on the environmental qualification form in association with any environmental test procedure of this document is reserved for the case where the equipment supplier wishes to indicate that compliance with equipment performance standards has not been demonstrated under the environmental conditions addressed by that particular procedure.

If any category listed on the Environmental Qualification Form is not sufficient for a specific aircraft certification, then additional testing may be required.

When the statement “DETERMINE COMPLIANCE WITH APPLICABLE EQUIPMENT PERFORMANCE STANDARDS” is found at the end of or during the test procedures, it should be understood that performance compliance and verification is considered to be the requirement that allows the equipment to be certified as to its ability to perform its intended function(s) during and/or after a specific test category.

2.9 Applicability of Test Results

The results of the testing using these procedures are only valid for the test configuration (test set up, external configuration and internal configuration) used during the qualification tests. Any change from this configuration, either externally or internally (such as: PCB lay-out, component change inside the unit, installation wiring, etc.) must be assessed to ensure that the test results are still applicable. If an assessment cannot show that the results are still applicable, re-testing is required.

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3 Conditions of Tests

3.1 Connection and Orientation of Equipment

Unless otherwise stated, connect and orient the equipment (e.g. mechanically and electrically) as recommended by the equipment manufacturer for normal service installation, including any cooling provisions, as necessary to perform the tests and to DETERMINE COMPLIANCE WITH APPLICABLE EQUIPMENT PERFORMANCE STANDARDS. Interconnecting cable lengths, where not specified, shall be at least 1.50 m long and shall be configured so as to allow one common bundle of 1.20 m. Any inputs or outputs to or from other equipment(s) normally associated with the equipment(s) under test shall be connected or adequately simulated.

Note: Paragraphs 19.3 and 20.3, if applicable, will require an interconnecting cable longer than these minimums.

3.2 Order of Tests, Multiple Test Articles

It is the responsibility of the equipment manufacturer to determine any requirements for cumulative or combined testing, and to reflect these requirements in the equipment specification and test plan. Insofar as any such requirements are not compromised, multiple test articles may be used, tests may be performed in any order, and separate test articles may be used for demonstrating compliance with the separate tests.

Note: In cases where cumulative testing is required, or multiple tests are to be performed upon a single test article, the following provisions shall apply:

- a. The salt fog test shall not be conducted prior to the fungus resistance test.
- b. The sand and dust test shall not be conducted prior to the fungus resistance, salt fog, or humidity tests.
- c. The explosive atmosphere tests shall not be conducted prior to any other DO-160 tests.
- d. The flammability tests shall not be conducted prior to any other DO-160 tests.

3.3 Combining Tests

It is acceptable to employ alternate procedures developed as combinations of the procedures described herein, provided it can be demonstrated that all applicable environmental conditions specified in the original procedures are duplicated or exceeded in the combined procedure. If alternate procedures are used, appropriate information should be provided along with the Environmental Qualification Form, (see Appendix A).

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3.4 Measurement of Air Temperature in the Test Chamber

The temperature of the air in the test chamber shall be measured at a location where the air conditions are representative of that immediately surrounding the equipment. Measurement of chamber wall temperature is not suitable, due to temperature lag and heat transfer through the chamber wall.

A means of circulating air in the test chamber should be employed to assure an approximate uniform air temperature condition throughout the chamber. When such means are employed, the air movement shall not be directed on the equipment under test, and the equipment shall be tested at the minimum flow rate consistent with the purpose of maintaining a uniform temperature distribution in the chamber. The ambient air velocities surrounding equipment not requiring auxiliary cooling shall remain comparable to those air velocities that occur from natural convection.

For equipment that requires auxiliary cooling to assure proper operation, as defined in the equipment installation instructions, the following applies:

- a. If air is the cooling medium, the supplied cooling air characteristics shall be the same as the specified chamber air characteristics, unless otherwise specified by the equipment manufacturer.
- b. If the cooling medium is not air, the medium and its supply temperature shall be as specified by the equipment manufacturer.

Note: For equipment whose installation location is known and defined relative to other equipment, sources of radiated heat and/or impediments to normal convection should be simulated in the test.

3.5 Ambient Conditions

Unless otherwise specified, all tests shall be made within the following ambient conditions:

- a. Temperature: +15 to +35 degrees Celsius.
- b. Relative Humidity: Not greater than 85 percent.
- c. Ambient Pressure: 84 to 107 kPa (equivalent to +5,000 to -1,500 ft) (+1525 to -460 m).

When tests are conducted at ambient conditions that differ from the above values, the actual conditions shall be recorded.

3.6 Environmental Test Condition Tolerances

Unless otherwise specified, tests made at environmental conditions other than ambient, as defined above, shall be conducted subject to the following tolerances:

- a. Temperature: $\langle \equiv \sim 3$ degrees Celsius.
- b. Altitude: $\langle \equiv \sim 5$ percent of specified pressure.

3.7 Test Equipment

All stimulus and measurement equipment used in the performance of the tests should be identified by make, model, serial number and the calibration expiration date and/or the valid period of calibration where appropriate. When appropriate, all test equipment calibration standards should be traceable to national and/or international standards.

3.8 Multiple Unit Equipment

If the equipment to be tested consists of several separate units, these units may be tested separately, provided the functional aspects are maintained as defined in the relevant equipment specification.

3.9 EUT Configuration for Susceptibility Tests

During any environmental test of electrical and electronic equipment (for example, susceptibility test) conducted per this document, the equipment under test shall be configured in the most sensitive functioning mode that could be encountered during its normal operation in the field. When the equipment is embedded with basic and/or application software, it must be tested with software functions, operating (or simulated), to exhibit the maximum sensitivity to the test environment. The description and the justification for the functional configuration, including software, shall be reported or referenced in the test report.

Unless otherwise specified in the applicable minimum performance standard, special purpose test firmware/software is acceptable provided that the hardware and interfaces are comprehensively exercised and yields good test coverage based on validated requirements, and the configuration is controlled. The special purpose test firmware/software, when used, should be capable of thoroughly exercising the hardware functions.

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Environmental Conditions and Test Procedures for Airborne Equipment

Section 4

Temperature and Altitude

Important Notice

Information contained in these sections is pertinent to all test procedures described in the other sections of this document. Further, Appendix A is applicable for identifying environmental tests performed.

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4.0 Temperature and Altitude

4.1 Purpose of the Tests

These tests determine the performance characteristics of equipment at the applicable categories for the temperatures and altitudes specified in [Table 4-1](#) and at the pressures defined in [Table 4-2](#).

4.2 General

Several temperature and altitude test procedures are defined, each to be selected according to the category for which the equipment is designed to be used when installed in an aircraft (see Subsection 4.3 and Table 4-1).

Note: The selection of a temperature/altitude category depends on the location in (or on) the aircraft, the maximum operating altitude of the aircraft and whether the equipment is located within a temperature and/or pressure controlled area. The above conditions must be taken into consideration by the equipment designer in evaluating these requirements, which are determined by the end application and use of the equipment.

4.3 Equipment Categories

The following categories cover the wide range of environments known to exist in the majority of aircraft types and installation locations. It should be recognized that not all possible combinations of temperatures and altitude limits are covered in these equipment categories. Categories for in-flight loss of cooling are defined in paragraph 4.5.5.

Category A1

Equipment intended for installation in a controlled temperature and pressurized location, on an aircraft within which pressures are normally no lower than the altitude equivalent of 15,000 ft (4,600 m) Mean Sea Level (MSL), is identified as Category A1. This category may also be applicable to equipment installed in temperature controlled but unpressurized locations on an aircraft that operates at altitudes no higher than 15,000 ft (4,600 m) MSL.

Category A2

Equipment intended for installation in a partially controlled temperature but pressurized location on an aircraft within which the pressures are normally no lower than the altitude equivalent of 15,000 ft (4,600 m) MSL is identified as Category A2. This category may also be applicable to equipment installed in partially controlled temperature but unpressurized locations on an aircraft that operates at altitudes no higher than 15,000 ft (4,600 m) MSL.

Category A3

Equipment intended for installation in a controlled or partially controlled temperature but pressurized location within an aircraft within which the pressures are normally no lower than the altitude equivalent of 15,000 ft (4,600 m) MSL, where the temperatures will be more severe than those for categories A1 and A2, is identified as Category A3.

Category A4

Equipment intended for installation in a controlled temperature and pressurized location, on an aircraft within which pressures are normally no lower than the altitude equivalent of 15,000 ft. (4,600m) Mean Sea Level (MSL), for which temperature requirements differ from category A1 as declared by the equipment manufacturer. This category may also be applicable to equipment installed in a temperature controlled but unpressurized locations on an aircraft that operates at altitudes no higher than 15,000ft. (4,600m) MSL, for which temperature requirements differ from category A1 as declared by the equipment manufacturer.

Category B1

Equipment intended for installation in a non-pressurized but controlled temperature location in an aircraft that is operated at altitudes up to 25,000 ft (7,620 m) MSL is identified as Category B1.

Category B2

Equipment intended for installation in non-pressurized and non-controlled temperature locations on an aircraft that is operated at altitudes up to 25,000 ft (7,620 m) MSL is identified as Category B2.

Category B3

Equipment intended for installation in the power plant compartment of an aircraft that is operated at altitudes up to 25,000 ft (7,620 m) MSL is identified as Category B3.

Category B4

Equipment intended for installation in a non-pressurized location on an aircraft that is operated at altitudes up to 25,000 ft (7,620 m) MSL, for which temperature requirements differ from B1 and B2, is identified as Category B4.

Category C1

Equipment intended for installation in a non-pressurized but controlled temperature location in an aircraft that is operated at altitudes up to 35,000 ft (10,700 m) MSL is identified as Category C1.

Category C2

Equipment intended for installation in non-pressurized and non-controlled temperature locations within an aircraft that is operated at altitudes up to 35,000 ft (10,700 m) MSL is identified as Category C2.

Category C3

Equipment intended for installation in the power plant compartment of an aircraft that is operated at altitudes up to 35,000 ft (10,700 m) MSL is identified as Category C3.

Category C4

Equipment intended for installation on a non-pressurized aircraft that is operated at altitudes up to 35,000 ft (10,700 m) MSL, for which temperature requirements differ from C1 and C2, is identified as Category C4.

Category D1

Equipment intended for installation in a non-pressurized but controlled temperature location on an aircraft that is operated at altitudes up to 50,000 ft (15,200 m) MSL is identified as Category D1.

Category D2

Equipment intended for installation in non-pressurized and non-controlled temperature locations on an aircraft that is operated at altitudes up to 50,000 ft (15,200 m) MSL is identified as Category D2.

Category D3

Equipment intended for installation in the power plant compartment of an aircraft that is operated at altitudes up to 50,000 ft (15,200 m) MSL is identified as Category D3.

Category E1

Equipment intended for installation in non-pressurized and non-controlled temperature locations on an aircraft that is operated at altitudes up to 70,000 ft (21,300 m) MSL is identified as Category E1.

Category E2

Equipment intended for installation in the power plant compartment of an aircraft that is operated at altitudes up to 70,000 ft (21,300 m) MSL is identified as Category E2.

Category F1

Equipment intended for installation in non-pressurized but controlled temperature locations on an aircraft that is operated at altitudes up to 55,000 ft (16,800 m) MSL is identified as Category F1.

Category F2

Equipment intended for installation in non-pressurized and non-controlled temperature locations on an aircraft that is operated at altitudes up to 55,000 ft (16,800 m) MSL is identified as Category F2.

Category F3

Equipment intended for installation in the power plant compartment of an aircraft that is operated at altitudes up to 55,000 ft (16,800 m) MSL is identified as Category F3.

4.4 Definitions of Terms

Operating Low Temperature

Operating low temperature is the lowest temperature at which equipment will normally be exposed and be required to operate.

Operating High Temperature

The operating high temperature values given in [Table 4-1](#) are the maximum levels that the equipment will be exposed to within the particular installation area, e.g. in an enclosed space behind an instrument panel, equipment racks, power plant areas, etc., under normal operating conditions.

Short-Time Operating Temperature

These are startup conditions where equipment is turned on following a ground soak. It is expected that these temperature conditions will occur infrequently and be of short duration, since cooling or heating air circulation or other means of controlling temperature would be enabled concurrent with equipment operation.

Ground Survival Temperatures

These are the lowest and highest ground temperatures that the equipment is normally expected to be exposed to during aircraft storage or exposure to climatic extremes. The equipment is not expected to operate within specification limits at these temperatures but is expected to survive without damage.

In-Flight Loss of Cooling

This condition represents the failure of the external or internal system that normally provides dedicated cooling for the equipment. Certain equipment must survive for a limited time in the absence of cooling. Test requirements for this type of equipment shall be specified in the equipment performance specification.

4.5 Temperature Tests

4.5.1 Ground Survival Low Temperature Test and Short-Time Operating Low Temperature Test

At the ambient pressure and with the equipment not operating, stabilize the equipment at the appropriate ground survival low temperature specified in [Table 4-1](#). Maintain this temperature for at least three hours. Then with the equipment not operating, increase the temperature to the

short time operating low temperature specified in [Table 4-1](#) at a minimum rate of 2°C/minute. Once the temperature has reached the short-time operating low temperature, soak the equipment for 30 +5/-0 minutes or until internal stabilization is established. Place the equipment into the operating state and maintain the test chamber air temperature at the appropriate short time operating low temperature specified in [Table 4-1](#). Operate the equipment for at least 30 minutes. Verify equipment operation per note 1 during this operating period. The test profile is shown graphically in [Figure 4-1](#).

- Note:*
- 1) *This test simulates temperature conditions that may be encountered by equipment while the aircraft is on the ground. In determining the level of performance required during the period of this test, the operational requirements of the particular equipment or systems shall be stated in the test procedure and report or in the specific equipment performance standard.*
 - 2) *If the short time operating low temperature and operating low temperature are the same, the short-time operating low temperature need not be conducted. The ground survival low temperature test may not be deleted, even if the short-time operating low temperature is identical to the operating low temperature. Power should be applied at the operating low temperature after the un-powered low temperature soak specified in paragraph 4.5.1.*

4.5.2 Operating Low Temperature Test

With the equipment operating, adjust the test chamber air temperature to the appropriate operating low temperature specified in [Table 4-1](#) at ambient pressure. After the equipment temperature has become stabilized, operate the equipment for a minimum of two hours while maintaining the temperature of the air in the test chamber at the operating low temperature. DETERMINE COMPLIANCE WITH APPLICABLE EQUIPMENT PERFORMANCE STANDARDS during this operating period. The test profile is shown graphically in [figure 4-2](#).

4.5.3 Ground Survival High Temperature Test and Short-Time Operating High Temperature Test

At ambient pressure and with the equipment not operating, stabilize the equipment at the appropriate ground survival high temperature of [Table 4-1](#). Maintain this temperature for at least three hours. Then with the equipment not operating, reduce the temperature to the short-time operating high temperature specified in [Table 4-1](#) at a minimum rate of 2°C/minute. Once the temperature has reached the short-time operating high temperature, soak the equipment for 30 +5/-0 minutes or until internal stabilization is established. Place the equipment into the operating state and maintain the test chamber air temperature at the appropriate short-time operating high temperature specified in [Table 4-1](#). Operate the equipment for at least 30 minutes. Verify equipment operation per note 1 during this operating period. The test profile is shown graphically in [Figure 4-3](#).

- Note:*
- 1) *This test simulates temperature conditions that may be encountered by equipment while the aircraft is on the ground. In determining the level of performance required during the period of this test, the operational requirements of the particular equipment or systems shall be stated in the test procedure and report or in the specific equipment performance standard.*

2) *If the short-time operating high temperature and operating high temperature are the same, the short-time operating high temperature test need not be conducted. The ground survival high temperature test may not be deleted, even if the short-time high temperature is identical to the operating high temperature. Power should be applied at the operating high temperature after the un-powered high temperature soak specified in paragraph 4.5.3.*

4.5.4 Operating High Temperature Test

With the equipment operating, adjust the test chamber air temperature to the appropriate operating high temperature specified in [Table 4-1](#) at ambient pressure. After the equipment temperature has become stabilized, operate the equipment for a minimum of two hours while maintaining the temperature of the air in the test chamber at the operating high temperature. DETERMINE COMPLIANCE WITH APPLICABLE EQUIPMENT PERFORMANCE STANDARDS during the operating period. The test profile is shown graphically in [Figure 4-4](#).

4.5.5 In-Flight Loss of Cooling Test

Categories of In-Flight Loss of Cooling Test Periods are defined by periods during which cooling is removed.

Category V - 30 minutes minimum
Category W - 90 minutes minimum
Category P - 180 minutes minimum
Category Y - 300 minutes minimum
Category Z - As defined in the equipment specification

With the equipment operating at ambient room pressure, and with cooling air supplied in accordance with the conditions specified in Subsection 3.4, adjust the test chamber air temperature to the value specified in [Table 4-1](#) for the loss of cooling test, and allow the equipment temperature to stabilize. Turn off the equipment cooling air supply, and operate the equipment for the period of time specified for the applicable category while maintaining the temperature of the air in the test chamber at the value specified in [Table 4-1](#). During this period DETERMINE COMPLIANCE WITH APPLICABLE EQUIPMENT PERFORMANCE STANDARDS. The test profile is shown graphically in [Figure 4-5](#).

Note: This test applies to equipment that requires cooling for proper operation during the operating high temperature test, paragraph 4.5.4, has functions whose failure following in-flight loss of cooling would contribute to or cause a failure condition that would prevent the continued safe flight and landing of the airplane, and in which the cooling is externally supplied or powered.

4.6 Altitude, Decompression and Overpressure Tests

Refer to [Table 4-1](#) for altitude and to [Table 4-2](#) for pressure values.

4.6.1 Altitude Test

Conduct this test at ambient temperature. Operate the equipment at maximum duty cycle. Decrease the pressure in the test chamber to the appropriate maximum operating altitude specified in [Table 4-1](#). Allow the equipment temperature to stabilize. Maintain this pressure for at least two hours. DETERMINE COMPLIANCE WITH APPLICABLE EQUIPMENT PERFORMANCE STANDARDS during the two-hour period or at the maximum duty cycle, whichever is longer. The test profile is shown graphically in [Figure 4-6](#).

Note: When the equipment manufacturer requires that the equipment be tested for spark-producing conditions at altitude, Sections 9.6a and 9.6b may apply. If so, the procedures of 9.7 shall be conducted at the maximum test altitude, and paragraph 3.3 (Combining Tests) may be applicable.

4.6.2 Decompression Test

Conduct this test at ambient temperature. With the equipment operating, adjust the absolute pressure to an equivalent altitude of 8,000 ft (2,400 m) MSL and allow the equipment temperature to stabilize. Reduce the absolute pressure to the equivalent of the maximum operational altitude for the aircraft on which the equipment will be installed (see [Table 4-1](#)). This reduction in pressure shall take place within 15 seconds. Maintain this reduced pressure for at least 10 minutes or as specified in the equipment specification. DETERMINE COMPLIANCE WITH APPLICABLE EQUIPMENT PERFORMANCE STANDARDS during the period at maximum operating altitude. The test profile is shown graphically in [Figure 4-7](#).

Note: The decompression test is intended for equipment as follows:

- 1) Equipment installed in pressurized areas on the aircraft required to operate during and following an emergency descent.*
- 2) Equipment utilizing high voltage electrical/electronics circuits, i.e. displays etc...*

Equipment intended for installation in areas that are subject to partial pressurization shall be tested in accordance with paragraph 4.6.1 above.

4.6.3 Overpressure Test

With the equipment not operating, unless otherwise specified in the equipment specification, subject the equipment to an absolute pressure equivalent to -15,000 ft altitude (170 kPa). Maintain this condition for at least 10 minutes. Return the equipment to the ambient atmospheric pressure and DETERMINE COMPLIANCE WITH APPLICABLE EQUIPMENT PERFORMANCE STANDARDS. The test profile is shown graphically in [Figure 4-8](#).

Note: 1) This test is for equipment installed in pressurized areas. The test determines whether the equipment will withstand cabin overpressures resulting from routine aircraft pressurization system testing.

2) Equipment installed in a pressurized area and whose internal sections are vented external to the pressurized area shall have these internal sections exposed to the pressure specified in the equipment specification during the overpressure test.

Table 4-1 Temperature and Altitude Criteria

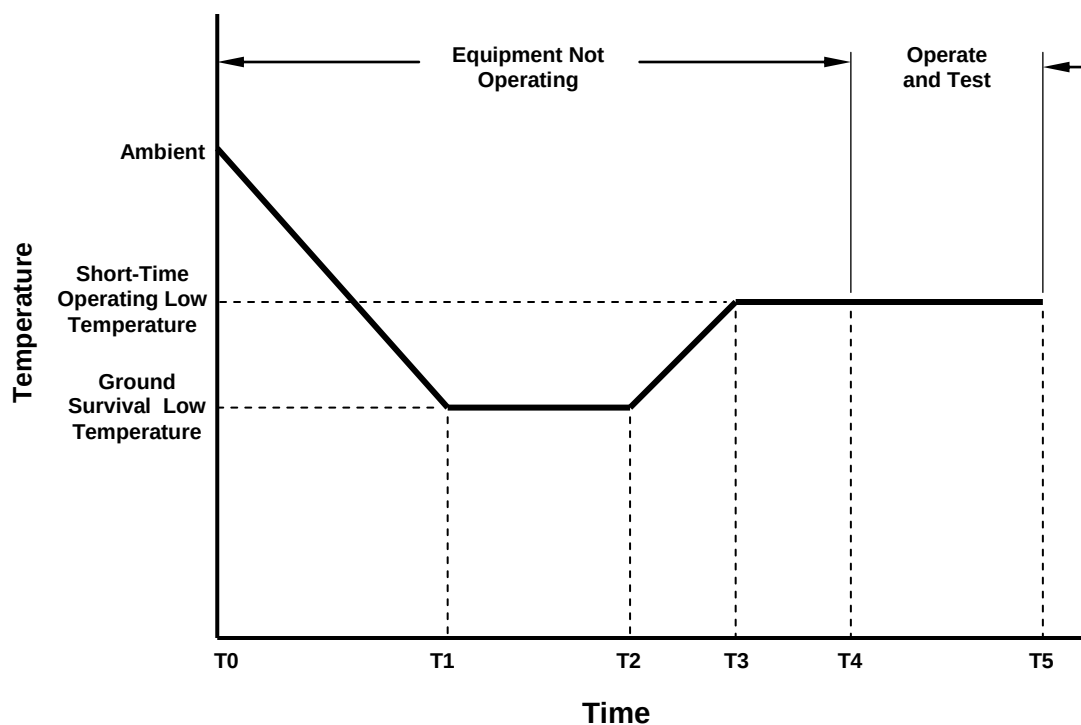
Environmental Tests	Category Paragraph 4.3																			
	A				B				C				D			E		F		
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	1	2	1	2	3
Operating Low Temp.	-15	-15	-15	-15	-20	-45	-45	Note (4)	-20	-55	-55	Note (4)	-20	-55	-55	-55	-55	-20	-55	-55
Degrees C Paragraph 4.5.2																				
Operating High Temp.	+55	+70	+70	Note (3)	+55	+70	Note (3)	Note (4)	+55	+70	Note (3)	Note (4)	+55	+70	Note (3)	Note (3)	Note (3)	+55	+70	Note (3)
Degrees C Paragraph 4.5.4																				
Short-Time Operating Low Temp.	-40	-40	-40	Note (3)	-40	-45	Note (3)	Note (4)	-40	-55	Note (3)	Note (4)	-40	-55	-55	-55	-55	-40	-55	-55
Degrees C Paragraph 4.5.1																				
Short-Time Operating High Temp.	+70	+70	+85	Note (3)	+70	+70	Note (3)	Note (4)	+70	+70	Note (3)	Note (4)	+70	+70	Note (3)	Note (3)	Note (3)	+70	+70	Note (3)
Degrees C Paragraph 4.5.3																				
Loss of Cooling Test	+30	+40	+45	Note (3)	+30	+40	Note (3)	Note (3)	+30	+40	Note (3)	Note (3)	+30	+40	Note (3)	Note (3)	Note (3)	+30	+40	Note (3)
Degrees C Paragraph 4.5.5																				
Ground Survival Low Temperature	-55	-55	-55	Note (3)	-55	-55	Note (3)	-55	-55	-55	Note (3)	-55	-55	-55	-55	-55	-55	-55	-55	-55
Degrees C Paragraph 4.5.1																				
Ground Survival High Temperature	+85	+85	+85	Note (3)	+85	+85	Note (3)	+85	+85	+85	Note (3)	+85	+85	+85	Note (3)	+85	Note (3)	+85	+85	Note (3)
Degrees C Paragraph 4.5.3																				
Altitude	15	15	15	15	25	25	25	25	35	35	35	35	50	50	50	70	70	55	55	55
Thousands of Feet Thousands of Meters Paragraph 4.6.1	4.6	4.6	4.6	4.6	7.6	7.6	7.6	7.6	10.7	10.7	10.7	10.7	15.2	15.2	15.2	21.3	21.3	16.8	16.8	16.8
Decompression Test	Note (1)	Note (1)	Note (1)	Note (1)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Paragraph 4.6.2	(4)	(4)	(4)	(4)																
Overpressure Test	Note (2)	Note (2)	Note (2)	Note (2)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Paragraph 4.6.3																				

Note:

- 1) The lowest pressure applicable for the decompression test is the maximum operating altitude for the aircraft in which the equipment will be installed.
- 2) The absolute pressure is 170 kPa (-15,000 ft or -4,600 m).
- 3) To be declared by the equipment manufacturer relative to temperature extremes.
- 4) To be declared by the equipment manufacturer and defined in the manufacturer's installation instructions when specific critical criteria exist.

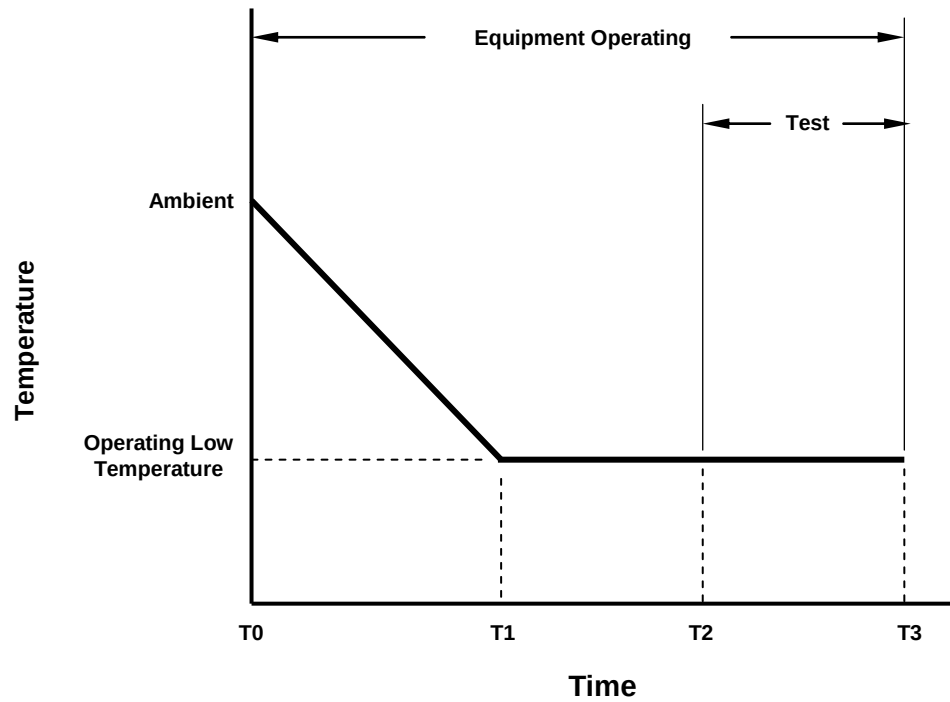
Table 4-2 Pressure Values for Various Pressure Altitude Levels

Pressure Altitude	Absolute Pressure			
	kPa	(mbars)	(in Hg)	mm Hg
-15,000 ft (-4,572 m)	169.73	1697.3	50.12	1273.0
-1,500 ft (-457 m)	106.94	1069.4	31.58	802.1
0 ft (0m)	101.32	1013.2	29.92	760.0
+8,000 ft (+2,438 m)	75.26	752.6	22.22	564.4
+15,000 ft (+4,572 m)	57.18	571.8	16.89	429.0
+25,000 ft (+7,620 m)	37.60	376.0	11.10	282.0
+35,000 ft (+10,668 m)	23.84	238.4	7.04	178.8
+50,000 ft (+15,240 m)	11.60	116.0	3.42	87.0
+55,000 ft (+16,764 m)	9.12	91.2	2.69	68.3
+70,000 ft (+21,336 m)	4.44	44.4	1.31	33.3



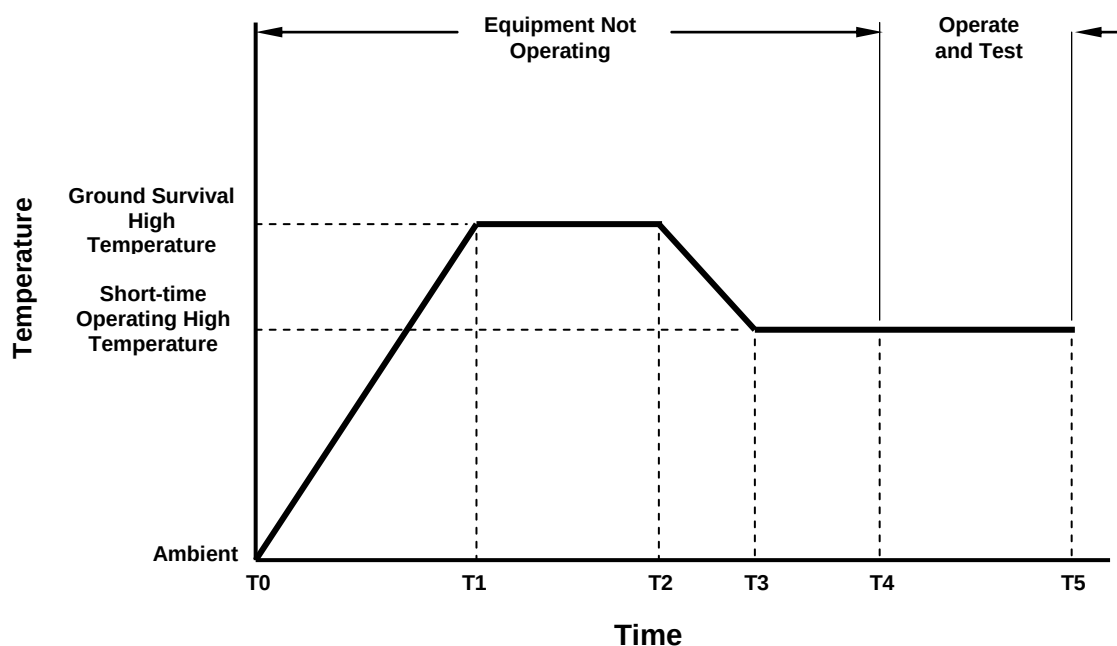
- Note:
- 1) Temperature change rate from T0 to T1 is not specified.
 - 2) T1 to T2 is time for equipment temperature stabilization time, plus a minimum of three hours.
 - 3) T2 to T3 is at a minimum rate of 2°C/minute
 - 4) T3 to T4 is 30 +5/-0 minutes or the time for internal stabilization.
 - 5) T4 to T5 is 0.5 hours, minimum.
 - 6) If the Short-Time Low and Ground Survival Low Temperatures are identical, the time from T2 to T4 is zero.
 - 7) See Note 2 of the test procedure if the short-time low operating temperature is the same as the operating low temperature.

Figure 4-1 **Ground Survival Low Temperature and Short-Time Operating Low Temperature Test**



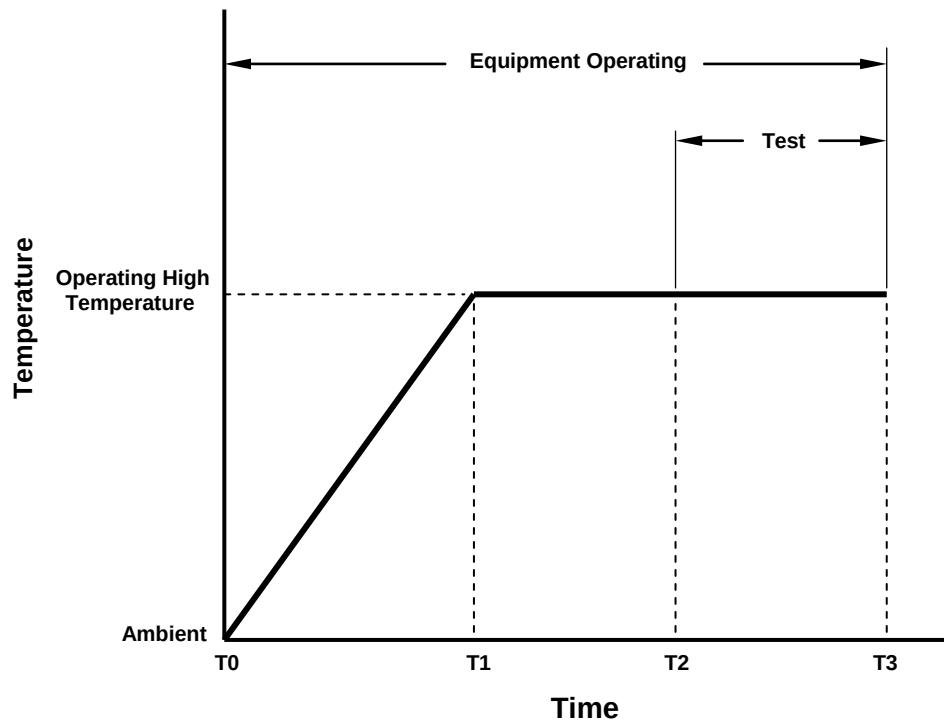
- Note:
- 1) Temperature change rate from T0 to T1 is not specified.
 - 2) T1 to T2 is time for equipment temperature to stabilize.
 - 3) T2 to T3 is 2.0 hours, minimum.

Figure 4-2 Operating Low Temperature Test



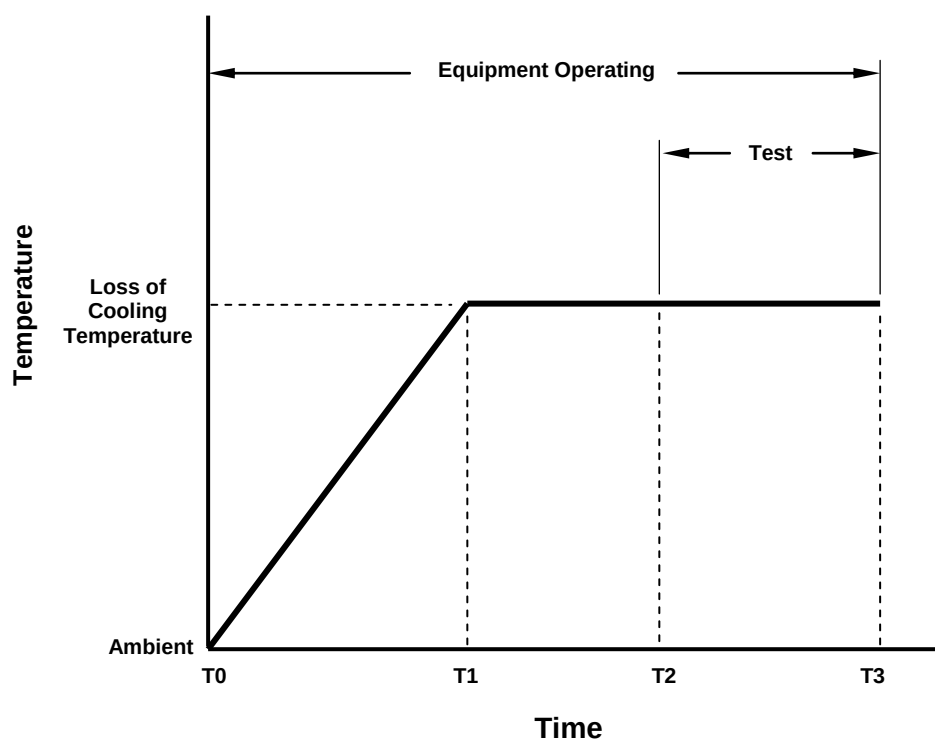
- Note:
- 1) Temperature change rate from T0 to T1 is not specified.
 - 2) T1 to T2 is time for equipment temperature stabilization time, plus a minimum of three hours.
 - 3) T2 to T3 is at a minimum rate of 2°C/minute
 - 4) T3 to T4 is 30 +5/-0 minutes or the time for internal stabilization.
 - 5) T4 to T5 is 0.5 hours, minimum.
 - 6) If the short-time high and ground survival high temperatures are identical, the time from T2 to T4 is zero.
 - 7) See Note 2 of the test procedure if the short-time high operating temperature is the same as the operating high temperature.

Figure 4-3 Ground Survival High Temperature and Short-Time Operating High Temperature Test



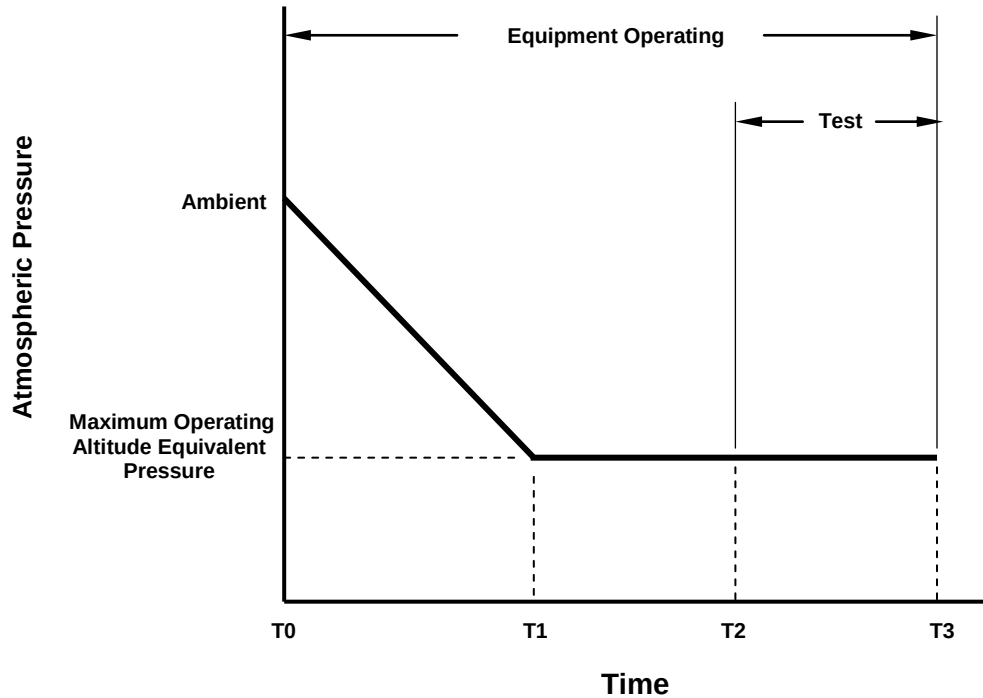
- Note:
- 1) Temperature change rate from T_0 to T_1 is not specified.
 - 2) T_1 to T_2 is time for equipment temperature to stabilize.
 - 3) T_2 to T_3 is 2.0 hours, minimum.

Figure 4-4 Operating High Temperature Test



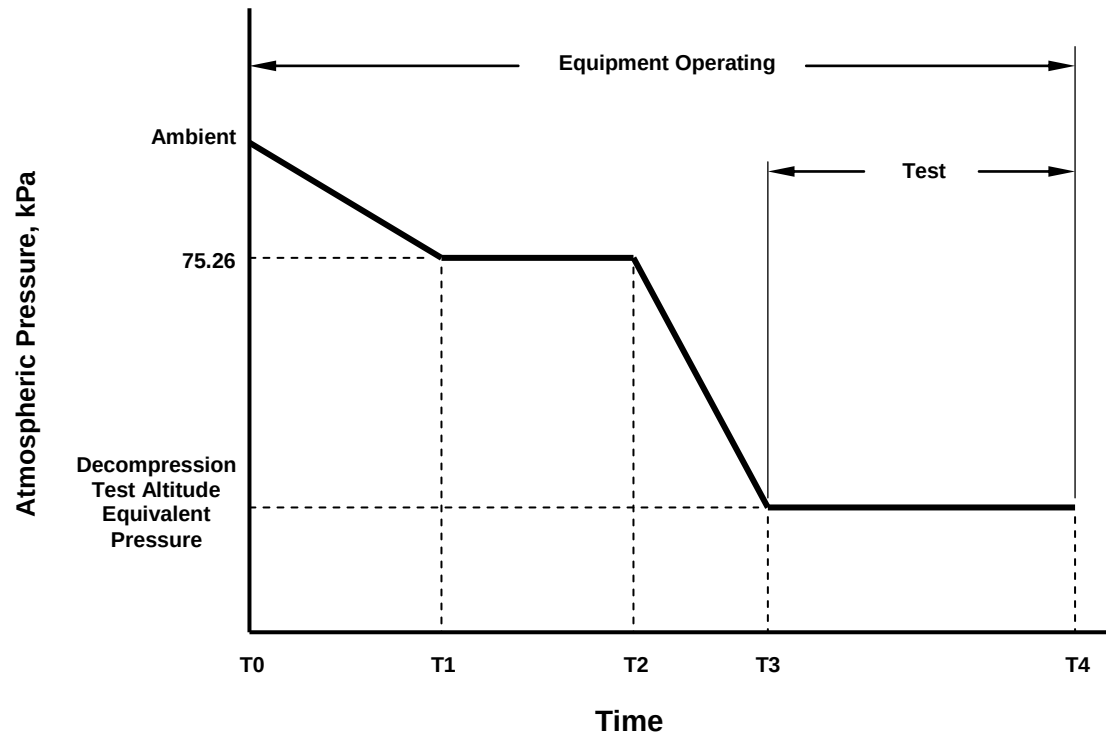
- Note:
- 1) Temperature change rate from T_0 to T_1 is not specified.
 - 2) T_1 to T_2 is time for equipment temperature to stabilize.
 - 3) See paragraph 4.5.4 for time duration T_2 to T_3 .

Figure 4-5 In-Flight Loss of Cooling Test



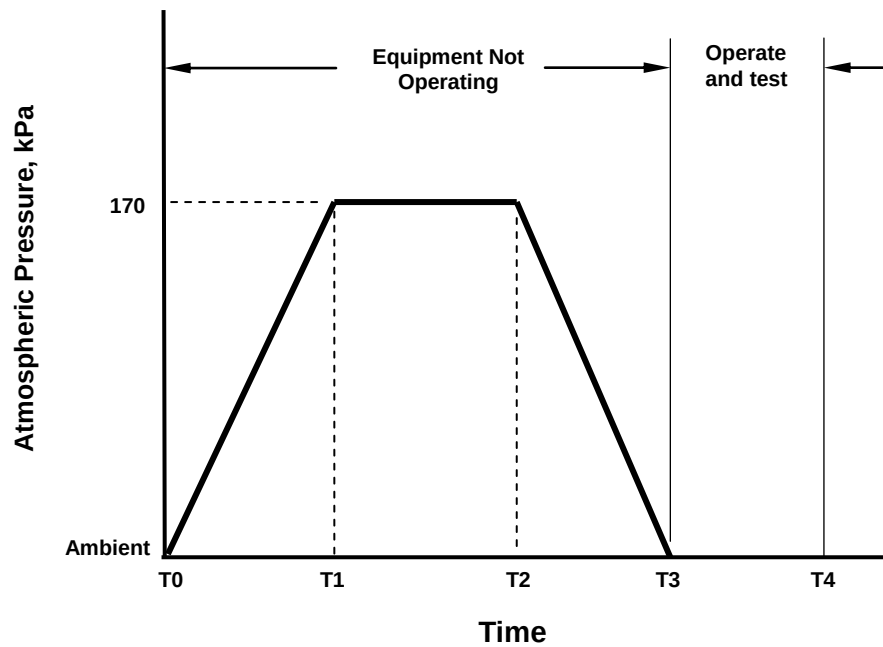
- Note:
- 1) Pressure change rate from T_0 to T_1 is not specified.
 - 2) T_1 to T_2 is time for equipment temperature to stabilize.
 - 3) T_2 to T_3 is 2.0 hours, minimum.

Figure 4-6 Altitude Test



- Note:
- 1) Pressure change rate from T0 to T1 is not specified
 - 2) T1 to T2 is time for equipment temperature to stabilize
 - 3) T2 to T3 is 15 seconds, maximum
 - 4) T3 to T4 is 10 minutes, minimum

Figure 4-7 Decompression Test



- Note:*
- 1) *Pressure change rates from T0 to T1 and from T2 to T3 are not specified.*
 - 2) *T1 to T2 is 10 minutes, minimum.*
 - 3) *T3 to T4 is minimum time necessary to operate and test equipment.*

Figure 4-8 Overpressure Test

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**Environmental Conditions and Test
Procedures for Airborne Equipment**

Section 5

Temperature Variation

Important Notice

Information contained in these sections is pertinent to all test procedures described in the other sections of this document. Further, Appendix A is applicable for identifying environmental tests performed.

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5.0 Temperature Variation

5.1 Purpose of the Test

This test determines performance characteristics of the equipment during temperature variations between high and low operating temperature extremes. The applicable categories for flight operations are shown in Table 4-1. For categories A, B, and C, it is required that the equipment be subjected to the temperature variation test in 5.3.1 when such equipment is tested according to the procedures contained in Paragraphs 4.5.1, 4.5.2, 4.5.3, and 4.5.4. For categories S1 and S2, it is required that the equipment be subjected to the temperature shock test per Paragraph 5.3.2 or 5.3.3.

Note: The test is not intended to verify the behavior of the equipment in wet or icing conditions. In conducting this test, the test chamber may incorporate the capability of controlling or altering humidity to the extent that condensation is minimized or does not occur.

5.2 Temperature Change Rates

The rates applicable to the temperature variation procedures defined in Subsection 5.3 are as follows:

Category A - For equipment external to the aircraft or internal to the aircraft:

10 degrees Celsius minimum per minute.

Category B - For equipment in a non-temperature-controlled or partially temperature controlled internal section of the aircraft:

5 degrees Celsius minimum per minute.

Category C - For equipment in a temperature-controlled internal section of the aircraft:

2 degrees Celsius minimum per minute.

Category S1 - For equipment external to the aircraft or internal to the aircraft:

Known rate of change greater than 10 degrees Celsius per minute. The rate of change shall be noted in the Qualification Form.

Category S2 - For equipment external to the aircraft or internal to the aircraft:

Unknown rate of change greater than 10 degrees Celsius per minute.

Note: 1) *Equipment qualified to Category B is considered to have met Category C.*

2) *Rates of change greater than 10 degrees Celsius minimum per minute are considered as temperature shocks. Categories S1 and S2 are intended to evaluate the effects of more rapid or sudden temperature changes to the*

equipment. The outer surfaces, regions, or interfaces of the equipment may be of primary interest during temperature shock as the internal regions can have comparatively long time constants to reach stabilization.

- 3) *For Categories S1 and S2, Thermal Shock, Category S2 shall be used unless the temperature change rate is known, then Category S1 may be used.*

5.3 Test Procedures

5.3.1 Test Procedure Categories A, B, and C

The temperature variation test (except for Categories S1 and S2) can be combined to include the procedures of the ground survival low temperature test and short-time operating low temperature test, Paragraph 4.5.1, the operating low temperature test, Paragraph 4.5.2, the ground survival high temperature test short-time operating high temperature test, Paragraph 4.5.3, and the operating high temperature test, Paragraph 4.5.4. The following procedures shall apply:

- a. If the test is a combined test, proceed in accordance with Paragraph 4.5.1, which describes the ground survival low temperature test and the short-time operating low temperature test, and Paragraph 4.5.2, the operating low temperature test without transition to ambient temperature. After completion of the test defined in Paragraph 4.5.1 and 4.5.2, proceed to Subparagraph c. If the test is not a combined test, commencing at ambient temperature with the equipment operating, lower the temperature in the chamber towards the operating low temperature level at the applicable rates specified in Subsection 5.2.
- b. Stabilize the equipment in the operating mode at this operating low temperature level.
- c. Raise the temperature in the chamber towards the operating high temperature at the applicable rate specified in Subsection 5.2. During this temperature change, DETERMINE COMPLIANCE WITH THE APPLICABLE EQUIPMENT PERFORMANCE STANDARDS.
- d. Stabilize the equipment at the operating high temperature. If this is a combined test, proceed in accordance with Paragraph 4.5.3, the ground survival high temperature test and short-time operating high temperature test, and subsequently Paragraph 4.5.4, the operating high temperature test without transition to ambient temperature. Maintain the equipment in a non-operating state for a minimum of 2 minutes.
- e. Turn the equipment on and lower the temperature in the chamber towards the operating low temperature level at the applicable rate specified in Subsection 5.2. During this temperature change DETERMINE COMPLIANCE WITH THE APPLICABLE EQUIPMENT PERFORMANCE STANDARDS.
- f. Stabilize the equipment temperature with the chamber at the operating low temperature, and then operate the equipment for at least one hour. Then turn off the equipment for 30 minutes, and restart the equipment while maintaining the chamber at the operating low temperature.
- g. Change the temperature of the chamber towards the ambient temperature at the applicable rate specified in Subsection 5.2.

- h. Stabilize the chamber and the equipment at ambient temperature. DETERMINE COMPLIANCE WITH THE APPLICABLE EQUIPMENT PERFORMANCE STANDARDS in the second, or last, cycle as appropriate.

A minimum of two cycles (a. through h. above) shall be accomplished. If complete determination of compliance with applicable equipment performance standards can be accomplished during each temperature change period of a single cycle, then testing is required during the second cycle only. If the time during a temperature change period does not allow for complete determination of compliance with applicable equipment performance standards, a sufficient number of cycles shall be accomplished so that complete compliance can be determined. When temperature rise induces a potential risk of condensation on the equipment under test, the humidity level of the air in the chamber should be controlled to eliminate this condensation. The test profile is shown graphically in [Figure 5-1](#).

It is permissible to allow additional time with the equipment un-powered at ambient conditions, between the first and second, and subsequent, cycles to accommodate test facility and personnel schedules. Resumption of the second, or subsequent, cycle must be accomplished within 24 hours. No other environmental testing may be performed between cycles.

Note: If this is a combined test, it is not necessary to repeat the Ground Survival Low Temperature, Short-Time Operating Low Temperature, Ground Survival High Temperature, and Short Time Operating High Temperature tests as defined in steps a. and d. above during the second cycle.

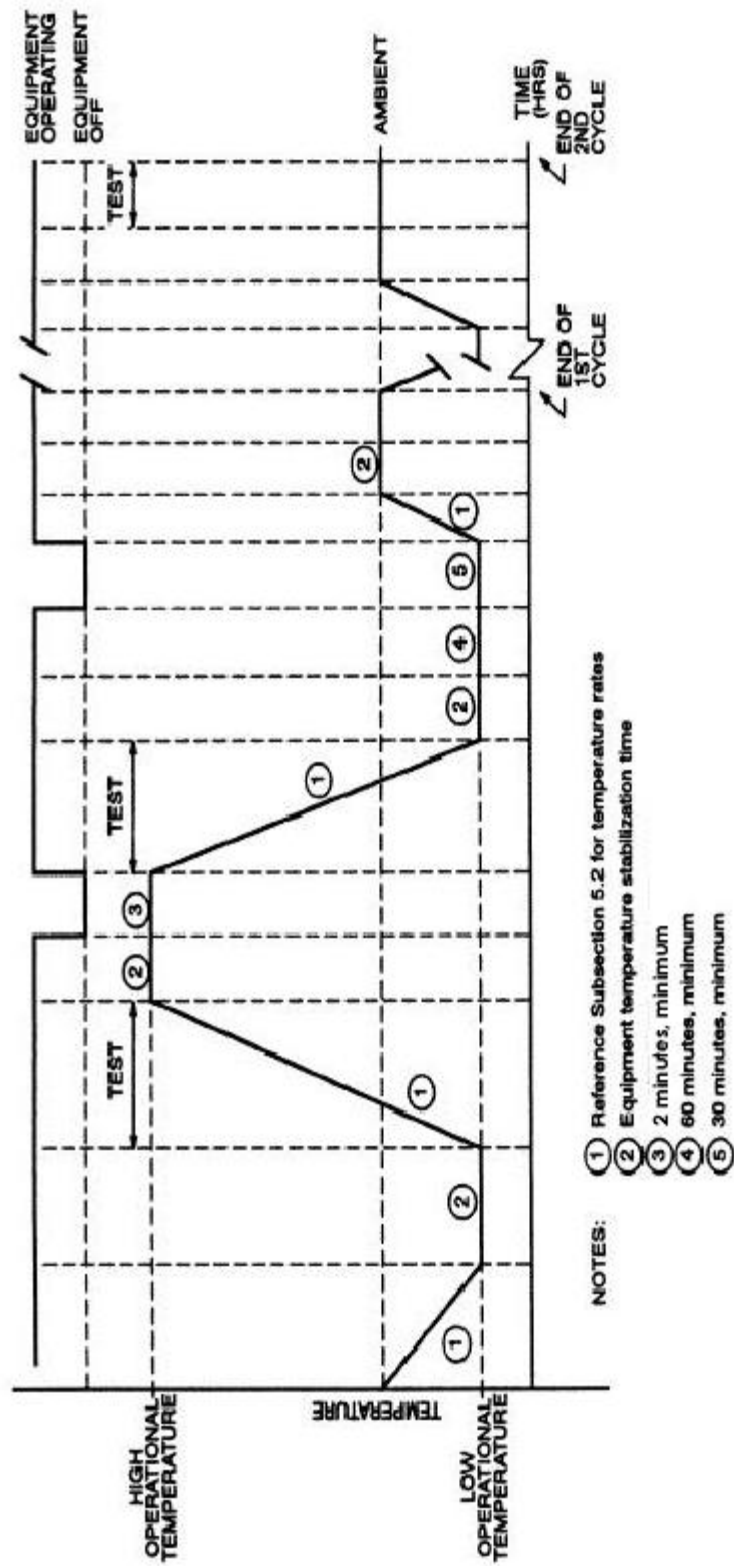


FIGURE 5-1 TEMPERATURE VARIATION TEST

5.3.2 Test Procedure Category S1

The temperature variation test for Category S1 should not be combined with other temperature testing.

The following procedures shall apply:

- a. Commencing at ambient temperature with the equipment operating, lower the temperature in the chamber towards the operating low temperature level at the applicable rates specified in Subsection 5.2.
- b. Stabilize the equipment, if workable, at this operating low temperature level.
- c. Raise the temperature in the chamber towards the operating high temperature at the applicable rates specified in Subsection 5.2. During this temperature change, DETERMINE COMPLIANCE WITH THE APPLICABLE EQUIPMENT PERFORMANCE STANDARDS.
- d. Stabilize the equipment at the operating high temperature, if workable. Maintain the equipment in a non-operating state for a minimum of 2 minutes.
- e. Turn the equipment on and lower the temperature in the chamber towards the operating low temperature level at the applicable rates specified in Subsection 5.2. During this temperature change DETERMINE COMPLIANCE WITH THE APPLICABLE EQUIPMENT PERFORMANCE STANDARDS.
- f. Stabilize the equipment temperature, if workable, with the chamber at the operating low temperature, and continue to operate the equipment for at least one hour. Then turn off the equipment for 30 minutes, and restart the equipment while maintaining the chamber at the operating low temperature.
- g. Change the temperature of the chamber towards the ambient temperature at the applicable rates specified in Subsection 5.2.
- h. Stabilize the chamber and the equipment at ambient temperature, if workable. DETERMINE COMPLIANCE WITH THE APPLICABLE EQUIPMENT PERFORMANCE STANDARDS in the second, or last, cycle as appropriate.

A minimum of two cycles (a. through h. above) shall be accomplished. If complete determination of compliance with applicable equipment performance standards can be accomplished during each temperature change period of a single cycle, then testing is required during the second cycle only. If the time during a temperature change period does not allow for complete determination of compliance with applicable equipment performance standards, a sufficient number of cycles shall be accomplished so that complete compliance can be determined. When temperature rise produces condensation on the equipment tested, the humidity level of the air in the chamber should be controlled to eliminate this condensation.

5.3.3 Test Procedure Category S2

The temperature variation test for Category S2 shall not be combined with other temperature testing.

The required test apparatus shall consist of either one two-celled chamber or two separate chambers in which the test conditions can be established and maintained. Chamber 1 shall be set to the operating low temperature and chamber 2 shall be set to the operating high temperature. The insertion of equipment in test chambers can modify its environmental condition. In this case, the temperature shall be stabilized within five minutes after transfer of the test item.

The following test procedure shall apply:

- a. Place the equipment into chamber 1, and turn the equipment on.
- b. Stabilize the equipment, if workable, at the operating low temperature.
- c. Transfer the equipment from chamber 1 to chamber 2 as rapidly as possible but in no more than five minutes. In the case of when separate chambers are used, it is permissible to turn the equipment on immediately after the equipment transfer. If the transfer requires more than five minutes, it shall be indicated in the qualification form.
- d. Stabilize the equipment at the operating high temperature, if workable. During this temperature stabilization, DETERMINE COMPLIANCE WITH THE APPLICABLE EQUIPMENT PERFORMANCE STANDARDS.
- e. Turn the equipment off, and keep it in a non operating state for a minimum of 2 minutes
- f. Turn the equipment on, and transfer the equipment from chamber 2 to chamber 1 (from high to low temperature) as rapidly as possible but in no more than five minutes. In the case of when separate chambers are used, it is permissible to turn the equipment on immediately after the equipment transfer. If the transfer requires more than five minutes, it shall be indicated in the Qualification Form
- g. Stabilize the equipment at the operating low temperature, if workable, and continue to operate the equipment for at least one hour. During the temperature stabilization, DETERMINE COMPLIANCE WITH THE APPLICABLE EQUIPMENT PERFORMANCE STANDARDS.
- h. Turn off the equipment for 30 minutes and restart the equipment while maintaining the chamber 1 at operating low temperature
- i. Transfer the equipment at ambient temperature, and after equipment temperature stabilization, DETERMINE COMPLIANCE WITH THE APPLICABLE EQUIPMENT PERFORMANCE STANDARDS in the second, or last, cycle as appropriate.

A minimum of two cycles (a. through i. above) shall be accomplished. If complete determination of compliance with applicable equipment performance standards can be accomplished during each temperature change period of a single cycle, then testing is required during the second cycle only. If the time during a temperature change period does not allow for complete determination of compliance with applicable equipment performance standards, a sufficient number of cycles shall be accomplished so that complete compliance can be determined. When temperature rise induces a potential risk of condensation on the equipment under test, the humidity level of the air in the chamber should be controlled to eliminate this condensation.

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**Environmental Conditions and Test
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Section 6

Humidity

Important Notice

Information contained in these sections is pertinent to all test procedures described in the other sections of this document. Further, Appendix A is applicable for identifying environmental tests performed.

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