MIL-E-81910A(AS)
21 November 1977
Superseding
MIL-E-81910(AS)
28 November 1972

MILITARY SPECIFICATION

Electric Power Generating and Control Equipment, Aircraft, Testing, General Specification for

This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE.

1.1 Inspection. This specification covers Qualification and Qualification Verification Inspection by the Government, of electric power generating systems and related equipment for installation in aircraft.

2. APPLICABLE DOCUMENTS

2.1 Issues. The following documents, of the issues in effect on date of invitation for bids, form a part of this specification to the extent specified herein:

SPECIFICATIONS

Military

MIL-L-23699	Lubricating Oil, Aircraft, Turbine Engines Synthetic Base

STANDARDS

Military

MIL-STD-461	Electromagnetic Interference Characteristics, Requirements for Equipment
MIL-STD-462	Electromagnetic Interference Characteristics, Measurement of

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Engineering Specifications and Standards Department (Code 93), Naval Air Engineering Center, Lakehurst, NJ 08733, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

FSC 6110

STANDARDS

Military (Continued)

MIL-STD-810	Environmental Test Methods
MS33542	Criteria-Temperature and Altitude Range, Blast-Cooled Electric Equipment
MS33543	Criteria-Temperature and Altitude Range, Self-Cooled Electric Equipment

(Application for copies should be addressed to, Commanding Officer, Naval Aviation Supply Depot, Code 105, 5801 Tabor Avenue, Philadelphia, Pennsylvania 19120).

3. REQUIREMENTS

3.1 Test facilities.

3.1.1 Apparatus. The apparatus used in conducting tests shall be capable of producing and maintaining the test conditions.

3.1.2 Volume. The volume of the test facility shall be such that the bulk of the system or component being tested shall not interfere with the generation and maintenance of test conditions.

3.1.3 Heat source. The heat source of the test facility shall be so located that radiant heat shall not fall directly on the system or component being tested, except where application of radiant heat is one of the test conditions.

3.1.4 Standard conditions. The standard ambient conditions shall be as follows:

a. Temperature: $23^{\circ} \pm 10^{\circ}C$ ($73^{\circ} \pm 18^{\circ}F$).

b. Relative Humidity: 50 ± 30 percent.

c. Atmospheric Pressure: $725 \begin{smallmatrix} +50mm \\ -75mm \end{smallmatrix}$ of Mercury

$\begin{smallmatrix} +2.0in. \\ -3.0in. \end{smallmatrix}$ (28.5 of Mercury)

3.2 Measurements. All measurements shall be made with instruments and test equipment which are calibrated utilizing reference standards whose calibration is traceable to prime standards at the National Bureau of Standards. In addition, the instruments and test equipment shall have an accuracy not greater than one-third of the tolerance on the variable to be measured, and shall be appropriate for measuring the test parameters.

3.2.1 Tolerances. The maximum allowable tolerances on test conditions shall be as follows:

a. Temperature: ± 2°C (± 3.6°F). (Exclusive of instrument accuracy).

b. Altitude: ± 5 percent.

c. Relative Humidity: ± 5 percent.

d. Vibration Amplitude: Sinusoidal: ± 10 percent

Random: $\begin{pmatrix} +3.0db \\ -1.5db \end{pmatrix}$ < 500 Hz

$(\pm 3.0db)$ ≥ 500 Hz

e. Vibration Frequency: ± 2 percent, or ± 1/2 Hz below 25 Hz.

f. Acceleration: ± 10 percent.

3.2.2 Temperature stabilization. Temperature stabilization will have been attained when the temperature of the part of the system or component considered to have the longest thermal lag does not change more than 2°C (3.6°F) per hour.

3.3 Performance record. Before and after conducting any of the tests specified herein, the system or component shall be subjected to a test program under standard conditions to determine compliance with the equipment specification. The equipment specification shall provide the criteria for checking satisfactory performance of the system or component before, during, and after environmental tests. At the conclusion of the test, the system or component shall be inspected for evidence of deterioration.

3.4 Installation check. Following installation in the test facility and before the application of the test environment, the system or component shall be operated to insure that no malfunction or damage resulted from faulty installation procedures or handling.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. All of the inspections covered by this specification will be performed by the Government, at the Government testing agency called out in the equipment specification.

4.2 Classification of inspections. The inspection requirements of this specification are classified as follows:

a. Qualification Inspection. Qualification Inspection is inspection performed on sample items submitted for inspection for qualification to be offered on a bid.

b. Qualification Verification Inspection. Qualification Verification Inspection is inspection performed on sample items selected from production lots and inspected to verify qualification to be offered on a bid.

4.3 Qualification Inspection. A sample for Qualification Inspection shall consist of three or four items, as specified in the equipment specification, all of which shall be identical to one another. The sample items shall be subjected to the qualification tests listed in Table I or II, as applicable.

4.3.1 Rework and resubmission. When an item fails a qualification test, the manufacturer may, at his option, rework it and resubmit it, or submit a new item in place of it. The manufacturer shall furnish a detailed report of his investigation of the cause of the failure and the action taken to correct it. The reworked or new item may, at the discretion of the testing activity, be subjected to any tests of this specification beside those which the item had not passed before the failure.

4.4 Qualification Verification Inspection. Qualification Verification Inspection shall be performed in accordance with the following for each contract under which a number of items equal to at least one-half the basic lot size are to be delivered for use: In addition to the items to be delivered for use, the manufacturer shall produce the items to be delivered for test and shall include the cost of the test items in the contract bid. For each group of items equal to the basic lot size (or remaining quantity (N) less than the basic lot size, but equal to at least one-half the basic lot size) to be delivered for use, the manufacturer shall produce a lot of items equal to the basic lot size plus one (or N plus one). If there is a remaining group of items less than one-half the basic lot size to be delivered for use, they shall be combined with the preceeding lot. The manufacturer shall submit to the Government Inspector a check for the amount specified in the contract for Qualification Verification Inspection of the sample item(s) representing that lot. The Government Inspector shall select one sample item from each lot, at his discretion, and shall send it to the Government testing agency specified in the contract. The manufacturer's check shall accompany the sample item(s) selected for Qualification Verification Inspection. No item will be accepted from any lot unless the manufacturer's check has been submitted. The sample item(s) shall be subjected to the Qualification Verification tests specified in Table I or II, as applicable. If the contract consists of a firm quantity and one or more optional quantities, the preceeding requirements apply to the firm quantity and to each optional quantity individually.

Table I. Test Plans for Three Samples

Test Paragraph		Qualification Sample Number		
		1	2	3
		Qualification Verification Sample Number		
Number	Title	1, 4, 7, etc.	2, 5, 8, etc.	3, 6, 9, etc.
4.6.1	Acceleration	X		
4.6.2	Dust	X		
4.6.3 4.6.3.1	Salt Fog or Oil-Saltwater Ingestion	X		
4.6.4	Temperature-Altitude		X	
4.6.5	Mechanical Shock		X	
4.6.6	Fungus		X	
4.6.7.1 4.6.7.2	Electromagnetic Interference Electromagnetic Susceptibility	X		X
4.6.8	Humidity			X
4.6.9.1 4.6.9.2	Engine Mounted Component Vibration or Non-engine Mounted Component Vibration			X X
4.6.10	Burn-In	X	X	X

Table II. Test Plans for Four Samples

Test Paragraphs		Qualification Sample Number			
		1	2	3	4
		Qualification Verification Sample Number			
Number	Title	1,5,9 etc	2,6,8 etc	3,7,11, etc	4,8,12, etc
4.6.1	Acceleration	X			
4.6.2	Dust				X
4.6.3 4.6.3.1	Salt Fog or Oil-Saltwater Ingestion	X			
4.6.4	Temperature-Altitude		X		
4.6.5	Mechanical Shock		X		
4.6.6	Fungus		X		
4.6.7.1 4.6.7.2	Electromagnetic Interference Electromagnetic Susceptibility	X			X
4.6.8	Humidity			X	
4.6.9.1 4.6.9.2	Engine Mounted Component Vibration or Non-engine Mounted Component Vibration			X X	X
4.6.10	Burn-In	X	X	X	X

4.5 Failure criteria. The item is considered failed if during or after any test herein, the item will not meet the specified performance limits, or if the maintenance of the item is impeded, or if the item requires the replacement of components.

4.6 Tests.

4.6.1 Acceleration. The item shall be subjected to the acceleration test of MIL-STD-810 Method 513.2, Procedure I and II. The test level for all directions in Procedure I (Structural Test-Non Operating) shall be accomplished using an acceleration level of 13.5g. The g level shall be applied along three mutually perpendicular axes in two opposite directions along each axis. The test time duration in each direction shall be at least one minute following centrifuge stabilization. At the conclusion of the test, the item shall be operated per 3.3. There shall be no mechanical or structural failures due to applied acceleration. For Procedure II (Operational Test), the required acceleration level for all directions shall be 9.0g. The 9.0g level shall be applied along three mutually perpendicular axes in two opposite directions along each axis. The test time duration in each direction shall be at least one minute following centrifuge stabilization and the item shall be operated continuously at full load during the test. Any deterioration or change in performance shall not exceed that defined per 4.5.

4.6.2 Dust. The item shall be subjected to the dust tests, Procedure I, Method 510.1, MIL-STD-810. The item shall be oriented so as to expose the most critical or vulnerable parts of the items to the dust stream. In Steps 1 and 3, the item shall be operated continuously at no load and applicable operating conditions, such as rated voltage, frequency, and speed, shall be maintained. Immediately after reaching temperature stabilization in Step 2, the second six-hour test (Step 3) shall be performed. Upon completion of the exposure period, the item shall be removed from the chamber and allowed to cool to room temperature. Accumulated dust shall be removed from the test item by brushing, wiping or shaking, and with care being taken to avoid the introduction of additional dust into the specimen. Under no circumstances shall dust be removed by either blast or vacuum cleaning. The item shall then be operated per 3.3. Bearings, grease seals, relays, contacts, etc., shall be examined for the presence of sand and dust deposits. Any deterioration or change in performance shall not exceed that defined per 4.5.

4.6.3 Salt fog. All components except those defined in 4.6.3.1 shall be subjected to the salt fog tests, Procedure I, Method 509.1, MIL-STD-810. The required salt solution shall be formulated as follows:

Salt	Grams Per Liter
Sodium Chloride	24.540
Magnesium Chloride	11.110
Sodium Sulfate	4.094
Calcium Chloride	1.159
Potassium Chloride	0.695
Sodium Bicarbonate	0.201
Potassium Bromide	0.101
Strontium Chloride	0.042
Boric Acid	0.027
Sodium Fluoride	0.003

Adjust the pH of this solution, if necessary, to 8.2 with 0.1 normal sodium carbonate solution.

The component shall be oriented so as to expose the most critical or vulnerable parts to the salt fog. The duration of the exposure period shall be 48 hours and the component shall be nonoperating. At the completion of this exposure period, the component shall be dried for 24 hours. The component shall then be operated and inspected per 3.3. Metal parts shall be examined for corrosion, moving parts for clogging or binding, plastic parts for distortion, paint for blistering, and hygroscopic materials for swelling. Any deterioration or change in performance shall not exceed that defined per 4.5.

4.6.3.1 Oil-saltwater ingestion. Components cooled by blast air ducted directly into the component from outside the aircraft shall be subjected to the following test procedure:

4.6.3.1.1 Preparation of test item. Brushless generators shall be immersed longitudinally in engine oil up to the bearings and the generator shall be rotated in the oil approximately 60° every 15 minutes for 16 hours. Brush type generators shall be immersed with the flange end down in engine oil up to, but not including, the brush rigging. Heat exchangers shall be submerged in engine oil for 16 hours and then drained for one hour. The engine oil shall conform to MIL-L-23699 at 25° ± 10°C (77° ± 18°F).

4.6.3.1.2 Operating conditions. Subject the drained generators and heat exchangers to 25 four-hour cycles during which engine oil (MIL-L-23699) shall be continuously injected into the cooling air at the rate of 5 milliliters per hour. During the first two hours of each cycle, synthetic sea water as formulated per 4.6.3 shall be continuously introduced with the cooling air at the rate of 8.33 milliliters per minute. For the next ten minutes, 750 milliliters per minute of fresh water shall be continuously injected into the cooling air. For the last one hour and 50 minutes of each cycle, no water is to be injected into the cooling air. The load on the component shall be varied as follows, in successive four-hour cycles: one hour each at no load, one-half load, three-quarters load, and full load. At the completion of the test, the component shall be operated and inspected per 3.3. Any deterioration or change in performance shall not exceed that defined per 4.5.

4.6.4 Temperature-altitude. In making the transition from one temperature-altitude condition to another, the rates of change of temperature and pressure shall not exceed 1°C (1.8°F) per second and 0.5 inch of mercury per second, respectively. The dew point shall be maintained 10°C or more below the ambient chamber temperature for all tests. The velocity of the air throughout the test chamber shall not exceed 100 feet per minute for altitude settings below 20,000 feet.

4.6.4.1 Self-cooled components. The component shall be subjected to the temperature-altitude requirements of Figure 1 (Modified Curve I, MS33543). With the component inoperative, adjust the test chamber to sea level and a temperature of 85°C. Operate the component at rated output and allow the component to reach temperature stabilization. After the component has attained temperature stabilization, perform such electrical tests as are required by the equipment specification. The above procedure shall be repeated at 10,000-foot increments to the maximum altitude indicated by the equipment specification. The tests shall be performed utilizing the maximum temperature-altitude conditions of Figure 1. Intermediate points on the maximum temperature-altitude curve may be checked at the option of the test activity. At the conclusion of the test, the component shall be operated and inspected per 3.3. Any deterioration or change in performance shall not exceed that defined in 4.5.

4.6.4.1.1 Minimum temperature-altitude criteria. The above test shall be repeated using the minimum temperature-altitude curve of Figure 1.

4.6.4.2 Blast-cooled components. The component shall be subjected to the maximum temperature-altitude requirements of Figure 2 (Modified MS33542). With the component non-operating, adjust the test chamber to sea level and a temperature of 71°C. Operate the component at rated output and allow the component to reach stabilization. After the component has attained temperature stabilization, perform such electrical tests as are required by the equipment specification. The above procedure shall be repeated at 10,000-foot increments to the maximum altitude indicated by the equipment specification. Intermediate points on the maximum temperature-altitude

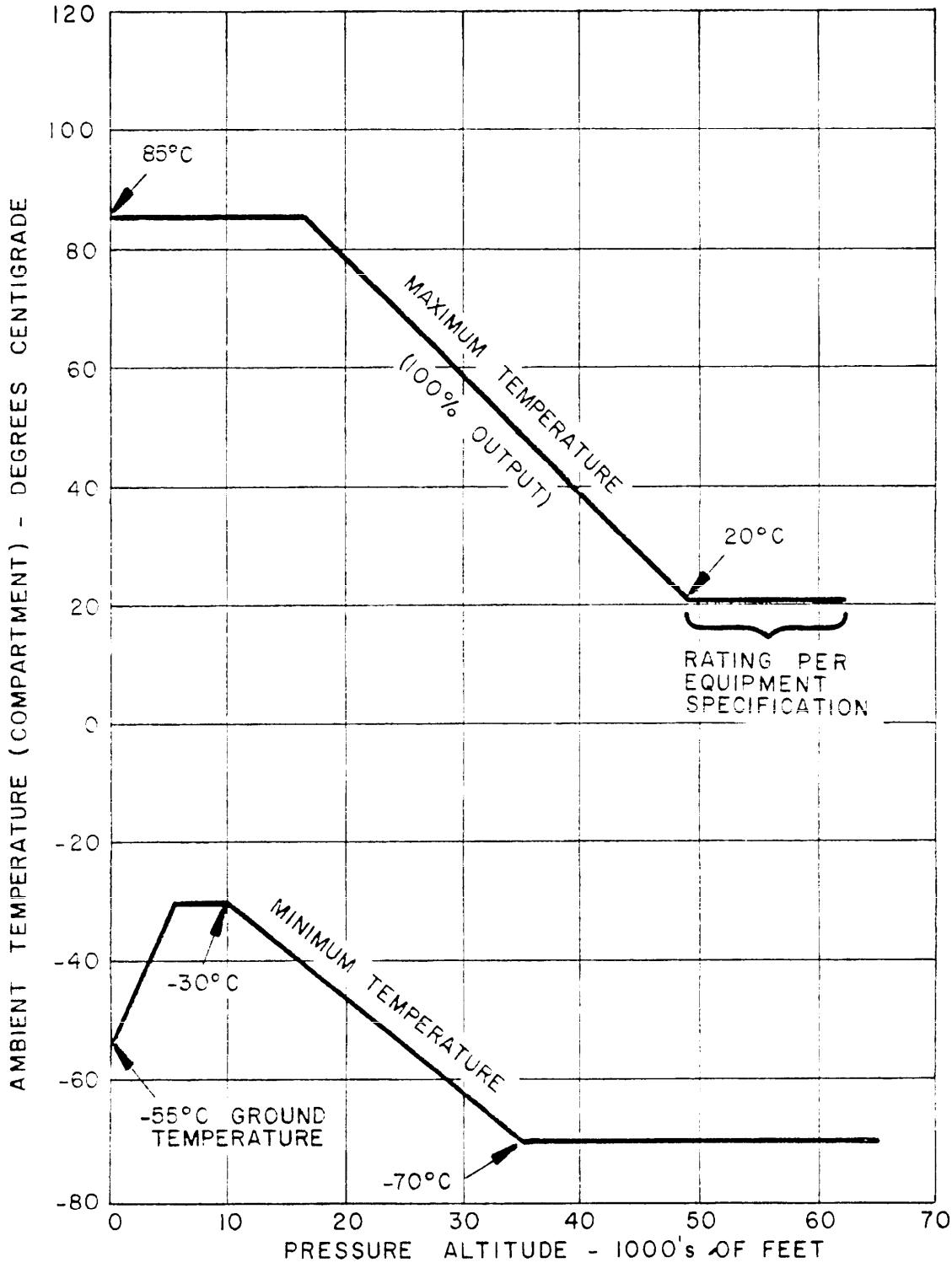

Figure 1. Temperature-Altitude Requirements For Self-Cooled Components

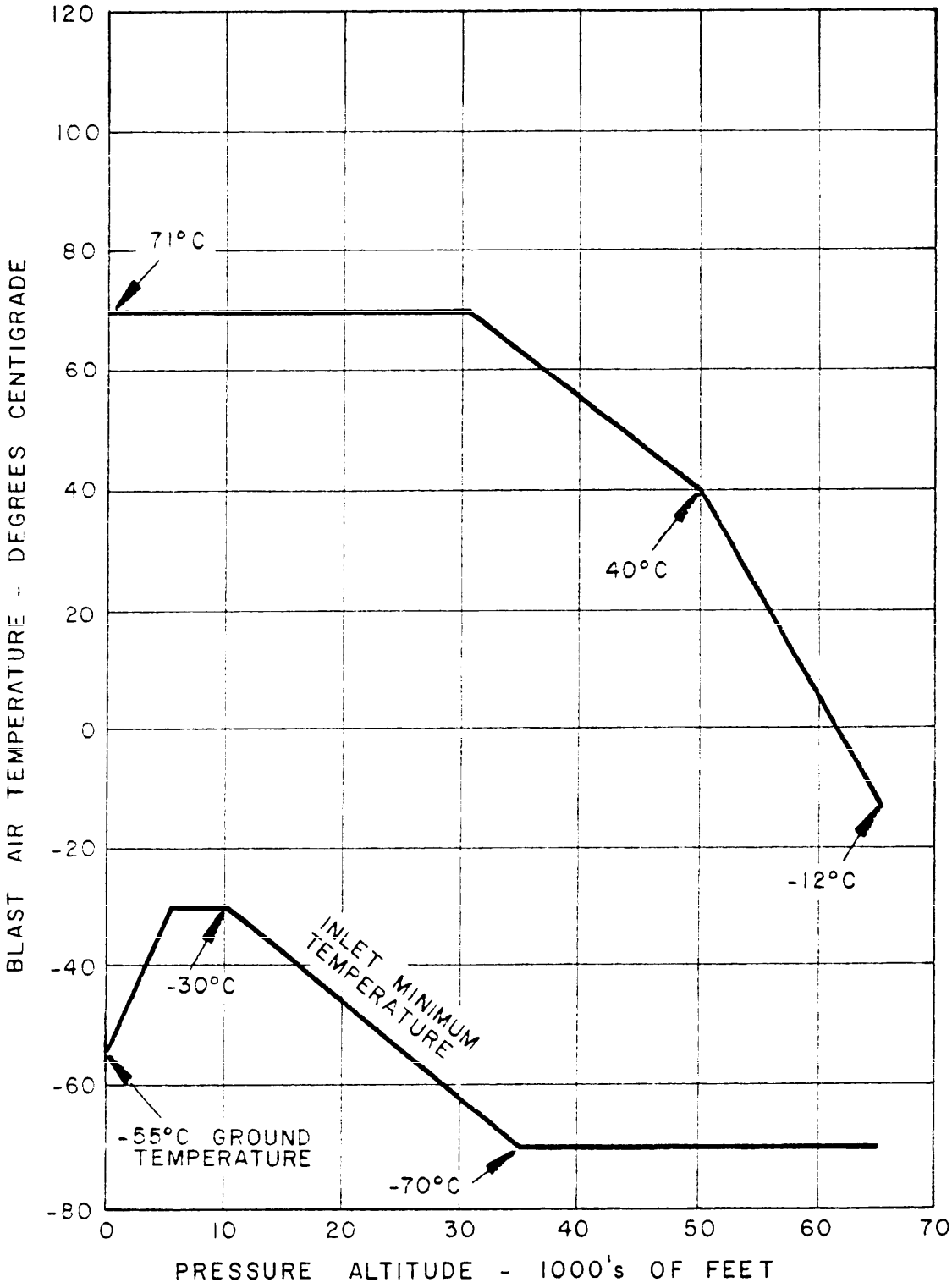

Figure 2. Temperature-Altitude Requirements For Blast-Cooled Components

curve may be checked at the option of the test activity. At the conclusion of the test, the component shall be operated and inspected per 3.3. Any deterioration or change in performance shall not exceed that defined per 4.5.

4.6.4.3 Minimum temperature-altitude criteria. The above test shall be repeated using the minimum temperature-altitude curve of Figure 2.

4.6.5 Mechanical shock. The item shall be subjected to the shock tests of MIL-STD-810, Method 516.2, Procedures I and III. Procedure I tests shall be accomplished using a shock pulse in accordance with Figure 516.2-2, of amplitude 15g, and a time duration of 11 milliseconds. Three shocks in each direction shall be applied along three mutually perpendicular axes of the item (total of 18 shocks). The item shall not be operating during the test. At the conclusion of the test, the item shall be operated and inspected as specified in 3.3. Any deterioration or change in performance shall not exceed that defined per 4.5. Procedure III (Equipment Crash Safety) shall be accomplished using a shock pulse in accordance with Figure 516.2-2, of amplitude 30g, and a time duration of 11 milliseconds. The shocks shall be applied to the item in each direction along each of three mutually perpendicular axes (total of 12 shocks). There shall be no failure of the mounting attachment, and the item or dummy load shall remain in place and not create a hazard. However, bending and distortion shall be permitted.

4.6.6 Fungus. The item shall be subjected to the fungus tests, Procedure I, Method 508.1, MIL-STD-810. The item shall be removed from the test chamber and excess moisture may be removed by turning the item upside down or by shaking. No washing or wiping of the item is permitted. The item shall then be operated and inspected per 3.3. Any deterioration or change in performance shall not exceed that defined per 4.5.

4.6.7 Electromagnetic compatibility.

4.6.7.1 Electromagnetic interference. At no load and full load, and in the case of generators, at minimum and maximum rated speeds, both broadband conducted and radiated electromagnetic interference measurements shall be taken on the test item. Broadband conducted tests shall be performed according to MIL-STD-462, Method CE03, from 150 KHz to 50 MHz. Radiated broadband tests shall be in accordance with MIL-STD-462, Method RE02 and shall cover a frequency range from 150 KHz to 1000 MHz. The test item shall conform to the broadband conducted and radiated emission requirements of CE03 and RE02, respectively, as contained in MIL-STD-461.

4.6.7.2 Electromagnetic susceptibility. The test item, with the exception of generators, shall be subjected to both conducted and radiated susceptibility tests. Conducted susceptibility shall be performed using Method CS02, MIL-STD-462. An RF signal level of 1.0 volt shall

be injected into the positive input lead(s) over a frequency range of 50 KHz to 400 MHz. Radiated susceptibility shall be performed using Method RS03, MIL-STD-462. The test item shall be subjected to a 1.0 volt/meter electric field radiated from antennas across the frequency range 14 KHz to 400 MHz. During the application of the conducted and radiated levels cited above, performance shall not be degraded beyond the tolerance given in the equipment specification.

4.6.8 Humidity. The item shall be subjected to the humidity test, Procedure II, Method 507.1, MIL-STD-810. The item shall be operated only for the last 15 minutes for each 48-hour cycle. The item shall be operated continuously at no load, and applicable operating conditions such as rated voltage, frequency, and speed shall be maintained. After exposure, the item shall be removed from the chamber and excess moisture may be removed by turning the item upside down or by shaking. The item shall then be conditioned for 24 hours at 23°C (73°F) and 50 $\pm$ 10 percent relative humidity. The item shall then be operated and inspected per 3.3. Metal parts shall be examined for corrosion, plastic parts for distortion, moving parts for insufficient lubrication, paint for blistering and hygroscopic materials for swelling. Any deterioration or change in performance shall not exceed that defined per 4.5.

4.6.9 Vibration. Components shall be classified as engine-mounted (starters, generators, constant speed drives, etc.) or non-engine-mounted (inverters, converters, regulators, power monitors, etc.). Engine-mounted components shall be subjected to sinusoidal type forcing functions whereas non-engine-mounted components shall be subjected to both sinusoidal and random vibration forcing functions.

4.6.9.1 Engine-mounted components. Engine-mounted components shall be vibrated in accordance with Procedure I, Method 514.2, MIL-STD-810. Procedure I shall be accomplished using the vibration test curve of Figure 3 and the test time schedule of Table III. One thirty-minute dwell shall be performed at 17 Hz. In addition, any major resonances up to a total of three shall be performed for 30 minutes each. Sinusoidal cycling shall not be conducted for more than 150 minutes or less than 60 minutes per axis. The sweep time for sinusoidal cycling over the frequency range of 5 to 2,000 Hz and back to 5 Hz shall be 20 minutes. The component shall be operated at no load, but other applicable conditions such as rated voltage, frequency, and speed shall be maintained. At the conclusion of the test, the component shall be operated and inspected per 3.3. There shall be no evidence of cracking or rupture of any part of the component or of the mounting assembly. Any deterioration or change in performance shall not exceed that defined in 4.5.

Table III

Dwell Time (Minutes)		Sinusoidal Cycling Time (Minutes)
17 Hz 3 Major Resonances	30 30 each	180 Less dwell time

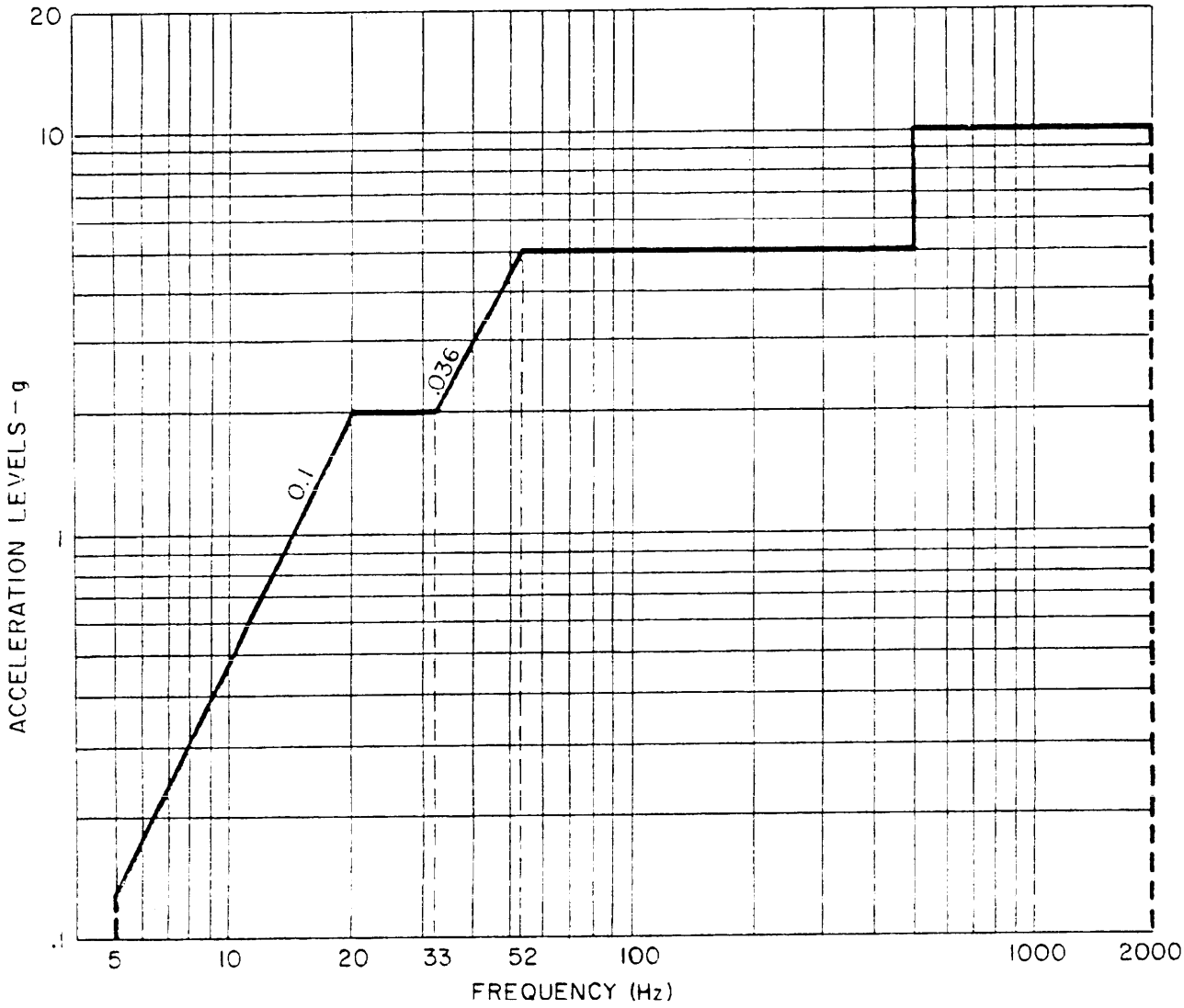

Figure 3. Vibration Test Curve For Engine-Mounted Components

4.6.9.2 Non-engine-mounted components. Non-engine-mounted components shall be vibrated in accordance with Procedure IA, Method 514.2, MIL-STD-810. Procedure IA shall be accomplished using broadband random vibration exitation. A functional level and an endurance level are required along each of three orthogonal axes of the component. The acceleration power and spectral density (G^2/Hz) and test envelope for the functional and endurance test shall be as depicted in Figures 4 and 5, respectively. The functional and endurance test time durations shall be one hour each. In addition, the same sample or another sample shall be subjected, via Procedure I, Method 514.2, MIL-STD-810, to the requirements of test curve M, Figure 514.2-23 and the test time schedule of 5.4.2-III, for components mounted without vibration isolators. During the tests, the component shall operate at full electric load, and when functioning as a control component it shall control the other components of the system as specified in the equipment specification. Any deterioration or change in performance of the component shall not exceed that defined per 4.5. At the conclusion of the test, the component shall be operated and inspected per 3.3. There shall be no evidence of cracking or rupture of any solder connection or part of the component, or of the mounting assembly.

4.6.10 Burn-In. Non-rotating equipment* shall be subjected to one or more cycles of testing conforming to Figure 6, and the number of cycles shall be determined by referencing Table IV. The heating and cooling temperature ramps of Figure 6 shall be performed at a minimum of 5°C/minute. The equipment shall be turned off during the cool down period (cooling ramp) and turned on for the balance of each cycle. The equipment shall be vibrated in one axis with an amplitude of $0.02g^2/Hz$ over a frequency range of 20 - 2,000 Hz during the last twenty minutes of each four hour stabilized temperature condition. Failures may occur and be corrected in any cycle prior to the final cycle. The burn-in is considered acceptable if there is no failure during the final cycle. If a failure occurs in the final cycle, the equipment may be corrected, subject to approval by the Government, and a failure-free cycle run.

Table IV.

Number of Burn-In Cycles

Number of Electronic Parts	Number of Cycles
0-100	1
101-500	3
501-2000	6
2001+	10

*Rotary inverters are considered non-rotating equipment for this test.

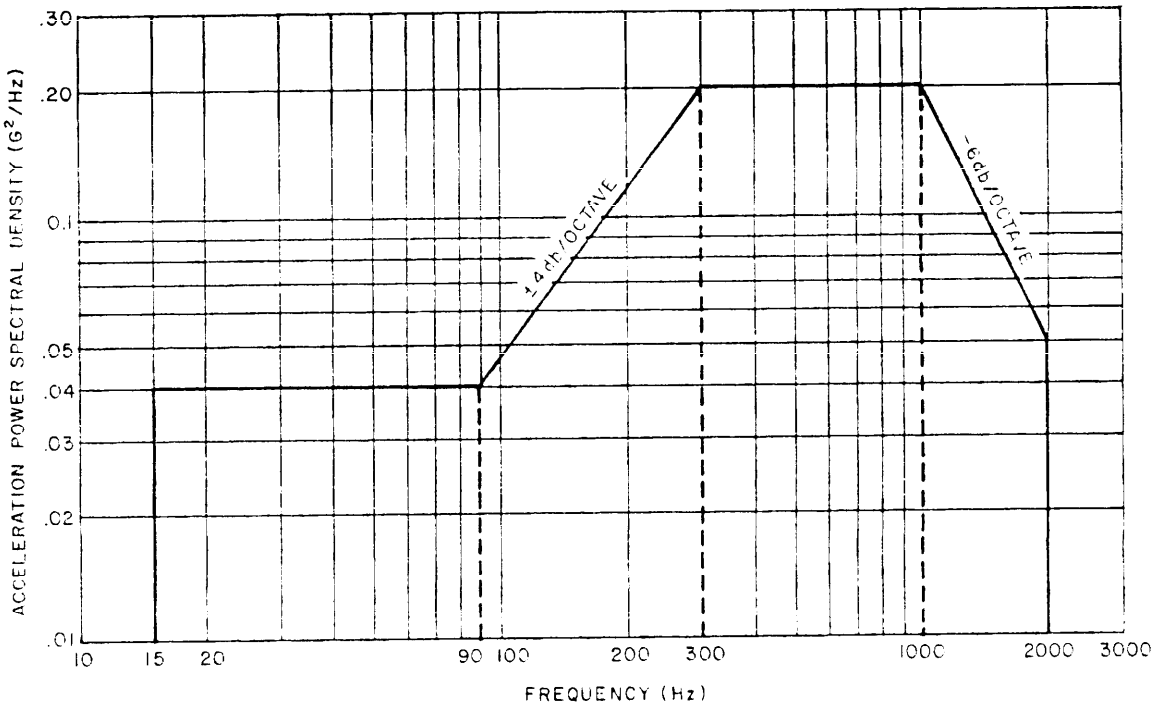

Figure 4. Functional Test Curve For Non-Engine-Mounted Components

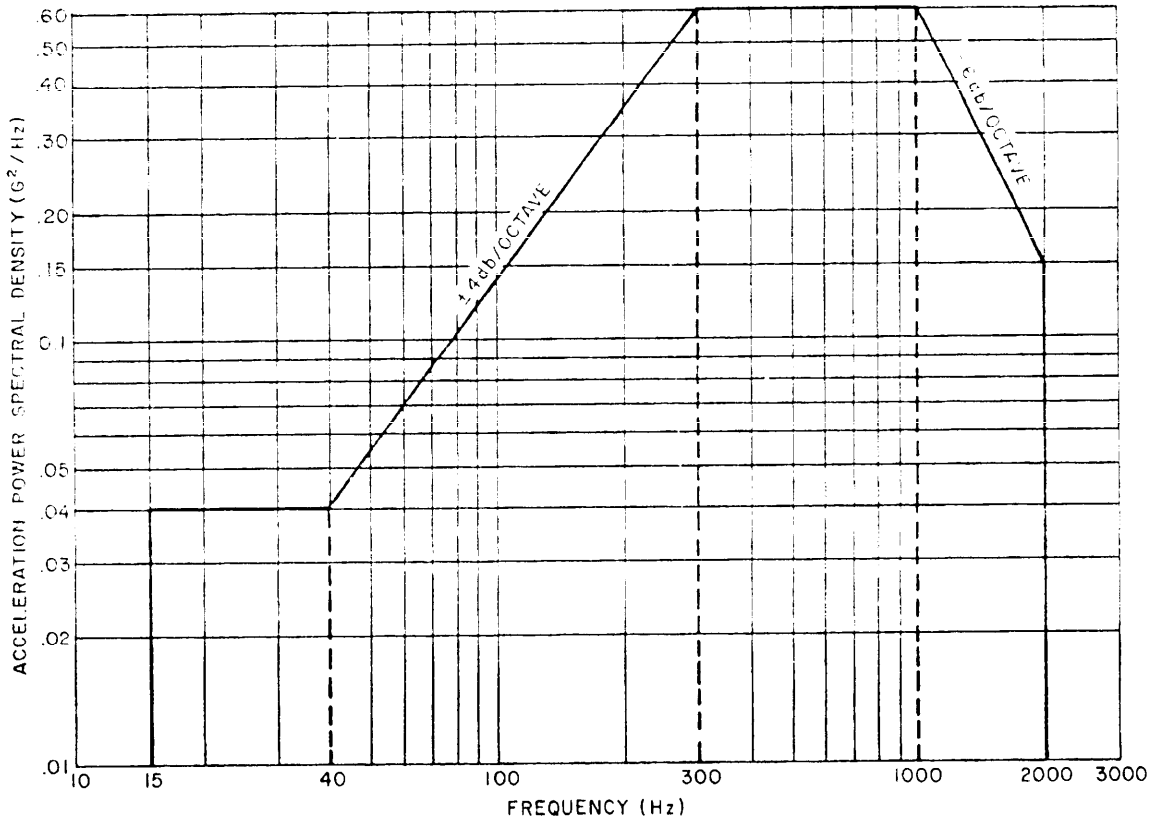

Figure 5. Endurance Test Curve For Non-Engine-Mounted Components

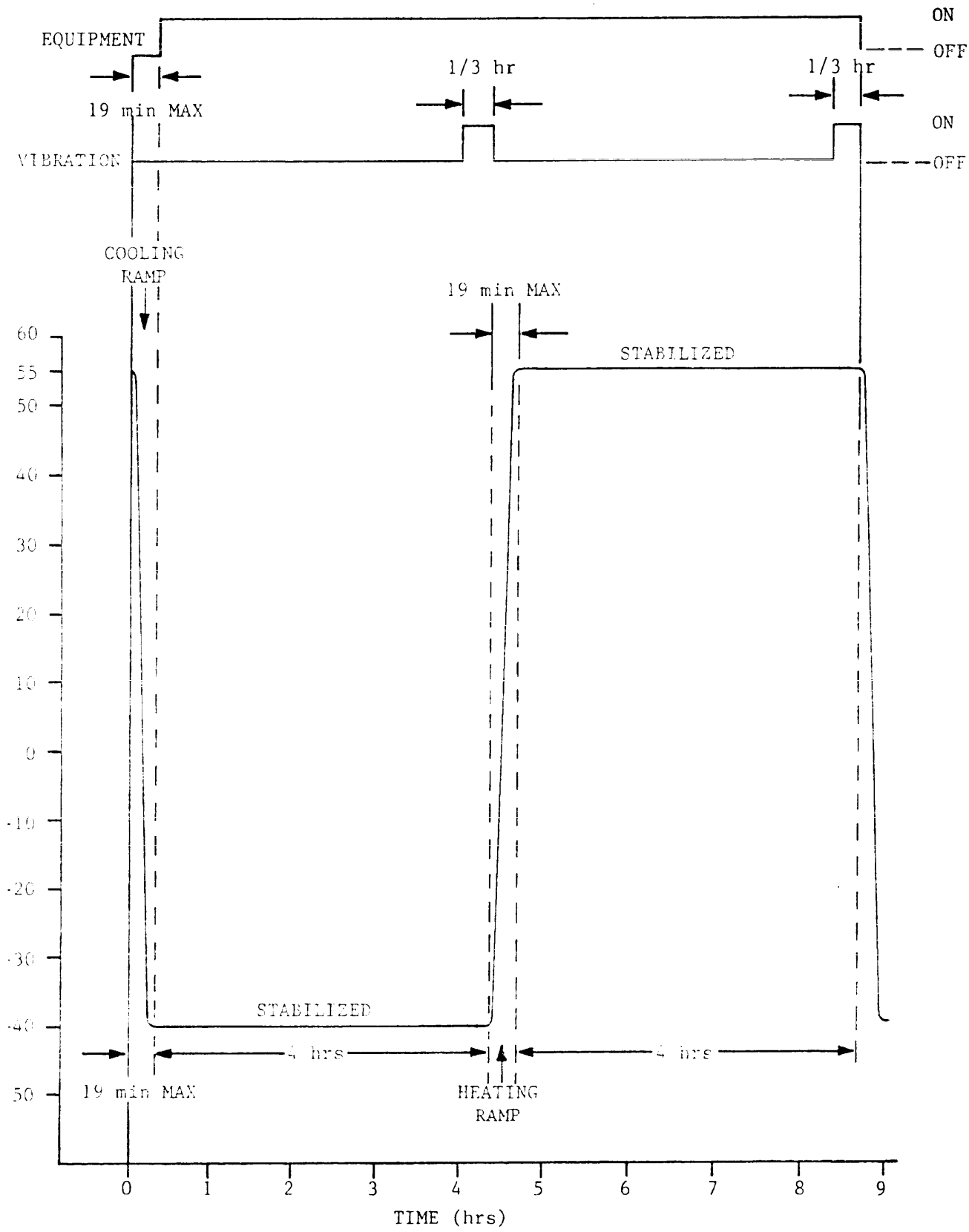

Figure 6. Typical Burn-In Test Cycle

5. NOTES

5.1 Intended use. This specification is intended to prescribe conditions to be followed in subjecting electric power generating systems and related equipment to simulated and accelerated environmental conditions in order to assure satisfactory operation and to reduce deteriorati when the item is operated in any global locality.

5.2 General application.

5.2.1 Determination of temperature stabilization. Temperature stabilization of equipment may be checked by a thermal measuring device in good thermal contact with the largest, centrally located mass.

5.3 Inclusions in equipment specifications. Equipment specifications referencing this specification must include the following:

a. Criteria test. A criteria for checking the equipment performance before, during, and after the test specified herein. See 3.3.

b. Adjustments. Any adjustments to equipment and circumstances under which permitted.

c. Additional requirements. Any additional environmental requirements beyond those specified herein.

d. Qualification samples. The number of sample items required for qualification inspection.

e. Basic lot size. The basic lot size for Qualification Verification Inspection. The factors most likely to determine the basic lot size to use are:

1. The cost of testing a sample item.

2. Whether sample items which have been tested can be rebuilt and used.

3. The cost of the extra items for testing, or the cost of rebuilding them.

f. Testing agency. The name and address of the Government testing agency to which Qualification and Qualification Verification sample items are to be sent to be tested.

g. Item. If there is any likelihood of doubt about what constitutes an item, the equipment specification should state what constitutes an item.

h. Electromagnetic susceptibility. The tolerance for the electromagnetic susceptibility test.

Preparing Activity
Navy - AS

(Project No. 6110-0219)

* U.S. GOVERNMENT PRINTING OFFICE: 1977 — 730-122/144

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

OMB Approval
No. 22-R255

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