

IEEE Standard for Environmental Conditions for Transit Railcar Electronic Equipment

IEEE Vehicular Technology Society

Sponsored by the
Rail Transportation Standards Committee



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IEEE Standard for Environmental Conditions for Transit Railcar Electronic Equipment

Sponsor

Rail Transportation Standards Committee
of the
IEEE Vehicular Technology Society

Approved 31 October 2013

IEEE-SA Standards Board

Abstract: Baseline environmental conditions under which transit railcar 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, IEEE 1478™, shock, temperature, vibration, water

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Introduction

This introduction is not part of IEEE Std 1478™-2013, IEEE Standard for Environmental Conditions for Transit Railcar Electronic Equipment.

This standard establishes environmental conditions under which transit railcar electronic equipment shall both operate and/or survive, but not the conditions to be considered for the calculation for reliability. 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. This standard is intended to cover the application of electronic equipment. It may be applied with consideration to electrical equipment and subsystems.

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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~~Normative references

~~This standard shall be used in conjunction with the following publications. ASTM B 117, Test Method for Salt Spray (Fog) Testing.¹~~

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

ASTM-B-117, ~~Test Method for Salt Spray (Fog) Testing.~~ Standard Practice for Operating Salt Spray (Fog) Apparatus.¹

ASTM-B-368, ~~Copper-Nickel-Chromium Electrodeposited Coatings,~~ Standard Testing 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.~~

¹ ASTM 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/>).

[ASTM-G85, Standard Practice for Modified Salt Spray \(Fog\) Testing.](#)

[IEC 60529, Degrees of Protection Provided by Enclosures \(IP Code\).](#)²

~~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.~~

[IEC 60721-3-5, Classification of Environmental Conditions Part 3: Classification of Groups of Environmental Parameters and Their Severities – Section 5: Ground Vehicle Installations.](#)

[IEC 61373, Railway Applications – Rolling Stock Equipment – Shock and Vibration Tests \(second edition\).](#)

[MIL-STD-810G, Environmental Engineering Considerations and Laboratory Tests, Oct 31, 2008.](#)³

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

² [IEC publications are available from the International Electrotechnical Commission \(http://www.iec.ch/\).](http://www.iec.ch/) IEC publications are also available in the United States from the American National Standards Institute (<http://www.ansi.org/>).

³ [MIL publications are available from the U.S. Department of Defense \(http://www.defense.gov/\).](http://www.defense.gov/)

3. Definitions ~~,abbreviations,and acronyms~~

For the purposes of this ~~standard~~document, the following terms and definitions apply. ~~IEEE 100,~~
The ~~Authoritative Dictionary of IEEE Standards Terms, Seventh Edition [B1]³~~; ictionary Online should be
~~referenced~~consulted for terms not ~~defined~~defined in this ~~subclause~~. ~~Webster's New Collegiate~~
~~Dictionary [B2] shall apply otherwise.~~clause.⁴

active means for environmental control: Systems or components whose function is to supplement or enhance inherent capability to operate successfully in the specified environment, and which require external power for their operation. Examples may include forced air cooling apparatus, heaters, and the like.

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

electronics supplier: The manufacturer and / or designer of either Class 1 or Class 2 rail car electronic equipment.

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

⁴IEEE Standards Dictionary Online subscription is available at:
http://www.ieee.org/portal/innovate/products/standard/standards_dictionary.html

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

function properly: As used in this standard defines the operation of equipment under test, within specific predetermined limits or behavior, which are to be specified by the supplier and approved by the Integrator or Authority Having Jurisdiction as applicable, as part of the test procedure.

integrator: Designer of rail cars, equipment and or subsystems that can incorporate Class 1 or Class 2 rail car electronic equipment.

normal operation: Any and all functional modes that are foreseen as part of the expected functional requirements. This definition is made to distinguish normal operation of the electronic components and assemblies covered by this specification from the term “normal operation” used in many

passenger rail car specifications which distinguish revenue service conditions from atypical operating conditions such as vehicle recovery/towing or degraded performance conditions due to multiple failures of redundant systems on a vehicle. All these conditions, as far as the electronics are concerned, are “normal.”

railcar electronic equipment: Electronic equipment falling into one of two distinctly different classes. (A) Class 1 products are assemblies which predominantly contain electronic circuits, and which are packaged to be mounted directly in or on the rail vehicle, and which have some form of environmental protection integrated into the packaging. (e.g., radios, transducers, probes). For these assemblies, it is the responsibility of the car builder to ensure that the ambient conditions are respected. (B) Class 2 products are electronic circuit boards and racks, which do not include environmental protection, and which are mounted either inside the rail car in equipment lockers, or in other enclosures. For these components, it is the responsibility of the integrator to ensure the ambient conditions and temperatures specified herein are respected.

4. Standard environmental conditions for design

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 [B1],⁵ 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) and available on ~~Weather of U.S. Cities, Fifth Edition, Volumes 1 and 2,~~ summarizes the NOAA data in convenient form website.

⁴~~Information on references can be found in Clause 2.~~

⁵The numbers in brackets correspond to those of the bibliography in Annex A.

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

~~Testing—The requirements and 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~~ for operation and exposure.

The equipment design may include active means of environmental control in order to meet the requirements of 4.1 through 4.5 and Clause 5).

4.1 Definition of environmental conditions

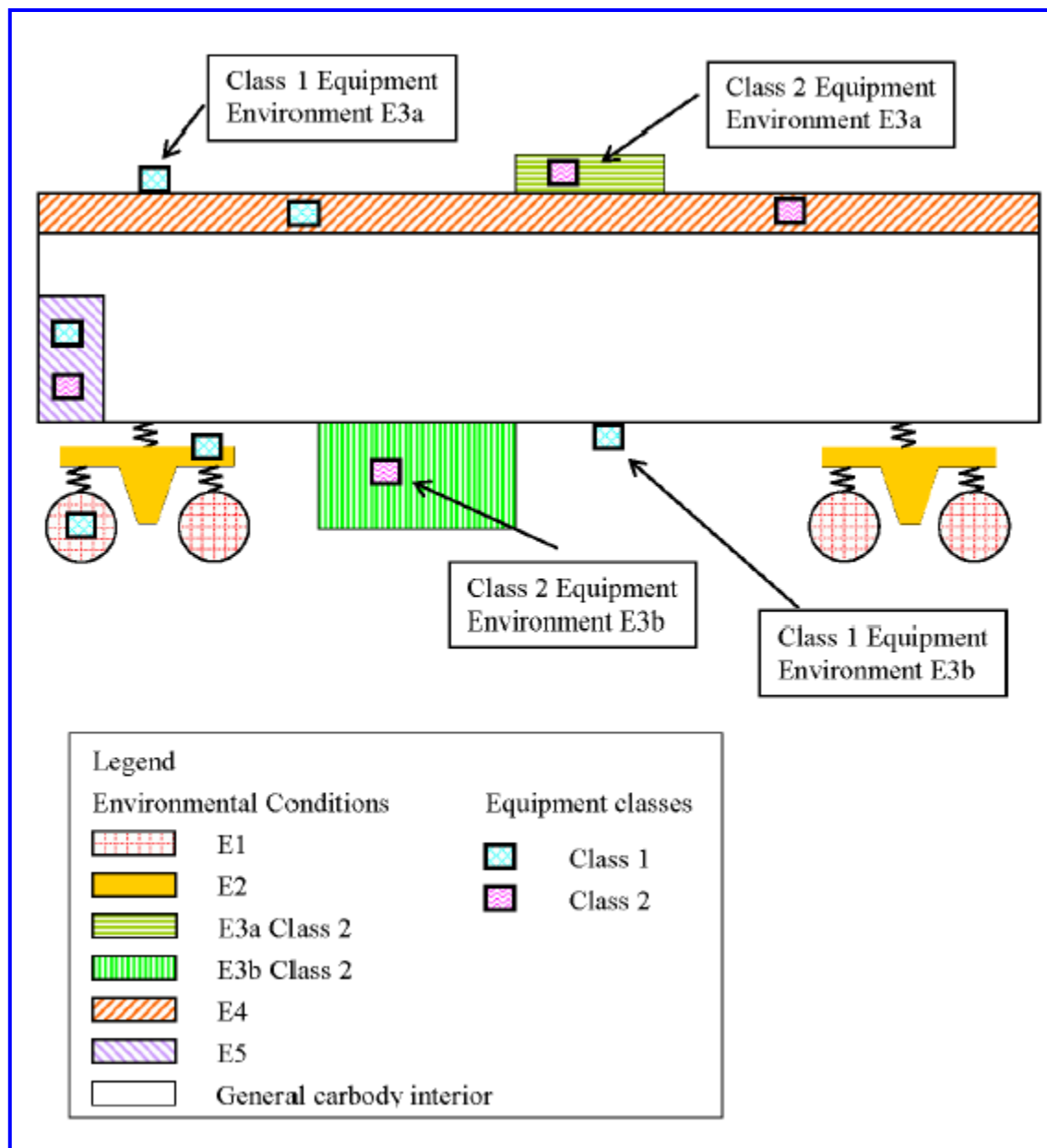
~~4.1 Temperature, relative humidity, vibration, mechanical shock, corrosive and abrasive environment~~

~~Five~~ Six ambient environmental conditions are defined as follows:

- *E1. Vehicle Exterior, Truck Unsprung:* Equipment is mounted on “unsprung” components of the truck, such as wheels, axles and bearing housings.
- *E2. Vehicle Exterior, Truck Sprung:* Equipment is mounted on the sprung part of a truck.
- *E3a. Vehicle Exterior, ~~Body~~Roof Mounted:* Equipment is mounted on the car body in space outside the enclosed areas of the vehicle, on the roof.

- [E3b. Vehicle Exterior, Underfloor Mounted](#): Equipment is mounted on the car body in space outside the enclosed areas of the vehicle, [under the car](#).
- E4 Vehicle Interior, Non-[Environmentally](#) Conditioned: Equipment is mounted in the enclosed interior spaces of the vehicle that are not environmentally conditioned.
- E5 Vehicle Interior, [Environmentally](#) Conditioned: Equipment is mounted in the enclosed interior spaces of the vehicle that are environmentally conditioned.

[The ambient environments in the list above are depicted in Figure 1 and](#) the parameter limits for each of the above ambient environments are specified in Table 1, and in ~~4.1.1 through 4.1.6~~; [4.2 through 4.6](#).



(New)

Figure 1 – Description of environmental locations and equipment classes

Table 1—Environmental parameter limits

Parameter	Condition	E1, Vehicle exterior, axle mounted	E2, Vehicle exterior, truck mounted	E3a, Vehicle exterior, Roof mounted	E3b, Vehicle exterior, undercar mounted	E4, Vehicle interior, non-conditioned	E5, Vehicle interior, conditioned
Temperature	<i>Operating</i> Minimum Maximum	-40 °C +70 °C ^a	-40 °C +70 °C ^a	-40 °C +70 °C ^a	-40 °C +70 °C ^a	-40 °C +70 °C ^a	-25 °C +70 °C ^{ab} Transient at start up +40 °C sustained
	<i>Storage</i> Minimum Maximum	-55 °C +85 °C	-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	Class 1 10–100% Condensing	Class 1 10–100% Condensing	10%–95% Non-condensing	10%–95% Non-condensing
	<i>Storage</i>	10%–100% Condensing	10%–100% Condensing	Class 2 10%–95% Non-Condensing	Class 1 and 2 10%–100% Condensing	10%–100% Condensing	10%–100% Condensing
Vibration	Functional / operating	IEC 61373 Table 1 Category 3	IEC 61373 Table 1 Category 2	Class 1 Equipment IEC 61373 Table 1 Category 1 Class A Class 2 equipment IEC 61373 Table 1 Category 1 Class A			

(New)



Table 1—Environmental parameter limits (continued)

Parameter	Condition	E1. Vehicle exterior, axle mounted	E2. Vehicle exterior, truck mounted	E3a. Vehicle exterior, Roof mounted	E3b. Vehicle exterior, undercar mounted	E4. Vehicle interior, non-conditioned	E5. Vehicle interior, conditioned
Vibration	Endurance / non operational during test	IEC 61373 Table 2 Category 3 using the following RMS value (m/s ²) Vertical 300, Transverse 270 Longitudinal 135 and ASD level (m/s ³) ² /Hz Vertical 545.2, Transverse 441.2 Longitudinal 110.3	IEC 61373 Table 2 Category 2 using the following RMS value (m/s ²) Vertical 42.5, Transverse 37.0 Longitudinal 20.0 and ASD level (m/s ³) ² /Hz Vertical 11.83, Transverse 8.96 Longitudinal 2.62	Class 1 Equipment IEC 61373 Table 2 Category 1 Class A, using the following RMS value (m/s ²) for vibration, Vertical 5.9, Transverse 2.9, Longitudinal 3.9 and ASD level in (m/s ³) ² /Hz, Vertical 1.034, Transverse 0.250, Longitudinal 0.452 Class 2 equipment IEC 61373 Table 2 Category 1 Class A using the following RMS value (m/s ²) for vibration, Vertical 7.9, Transverse 3.5, Longitudinal 5.5 and ASD level in (m/s ³) ² /Hz Vertical 1.857, Transverse 0.366, Longitudinal 0.901			
Mechanical Shock	Shipping Operating	IEC-61373 Table 3 Category 3	IEC-61373 Table 3 Category 2	Class 1 and 2 Equipment IEC 61373 Table 3 Category 1 Class A and B			
Precipitation and flooding	Operating	Class 1 equipment, or the requirements of the integrator for Class 2 equipment minimum rate of 13 cm/h, and an accompanying wind speed of 18 m/s Test Method 506.5, Procedure 1 of MIL-STD-810G Alternatively IEC 60529 - IP56 / NEMA 4				None. Protection provided by the integrator	
Salt fog		Class 1 equipment, or the requirements of the integrator for Class 2 equipment Test Method 509.5 of MIL-STD-810G SO ₂ shall be injected as specified in ASTM-B-117 and ASTM-B-368 and ASTM G85					
Sand and dust	Blowing sand	Class 1 equipment, or the requirements of the integrator for Class 2 equipment Test Method 510.5 of MIL-STD-810G					
	Blowing dust	Class 1 equipment, or the requirements of the integrator for Class 2 equipment Test Method 510.5 of MIL-STD-810G					

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

^b The 70 °C requirement for condition E5 is a transient temperature at start-up where the equipment will be switched on at the same time as the environmental conditioning equipment, and will need to function correctly (or as specified by the Authority Having Jurisdiction) as the environmental conditioning equipment linearly reduces the temperature from 70 °C to 40 °C within 30 min.

(New)



4.2 Temperature

4.2.1 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 conformance with this standard, the ambient temperature is the temperature at which a test chamber shall be maintained while testing the equipment.

4.12.2 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~~conformance 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.~~

4.3 Thermal shock

All equipment shall be capable of withstanding temperature changes of 5 °C per min. (reference Table 1 in IEC 60721-3-5) ⁶ and transitions between maximum and minimum temperatures shall be carried out at a rate of change of temperature of 5 °C per min.

4.24 Precipitation and flooding

Exterior mounted car equipment (environmental conditions E1, E2, E3a and E3b of 4.1) is to be protected against rain, flooding, snowfall, and icing to operate successfully and without damage in the following conditions:

4.2.4.1 Rain

~~Exterior~~ For Class 1 equipment: 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 506.35, Procedure I of MIL-STD-810EG.

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 5.2.14, 5.17 and paragraph ~~I-4.1-5~~ of Test Method 506.3-5 of MIL-STD-810EG.

Enclosures that meet the requirements of IEC 60529 IP56 / NEMA 4, including all cable entries, covers, connectors etc. which could compromise sealing, would be considered as conformant to this specifications requirements.

⁶ Information on references can be found in Clause 2.

[For Class 2 equipment the integrator is responsible to provide environmental protection outlined in this subclause for Class 1 equipment.](#)

[4.4.2.2](#) 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.

[4.1.6.5](#) Corrosive/Abrasive environment

The following shall apply to exterior equipment ([Class 1](#)) under environmental conditions E1, E2, and E3 of 4.1. [The equipment integrator is responsible for ensuring that Class 2 equipment is protected from this environment, or specifying appropriate environmental conditions if the equipment is not fully protected.](#)

[4.1.6.5.1](#) 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.[35](#) of MIL-STD-810[EG](#). A five percent salt concentration, by weight, shall be used. SO₂ shall be injected as specified in ASTM-B-117, [ASTM-B-368](#) and [ASTM-B-368-G85](#). The equipment under test shall be capable of passing the salt fog test when tested in the context of Test Method 509.[3-5](#) of MIL-STD-810[EG](#).

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.[2.14](#), [5.17](#) and paragraph [I-4.1 5](#) of Method 509.[35](#) of MIL-STD-810[EG](#).

4.1.6.5.2 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 510.35 of MIL-STD-810EG., where the sand and dust particles vary in size from 1 μm to 650 micrometers μm in diameter.

4.5.2.1.6.3 Blowing sand

The blowing sand testing procedures, as specified in Test Method 510.35 of MIL-STD-810EG., 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-3.4.2, subparagraph (d.)~~ 1.3 of Test Method 510.5 of MIL-STD-810EG.. The sand concentration shall be maintained at 1.1 g/m^3 . 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.

4.1.6.4.5.2.2 Blowing dust

The blowing dust testing procedures, as specified in Test Method 510.35 of MIL-STD-810EG., 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.)~~ 4.1.1.4 of Test Method 510.5 of MIL-STD-810EG.. The dust concentration shall be maintained at 10.6 g/m^3 . 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 5.2.14, 5.17 and paragraph 4.4.5 of Method 510.35 of MIL-STD-810E.

4.1.6.5 5.2.3 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

Petrochemical products (e.g., oil vapor, diesel fuel and vapor, lubricants, solvents)

Oxides of nitrogen

Ozone

Carbon dust

Copper dust

Hair

4.5.3 Car cleaning solutions

Exterior equipment shall be capable of operating and withstanding exposure to commercially available vehicle car wash solutions, and the resultant dry-out residue which will also contain the mineral content of local water supplies and which will remain after the initial exposure, and may be concentrated by pooling of water and evaporation.

These solutions may be acidic, in the range of pH1 to pH3, neutral in the range of pH7, moderately alkaline in the range of pH10 or highly alkaline pH12.5.

4.6 Vibration and shock

Note that although Table 1 defines the storage and shipping temperature, it is not within the scope of this standard to attempt to define the storage and shipping shock and vibration levels in excess of IEC 61373. However the manufacturer and integrator shall be aware that shipping shock and vibration levels may exceed IEC 61373 and take appropriate measures to ensure the product can withstand foreseeable forces that will result from shipping and handling respectively.

4.6.1 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 IEC 61373 as defined in Table 1.

42 46.2 Mechanical shock

Equipment shall withstand the Table 1 shock conditions without damage, degradation, or abnormal operation.

4.37 Solar radiation

4.7.1 Ultraviolet radiation

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

If testing is required by the Authority Having Jurisdiction, testing shall be done in accordance with ISO 4892-2 method A.

4.4.8 Altitude

The equipment shall function properly in the altitude range of -100 m to ~~3,2~~2000 m with respect to sea level.

Table 1—Environmental parameter limits

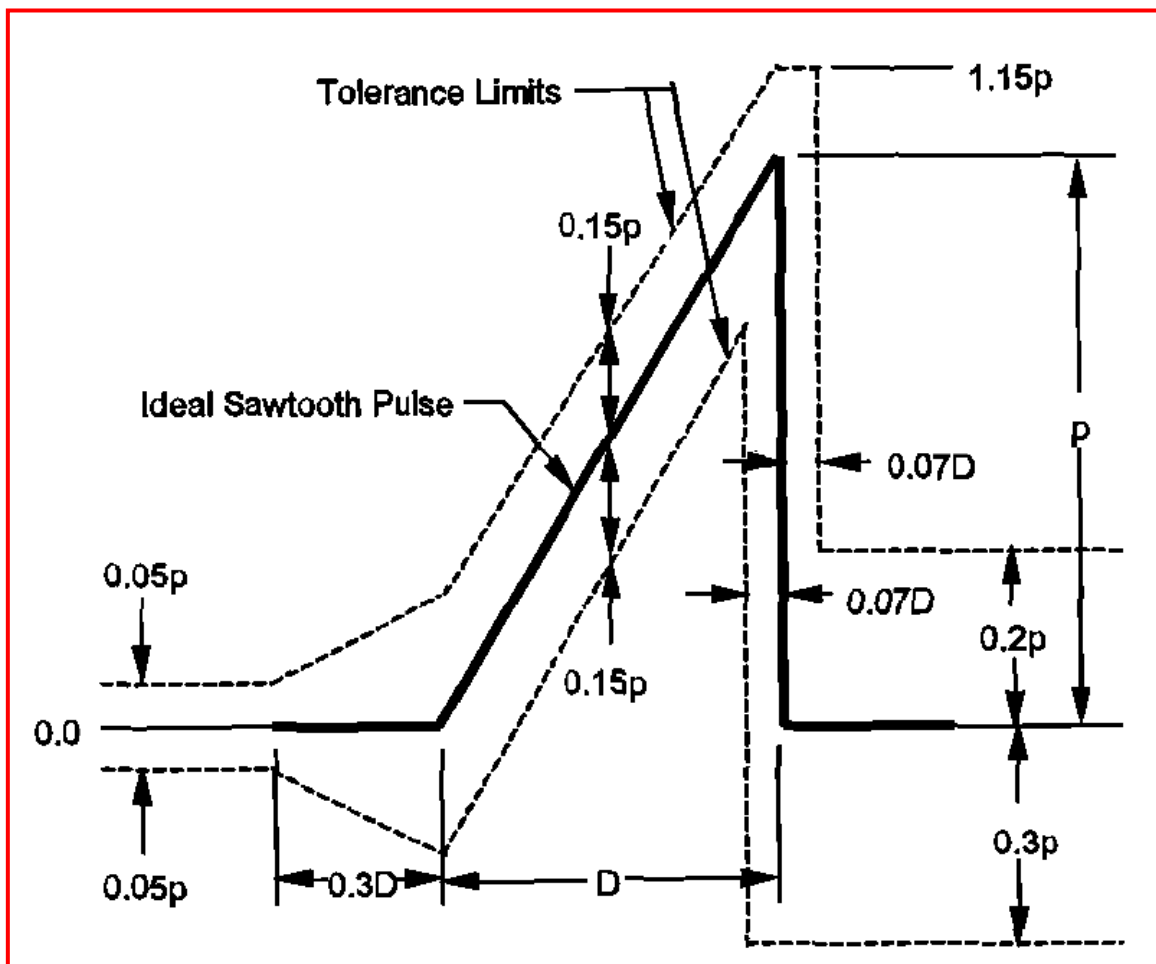
Parameter	Condition	E1. Vehicle exterior, axle mounted	E2. Vehicle exterior, truck mounted	E3. Vehicle exterior, body mounted	E4. Vehicle interior, non-conditioned	E5. Vehicle interior, conditioned
Temperature	<i>Operating</i>	-40°C	-40°C	-40°C	-40°C	-25°C
	<i>Minimum</i>	+70°C ^a	+70°C ^a	+70°C ^a	+70°C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

(Deleted)

^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~~



~~(Deleted)~~

~~Figure 1—Mechanical shock pulse configuration and tolerances~~

5. Utilization of active means for environmental control

Operation within the environmental conditions described in Clause 4 may require active means, e.g., heaters, forced cooling, filtering, or other means. In addition, should extreme conditions such as described in Clause 6 be specified or part of the design requirements, such extreme conditions may similarly require active means to accommodate them. In either case, system design shall be such that the status of said active means for environmental control is monitored, and failures are annunciated. Action to be taken upon the occurrence of such a failure should be predicated on the severity of the effects (i.e., risk of immediate failure versus risk of long-term degradation); to the extent practicable, “fail operational” design principles shall be utilized in the interest of service reliability.

NOTE—The use of active heating and cooling may not be suitable for certain critical applications in which reliability or safety considerations may dictate that the equipment accommodate the specified environment without active means.⁷

⁷Notes in text, tables, and figures of a standard are given for information only and do not contain requirements needed to implement this standard.

6. Extreme environmental conditions

The definition of extreme environmental conditions, i.e. those outside the conditions defined in Clause 4 are beyond the scope of this standard, however, the test procedures in this standard may be used, with modifications agreed between the supplier and the Authority Having Jurisdiction to demonstrate conformance to the extreme conditions in Annex B. Two specific examples (altitude and temperature) are addressed in 7.4 and Annex B respectively.

7. Testing

7.1 Frequency of testing

This standard does not impose any requirements concerning the frequency of tests 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 herein. Such testing shall be type (i.e., proof of design) testing unless specified otherwise by the Authority Having Jurisdiction, and shall be performed on the complete assembly for the class of equipment.

Equipment previously qualified under earlier revisions of this Standard need not be re-qualified unless otherwise specified by the Authority Having Jurisdiction.

7.2 Thermal testing

The equipment shall be qualified to the temperature ranges outlined in Clause 4 with consideration given to the subsections below, to address specific points of concern in demonstrating conformance to the design requirements.