

IEEE Standard for Environmental Conditions for Transit Rail Car Electronic Equipment

IEEE Vehicular Technology Society

Sponsored by the
Rail Transit Vehicle Interface Standards Committee



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IEEE Standard for Environmental Conditions for Transit Rail Car Electronic Equipment

Sponsor

**Rail Transit Vehicle Interface Standards Committee
of the
IEEE Vehicular Technology Society**

Approved 26 January 2001

IEEE-SA Standards Board

Abstract: Baseline environmental conditions under which transit rail car electronic equipment shall both operate and/or survive are specified in this standard.

Keywords: atmospheric pressure, authority having jurisdiction, corrosive elements, equipment under test, humidity, temperature, water, vibration.

The Institute of Electrical and Electronics Engineers, Inc.
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Introduction

(This introduction is not part of IEEE Std 1478-2001, IEEE Standard for Environmental Conditions for Transit Rail Car Electronic Equipment.)

This standard establishes environmental conditions under which transit rail car electronic equipment shall both operate and/or survive. Environmental conditions specified include: temperature, humidity, vibration, mechanical shock, corrosives and abrasives, precipitation, flooding, ultraviolet radiation, and altitude. This standard does not cover electromagnetic interference (EMI) or radio frequency interference (RFI). Environmental conditions depend upon equipment location such as vehicle exterior—axle mounted, truck sprung and body mounted and vehicle interior—non-conditioned and conditioned.

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Contents

1. Overview 1

 1.1 Scope 1

 1.2 Purpose 1

2. References 1

3. Definitions, abbreviations, and acronyms 2

 3.1 Defintions 2

 3.2 Abbreviations and acronyms 2

4. Standard enivironmental conditions 2

 4.1 Temperature, relative humidity, vibration, mechanical shock, corrosive and abrasive environ-
ment 3

 4.2 Precipitation and flooding 6

 4.3 Ultraviolet radiation 6

 4.4 Altitude 6

Annex A (informative) Bibliography 9

Annex B (informative) Excerpts from MIL-STD-810E 10

IEEE Standard for Environmental Conditions for Transit Rail Car Electronic Equipment

1. Overview

1.1 Scope

This standard specifies baseline environmental conditions under which transit rail car electronic equipment shall both operate and/or survive. Special requirements anticipated for applications that have environmental conditions outside these baseline conditions are neither covered nor intended herein. Environmental conditions include: temperature, humidity, atmospheric pressure, water, corrosive elements, and vibration/shock. These conditions depend upon equipment location such as under car, interior, truck mounted, and carbody mounted.

1.2 Purpose

The purpose of the standard is to provide a baseline for contract specifications, design and manufacture of electronic equipment to be supplied for transit rail cars to eliminate unnecessary variability in specifications, allowing manufacturers to provide consistent product lines that can meet the needs of the industry, save costs and improve reliability.

2. References

This standard shall be used in conjunction with the following publications.

ASTM-B-117, Test Method for Salt Spray (Fog) Testing.¹

ASTM-B-368, Copper-Nickel-Chromium Electrodeposited Coatings, Method for Copper-Accelerated Acetic-Acid-Salt Spray (FOG) Testing (CASS-TEST).

Local Climatologic Data, Annual Summary with Comparative Data, National Oceanic and Atmospheric Administration, 1994.

¹ASTM publications are available from the American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, USA (<http://www.astm.org/>).

MIL-STD-810E, Environmental Test Methods Guidelines, September 1, 1993.²

Weather of U.S. Cities, Fifth Edition, Volumes 1 and 2, James A. Ruffner and Frank E. Bair, Gale Research Company, Detroit Michigan, 1996; Library of Congress Card Number 87-11869, ISBN 0-8103-5525-6.

3. Definitions, abbreviations, and acronyms

3.1 Defintions

For the purposes of this standard, the following terms and definitions apply. IEEE 100, *The Authoritative Dictionary of IEEE Standards Terms*, Seventh Edition [B1]³, should be referenced for terms not defined in this subclause. *Webster's New Collegiate Dictionary* [B2] shall apply otherwise.

3.1.1 Authority Having Jurisdiction: The entity that defines the contractual (including specification) requirements for the procurement.

3.2 Abbreviations and acronyms

ASCE	American Society of Civil Engineers
AREMA	American Railway Engineering and Maintenance of Way Association
ASTM	American Society for Testing and Materials
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronic Engineers
ISO	International Organization for Standards
NOAA	National Oceanic and Atmospheric Administration
SAE	Society of Automotive Engineers

4. Standard environmental conditions

Users of this standard are reminded that these are general environmental limits that may need to be supplemented in accordance with site and/or application specific conditions. The user is advised to review local ambient conditions. For specifying site-specific design climatic values Local Climatologic Data, Annual Summary with Comparative Data⁴, provides a basic compilation of low, high, and mean values of temperature, humidity, steady and gusting winds, rainfall rates, and other climatic characteristics as compiled by the National Oceanic & Atmospheric Administration (NOAA). Weather of U.S. Cities, Fifth Edition, Volumes 1 and 2, summarizes the NOAA data in convenient form.

Where the proposed site is located within a microclimate, data from these sources should be augmented with local Weather Bureau data.

Testing methods identified herein are solely intended to unambiguously define the environmental requirements. This standard does not impose any requirements concerning whether or how many times tests are to be conducted to verify conformance to these environmental requirements. However, in the event it is desired to verify conformance to this standard, testing shall be per the methods identified in this clause.

²MIL publications are available from Customer Service, Defense Printing Service, 700 Robbins Ave., Bldg. 4D, Philadelphia, PA 19111-5094.

³The numbers in brackets correspond to those of the bibliography in Annex A.

⁴Information on references can be found in Clause 2.

4.1 Temperature, relative humidity, vibration, mechanical shock, corrosive and abrasive environment

Five ambient environmental conditions are defined as follows:

E1. Vehicle Exterior, Truck Unsprung—Equipment is mounted on “unsprung” components of the truck, such as wheels and axles.

E2. Vehicle Exterior, Truck Sprung—Equipment is mounted on the sprung part of a truck.

E3. Vehicle Exterior, Body Mounted—Equipment is mounted on the car body in space outside the enclosed areas of the vehicle.

E4. Vehicle Interior, Non-Conditioned—Equipment is mounted in the enclosed interior spaces of the vehicle that are not environmentally conditioned.

E5. Vehicle Interior, Conditioned—Equipment is mounted in the enclosed interior spaces of the vehicle that are environmentally conditioned.

The parameter limits for each of the above ambient environments are specified in Table 1 and in 4.1.1 through 4.1.6:

4.1.1 Ambient storage temperature

The specified temperatures are the lowest and highest ambient temperatures expected to be experienced during storage or in service with power off. Equipment is not expected to be capable of operating at these temperatures, but shall survive them without damage or degradation. For verification of compliance with this standard, the ambient temperature is the temperature at which a test chamber shall be maintained while testing the equipment.

4.1.2 Ambient operating temperature

The temperatures specified in Table 1 are the lowest and highest ambient temperatures under which the equipment shall start and operate within its specified performance parameters during normal operation. For verification of compliance with this standard, the ambient temperature is the temperature at which a test chamber shall be maintained while testing the equipment. Equipment shall begin its initialization process within 30 seconds of applying power within the temperature limits of Table 1.

All equipment under test verification shall be tested in the production and application configuration with no additional internal or external fans or heaters added for the purpose of passing the temperature extremes testing. Temperature testing shall include a minimum of 4 hours soak time at each temperature extreme after test chamber temperature stabilization.

NOTE—Active heating and cooling may not be suitable for certain critical equipment.

4.1.3 Ambient relative humidity

The equipment shall be operated or stored without damage or degradation at the specified ambient non-condensing and condensing humidity. The specified humidity is for an ambient operating temperature of 30°C and storage temperature of 60°C. “Non-condensing” is a condition where equipment is at or above dew point temperature and liquid water is not condensing on the inside or outside surfaces of the equipment.

4.1.4 Vibration

Equipment shall withstand the Table 1 vibration environments in all shipping, storage and operating modes without damage, degradation, or abnormal operation.

To verify that the equipment can withstand the operating environment vibration tests shall be performed according to the following procedures:

- a) The equipment shall be subjected to sinusoidal cycling along each of the three mutually perpendicular axes. Each cycle shall consist of a sine sweep from 5 Hz to 1000 Hz and back to 5 Hz for conditions E1, E2 and E3 of Table 1 and from 5 Hz to 200 Hz and back to 5 Hz for conditions E4 and E5 of Table 1. During each sine sweep, the frequency of applied vibration shall be swept over the specified range logarithmically. Sweep times shall be 12 minutes for the 5 Hz–200 Hz–5 Hz range and 17 minutes for the 5 Hz–1000 Hz–5 Hz range. These sweep times are equivalent to a logarithmic sweep rate of approximately 0.9 octave per minute. Twenty (20) complete sine sweep cycles shall be applied along each of the three mutually perpendicular axes. Test durations for each axis shall be 4 hours for the 5 Hz–200 Hz–5 Hz sweep case and 5 hours 40 minutes for the 5 Hz–1000 Hz–5 Hz sweep case. Input vibration levels shall be as specified in Table 1. Each sine sweep consists of a constant displacement input over the initial low frequency range, followed by a constant acceleration input over the remainder of the frequency range up to the peak frequency.
- b) *Exploratory Sine Sweep:* It is recommended that an exploratory sine sweep test be conducted during the design phase to identify equipment resonances and potential problem areas. This test should be conducted at a vibration level of 1.3 mm peak-to-peak displacement (5–14 Hz) and an acceleration input of 5m/s^2 peak over the remaining frequency range for the appropriate conditions where the equipment is applied as specified in Table 1.
- c) *Equipment Mounting Technique:* The equipment shall be attached directly to the vibration exciter or transition table. For large equipment items that do not conveniently fit the vibration exciter or transition table, a rigid fixture shall be used to connect the equipment item to the exciter or transition table. The rigid fixture shall be capable of transmitting the vibration conditions specified herein. The input control sensing device(s) shall be rigidly attached to the vibration table, or fixture if used, as near as possible to the attachment point(s) of the test item.

Equipment that is normally vibration-isolated in service shall use the service isolators when mounted for the vibration tests.
- d) *Test tolerances:* The tolerances for the test conditions shall be as follows:
Vibration Frequency: ± 2 percent or ± 0.5 Hz for frequencies below 25 Hz
Vibration Amplitude: ± 10 percent
- e) In the sweep test, sufficient number of accelerometers shall be used to identify vibration characteristics of those units or subassemblies, which are susceptible to the vibration, representative of other units, and/or critical to performance of the equipment.

4.1.5 Mechanical shock

Equipment shall withstand the Table 1 shock conditions without damage, degradation, or abnormal operation. The equipment shall be capable of withstanding six shock pulses of terminal-peak sawtooth shape along each of the three mutually perpendicular axes (three shock pulses in each positive direction and three shock pulses in each negative direction). The peak value (P) and duration (D) of each shock shall be as specified for the particular equipment class in Table 1. A 3-axis shock pulse test shall be used to confirm compliance with these requirements. The equipment shall function properly without failure after being subjected to these shock pulse tests. Shock pulse tolerance limits are as specified in Figure 1.

4.1.6 Corrosive/abrasive environment

The following shall apply to exterior equipment under environmental conditions E1, E2, and E3 of 4.1.

4.1.6.1 Salt fog

Exterior equipment shall be capable of operating in or protected from heavy salt spray, as would be experienced in seacoast areas, and in the vicinity of salted roadways. The salt fog test shall be performed using apparatus qualified to the standards contained in Test Method 509.3 of MIL-STD-810E. A five percent salt concentration, by weight, shall be used. SO₂ shall be injected as specified in ASTM-B-117 and ASTM-B-368. The equipment under test shall be capable of passing the salt fog test when tested in the context of Test Method 509.3 of MIL-STD-810E.

The equipment under test shall function without damage, degradation, or abnormal operation during and after being subjected to the specified salt fog testing. The equipment under test shall also meet the failure requirements of Section 5.2.7 and paragraph I-4.1 of Method 509.3 of MIL-STD-810E.

4.1.6.2 Sand and dust

The equipment shall function properly without damage, degradation, or abnormal operation during and after being subjected to the sand and dust test of Test Method 510.3 of MIL-STD-810E, where the sand and dust particles vary in size from 1 to 650 micrometers in diameter.

4.1.6.3 Blowing sand

The blowing sand testing procedures, as specified in Test Method 510.3 of MIL-STD-810E, shall be required to be performed on exterior equipment. The sand composition used as test media for this test shall be as specified in paragraph I-3.2, subparagraph (d.) of MIL-STD-810E. The sand concentration shall be maintained at 1.1 g/m³. The air velocity shall be 29 m/s. The test shall be run for a duration of 90 minutes per equipment face, with the air velocity oriented perpendicular to each of the equipment faces in turn. The equipment shall function properly without damage, degradation, or abnormal operation during and after being subjected to the specified testing.

4.1.6.4 Blowing dust

The blowing dust testing procedures, as specified in Test Method 510.3 of MIL-STD-810E, shall be performed on exterior equipment. The dust composition used as test media for this test shall be as specified in paragraph I-3.2, subparagraph (d.) of MIL-STD-810E. The dust concentration shall be maintained at 10.6 g/m³. The air velocity shall be 8.9 m/s. The test shall be run for a duration of 6 hours at 23°C and 6 hours at the specified high operating temperature of the equipment. See Table 1 for specified high operating temperature for each equipment category.

The equipment under test shall function properly without damage, degradation, or abnormal operation during and after being subjected to the specified sand and dust testing. The equipment under test shall also meet the failure requirements of Section 5.2.7 and paragraph I-4.1 of Method 510.3 of MIL-STD-810E.

4.1.6.5 Contaminants

Equipment should be capable of resisting the effects of contaminants that may penetrate into the equipment. Exterior equipment should function without experiencing degradation in performance and reliability in the presence of high-pressure water, and as a minimum, but not limited to the following list of contaminants:

- Iron dust
- Oil vapor
- Oxides of nitrogen
- Ozone
- Carbon dust
- Copper dust
- Hair

4.2 Precipitation and flooding

Exterior mounted car equipment (environmental conditions E1, E2, and E3 of 4.1) is to be protected against rain, flooding, snowfall, and icing to operate successfully and without damage in the following conditions:

4.2.1 Rain

Exterior vehicle equipment shall be capable of operating in rain at a minimum rate of 13 cm/h and an accompanying wind speed of 18 m/s. The equipment shall function properly when tested in accordance with Test Method 506.3, Procedure I of MIL-STD-810E.

The equipment under test shall function properly without failure after being subjected to the specified rain testing. The equipment under test shall also meet the failure requirements of Section 5.2.7 and paragraph I-4.1 of Test Method 506.3 of MIL-STD-810E.

4.2.2 Snowfall, flooding and icing

Snowfall, flooding and icing requirements are not specified in this standard. It is recommended that the designer consider local conditions for these requirements.

4.3 Ultraviolet radiation

Materials normally exposed to the sun should be selected to minimize the deleterious effects of ultraviolet radiation.

4.4 Altitude

The equipment shall function properly in the altitude range of -100 m to 3,000 m with respect to sea level.

Table 1—Environmental parameter limits

Parameter	Condition	E1. Vehicle exterior, axle mounted	E2. Vehicle exterior, truck mounted	E3. Vehicle exterior, body mounted	E4. Vehicle interior, non-conditioned	E5. Vehicle interior, conditioned
Temperature	<i>Operating</i>	-40°C +70°C ^a	-40°C +70°C ^a	-40°C +70°C ^a	-40°C +70°C ^a	-25°C +70°C ^a
	<i>Storage</i>	-55°C +85°C	-55°C +85°C	-55°C +85°C	-55°C +85°C	-55°C +85°C
Relative Humidity	<i>Operating</i>	10–100% Condensing	10–100% Condensing	10–100% Condensing	10–95% Non-condensing	10–95% Non-condensing
	<i>Storage</i>	10–100% Condensing	10–100% Condensing	10–100% Condensing	10–100% Condensing	10–100% Condensing
Vibration	5–10 Hz 10–200 Hz 200–1000 Hz			13 mm p–p ^b 25 m/s ² p ^c 25 m/s ² p	8 mm p–p 15 m/s ² p --	8 mm p–p 15 m/s ² p --
	5–20 Hz 20–1000 Hz	23 mm p–p 200 m/s ² p	13 mm p–p 100 m/s ² p			
Mechanical Shock (D=11 ms pulse)	Shipping Operating	100 m/s ² p 1000 m/s ² p	100 m/s ² p 200 m/s ² p	100 m/s ² p 100 m/s ² p	100 m/s ² p 100 m/s ² p	100 m/s ² p 100 m/s ² p

^a These maximum operating temperatures may be reduced in specific situations with the approval of the Authority Having Jurisdiction.

^b p–p : peak-to-peak

^c p : peak

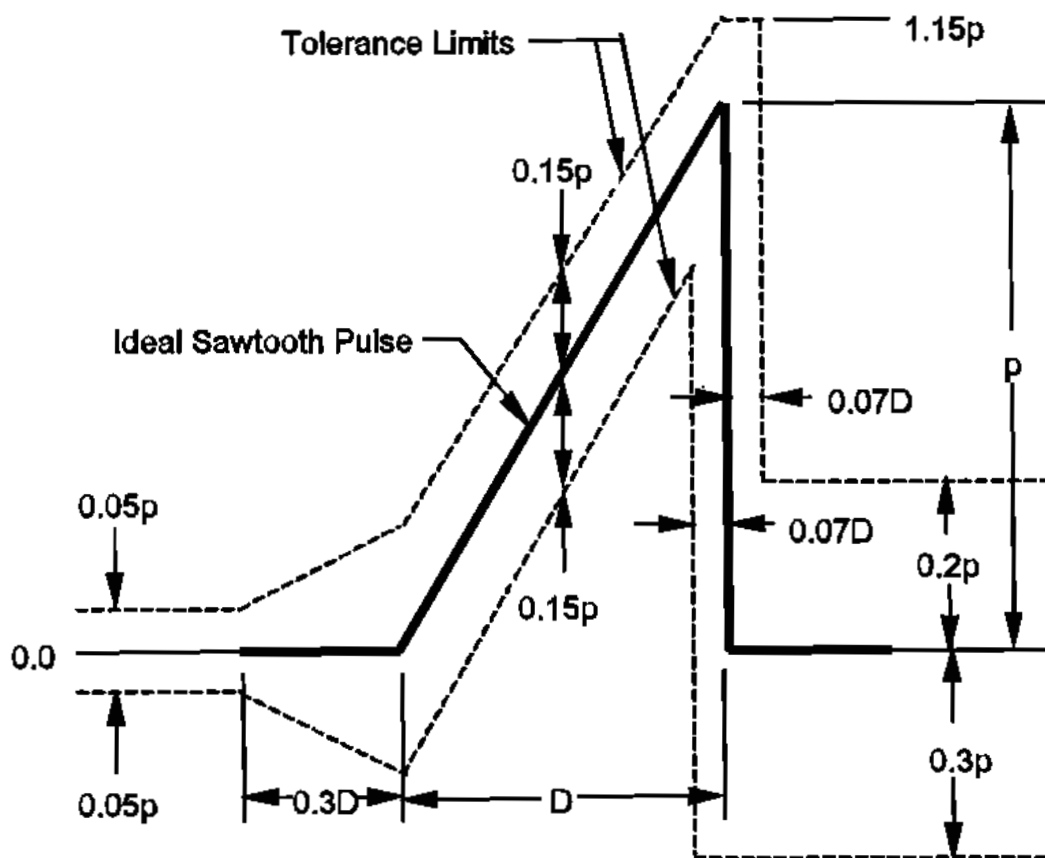


Figure 1—Mechanical shock pulse configuration and tolerances

Annex A

(informative)

Bibliography

IEEE 100, *The Authoritative Dictionary of IEEE Standards Terms*, Seventh Edition.

Webster's New Collegiate Dictionary, Springfield, MA: Merriam-Webster, Inc.

Annex B

(informative)

Excerpts from MIL-STD-810E

A new version of MIL-STD-810 (MIL-STD-810F) has been released. This version no longer includes the rain, salt, sand, and dust tests in version E, which have been referenced in this standard. Therefore, the relevant sections of MIL-STD-810E are included here as an informative annex.

(3) The environmental and operating conditions under which the measurements were made.

(4) The type and calibration status of data recording and analysis equipment and instrumentation.

In addition, the measured data should be analyzed and formatted to be compatible with the specific test procedure for which they are being considered.

c. Data quantity. Sufficient data are needed to adequately describe the conditions being evaluated, but the requirements for sufficiency will vary with the environmental conditions, physical and performance characteristics of the hardware type, and program needs. Consideration shall be given to:

(1) The number and nature of the data measurement points.

(2) The number and scope of trials conducted to record data.

Some engineering judgment may be required to assess the applicability of data when constraints limit the number and location of measurement points.

5. TEST METHODS.

5.1 Test conditions. Unless otherwise specified herein or in the equipment specification, measurements and tests shall be made at the following conditions:

a. Standard ambient. Ambient measurements and checks (e.g., pre- and post-test) are conducted at room ambient conditions as follows:

Temperature:	25°C $\pm$ 10°C (77°F $\pm$ 18°F)
Relative humidity:	Uncontrolled room ambient
Atmospheric pressure:	Site pressure

b. Controlled ambient. When the ambient conditions must be closely controlled, the following shall be maintained:

Temperature	23°C $\pm$ 2°C (73°F $\pm$ 3.6°F)
Relative humidity:	50 percent $\pm$ 5 percent
Atmospheric pressure:	96.45 $\pm$ 6.6 kPa -10.0
	(725 $\pm$ 50 mmHg) -70
	(28.5 $\pm$ 2.0 inHg) -3.0

5.1.1 Tolerances for test conditions. Unless otherwise specified, tolerances for test conditions shall be as follows:

a. Temperature. The test item shall be totally surrounded by an envelope of air (except at necessary support points). The temperature of the test section measurement system and the temperature gradient throughout this envelope, which is measured close to the test item, shall be within $\pm 2^{\circ}\text{C}$ ($\pm 3.6^{\circ}\text{F}$) of the test temperature and shall not exceed 1°C per meter or a maximum of 2.2°C total (equipment nonoperating).

b. Pressure. $\pm 5\%$ (± 200 Pa).

c. Humidity. Relative humidity at the chamber control sensor shall be ± 5 percent RH of the measured value.

d. Vibration amplitude

Sinusoidal: ± 10 percent

Random: See method 514.4

e. Vibration frequency. Vibration frequency shall be measured with an accuracy of ± 2 percent, or $\pm 1/2$ Hz below 25 Hz.

f. Acceleration. Acceleration (g's) shall be measured to within $\pm 10\%$.

g. Time. Elapsed time shall be measured with an accuracy of $\pm 1\%$.

h. Air velocity. Air velocity shall be within 10% of specified value.

5.1.2 Accuracy of test instrumentation calibration. The accuracy of instruments and test equipment used to control or monitor the test parameters shall be verified prior to and following each test and then calibrated in predetermined intervals and shall meet the requirements of ANSI NCSL Z540-1 to the satisfaction of the procuring activity. All instruments and test equipment used in conducting the tests specified herein shall:

a. Be calibrated to laboratory standards whose calibration is traceable to the National Standards via primary standards.

b. Have an accuracy of at least one-third the tolerance for the variable to be measured. In the event of conflict between this accuracy and a requirement for accuracy in any one of the test methods of this standard, the latter shall govern.

5.1.3 Stabilization of test temperature

5.1.3.1 Test item operating. Unless otherwise specified, temperature stabilization is attained when the temperature of the operating part of the test item considered to have the longest thermal lag is changing no more than 2.0°C (3.6°F) per hour.

5.1.3.2 Test item nonoperating. Unless otherwise specified, temperature stabilization is attained when the temperature of the operating part of the test item considered to have the longest thermal lag reaches a temperature within test tolerances of the nominal test temperature, except that any critical component (e.g., battery electrolyte for engine starting test) will be within 1°C (1.8°F). Structural or passive members are not normally considered for stabilization purposes. When changing temperatures, for many test items, the temperature of the chamber air may be adjusted beyond the test condition limits to reduce stabilization time, provided the extended temperature does not induce response temperature in a critical component or area of the test item beyond the test temperature limits for the test item.

5.1.4 Test sequence. Experience has shown definite advantages to performing certain tests immediately before, in combination with, or immediately following other tests. Where these advantages have been identified, guidance has been put in I-3c of the test methods and shall be followed. Other sequences and combination consistent with 1.2 and 4.2.1 of General Requirements may be used with the permission of the acquisition agency.

5.1.5 Test procedures. Guidance for choosing among the procedures of a method is found in section I of each method.

5.1.6 Test conditions. Whenever practical, specific test levels, ranges, rates, and durations shall be derived from measurements made on actual or appropriately similar equipment (see 4.3). When specific measured data are not available, the test characteristics shall be tailored using the guidance found in section 5.

5.2 General test performance guidance.

5.2.1 Pretest performance record. Before testing, the test item should be operated at standard ambient conditions (see 4.4) to obtain and record data determining compliance with the requirements document(s) and for comparison with data obtained before, during, and after the environmental test(s). The identification and environmental test history of the specific test item(s) should be documented for failure analysis purposes. The pre-test record shall include (as applicable):

a. The functional parameters to be monitored during and after the test if not specified in the equipment specification or requirements document. This shall include acceptable functional limited (with permissible degradation) when operation of the test item is required.

b. Additional evaluation criteria (in addition to 5.2.7).

5.2.2 Installation of test item in test facility. Unless otherwise specified, the test item shall be installed in the test facility in a manner that will simulate service usage, with connections made and instrumentation attached as necessary.

a. Plugs, covers, and inspection plates not used in operation, but used in servicing, shall remain in place.

b. Electrical connections normally used in service but not in test shall be provided with electrical connectors having dummy cables with protected terminations. Such mechanical connections shall also be protected.

c. For tests where temperature values are controlled, the test chamber shall be at standard ambient conditions when the test item is installed or as specified in the individual methods.

d. The test item shall be operated according to the applicable technical order or technical manual, when available, to determine that no malfunction or damage has resulted from faulty installation or handling. The requirement to operate the test item after its installation in the test facility applies only when the item is required to operate during the test.

e. Test items shall be positioned at least 15 cm (6 inches) from each other or from walls, floors, ceilings, etc. to allow for adequate circulation.

f. If the item to be tested consists of several separate units, these units may be tested separately provided the functional aspects are maintained as defined in the requirements document.

5.2.3 Performance check during test. When operation of the test item is required during the test exposure, suitable tests shall be performed to determine whether the test exposure is producing changes in performance when compared with pretest data.

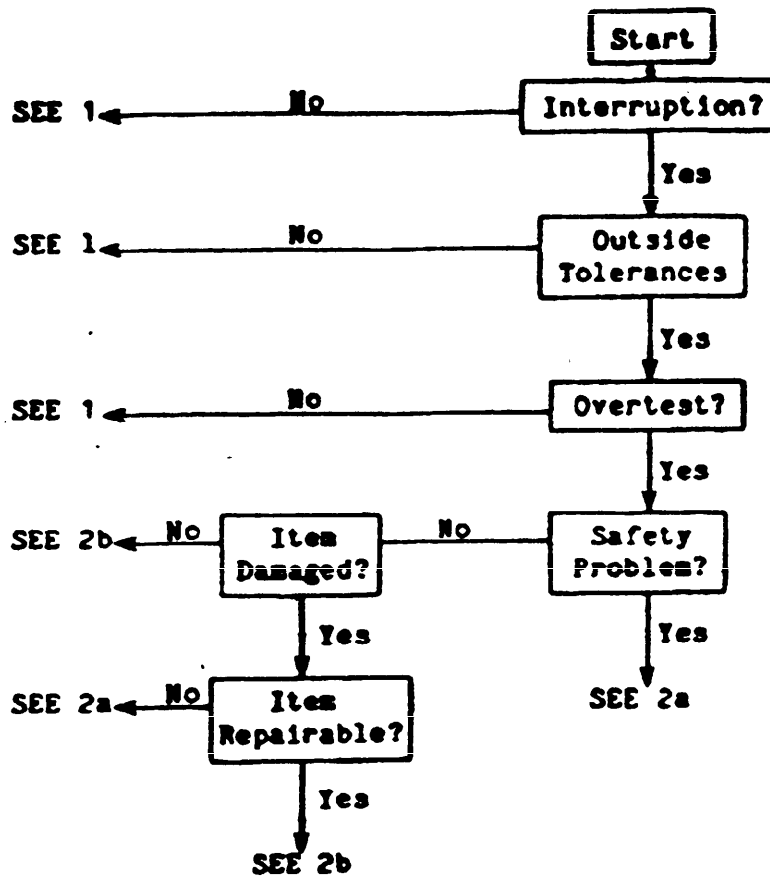
5.2.4 Interrupted tests. Unless otherwise specified in the individual methods, the following procedures shall be followed when a test is interrupted. Any deviation from this guidance shall be explained in the test report.

5.2.4.1 In-tolerance interruptions. Interruptions during which the prescribed test tolerances are not exceeded shall be considered as part of the total test duration. (no allowance is necessary if exposure to the proper test levels was maintained.)

5.2.4.2 Methods 505.3, 506.3, 510.3, 511.3, 514.4, 516.4 and 519.4 (See figure 4)

a. Undertest. If test tolerances have been exceeded resulting in an undertest condition, the test may be resumed from the point at which tolerances were exceeded following reestablishment of prescribed conditions (except as noted in the individual methods), and extended to insure that the prescribed test cycle is achieved.

b. Overtest. If an overtest condition occurs, the preferable course of action is to stop the test and start over with a new test item. However, if any damage is a direct result of the overtest conditions and will not affect other test item



NOTES:

1. Continue test (see individual methods); extend test time if necessary.
2. Alternatives:
 - a. Restart at the beginning.
 - b. Complete the test with undamaged or repaired test item.
(NOTE: Test results will be invalid if an item failure occurs.)

FIGURE 4. Interrupted test cycle logic - Methods 503.3, 506.3, 510.3, 511.3, 514.4, 516.4, and 519.4

characteristics, or if the item can be repaired, the test may be resumed and extended as in the undertest condition. If an item failure occurs during the remainder of the test, the test results shall be considered invalid.

5.2.4.3 Methods 500.3, 501.3, 502.3, 505.3, 508.4, 509.3, 512.3, 513.4, 520.1 and 521.1. Each of these methods contains guidance for handling out-of-tolerance-test interruptions. Any such interruption must be carefully analyzed. If the decision is made to continue testing from the point interruption, to restart the last successfully completed test cycle, or to restart the entire test with the same test item, and a failure occurs, it is essential to consider the possible effect of the interruption or of the extended length of the test.

5.2.5 Combined tests. Combinations of tests may produce a more realistic representation of the effects of the environment than a series of single tests can. Combined testing is encouraged.

5.2.6 Post-test data. At the completion of each environmental test, the test item shall be inspected in accordance with the equipment specifications, and the results shall be compared with the pretest data obtained in accordance with 5.2.1. Post-test data shall include:

- a. Complete identification of all test equipment and accessories.
- b. The actual test sequence (program) used.
- c. Deviation from the planned test program.
- d. The room ambient test conditions recorded periodically during the test period.
- f. A signature and data block for certification of the test data by the test engineer.
- g. Other data as specified in the individual methods or equipment requirements document(s).

5.2.7 Failure criteria. Failure of the test item to meet any one of the following conditions shall constitute a test item failure.

- a. Deviation of monitored functional parameter levels beyond acceptable limits established in 5.2.1 and specified in the requirements document.

NOTE: Certain types of equipment (e.g., propellants and electrically driven devices) are often expected to demonstrate lesser performance at an environmental extreme, particularly low temperature. A failure would occur only if degradation is more than permissible.

- b. Nonfulfillment of safety requirements or the development of safety hazards.

c. Nonfulfillment of specific test item requirements.

d. Changes to the test item which could prevent the equipment from meeting its intended service life or maintenance requirements. (For example: Corroded oil drain plug cannot be removed with specified tools.)

e. Deviation from established environmental requirements.

5.2.8 Additional or different failure criteria. Any additional or different failure criteria shall be as specified in the equipment specification.

5.2.9 Environmental test report. An environmental test report shall be completed according to DID DI-ENVR-80863.

5.3 Climatic regions. For the purposes of this document three climatic regions are defined to which equipment may be designed and tested: hot/dry, hot/humid (or 'basis'), and cold.

5.3.1 Map of climatic regions. Figures 5a and 5b show land areas where the various climatic regions exist.

5.3.2 Delimitation of climatic design types. The climate types are distinguished primarily by temperature, and secondarily by humidity.

a. **Hot-climatic regions.** This region includes most of the low-latitude deserts of the world. During summer in these areas, temperatures above 43°C (110°F) occur frequently, but except for a few specific places, temperatures will seldom be above 49°C (120°F). In winter, temperatures are likely to be in the same range as for the 'basis' climatic region. If materiel is designed only for the hot climate, a specially tailored low temperature design value should be sought. Small portions of this area are sometimes subject to very high absolute humidity, although the highest temperatures and highest dewpoints do not occur at the same time.

b. **Basic climatic regions.** These regions include the most densely populated and heavily industrialized parts of the world as well as the humid tropics. The entire range of basic design conditions does not necessarily occur in any one place. Each single condition (high temperature, low temperature, high humidity) occurs in a wide area. When taken together, the design values should provide for satisfactory equipment throughout the area. Tropical areas are included in this climate type because their temperature is quite moderate, and their humidity levels are equalled in the mid-latitudes. The feature of the tropics most important for equipment design is the persistence of high humidity over long periods of time. This condition not only promotes corrosion but is an excellent environment for insect and microbiological damage.

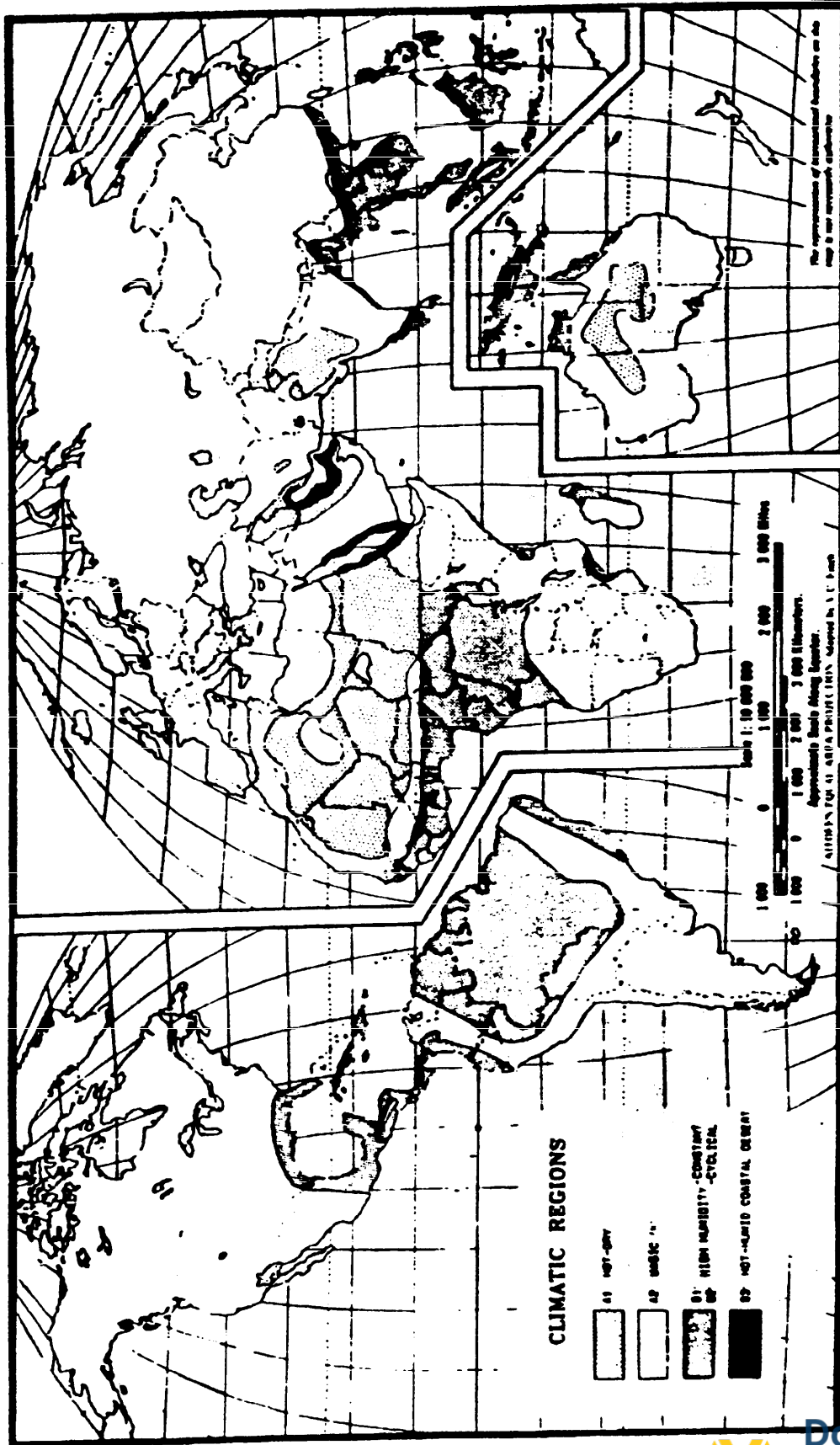


FIGURE 5a. World climatic regions - hot.

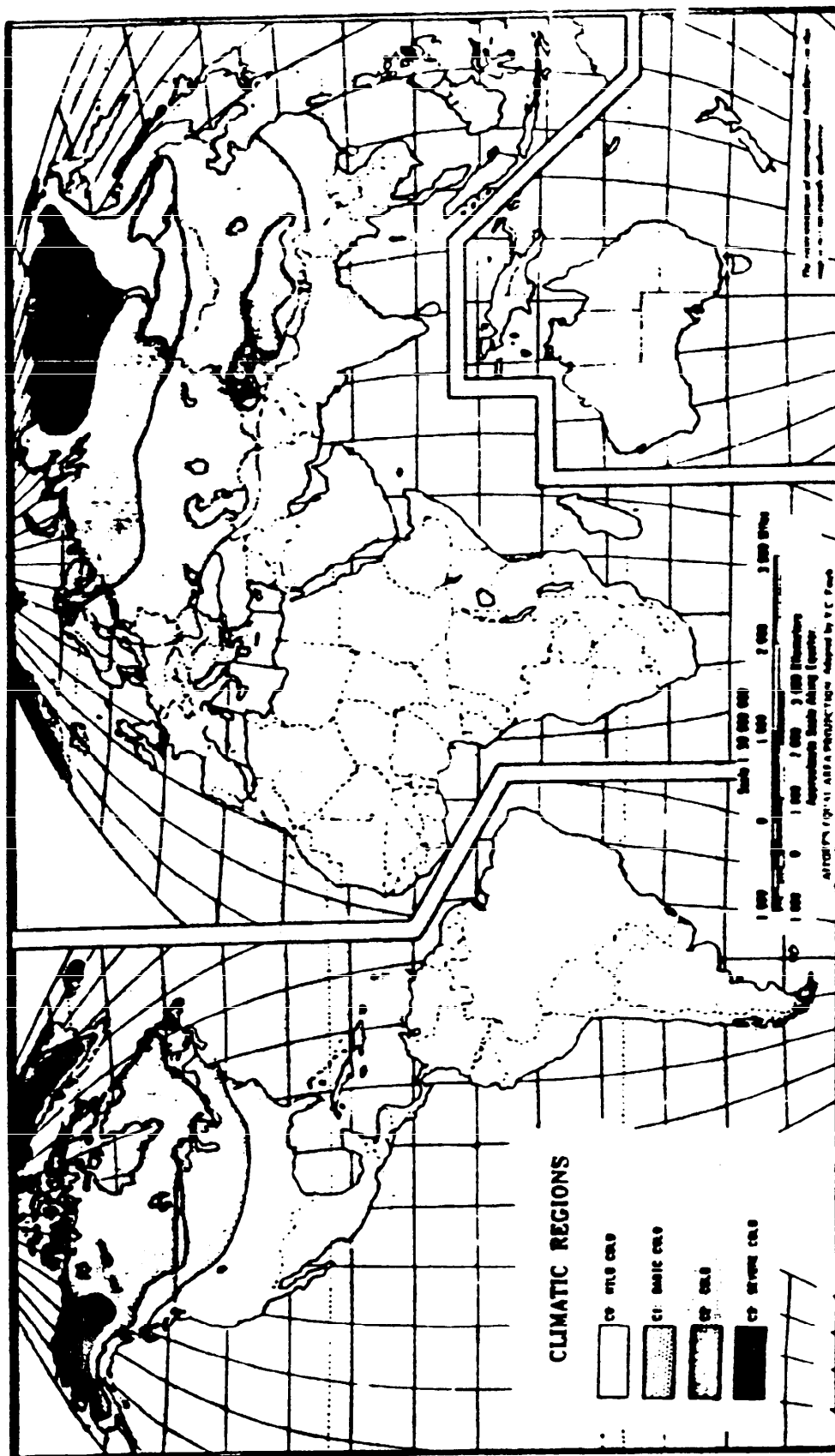


FIGURE 5b. World aluminum rationing - sold.