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## **ERTMS/ETCS Environmental Requirements**

COMMENT : This document will continue to be the subject of review during the ERTMS trial period in order to:

- ensure the environmental policy is both acceptable to the railways and workable for industry and,
- become a new CENELEC standard.

If some railway wishes to use other kind of tests different from the ones required in this document, a request has to be sent to the EEIG ERTMS Users Group. This request will be proposed to the other railways for approval.



**THIS PROJECT IS BEING PART FINANCED  
BY THE EUROPEAN COMMISSION**

**VERSIONS & MODIFICATIONS**

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## REFERENCES

EN 50081-2	Electromagnetic compatibility - generic emission standard Industrial environmental mandate BC/CLC/03-88
EN 50123-1	Railway applications - Fixed installations D.C. switchgear. General Amendment of September 1995
EN 50123-2	Railway applications - Fixed installations D.C. switchgear. D.C. circuit breakers Amendment of September 1995
EN 50155	Railway applications: Electronic equipment used on rolling stock equipment, 1995
EN 50163	Railway applications - supply voltages of traction systems
EN 50178	Electronic Equipment for use in power installation - Oct 1996
EN 61000	Electromagnetic Compatibility - Part4 (Testing) Sections 1 to 9 inclusive
ENV 50121-1	Railway applications - electromagnetic compatibility - general
ENV 50121-2	Railway applications - electromagnetic compatibility - emission of the whole railway system to the outside world
ENV 50121-3-1	Railway applications - electromagnetic compatibility - Rolling stock- train and complete vehicle
ENV 50121-3-2	Railway applications - electromagnetic compatibility - Rolling stock- apparatus
ENV 50121-4	Railway applications - electromagnetic compatibility - emission and immunity of the signalling and telecommunications apparatus
ENV 50121-5	Railway applications - electromagnetic compatibility - fixed power supply installations
ERTMS Users Group: 97e4612-	Functional Requirements Specification - ERTMS Trainborne Recording Unit
IEC 529	Degrees of protection provided by enclosures (IP Codes), Second edition, 1989
IEC 60038	IEC Standard voltages
IEC 60077	Rules for electric traction equipment
IEC 60870.2.1	Telecontrol equipment and systems - operating conditions - power supply and electromagnetic compatibility
IEC 68.1	Basic environmental testing procedures - Part 1 - General
IEC 68.2.10	Environmental testing - Test J and guidance. Mould growth
IEC 68.2.11	Environmental testing - Test Ka. Salt mist
IEC 68.2.13	Environmental testing - Test M. Low air pressure
IEC 68.2.14	Environmental testing - Test N. Change of temperature
IEC 68.2.17	Environmental testing - Test Q. Sealing
IEC 68.2.18	Environmental testing - Test methods- Test R and guidance. Water
IEC 68.2.2	Environmental testing - Test B: dry heat
IEC 68.2.27	Environmental testing - Tests - Test Ea and guidance. Shock
IEC 68.2.28	Environmental testing - Tests - Test C & D and Guidance. Damp heat tests
IEC 68.2.29	Environmental testing - Tests - Test Eb and guidance. Bump
IEC 68.2.3	Environmental testing - Test Ca: damp heat, steady state
IEC 68.2.30	Environmental testing - Test Db and guidance. Damp heat, cyclic (12+12 hour cycle)

IEC 68.2.31	Environmental testing - Test Ec. Drop and topple (primarily for equipment-type specimens)
IEC 68.2.32	Environmental testing - Test Ed. Freefall
IEC 68.2.33	Basic environmental testing procedures Part 2.2 - Guidance - Test N. Guidance on change of temperature tests
IEC 68.2.39	Environmental testing - Test Z/AMD. Combined sequential cold, low air pressure and damp heat test
IEC 68.2.40	Environmental testing -Test Z/AM. Combined cold low air pressure tests
IEC 68.2.41	Environmental testing - Test Z/BM. Combined dry heat/low air pressure tests
IEC 68.2.42	Environmental testing - Test Kc. Sulphur dioxide test for contacts and connections
IEC 68.2.43	Environmental testing - Test Kd. Hydrogen sulphide test for contacts and connections
IEC 68.2.45	Basic environmental testing procedures - Tests - Test Xa and guidance. Immersion in cleaning solvents
IEC 68.2.46	Basic environmental testing procedures - Part 2.1 - Tests - Test Kd. Guidance on Test Kd - Hydrogen sulphide test for contacts and connections
IEC 68.2.47	Specification for mounting of components, equipment and other articles for dynamic tests
IEC 68.2.48	Environmental testing - Guidance on the application of the tests of IEC 68 to simulate the effects of storage
IEC 68.2.5	Environmental testing - Test Sa : simulated solar radiation at ground level
IEC 68.2.5	Environmental testing - Part 2 - Tests - Test Sa - Guidance for solar radiation testing
IEC 68.2.50	Environmental testing - Test Z/AFc. Combined cold vibration (sinusoidal) tests for both heat dissipating and non heat dissipating specimens
IEC 68.2.52	Environmental testing - Test Kb. Salt mist, cyclic (sodium chloride solution)
IEC 68.2.53	Basic environmental testing procedures - Part 2.2 - Guidance - Tests Z/AFc and Z/BFc. Guidance on combined temperature (cold and dry heat) and vibration (sinusoidal) tests
IEC 68.2.55	Environmental testing - Test Ee and Guidance. Bounce
IEC 68.2.56	Environmental testing - Test Cb. Damp heat, steady state, primarily for equipment
IEC 68.2.57	Environmental testing - Test Ff. Vibration - time history method
IEC 68.2.62	Basic environmental testing procedures - Tests - Test method Ef. Impact pendulum hammer
IEC 68.2.64	Environmental testing - Vibration - Broad-band random (digital control) and guidance
IEC 68.2.68	Environmental testing - dust and sand. Test L
IEC 68.2.7	Basic environmental testing procedures - Part 2.1 - Tests - Test Ga and guidance. Acceleration, steady state
IEC 68.2.9	Basic environmental testing procedures - Part 2.2 - Guidance - Test Sa. Guidance for solar radiation testing
IEC 68.3.1	Basic environmental testing procedures - Part 3 - Background information - Tests A & B. Cold and dry heat
IEC 68.3.2	Basic environmental testing procedures - Part 3 - Background information - Tests Z/AM & Z/BM. Combined temp/low air pressure
IEC 695-1-1 and 1-2	Guidance for assessing fire hazard of electrotechnical products

IEC 721.1	Classification of environmental conditions - Part 1 - Environmental conditions appearing in nature, 1990 - Environmental parameters and their severities,
IEC 721.2.1	Classification of environmental conditions - Part 2 - Environmental conditions appearing in nature, 1988 - Section 2.1 - Temperature and humidity
IEC 721.2.2	Classification of environmental conditions - Part 2 - Environmental conditions appearing in nature, 1988 - Section 2.2 - Precipitation and wind
IEC 721.2.3	Classification of environmental conditions - Part 2 - Environmental conditions appearing in nature, 1987 - Section 2.3 - Air pressure
IEC 721.2.4	Classification of environmental conditions - Part 2 - Environmental conditions appearing in nature, 1987 - Section 2.4 - Solar radiation and temperature
IEC 721.2.5	Classification of environmental conditions - Part 2 - Environmental conditions appearing in nature, 1991 - Section 2.5 - Dust, sand, salt mist
IEC 721.2.7	Classification of environmental conditions - Part 2 - Environmental conditions appearing in nature, 1987 - Section 2.7 - Fauna and flora
IEC 721.2.8	Classification of environmental conditions - Part 2 - Environmental conditions appearing in nature, 1987 - Section 2.8 - Fire Exposure
IEC 721.3	Classification of environmental conditions - Part 3 - Classification of groups of environmental parameters and their severities - Section 3.0 - Introduction
IEC 721.3.1	Classification of environmental conditions - Part 3 - Classification of groups of environmental parameters and their severities - Section 3.1 - Storage
IEC 721.3.2	Classification of environmental conditions - Part 3 - Classification of groups of environmental parameters and their severities - Section 3.2 - Transportation
IEC 721.3.3	Classification of environmental conditions - Part 3 - Classification of groups of environmental parameters and their severities - Section 3.3 - Stationary use at weather protected locations
IEC 721.3.4	Classification of environmental conditions - Part 3 - Classification of groups of environmental parameters and their severities - Section 3.4 - Stationary use at non-weather protected locations
IEC 721.3.5	Classification of environmental conditions - Part 3 - Classification of groups of environmental parameters and their severities - Section 3.5 - Ground vehicle installations
IEC 721.3.7	Classification of environmental conditions - Part 3 - Classification of groups of environmental parameters and their severities - Section 3.7 - Portable and non-stationary use
ISO / DIS 4354	Wind actions on structures
ISO 2533	Standard atmosphere
ISO 2631	Guide for the evaluation of human exposure to whole-body vibration
ISO 5349	Mechanical vibration - guidelines for the measurement and the assessment of human exposure to hand transmitted vibration
ISO 7726	Thermal environments - Instrument and method for measuring physical quantities.
ISO 7730	Moderate thermal environment - determination of the PMV and PPD indices and specification of the conditions for thermal comfort
ISO 7731	Danger signals for work places - auditory danger signals
prEN 50124-1	Railway application insulation co-ordination part 1 - Basic

	Requirements Jan 1995
	part 2 Over voltage and related protection Nov 1995
prEN 50125-1	Railway applications: Environmental conditions for equipment Part 1: Equipment on board rolling stock, May 1995 (on-going)
prEN 50125-2, CLC/SC9XC/WGC8(CON)104	Railway applications: Environmental conditions for fixed electrical installations, 13/12/1996 (on-going)
prEN 50125-3 Draft 1.0	Railway applications: Environmental conditions for signalling and telecommunications, April 1998
UIC/ERRI	"ETCS - Functional Requirements Specification - Version 04.00, 27/08/96
UIC/ERRI	"ETCS - Environmental Specification - Part 1" Draft version 00.03, 27/06/96
UIC/ERRI A118	Report N°4
UIC/Leaflet 651	Layout on drivers cabs in locomotive, rail cars, multiple unit trains and driving trailers.



## TERMINOLOGY

TERM	DEFINITION
Fixed equipment	Equipment belonging in either Track (line side) or Track side installation locations (see Section 1.2.1 for further information).
Installation locations	Generic positions on a train or at track side where ERTMS equipment will be located (see Section 1.2 for further information).
Railway(s)	Organisations responsible for railway infrastructure or for the operation of railway lines.
N/A	Not applicable.
Parameter	A numeric value or text defining the value (severity) of an environmental condition.
Environmental condition	A component of the surroundings in which ERTMS equipment has to operate, e.g. temperature or solar radiation.
Performance test	A comprehensive series of measurements of the characteristics of the equipment to check that its performance is in accordance with the functional requirements of the particular equipment concerned (i.e. checks to ensure the item is neither sub-standard nor defective). The performance test is carried out before the environmental tests.

## 1. INTRODUCTION

This document describes the **minimum** system specific environmental requirements for the operation of ERTMS track side and train mounted equipment. If no other stipulations are made, in principle, the generic Standards listed at the front of this document have to be fulfilled.

### IMPORTANT NOTICES

1. To ensure the interoperability, inter-changeability and cross-acceptance of ERTMS equipment, **no** alterations in the specification parameters will be allowed in respect of trainborne equipment. However, for track (line side) and track side equipment, if a railway's requirements **exceed** those detailed in this specification, then it is the railway's responsibility to specify them to the manufacturer. No reduction in these requirements will be permitted.
2. In some instances the environmental requirements for certain items of ERTMS equipment exceed those shown within this document. For example, the impact requirements for the Trainborne Recording Unit exceed those shown in the Mechanical Section of this document. It is essential, therefore, to read this document in conjunction with the equipment specific specifications which may contain more severe requirements.

### 1.1 ENVIRONMENTAL CONDITIONS

This specification covers the following environmental conditions:

- Ambient temperature
- Solar Radiation
- Humidity
- Wind and pressure pulses
- Altitude
- Water and precipitation
- Pollutants and contaminants
- Mechanical (shock and vibration)
- Electrical (power supplies)
- Electromagnetic Compatibility
- Ergonomics

## 1.2 INSTALLATION LOCATIONS

The following is a list of anticipated ERTMS locations that may be influenced by environmental conditions. They are used consistently throughout this specification.

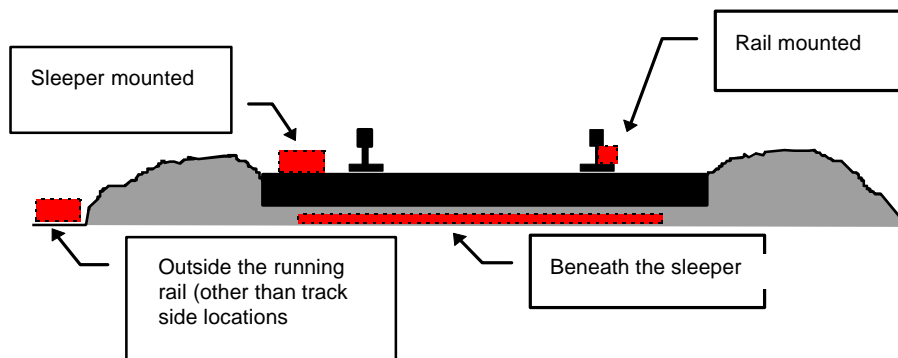
The manufacturer is responsible for identifying each piece of ERTMS equipment to one of the generic installation locations shown and then applying the appropriate environmental parameters shown within this specification.

<b>Track (Line side )</b>	<b>Track side</b>
<ul style="list-style-type: none"> <li>• rail mounted</li> <li>• sleeper mounted</li> <li>• mounted between the rails but not on the sleeper</li> <li>• beneath the sleeper (buried in the track formation)</li> <li>• outside the running rail (other than those locations listed in Track side)</li> </ul>	<ul style="list-style-type: none"> <li>• in an exposed (non weather protected) location case</li> <li>• in an enclosed (weather protected) location case</li> <li>• in an equipment room with climatic control (e.g. heating)</li> <li>• in an equipment room without climatic control (e.g. heating)</li> <li>• in a control room (climate controlled)</li> <li>• in a control room (without climate controlled)</li> </ul>
<b>Train (external)</b>	<b>Train (internal)</b>
<ul style="list-style-type: none"> <li>• on the wheelset</li> <li>• on the bogie</li> <li>• underframe</li> <li>• body/roof</li> </ul>	<ul style="list-style-type: none"> <li>• in the engine room</li> <li>• in the equipment room</li> <li>• in the driver's cab</li> <li>• in the coach</li> </ul>
<b>Outdoor portable equipment</b>	

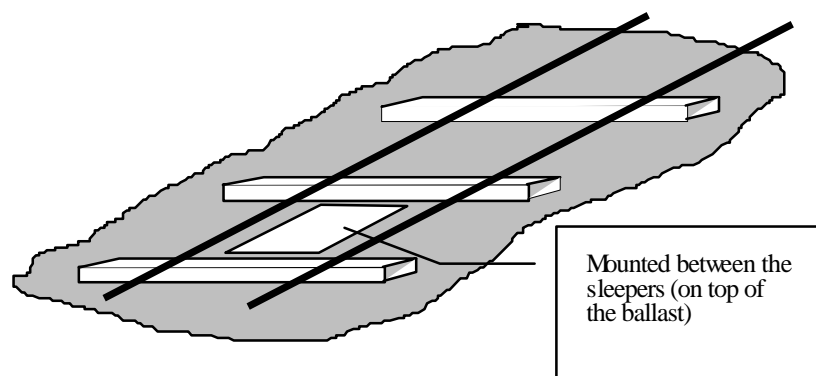
**Table 1: Installation locations**

## 1.2.1 Definitions

### 1.2.1.1 Track (line side)



**Figure 1: Track (line side) definitions - Schematic cross section through track**



**Figure 2: Track (line side) definitions - Schematic view of track**

### 1.2.1.2 Track side

Exposed (non weather protected) location case	An equipment cabinet exposed to the elements (e.g. no doors or side panels, and possibly only a roof offering minimal protection). Generally found adjacent to the running lines.
Exposed (weather protected) location case	An equipment cabinet protected from the elements (i.e. fully enclosed). Generally found adjacent to the running lines.
Equipment room with climate control	A man accessible (but not permanently manned) weather proof building in which the climate is maintained by artificial means (e.g. air conditioning)
Equipment room without climate control	A man accessible (but not permanently manned) weather proof building in which the climate is dictated by the prevailing external conditions.
Control Room (climate controlled)	A permanently manned weather protected building in which personnel and equipment coexist. The climate is maintained by artificial means (e.g. air conditioning)
Control room (without climate controlled)	A permanently manned weather protected building in which personnel and equipment coexist. The climate is dictated by the prevailing external conditions.

### 1.2.1.3 Train external

On the wheelset	That part of a bogie comprising wheels/axles and their associated housings.
On the bogie	Primary or secondary elements of the bogie unit excluding the wheelset.
Underframe	The train substructure beneath the main body.
Body/roof	The body work comprising the sides, ends and top of a coach or locomotive.

#### **1.2.1.4 Train internal**

Engine room	The enclosed area in which the engine (a.c./d.c. or thermal) is housed.
Equipment room	An enclosed area or cabinet independent of the engine room. Excludes the drivers cab.
Drivers cab	The area in which the train is driven.
Coach	Any carriage forming a train which does not have a driving cab or engine.

#### **1.2.1.5 Outdoor portable equipment**

Any item of ERTMS equipment which is not intended for permanent mounting on or in a train, or at a track (line side) or track side installation location, e.g. portable data logging equipment.

#### **NOTES**

1. Track (line side) and track side equipment are generically termed fixed equipment throughout this specification.
2. Train external and internal equipment are generically termed trainborne equipment throughout this specification.

## 1.3 THE USE OF IEC 721 IN THIS SPECIFICATION

### 1.3.1 IEC 721 Classifications

Where no suitable railway specific requirements are available IEC 721 classifications have been quoted. However, please note that where an IEC 721 classification has been quoted for one specific environmental condition, that classification **cannot be assumed to apply for the other environmental conditions**. In this respect each section of this specification must be considered in isolation. For example, the IEC 721 classifications quoted for Water and precipitation **CANNOT** be applied to say Pollutants and contaminants.

### 1.3.2 Situations

In accordance with the requirements of IEC 721, separate classes of environmental parameters are provided for the following equipment applications:

- Operational
- Storage
- Transportation

A summary of IEC 721 classifications and their values can be found in Annex A.

## 1.4 FORMAT OF THIS SPECIFICATION

Each section detailing an environmental condition is laid out as follows:

### Introduction.

- **Operational requirements.** The minimum mandatory parameters to which railways/manufacturers shall adhere. Storage and transportation requirements are detailed separately in Section 3.
- **Guidelines.** These are intended as an aid to the reader and do not form part of the requirements.
- **Test requirements.** For cross-acceptance purposes the tests within the specification have to be harmonised. Consequently, the ERTMS Users Group cannot generally accept nationally defined tests. The tests quoted in this specification shall be considered as mandatory. Should a railway want to use other international or European test standards for a precise requirement, that railway shall make a proposal to the ERTMS Users Group. After consideration a decision will be made on whether the test can be used, taking into account the requirements for cross-acceptance.



## **2. SYSTEM SPECIFIC REQUIREMENTS**

### **2.1 AMBIENT TEMPERATURE**

#### **2.1.1 Introduction**

Where possible, requirements for this section are derived from IEC 721, prEN 50125-3 and EN 50155. Where these standards are considered insufficient they have been supplemented with ERTMS system specific requirements.

#### **2.1.2 Operational requirements**

The equipment shall be designed and manufactured to meet the minimum temperature conditions given in Table 2. Should a railway consider that the temperature ranges for track (line side) and track side are not extreme enough for their own requirements, then the ranges may be increased in severity (i.e. low temperatures reduced and high temperatures increased). No changes in trainborne requirements will be permitted.

When equipment is turned on it shall operate without malfunction within the temperature ranges stipulated and be fully operational within the time specified in the ERTMS Performances document reference 96E166 (i.e. normally 15 seconds after initial turn on).

The permissible limit temperatures of the operating equipment shall not be allowed to be exceeded as a result of the temperature rise occurring in operation (including temporary acceleration).

The design of equipment shall take into account temperature increases within cubicles and equipment cases so as to ensure that the components do not exceed their specified temperature ranges.

For peripheral units (measuring transducers etc.) or situations where equipment is in a decentralised configuration, ambient temperature ranges can be frequently exceeded. In these cases the actual temperature occurring at the location of the equipment concerned shall be used in the design. If any such abnormal situation is known to occur, then the railway is responsible for advising the supplier.

A rate of increase of external ambient temperature (e.g. passage within a tunnel) of 3 °C/s with a maximum deviation in temperature of 40 °C shall be taken into consideration.

#### **2.1.2.1 Trainborne Recording Unit - Catastrophic events**

In the event of a catastrophic incident (e.g. derailment or collision) the Trainborne Recording Unit shall be capable of temporarily resisting the high temperatures resulting from a fire. These requirements exceed the general operational requirements shown above. Further details of these requirements can be found in the Functional Requirements Specification - ERTMS Trainborne Recording Unit (Document Ref: 97e461).

	External air temperature	Temperature inside vehicle compartment	Temperature inside cubicle	Air temp. surrounding the printed board assembly
<b>Train (External)</b>				
Wheel set	TX (-40 to +50) #		TX (-40 to +70) #	-40 to +100 *
Bogie	TX (-40 to +50) #		TX (-40 to +70) #	TX (-40 to +85) #
Under frame	TX (-40 to +50) #		TX (-40 to +70) #	TX (-40 to +85) #
Roof/Body	TX (-40 to +50) #		TX (-40 to +70) #	TX (-40 to +85) #
<b>Train (Internal)</b>				
Engine Room	TX (-40 to +50) #	TX (-40 to +70) #		TX (-40 to +85) #
Equipment Room	TX (-40 to +50) #	TX (-40 to +70) #		TX (-40 to +85) #
Drivers Cab	TX (-40 to +50) #	TX (-40 to +70) #		TX (-40 to +85) #
Coach	TX (-40 to +50) #	TX (-40 to +70) #		TX (-40 to +85) #

	External air temperature	Temperature inside cubicle	Temperature inside shelter	Temperature inside building
<b>Track (line side)</b>				
Rail mounted	TX (-55 to +40) ~	N/A	N/A	N/A
Sleeper mounted	TX (-55 to +40) ~	N/A	N/A	N/A
Beneath the sleeper (buried in track formation)	TX (-55 to +40) ~	N/A	N/A	N/A
Between the sleepers	TX (-55 to +40) ~	N/A	N/A	N/A
Outside the running rail	TX (-55 to +40) ~	N/A	N/A	N/A
<b>Track side</b>				
Non weather protected location case	TX (-55 to +40) ~	TX (-55 to +70) ~	N/A	N/A
Weather protected location case	TX (-55 to +40) ~	TX (-55 to +70) ~	N/A	N/A
Equipment room - no climate control	TX (-55 to +40) ~	N/A	TX (-35 to +55) ~	N/A
Equipment room - with climate control	TX (-55 to +40) ~	N/A	TX (+15 to +30) ~ †	N/A
Control Room (climate controlled)	TX (-55 to +40) ~	N/A	N/A	TX (+20 to +25) ~ †
Control Room (no climate control)	TX (-55 to +40) ~	N/A	N/A	TX (-5 to +45) ~
<b>Out door portable equipment</b>	TX (-55 to +40)	N/A	N/A	N/A

**Table 2: Temperatures****NOTES**

\* denotes a range not derived from generic standards.

~ denotes a range taken from prEN50125-3

† Railways should only adopt these reduced ranges if they are satisfied that their climate control systems are highly reliable. If in doubt the temperature requirements for Equipment and Control rooms with no climate control should be adopted

# denotes a range derived from EN 50155

N/A denotes not applicable to the installation location

### **2.1.3 Guidelines**

Equipment should be located so as to avoid any unnecessary temperature stresses.

The specified operating temperatures are the lowest and the highest ambient temperatures anticipated to be experienced by equipment during normal operation.

The limit temperature of operating equipment is the maximum or minimum temperature at which no disadvantageous change or deformation of operating equipment occurs. Ambient temperature is the temperature closest to the element (i.e. where it is positioned).

### **2.1.4 Test Requirements**

Evidence of the suitability of the equipment over the decisive temperature ranges is to be provided on the basis of the following tests.

Equipment shall be fully operational at all times during the tests, unless otherwise stated.

Test specimens shall be tested in their production configuration without the use of external devices that have been added expressly for the purpose of passing the test. For example, the use of cooling fans during the dry heat test is not permitted unless the fans are included in the finished product.

In all instances performance tests shall be carried out prior to commencement of the environmental tests to ensure the item being tested is fully functional (i.e. it is not sub-standard or defective). If, upon conclusion of an environmental test, the equipment has failed and has to be modified, the associated performance and environmental tests shall be repeated. The manufacturer is responsible for developing and implementing a suitable performance test schedule. For cross-acceptance purposes these schedules shall be provided to the ERTMS Users Group.

Storage and transportation tests are detailed in Section 3.

The manufacturer shall provide a full report (to the ERTMS Users Group) on each of the tests carried out. This report shall include, but not be limited to:

- The design solutions used to fulfil the requirements.
- The performance test schedule.
- Test results.
- Any failures during testing.
- Modifications made during the testing programme.
- Any further tests which are considered necessary.

- Any unresolved problems.
- Confirmation that, in the opinion of the manufacturer, the equipment meets the requirements of this specification and those required by International Laws (e.g. EMC Regulations and CE certification).
- If, in the opinion of the manufacturer, the equipment does not meet the requirements of this specification or those required by International Laws, state why and what is required for approval.

#### 2.1.4.1 IEC 68.2.1 - Cold temperature tests, A

These tests are mandatory for all items of ERTMS equipment.

TEST	Temperatures <sup>#</sup>	Duration	Final measurements / Acceptance criteria
Ab (Non heat-dissipating equipment) - Gradual change in temp.	See Table 2	16 hours	Equipment shall be fully functional both during (after reaching equilibrium temperature) and upon completion of the test (after recovery)
Ad (Heat dissipating) - Gradual change in temp.	See Table 2	16 hours	Equipment shall be fully functional both during (after reaching equilibrium temperature) and upon completion of the test (after recovery)

#### 2.1.4.2 IEC 68.2.2 - Dry heat temperature tests, B

These tests are mandatory for all items of ERTMS equipment.

TEST	Temperatures <sup>#</sup>	Duration	Final measurements / Acceptance criteria
Bb (Non heat-dissipating equipment) - Gradual change in temp.	See Table 2	16 hours	Equipment shall be fully functional both during (after reaching equilibrium temperature) and upon completion of the test (after recovery)
Bd (Heat dissipating) - Gradual change in temp.	See Table 2	16 hours	Equipment shall be fully functional both during (after reaching equilibrium temperature) and upon completion of the test (after recovery)

#### 2.1.4.3 IEC 68.2.14 - Rapid change of temperature test, Na.

Installation location specific tests are required as follows:

Track side	Track	Train External	Train Internal	Outdoor portable
Not required	Not required	Mandatory	Mandatory	Mandatory

TEST	Temperatures <sup>#</sup>	Duration etc.	Final measurements / Acceptance criteria
Test Na	See Table 2	5 cycles each of 3 hours Transition time 30s	Equipment shall be fully functional during the test

#### 2.1.4.4 IEC 68.2.14 - Change of temperature with specified rate of change test, Nb.

Installation location specific tests are required as follows:

Track side	Track	Train External	Train Internal	Outdoor portable
Mandatory	Mandatory	Not required	Not required	Not required

<sup>#</sup> Temperature to be taken from the maximum or minimum value for the chosen installation location, e.g. in the case of a control room the external ambient temperatures would apply. However, for a train wheelset it would be the temperature surrounding the printed circuit board.

TEST	Temperatures #	Duration etc.	Final measurements / Acceptance criteria
Test Nb	See Table 2	No of cycles - 2 Rate of change - 1°C/min	Equipment shall be fully functional during the test

## 2.2 SOLAR RADIATION

### 2.2.1 Introduction

Requirements for this section have been extracted from IEC 721.

### 2.2.2 Operational requirements

The equipment shall operate reliably and without malfunction when exposed to the following minimum severities of solar radiation.

INSTALLATION LOCATION	Solar radiation (showing minimum IEC 721 equivalent classification)
<b>Train (External)</b>	
Wheel set	5K3 (1120 W/m <sup>2</sup> )
Bogie	5K3 (1120 W/m <sup>2</sup> )
Under frame	5K3 (1120 W/m <sup>2</sup> )
Roof/Body	5K3 (1120 W/m <sup>2</sup> )
<b>Train (Internal)</b>	
Engine Room	5K2 (700 W/m <sup>2</sup> )
Equipment Room	5K2 (700 W/m <sup>2</sup> )
Drivers Cab	5K3 (1120 W/m <sup>2</sup> )
Coach	5K2 (700 W/m <sup>2</sup> )
<b>Track (line side)</b>	
Rail mounted	4K2 (1120 W/m <sup>2</sup> )
Sleeper mounted	4K2 (1120 W/m <sup>2</sup> )
Beneath the sleeper (buried in track formation)	N/A
Between the sleepers	4K2 (1120 W/m <sup>2</sup> )
Outside the running rail	4K2 (1120 W/m <sup>2</sup> )
<b>Track side</b>	
Non weather protected location case	4K2 (1120 W/m <sup>2</sup> )
Weather protected location case	3K2 (700 W/m <sup>2</sup> )
Equipment room - no climate control	3K2 (700 W/m <sup>2</sup> )
Equipment room - with climate control	3K2 (700 W/m <sup>2</sup> )
Control Room (climate controlled)	3K2 (700 W/m <sup>2</sup> )
Control Room (no climate control)	3K2 (700 W/m <sup>2</sup> )
<b>Out door portable equipment</b>	7K2 (1120 W/m <sup>2</sup> )

**Table 3: Solar radiation**

#### NOTES

- N/A denotes that IEC 721 solar radiation classification is not applicable for this installation location.

### 2.2.3 Guidelines

In accordance with the recommendations of UIC/ERRI A118 Report No 4, the requirements for electronic signalling systems are as follows:

The sun should be allowed to shine only on the smallest possible casing surfaces (normal protection) and the convection flow should sweep across the largest possible surfaces of materials with good conduction properties.

Windows should be avoided on the sunny side of rooms housing electronic equipment.

Air conditioning plant and cooling fans (when used) in rooms housing electronic equipment shall be efficient and reliable.

Heat sensitive parts shall be protected by heat shields made, for instance, of polished stainless steel or aluminium plate.

Care shall be taken to avoid the effects of Ultra Violet (UV) radiation on equipment exposed to solar radiation.

#### 2.2.4 Test requirements

Test methods for determining the suitability of a specimen shall accord with IEC 68.2.5: Environmental testing - Test Sa: Simulated solar radiation at ground level.

Installation location specific tests are required as follows:

Track side	Track (line side)	Train External	Train Internal	Outdoor portable
Mandatory	Mandatory	Mandatory	Mandatory	Mandatory

TEST	Duration etc.	Final measurements / Acceptance criteria
Test Sa	Procedure B Cycles. 56 cycles: Trackside (non weather protected) Track (lineside) Train (external) Train (internal) - Drivers cab Outdoor portable 10 cycles: Track side (except non-weather protected) Train internal (except Drivers cab) Enclosure temp. 55°C	Equipment shall be fully functional during the test

Equipment shall be fully functional at all times during the tests, unless otherwise stated.

Test specimens shall be tested in their production configuration without the use of external devices that have been added expressly for the purpose of passing the test. For example, heat shields shall not be used during testing, unless they are incorporated into the finished product.



In all instances performance tests shall be carried out prior to commencement of the environmental tests to ensure the item being tested is fully functional (i.e. it is not sub-standard or defective). If, upon conclusion of an environmental test, the equipment has failed and has to be modified, the associated performance and environmental tests shall be repeated. The manufacturer is responsible for developing and implementing a suitable performance test schedule. For cross-acceptance purposes these schedules shall be provided to the ERTMS Users Group.

Storage and transportation tests are detailed in Section 3.

The manufacturer shall provide a full report (to the ERTMS Users Group) on each of the tests carried out. This report shall include, but not be limited to:

- The design solutions used to fulfil the requirements.
- The performance test schedule.
- Test results.
- Any failures during testing.
- Modifications made during the testing programme.
- Any further tests which are considered necessary.
- Any unresolved problems.
- Confirmation that, in the opinion of the manufacturer, the equipment meets the requirements of this specification and those required by International Laws (e.g. EMC Regulations and CE certification).
- If, in the opinion of the manufacturer, the equipment does not meet the requirements of this specification or those required by International Laws, state why and what is required for approval.

## 2.3 HUMIDITY

### 2.3.1 Introduction

Requirements for this section have been derived from prEN 50125-1, prEN 50125-3 and EN 50155.

### 2.3.2 Operational requirements

Operationally caused infrequent and slight moisture condensation shall not cause malfunction of the equipment.

#### 2.3.2.1 Train (external and internal)

Equipment shall be designed and manufactured to meet the following external humidity levels (limit values), over the complete range of ambient temperature values as defined in Section 2.1 of this specification.

Duration	Limit Value
Yearly average	75% Relative Humidity
On 30 days in the year, continuously	95% Relative Humidity
On the other days, occasionally	100% Relative Humidity
On the other days, occasionally	30g/m <sup>3</sup> occurring in tunnels

**Table 4: Humidity - Trainborne equipment**

#### 2.3.2.2 Track (lineside), track side and portable equipment

Equipment shall be designed and manufactured to meet the external humidity levels (limit values) shown in Table 5 over the complete range of ambient temperature values as defined in Section 2.1 of this specification.

Should abnormal situations be known to occur outside these ranges then the railway is responsible for advising the supplier.

INSTALLATION LOCATION	Minimum Humidity (showing prEN 50125-3 levels)		Maximum Humidity (showing prEN 50125-3 levels))	
	Relative Humidity	Absolute Humidity	Relative Humidity	Absolute Humidity
<b>Track (lineside)</b>				
Rail mounted	TX - 15%	TX - 0.02 g/m <sup>3</sup>	TX - 100%	TX - 25 g/m <sup>3</sup> (30g/m <sup>3</sup> in tunnels)
Sleeper mounted	TX - 15%	TX - 0.02 g/m <sup>3</sup>	TX - 100%	TX - 25 g/m <sup>3</sup> (30g/m <sup>3</sup> in tunnels)
Beneath the sleeper (buried in track formation)	TX - 15%	TX - 0.02 g/m <sup>3</sup>	TX - 100%	TX - 25 g/m <sup>3</sup> (30g/m <sup>3</sup> in tunnels)
Between the sleepers	TX - 15%	TX - 0.02 g/m <sup>3</sup>	TX - 100%	TX - 25 g/m <sup>3</sup> (30g/m <sup>3</sup> in tunnels)
Outside the running rail	TX - 15%	TX - 0.02 g/m <sup>3</sup>	TX - 100%	TX - 25 g/m <sup>3</sup> (30g/m <sup>3</sup> in tunnels)
<b>Track side</b>				
Non weather protected location case	TX - 15%	TX - 0.02 g/m <sup>3</sup>	TX - 100%	TX - 25 g/m <sup>3</sup> (30g/m <sup>3</sup> in tunnels)
Weather protected location case	TX - 5%	TX - 0.02 g/m <sup>3</sup>	TX - 100%	TX - 25 g/m <sup>3</sup> (30g/m <sup>3</sup> in tunnels)
Equipment room - no climate control	TX - 5%	TX - 0.02 g/m <sup>3</sup>	TX - 100%	TX - 25 g/m <sup>3</sup>
Equipment room - with climate control	TX - 10%	TX - 2 g/m <sup>3</sup>	TX - 75%	TX - 22 g/m <sup>3</sup>
Control Room (climate controlled)	TX - 20%	TX - 4 g/m <sup>3</sup>	TX - 75%	TX - 15 g/m <sup>3</sup>
Control Room (no climate control)	TX - 5%	TX - 0.02 g/m <sup>3</sup>	TX - 95%	TX - 25 g/m <sup>3</sup>
<b>Out door portable equipment</b>	TX - 15%	TX - 0.02 g/m <sup>3</sup>	TX - 100%	TX - 25 g/m <sup>3</sup> (30g/m <sup>3</sup> in tunnels)

Table 5: Humidity - Track (line side), track side and portable equipment

### **2.3.3 Guidelines**

Equipment should be located such that humidity stresses are minimised.

### **2.3.4 Test requirements**

Evidence of the ability of equipment to function correctly during and after exposure to humidity shall be provided on the basis of the following tests.

Equipment shall be fully functional at all times during the tests, unless otherwise stated.

Test specimens shall be tested in their production configuration without the use of external devices that have been added expressly for the purpose of passing the test. For example, humidity control systems shall not be used during testing, unless they are incorporated into the finished product.

In all instances performance tests shall be carried out prior to commencement of the environmental tests to ensure the item being tested is fully functional (i.e. it is not sub-standard or defective). If, upon conclusion of an environmental test, the equipment has failed and has to be modified, the associated performance and environmental tests shall be repeated. The manufacturer is responsible for developing and implementing a suitable performance test schedule. For cross-acceptance purposes these schedules shall be provided to the ERTMS Users Group.

Storage and transportation tests are detailed in Section 3.

The manufacturer shall provide a full report (to the ERTMS Users Group) on each of the tests carried out. This report shall include, but not be limited to:

- The design solutions used to fulfil the requirements.
- The performance test schedule.
- Test results.
- Any failures during testing.
- Modifications made during the testing programme.
- Any further tests which are considered necessary.
- Any unresolved problems.
- Confirmation that, in the opinion of the manufacturer, the equipment meets the requirements of this specification and those required by International Laws (e.g. EMC Regulations and CE certification).

- If, in the opinion of the manufacturer, the equipment does not meet the requirements of this specification or those required by International Laws, state why and what is required for approval.

#### 2.3.4.1 IEC 68.2.56 - Damp heat, steady state test - equipment, Cb

Mandatory for climate controlled rooms only.

TEST	Duration etc.	Final measurements / Acceptance criteria
Test Cb	21 days duration 40° C 75% relative humidity (this is a non standard humidity level)	Equipment shall be fully functional both during (at stabilisation of humidity, then on a 7 day cycle) and upon completion of the test (after recovery)

An electrostatic discharge immunity test in accordance with EN 61000-4-2 shall be performed after completion of the above test. The immunity test shall be carried out by the contact discharge method with a test severity level 4. The equipment under test shall be fully functional at all times.

#### 2.3.4.2 IEC 68.2.30 - Damp heat, cyclic test, Db

Mandatory for all installation locations **except** where climate control is employed.

TEST	Duration etc.	Final measurements / Acceptance criteria
Test Db	Upper temp. 55° C Number of cycles - 6 Test variant 2	Equipment shall be fully functional both during (at the beginning of the second cycle following moisture condensation) and upon completion of the test (after recovery)

An electrostatic discharge immunity test in accordance with EN 61000-4-2 shall be performed after completion of the above test. The immunity test shall be carried out by the contact discharge method with a test severity level 4. The equipment under test shall be fully functional at all times.

## **2.4 WIND AND PRESSURE PULSES**

### **2.4.1 Introduction**

The stresses caused by natural wind and pressure pulses from crossing trains shall be taken into account when designing equipment.

This section is derived from prEN 50125-1 and prEN 50125-3.

### **2.4.2 Operational requirements**

#### **2.4.2.1 Wind**

ERTMS equipment shall function correctly at permanent cross winds of 35m/s. Exceptional gusts of 50 m/s and duration of 1 second per gust shall not affect the performance of equipment. For gusts of longer than 1 second the equipment performance may be affected but without permanent damage.

#### **2.4.2.2 Pressure pulses**

ERTMS equipment shall function correctly when subjected to pressure pulses caused by trains passing in tunnels. Evidence that the consequences of air pressure pulses have been taken into account at the design stage, shall be provided.

Particular local air pressure conditions may exist due to the effects of trains running through a tunnel. However, as a minimum, all ERTMS equipment shall function correctly when subjected to the following severity of pressure pulse:

$$\Delta P = \pm 5 \text{ kPa}$$

The associated rate of change of pressure is:

$$\Delta P / \Delta t = 1 \text{ kPa/s}$$

### 2.4.3 Guidelines

The wind forces acting on an item of equipment depend on the physical properties of that item (e.g. size and shape) and the installation location. For ERTMS equipment, the wind force ( $F_w$ ) shall be calculated using the following formula:

$$F_w = q \times c \times A$$

where:

$q$  = pressure head

$c$  = form factor

$A$  = equipment area in direction of wind

Pressure head  $q$  is calculated by:

$$q = d/2 \times V^2$$

where:

$d$  = density of air ( $\text{kg/m}^3$ )

$V$  = speed of air ( $\text{m/s}$ )

Note that density of air ( $d$ ) is dependant upon the altitude and temperature of the chosen installation location.

#### EXAMPLE

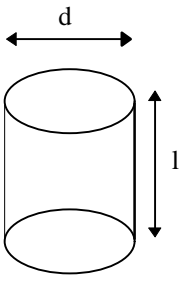
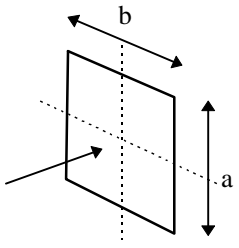
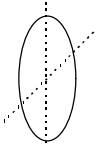
For permanent wind speeds of 35m/s at sea level with an air temperature of 0°C:

$$q = 1.275/2 \times 35 \times 35 = 0.78 \text{ KN/m}^2$$

Consequently:

$$F_w = 0.78 \times c \times A$$

Note - Form factor  $c$  depends on the shape and size of the item of equipment. The following table gives some of the more common values.

Shape	Form factor (c)												
	$\frac{l}{d} =$ <table> <tr><td>1</td><td>0.63</td></tr> <tr><td>5</td><td>0.74</td></tr> <tr><td>10</td><td>0.82</td></tr> <tr><td>40</td><td>0.98</td></tr> </table>	1	0.63	5	0.74	10	0.82	40	0.98				
1	0.63												
5	0.74												
10	0.82												
40	0.98												
	$\frac{a}{b} =$ <table> <tr><td>1</td><td>1.1</td></tr> <tr><td>2</td><td>1.15</td></tr> <tr><td>4</td><td>1.19</td></tr> <tr><td>10</td><td>1.29</td></tr> <tr><td>28</td><td>1.4</td></tr> <tr><td><math>\infty</math></td><td>2.01</td></tr> </table>	1	1.1	2	1.15	4	1.19	10	1.29	28	1.4	$\infty$	2.01
1	1.1												
2	1.15												
4	1.19												
10	1.29												
28	1.4												
$\infty$	2.01												
	1.11												

**Table 6: Wind forces- sample form factors**

Further information on wind forces can be found in ISO/DIS 4354 “Wind Actions on Structures”.

## 2.4.4 Test Requirements

### 2.4.4.1 Wind

No test requirements have been specified in this Section. Test Rb (impacting water) is specified in Section 2.6 (water and precipitation). This test is considered appropriate for assessing the effect of heavy wind driven rain.

Manufacturers are required to demonstrate that they have considered wind loading within their design.

### 2.4.4.2 Pressure pulses

Railways shall make suitable national recommendations for pressure pulse tests, preferably by reference to existing standards (either national or railway specific). For cross-acceptance purposes these national requirements shall be provided to the ERTMS Users Group.

Installation location specific pressure pulse tests are required as follows:



Track side	Track (line side)	Train External	Train Internal	Outdoor portable
Mandatory for location cases only.	Mandatory	Mandatory	Mandatory	Not required

The manufacturer shall provide a full report (to the ERTMS Users Group) on each of the tests carried out. This report shall include, but not be limited to:

- The design solutions used to fulfil the requirements.
- The performance test schedule.
- Test results.
- Any failures during testing.
- Modifications made during the testing programme.
- Any further tests which are considered necessary.
- Any unresolved problems.
- Confirmation that, in the opinion of the manufacturer, the equipment meets the requirements of this specification and those required by International Laws (e.g. EMC Regulations and CE certification).
- If, in the opinion of the manufacturer, the equipment does not meet the requirements of this specification or those required by International Laws, state why and what is required for approval.

## **2.5 ALTITUDE**

### **2.5.1 Introduction**

ERTMS equipment is required to operate without malfunction at an extreme range of altitudes.

### **2.5.2 Operational requirements**

ERTMS equipment shall be capable of operating without malfunction at altitudes between -120m (below sea level) and 2000m above sea level, which corresponds to an air pressure range of approximately 101.3 kPa to 79.5 kPa.

### **2.5.3 Guidelines**

For further information on natural air pressures refer to ISO 2533.

### **2.5.4 Test requirements**

Evidence of the ability of equipment to function correctly at altitude shall be provided on the basis of the following tests.

Equipment shall be fully functional at all times during the tests, unless otherwise stated.

Test specimens shall be tested in their production configuration without the use of external devices that have been added expressly for the purpose of passing the test. For example, pressure control systems shall not be used during testing, unless they are incorporated into the finished product.

In all instances performance tests shall be carried out prior to commencement of the environmental tests to ensure the item being tested is fully functional (i.e. it is not sub-standard or defective). If, upon conclusion of an environmental test, the equipment has failed and has to be modified, the associated performance and environmental tests shall be repeated. The manufacturer is responsible for developing and implementing a suitable performance test schedule. For cross-acceptance purposes these schedules shall be provided to the ERTMS Users Group.

Storage and transportation tests are detailed in Section 3.

The manufacturer shall provide a full report (to the ERTMS Users Group) on each of the tests carried out. This report shall include, but not be limited to:

- The design solutions used to fulfil the requirements.
- The performance test schedule.
- Test results.
- Any failures during testing.
- Modifications made during the testing programme.
- Any further tests which are considered necessary.
- Any unresolved problems.
- Confirmation that, in the opinion of the manufacturer, the equipment meets the requirements of this specification and those required by International Laws (e.g. EMC Regulations and CE certification).
- If, in the opinion of the manufacturer, the equipment does not meet the requirements of this specification or those required by International Laws, state why and what is required for approval.

#### 2.5.4.1 IEC 68.2.13 - Low air pressure test, M.

Mandatory for all installation locations.

TEST	Duration etc.	Final measurements / Acceptance criteria
Test M	Duration - 16 hours Air pressure - 79.5 kPa (this is a non standard value approximately equal to 2000m above sea level)	Equipment shall be fully functional both during (at stabilisation of pressure) and upon completion of the test (after recovery)

#### 2.5.4.2 IEC 68.2.39 - Combined sequential cold, low air pressure and damp heat test, Z/AMD

Mandatory for all installation locations.

TEST	Duration etc.	Final measurements / Acceptance criteria
Test Z/AMD	Temp. - See Table 2 <sup>#</sup> No. of cycles - 6 Air pressure - 79.5 kPa (this is a non standard value approximately equal to 2000m above sea level) Relative humidity - >95%	Equipment shall be fully functional both during (at stabilisation of pressure/temperature and then at stabilisation of humidity) and upon completion of the test (after recovery)

An electrostatic discharge immunity test in accordance with EN 61000-4-2 shall be performed after completion of the above test. The immunity test shall be carried out by the contact discharge method with a test severity level 4. The equipment under test shall be fully functional at all times.

<sup>#</sup> Temperature to be taken from the minimum value for the chosen installation location, e.g. in the case of a control room the external ambient temperatures would apply.

**2.5.4.3 IEC 68.2.40 - Combined cold/low air pressure test, Z/AM**

Mandatory for all installation locations.

TEST	Duration etc.	Final measurements / Acceptance criteria
Test Z/AM	Temp. - See Table 2 <sup>#</sup> Air pressure - 79.5 kPa (this is a non standard value approximately equal to 2000m above sea level) Duration - 16 hours	Equipment shall be fully functional both during (at stabilisation of temperature and then at stabilisation of pressure) and upon completion of the test (after recovery)

**2.5.4.4 IEC 68.2.41 - Combined dry heat/low air pressure test, Z/BM**

Mandatory for all installation locations.

TEST	Duration etc.	Final measurements / Acceptance criteria
Test Z/BM	Temp. - See Table 2 <sup>~</sup> Air pressure - 79.5 kPa (this is a non standard value approximately equal to 2000m above sea level) Duration - 16 hours	Equipment shall be fully functional both during (at stabilisation of temperature and then at stabilisation of pressure) and upon completion of the test (after recovery)

<sup>#</sup> Temperature to be taken from the minimum value for the chosen installation location, e.g. in the case of a control room the external ambient temperature would apply.

<sup>~</sup> Temperature to be taken from the maximum value for the chosen installation location, e.g. in the case of a location cabinet the internal temperature would apply.

## **2.6 WATER AND PRECIPITATION**

### **2.6.1 Introduction**

Equipment shall be capable of operating in rain, snow, hail and be unaffected by ice, and water.

IEC 721 classifications have been adopted for this section.

### **2.6.2 Operational requirements**

ERTMS equipment shall operate without malfunction when subjected to all forms of precipitation. In this respect, considerations shall be given to (but not limited to) the following:

- The effects of snow, ice and hail penetrating equipment housings.
- The effects of snow melting and freezing again.
- Hailstones of a maximum diameter of 15mm.
- Light dew
- Temporary immersion [Track (line side) equipment only]

ERTMS equipment shall operate without malfunction when subjected to the severities of water and precipitation shown in Table 7 (on page 38) in conjunction with the wind velocities detailed in Section 2.4.

#### **2.6.2.1 Trainborne Recording Unit - Catastrophic events**

In the event of a catastrophic incident (e.g. derailment or collision) the Trainborne Recording Unit shall be capable of resisting the effects of immersion in water (sea or river). These requirements exceed the general operational requirements shown above. Further details of these requirements can be found in the Functional Requirements Specification - ERTMS Trainborne Recording Unit (Document Ref: 97e461).

INSTALLATION LOCATION				
	Water and precipitation (showing minimum IEC 721 equivalent classifications)	Precipitation (mm/min)	Water from sources other than rain (m/s)	Low rain temperature (°C)
<b>Train (External)</b>				
Wheel set	5K4	15	3	N/A
Bogie	5K4	15	3	N/A
Under frame	5K4	15	3	N/A
Roof/Body	5K4	15	3	N/A
<b>Train (Internal)</b>				
Engine Room	5K2	N/A	0.3	N/A
Equipment Room	5K2	N/A	0.3	N/A
Drivers Cab	5K1	N/A	N/A	N/A
Coach				
<b>Track (line side)</b>				
Rail mounted	4K3 / 4Z8	15	Water jets and immersion (see note 3)	+5
Sleeper mounted	4K3 / 4Z8	15	Water jets and immersion (see note 3)	+5
Beneath the sleeper (buried in track formation)	See Note 2 below			
Between the sleepers	4K3 / 4Z8	15	Water jets and immersion (see note 3)	+5
Outside the running rail	4K3 / 4Z8	15	Water jets and immersion (see note 3)	+5
<b>Track side</b>				
Non weather protected location case	4K3 / 4Z8	15	Water jets	+5
Weather protected location case	3K1	N/A	N/A	N/A
Equipment room - no climate control	3K1	N/A	N/A	N/A
Equipment room - with climate control	3K1	N/A	N/A	N/A
Control Room (climate controlled)	3K1	N/A	N/A	N/A
Control Room (no climate control)	3K1	N/A	N/A	N/A
<b>Out door portable equipment</b>	7K5 / 7Z10	15	Spraying water	+5

**Table 7: Water and precipitation****NOTES**

1. N/A denotes that the IEC 721 water severity classification is not applicable for this installation location.
2. IEC 721 codes are not entirely appropriate for equipment buried within the track formation as it will not be directly exposed to rain. The equipment will, however, require protection against the affects of flooding and the damp environment within which it is placed. A minimum IEC 529 protection code of IP67 should be considered in

this respect. Manufacturers are, however, responsible for ensuring and proving the water tightness of the equipment.

3. Track (line side) equipment will require protection against the affects of temporary flooding of the track. A minimum IEC 529 protection code of IP67 should be considered in this respect. Manufacturers are, however, responsible for ensuring and proving the water tightness of the equipment.

### 2.6.3 Guidelines

Railways may choose to specify IEC 529 protection codes (IP codes) for all installation locations. These IP codes must however, meet or exceed the IEC 721 severities specified in Table 7.

A summary of IEC 529 protection codes is included as Annex B.

Means to reduce the effects of water by the use of protection may be considered. In this case the protection against water and solid objects may be specified by the railway.

(Note - If a manufacturer uses protective casings then they shall specify a suitable IEC 529 IP code)

As a guide the following IEC 529 protection codes could be adopted, although it is the responsibility of the manufacturer to ensure equipment is proof against the IEC 721 severities quoted in this specification.

INSTALLATION LOCATION	IEC 529 protection codes
<b>Train (External)</b>	
Wheel set	IP 66
Bogie	IP 66
Under frame	IP 66
Roof/Body	IP 66
<b>Train (Internal) - See Note below</b>	
Engine Room	IP 52
Equipment Room	IP 52
Drivers Cab	IP 52
Coach	IP 52
<b>Track (line side)</b>	
Rail mounted	IP 67
Sleeper mounted	IP 67
Beneath the sleeper (buried in track formation)	IP 67
Between the sleepers	IP 67
Outside the running rail	IP 67
<b>Track side</b>	
Non weather protected location case	IP 55

INSTALLATION LOCATION	IEC 529 protection codes
Weather protected location case	IP 51
Equipment room - no climate control	IP 51
Equipment room - with climate control	IP 51
Control Room (climate controlled)	IP 51
Control Room (no climate control)	IP 51
<b>Out door portable equipment</b>	IP 65

NOTE - These figures do not apply for the Trainborne Recording Unit. See Functional Requirements Specification - ERTMS Trainborne Recording Unit (Document Ref: 97e461) for details.

#### 2.6.4 Test requirements

Evidence of the ability of equipment to function correctly when subjected to water shall be provided on the basis of the following tests.

Equipment shall be fully functional at all times during the tests, unless otherwise stated.

Test specimens shall be tested in their production configuration without the use of external devices that have been added expressly for the purpose of passing the test. For example, encapsulated components shall not be used during testing, unless they are incorporated into the finished product.

In all instances performance tests shall be carried out prior to commencement of the environmental tests to ensure the item being tested is fully functional (i.e. it is not sub-standard or defective). If, upon conclusion of an environmental test, the equipment has failed and has to be modified, the associated performance and environmental tests shall be repeated. The manufacturer is responsible for developing and implementing a suitable performance test schedule. For cross-acceptance purposes these schedules shall be provided to the ERTMS Users Group.

Storage and transportation tests are detailed in Section 3.

The manufacturer shall provide a full report (to the ERTMS Users Group) on each of the tests carried out. This report shall include, but not be limited to:

- The design solutions used to fulfil the requirements.
- The performance test schedule.
- Test results.
- Any failures during testing.
- Modifications made during the testing programme.



- Any further tests which are considered necessary.
- Any unresolved problems.
- Confirmation that, in the opinion of the manufacturer, the equipment meets the requirements of this specification and those required by International Laws (e.g. EMC Regulations and CE certification).
- If, in the opinion of the manufacturer, the equipment does not meet the requirements of this specification or those required by International Laws, state why and what is required for approval.

#### 2.6.4.1 IEC 68.2.18 - Water - Falling drops, impacting water and immersion, tests R

##### Test Ra2 - Drip box

Installation location specific tests are required as follows:

Track side	Track (line side)	Train External	Train Internal	Outdoor portable
Mandatory for weather protected locations only	Not required	Not required	Mandatory	Not required

TEST	Duration etc.	Final measurements / Acceptance criteria
Test Ra	Drop falling height - 2m Duration - 60 mins Tilt angle - 0°	Equipment shall be fully functional both during and upon completion of the test (after recovery)

##### Test Rb - Impacting water

Installation location specific tests are required as follows:

Track side	Track (line side)	Train External	Train Internal	Outdoor portable
Mandatory for non-weather protected locations only	Mandatory	Mandatory	Not required	Mandatory

TEST	Duration etc.	Final measurements / Acceptance criteria
Test Rb	Method - Rb 1 Intensity - 1000 mm/hr Duration - 60 mins Tilt angle - All angles to be tested	Equipment shall be fully functional upon completion of the test (after recovery)

##### Test Rc - Immersion

Installation location specific tests are required as follows:

Track side	Track (line side)	Train External	Train Internal	Outdoor portable
Not required	Mandatory	Not required	Not required	Not required

TEST	Duration etc.	Final measurements / Acceptance criteria
Test Rc	Method - Rc1 Head of water - 0.40m Duration - 24 hours	Equipment shall be fully functional both during and upon completion of the test (after recovery)

**2.6.4.2 IEC 68.2.62 - Impact pendulum hammer test, Ef**

This is intended to represent the action of hail stones. It is also used as a means of testing the general robustness of the equipment housing (see Section 2.8.4.4).

Installation location specific tests are required as follows:

Track side	Track (line side)	Train External	Train Internal	Outdoor portable
Mandatory for non-weather protected locations only	Mandatory	Mandatory	Not required	Mandatory

TEST	Duration etc.	Final measurements / Acceptance criteria
Test Ef	Impact energy - 0.5 J Height of fall - 250 mm Impact locations - All aspects and housing joints	Equipment shall be fully functional upon completion of the test and the equipment housing must be intact.

## **2.7 POLLUTANTS AND CONTAMINANTS**

### **2.7.1 Introduction**

The requirements of IEC 529 and 721 are fundamental to the reliability of ERTMS equipment when it is exposed to pollution and contaminants.

### **2.7.2 Operational requirements**

The design of equipment shall take into account the effects of pollution.

Track ballast can cause serious damage to electrical equipment attached to the exterior of trains or located at the track side. The design shall take into account the effect of ballast and, for other circumstances, stones up to a diameter of 15 mm shall be considered.

Equipment shall be capable of operating in (or be protected from) the IEC 721 classifications of pollutants and contaminants shown on the following page.

INSTALLATION LOCATION	Biological	Chemically active	Mechanically active	Contaminating fluids
<b>Train (External)</b>				
Wheel set	5B2	5C2	5S3	5F3
Bogie	5B2	5C2	5S3	5F3
Under frame	5B2	5C2	5S3	5F3
Roof/Body	5B2	5C2	5S3	5F3
<b>Train (Internal) - See Note 2 below</b>				
Engine Room	5B2	5C2	5S2	5F3
Equipment Room	5B2	5C2	5S2	5F2
Drivers Cab	5B1	5C1	5S2	5F1
Coach	5B1	5C1	5S2	5F1
<b>Track (line side)</b>				
Rail mounted	4B1	4C3	4S3	N/A
Sleeper mounted	4B1	4C3	4S3	N/A
Beneath the sleeper (buried in track formation)	4B1	4C3	4S3	N/A
Between the sleepers	4B1	4C3	4S3	N/A
Outside the running rail	4B1	4C3	4S3	N/A
<b>Track side</b>				
Non weather protected location case	4B1	4C3	4S3	N/A
Weather protected location case	3B1	3C2	3S1	N/A
Equipment room - no climate control	3B1	3C2	3S1	N/A
Equipment room - with climate control	3B1	3C2	3S1	N/A
Control Room (climate controlled)	3B1	3C2	3S1	N/A
Control Room (no climate control)	3B1	3C2	3S1	N/A
<b>Out door portable equipment</b>	7B1	7C3	7S3	N/A

## NOTES

1. N/A denotes that there is no classification included in IEC 721. However, equipment shall be immune to the effects of contaminating fluids by utilising an appropriate level of protection in accordance with IEC 529.
2. These figures do not apply for the Trainborne Recording Unit. See Functional Requirements Specification - ERTMS Trainborne Recording Unit (Document Ref: 97e461) for details.

**Table 8: Pollutants and contaminants**

### 2.7.2.1 Trainborne Recording Unit - Catastrophic events

In the event of a catastrophic incident (e.g. derailment or collision) the Trainborne Recording Unit shall be capable of resisting the effects of exposure to pollutants and contaminants. These requirements exceed the general operational requirements shown above. Further details of these requirements can be found in the Functional Requirements Specification - ERTMS Trainborne Recording Unit (Document Ref: 97e461).

### 2.7.2.2 Eurobalise

Eurobalise and antenna air gap requirements are detailed in the Form Fit Functional Specification for Eurobalise Transmission Sub-System, which is reproduced below.

The following table specifies the debris on the Balise and the corresponding Classes; A and B.

Material	Description	Layer on top of Balise [mm]	
		Class B	Class A
Water	Clear	100	200
	0.5 % NaCl (weight)	10	100
Snow	Fresh, 0°C	300 (Note <sup>1</sup> )	300 (Note <sup>1</sup> )
	Wet, 20 % water	300 (Note <sup>1</sup> )	300 (Note <sup>1</sup> )
Ice	Non porous	100	100
Ballast	Stone	100	100
Sand	Dry	20	20
	Wet	20	20
Mud	Without salt water	50	50
	With salt water, 0.5 % NaCl (weight)	10	50
Iron Ore	Taconite	20	20
	Magnetite	2	20
Iron dust <sup>2</sup>	Braking dust	10	10
Coal dust	8 % sulphur	10	10
Oil and Grease		50	50

**Table 9: Debris layers on top of the Balise and its Classes**

The minimum debris layer on top of the Balise that shall be handled by each Balise shall be according to Class B.<sup>3</sup>

The influence of debris affects the transmission in two ways:

1. The Input /Output characteristics of the balise (e.g. the tuning of the balise) is affected.
2. The mutual coupling between balise and Antenna Unit is affected.

The balise should have a Balise Class A or B based on the influence corresponding to item 1 above.

There shall be a clear marking that identifies the Class of the balise.

<sup>1</sup> 300 mm or up to the bottom of the Antenna unit.

<sup>2</sup> A non-conductive mixture of grease and iron oxide which is normally encountered in Railway environment.

<sup>3</sup> It shall be allowed for an individual supplier to design Balises for more severe debris conditions than Class B.

The following debris table gives examples of debris under the Antenna unit.<sup>4</sup>

Material	Description	Layer below the bottom of the Antenna unit [mm]	
		Minimum	Maximum
Snow	Fresh, 0°C	20	top of Balise
	Wet, 20 % water	10	top of Balise
Ice		10	top of Balise
Mud	Without salt water	10	50
	With salt water, 0.5 % NaCl (weight)	-	50
Iron Ore	Taconite	-	5
	Magnetite	-	5
Iron dust	Braking dust	2	5
Coal dust	8 % sulphur	-	5
Oil and Grease		2	20

**Table 10: Examples of debris under the Antenna unit (for Balise)**

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<sup>4</sup> The manufacturer shall specify the performance of the Antenna unit and its maximum allowed debris.

### 2.7.2.3 Euroloop

Euroloop and antenna air gap requirements are detailed in the Form Fit Functional Specification for Euroloop Transmission Sub-System, which is reproduced below.

The following table specifies the debris on the Balise and the corresponding Classes; A and B.

Material	Description	Layer on top of Loop [mm]	
		Class B	Class A
Water	Clear	100	200
	0.5 % NaCl (weight)	10	100
Snow	Fresh, 0°C	300 (See note)	300 (See note)
	Wet, 20 % water	300 (See note)	300 (See note)
Ice	Non porous	100	100
Ballast	Stone	100	100
Sand	Dry	20	20
	Wet	20	20
Mud	Without salt water	50	50
	With salt water, 0.5 % NaCl (weight)	10	50
Iron Ore	Taconite	20	20
	Magnetite	2	20
Iron dust <sup>5</sup>	Braking dust	10	10
Coal dust	8 % sulphur	10	10
Oil and Grease		50	50

**Table 11: Debris layers on top of the Loop and its Classes**

Note - 300 mm or up to the bottom of the Antenna unit.

If the antennas are not placed under the vehicle, other requirements for debris shall be elaborated according to the proposed position of the antenna.

<sup>5</sup> A non-conductive mixture of grease and iron oxide which is normally encountered in Railway environment.

The following debris table gives examples of debris under the Antenna unit.<sup>6</sup>

Material	Description	Layer below the bottom of the Antenna unit [mm]	
		Proposed Maximum of normal case	Maximum of individual railway (worst case)
Snow	Fresh, 0°C	top of component mounted in the track	
	Wet, 20 % water	top of component mounted in the track	
Ice		50	top of component mounted in the track
Mud	Without salt water	10	50
	With salt water, 0.5 % NaCl (weight)	10	50
Iron Ore	Taconite	2	5
	Magnetite	2	5
Iron dust	Braking dust	2	5
Coal dust	8 % sulphur	2	5
Oil and Grease		2	20

**Table 12: Examples of debris under the Antenna unit (For Loop)**

If the antennas are not placed under the vehicle, other requirements for debris shall be elaborated according to the proposed position of the antenna.

### 2.7.3 Guidelines

Means to reduce pollution by the effective use of protection may be considered. In this case the protection against pollution may be specified by the railway.

(Note - If a manufacturer uses protective casings then they shall specify a suitable IEC 529 IP code)

As a guide the following IEC 529 protection codes could be adopted, although it is the responsibility of the manufacturer to ensure equipment is proof against the IEC 721 severities quoted in this specification (a summary of IEC 529 can be found in Annex B).

INSTALLATION LOCATION	IEC 529 protection codes
<b>Train (External)</b>	
Wheel set	IP 66
Bogie	IP 66
Under frame	IP 66
Roof/Body	IP 66
<b>Train (Internal) - see Note below</b>	
Engine Room	IP 52
Equipment Room	IP 52
Drivers Cab	IP 52

<sup>6</sup> The manufacturer shall specify the performance of the Antenna unit and its maximum allowed debris.



INSTALLATION LOCATION	IEC 529 protection codes
Coach	IP 52
<b>Track (line side)</b>	
Rail mounted	IP 67
Sleeper mounted	IP 67
Beneath the sleeper (buried in track formation)	IP 67
Between the sleepers	IP 67
Outside the running rail	IP 67
<b>Track side</b>	
Non weather protected location case	IP 55
Weather protected location case	IP 51
Equipment room - no climate control	IP 51
Equipment room - with climate control	IP 51
Control Room (climate controlled)	IP 51
Control Room (no climate control)	IP 51
<b>Out door portable equipment</b>	IP 65

NOTE - These figures do not apply for the Trainborne Recording Unit. See Functional Requirements Specification - ERTMS Trainborne Recording Unit (Document Ref: 97e461) for details.

#### 2.7.4 Test requirements

Evidence of the ability of equipment to function correctly when subjected to pollution and contamination shall be provided on the basis of the following tests.

Equipment shall be fully functional at all times during the tests, unless otherwise stated.

Test specimens shall be tested in their production configuration without the use of external devices that have been added expressly for the purpose of passing the test. For example, corrosive resistant components shall not be used during testing, unless they are incorporated into the finished product.

In all instances performance tests shall be carried out prior to commencement of the environmental tests to ensure the item being tested is fully functional (i.e. it is not sub-standard or defective). If, upon conclusion of an environmental test, the equipment has failed and has to be modified, the associated performance and environmental tests shall be repeated. The manufacturer is responsible for developing and implementing a suitable performance test schedule. For cross-acceptance purposes these schedules shall be provided to the ERTMS Users Group.

Storage and transportation tests are detailed in Section 3.

The manufacturer shall provide a full report (to the ERTMS Users Group) on each of the tests carried out. This report shall include, but not be limited to:

- The design solutions used to fulfil the requirements.
- The performance test schedule.
- Test results.
- Any failures during testing.
- Modifications made during the testing programme.
- Any further tests which are considered necessary.
- Any unresolved problems.
- Confirmation that, in the opinion of the manufacturer, the equipment meets the requirements of this specification and those required by International Laws (e.g. EMC Regulations and CE certification).
- If, in the opinion of the manufacturer, the equipment does not meet the requirements of this specification or those required by International Laws, state why and what is required for approval.

Note that the test for checking resistance to impact by track ballast is included in Section 2.6 - Water and Precipitation as IEC 68.2.68.

#### 2.7.4.1 IEC 68.2.10 - Mould growth, test J

Installation location specific tests are required as follows:

Track side	Track (line side)	Train External	Train Internal	Outdoor portable
Mandatory except for climate controlled rooms	Mandatory	Mandatory	Engine and equipment rooms only	Mandatory

TEST	Duration etc.	Final measurements / Acceptance criteria
Test J	Variant 1 (28 days)	Equipment shall be fully functional both during and upon completion of the test (after recovery)

#### 2.7.4.2 IEC 68.2.42 - Sulphur dioxide test for contacts and connections, test Kc

This test is mandatory for all installation locations.

TEST	Duration etc.	Final measurements / Acceptance criteria
Test Kc	21 days	Equipment shall be fully functional upon completion of the test (after recovery)

#### 2.7.4.3 IEC 68.2.43 - Hydrogen sulphide test for contacts and connections, test Kd

This test is mandatory for all installation locations.

TEST	Duration etc.	Final measurements / Acceptance criteria
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Test Kd	21 days	Equipment shall be fully functional upon completion of the test (after recovery)
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#### 2.7.4.4 IEC 68.2.52 - Salt mist cyclic (sodium chloride), test Kb

Installation location specific tests are required as follows:

Track side	Track (line side)	Train External	Train Internal	Outdoor portable
Mandatory for location cabinets only	Mandatory	Mandatory	Engine and equipment rooms only	Mandatory

TEST	Duration etc.	Final measurements / Acceptance criteria
Test Kb	Severity 1	Equipment shall be fully functional upon completion of the test ( <b>not</b> to be washed)

#### 2.7.4.5 IEC 529 - Test for protection against solid foreign bodies (Section 13)

Installation location specific tests are required as follows:

Track side	Track (line side)	Train External	Train Internal	Outdoor portable
Mandatory	Mandatory	Mandatory	Mandatory	Mandatory

Tests shall be in accordance with the requirements of IEC 529 and the severities detailed in Table 8 on page 44. Alternatively, the use of IEC 68.2.68 sand and dust test (Test La1) can be specified. Railways shall state their preference.

## 2.8 MECHANICAL

### 2.8.1 Introduction

Trainborne and fixed ERTMS equipment will be subjected to severe mechanical stresses (vibration and shocks) during their entire working life and shall, therefore, be capable of surviving in this hostile environment.

Requirements have been derived from CENELEC standards 50125, 50155 and ORE research paper A118 Report No. 4.

### 2.8.2 Operational requirements

#### 2.8.2.1 Trainborne equipment

Trainborne equipment and its mountings shall be capable of withstanding without deterioration or malfunction all mechanical stresses that occur in service. Equipment shall be constructed to meet the following severities:

##### 2.8.2.1.1 Vibrations

ERTMS equipment and its mountings shall be designed to withstand the following continuous sinusoidal vibration stresses, in all the three major axis.

Installation location	Mass of equipment Kg	Frequency range Hz	Cross-over frequency Hz	Displacement amplitude below cross-over frequency mm	Acceleration amplitude above cross-over frequency m/s <sup>2</sup>
Underframe/body/roof - Directly mounted equipment	> 2000	1 - 35	8.2	0.75	2
	< 2000	5 - 100	7.1	1.5	3
Underframe/body/roof - Equipment in frames and boxes	> 30	5 - 150	8.2	1.5	4
	3 - 30		8.4	2.5	7
	0.3 - 3		8.7	5	15
	< 0.3		22.5	1.5	30
Bogie	No limit	5 - 100 *	8.3 *	7.5 *	20 *
On the wheelset	No limit	5 - 100	20.5	12	200

\* For frequencies above 22 Hz use the following values:

22 - 32 Hz displacement amplitude 1 mm

32 - 100 Hz acceleration amplitude 40 m/s<sup>2</sup>

**Table 13: Mechanical vibrations for trainborne equipment**

##### 2.8.2.1.2 Shock

ERTMS equipment and mountings shall be designed to withstand the following shock stresses.

Installation location	Peak value of amplitude / half sine duration *		
	Vertical	Transverse	Longitudinal
Underframe/body/roof - Directly mounted equipment	3g / 30 ms	3g / 30 ms	3g / 100 ms
Underframe/body/roof - Equipment in frames and boxes	3g / 30 ms	3g / 30 ms	5g / 30 ms
Bogie	30g / 18 ms	30g / 18 ms	30g / 18 ms
Wheelset	100g / 6 ms	100g / 6 ms	100g / 6 ms

\* half sine form in accordance with IEC 68.2.27 Test Ea

**Table 14: Mechanical shocks for trainborne equipment**

#### 2.8.2.1.3 Other acceleration forces

ERTMS trainborne equipment and mountings shall also be capable of functioning when subjected to tilting and centrifugal acceleration forces. The equivalent maximum values of transverse acceleration applied to the body of the vehicle shall be taken as  $4 \text{ m/s}^2$  (less than 50 ms duration) or  $2 \text{ m/s}^2$  when the duration exceeds 50 ms.

During traction and braking operations, ERTMS trainborne equipment shall be capable of functioning when subjected to longitudinal acceleration forces of  $7 \text{ m/s}^2$  with a duration higher than 50 ms.

#### 2.8.2.1.4 Trainborne Recording Unit - Catastrophic events

In the event of a catastrophic incident (e.g. derailment or collision) the Trainborne Recording Unit shall be capable of surviving the effects of substantial impact and acceleration forces. These requirements exceed the general operational requirements shown above. Further details of these requirements can be found in the Functional Requirements Specification - ERTMS Trainborne Recording Unit (Document Ref: 97e461).

### 2.8.2.2 Track (line side) and track side equipment

#### 2.8.2.2.1 Shock

ERTMS fixed equipment and mountings shall be designed to withstand the following severities of shock.

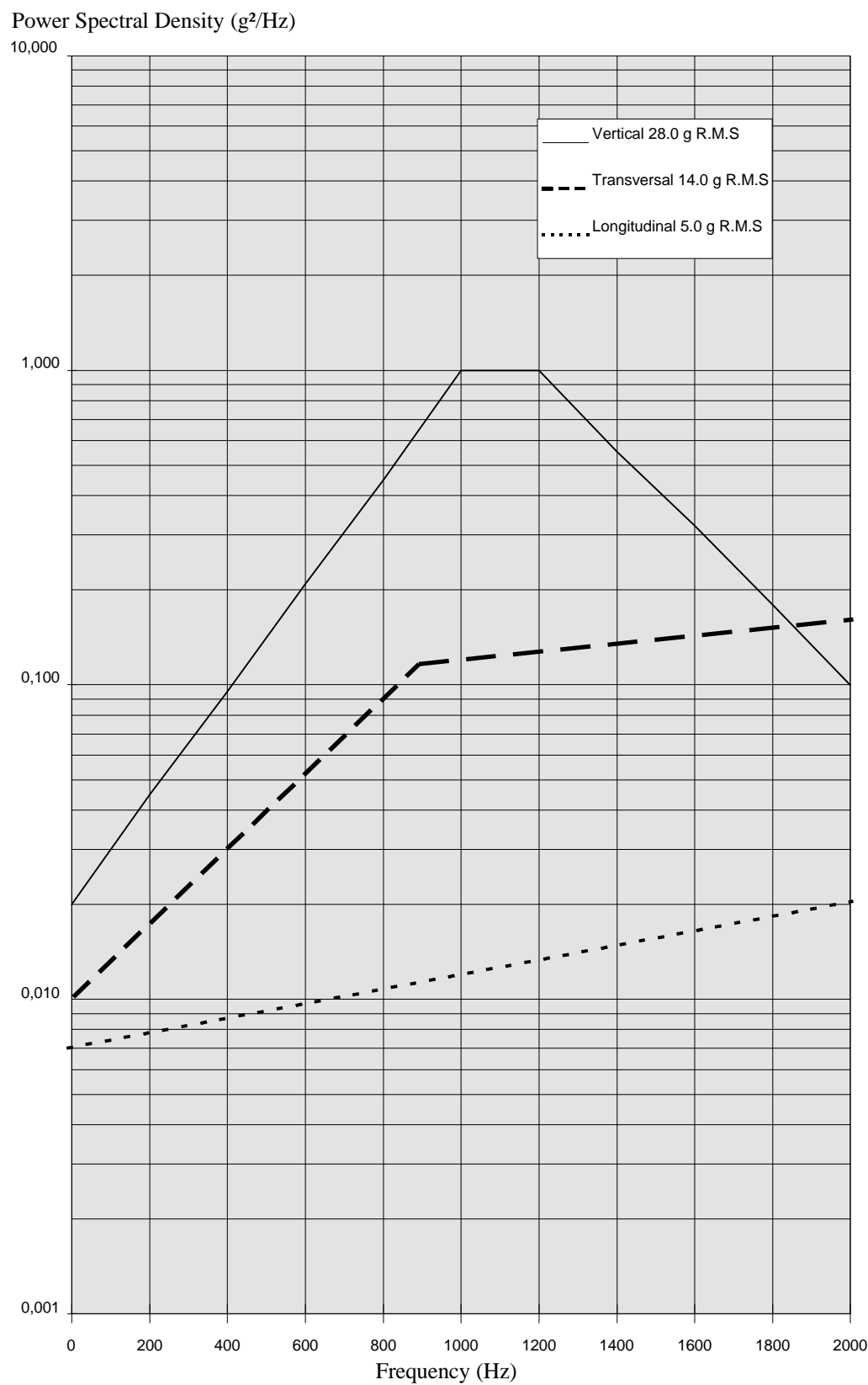
Installation location		Acceleration (g) *	
		Mean	Peak
Track (line side)	On the rail	42	250
	On sleeper	30	80
	On ballast	5	10
Track side (all locations)		2	2

\* Semi-sinusoidal shock, duration 11ms

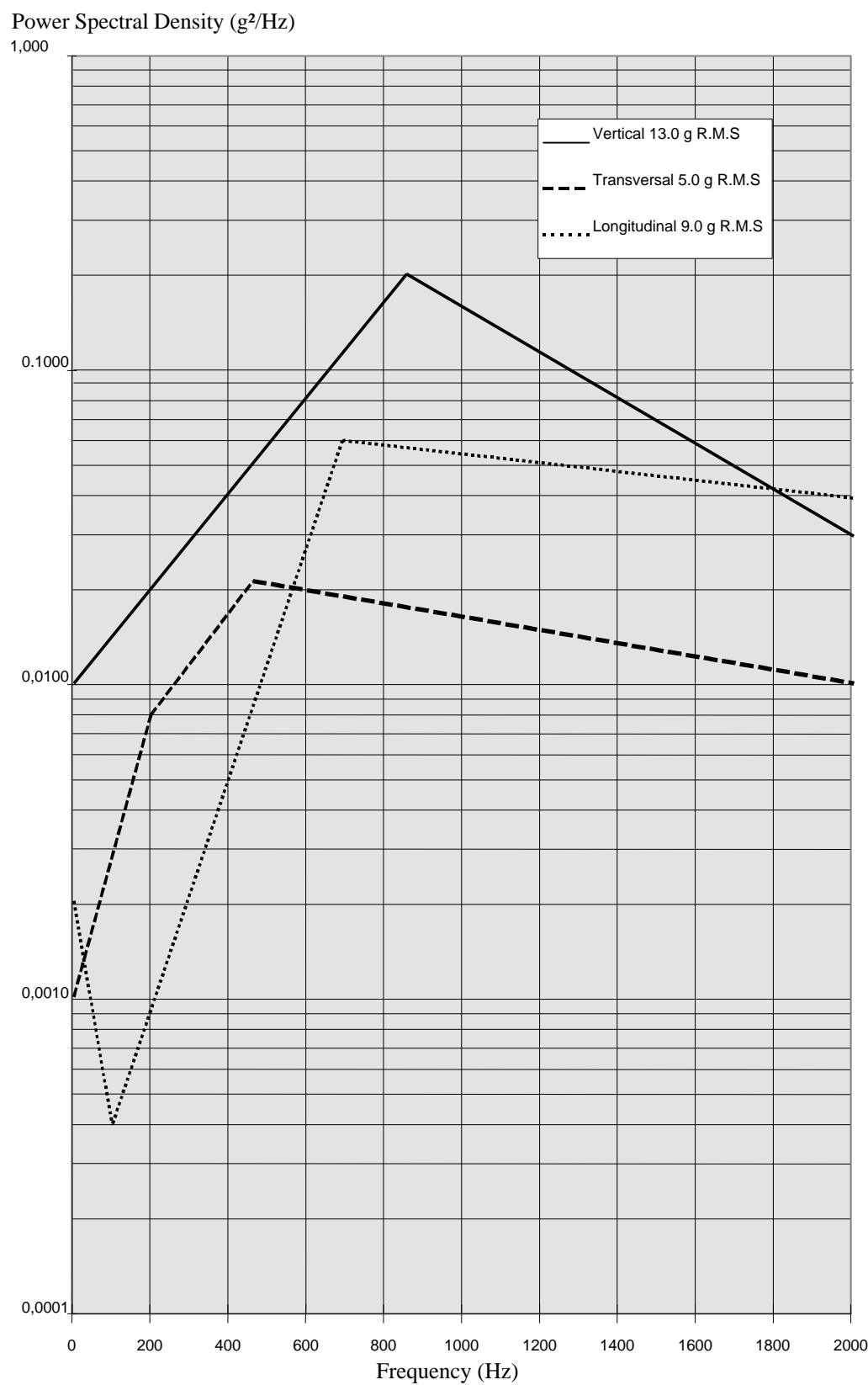
**Table 15: Mechanical shocks for track (lineside) and track side equipment**

#### 2.8.2.2.2 Vibration

ERTMS fixed equipment and mountings shall be capable of withstanding random vibrations with a power spectral density as shown in Figures 3 to 6 on the following pages.

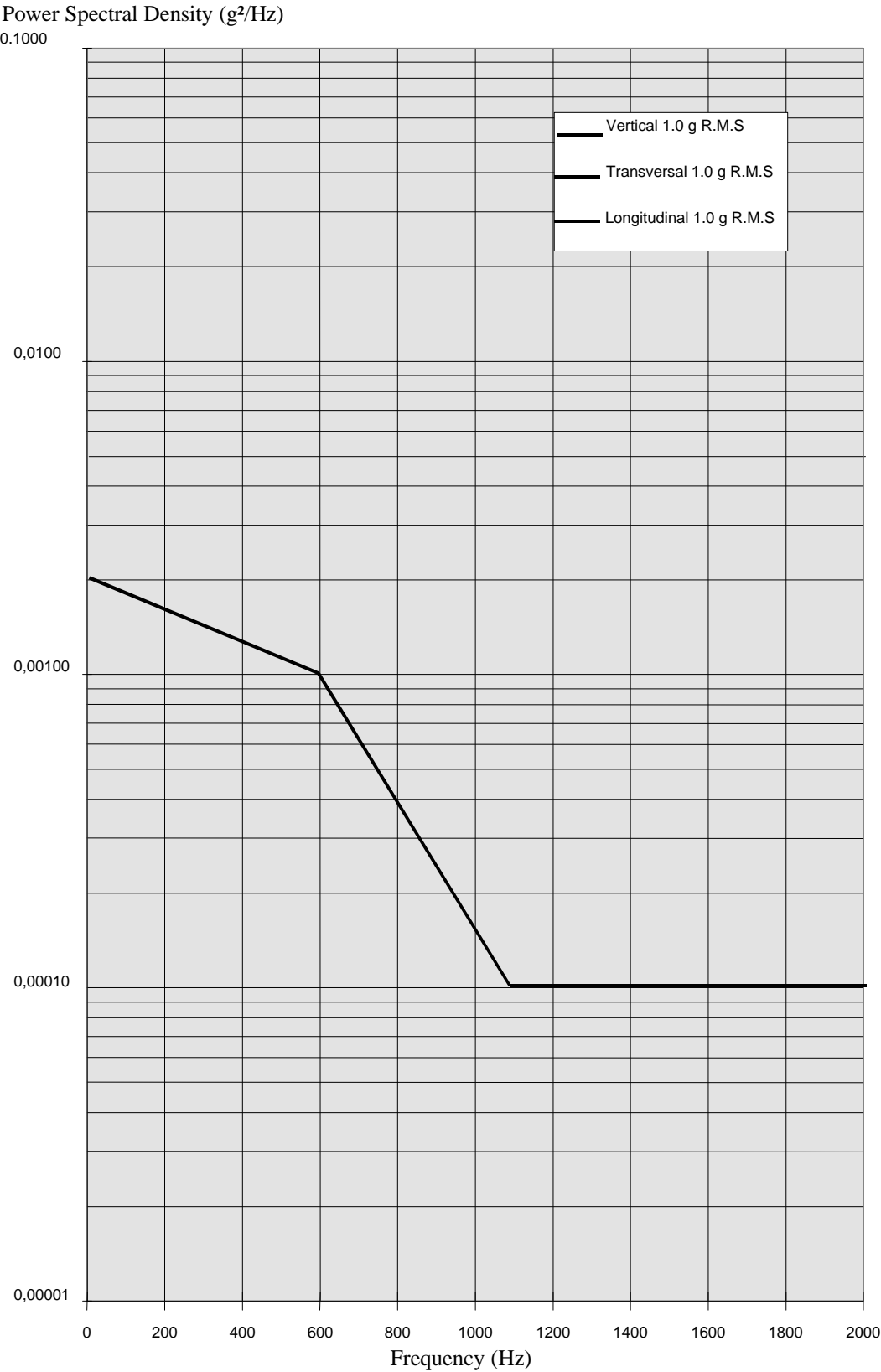


**Figure 3: Mechanical vibrations - Track (line side) Rail Mounted**

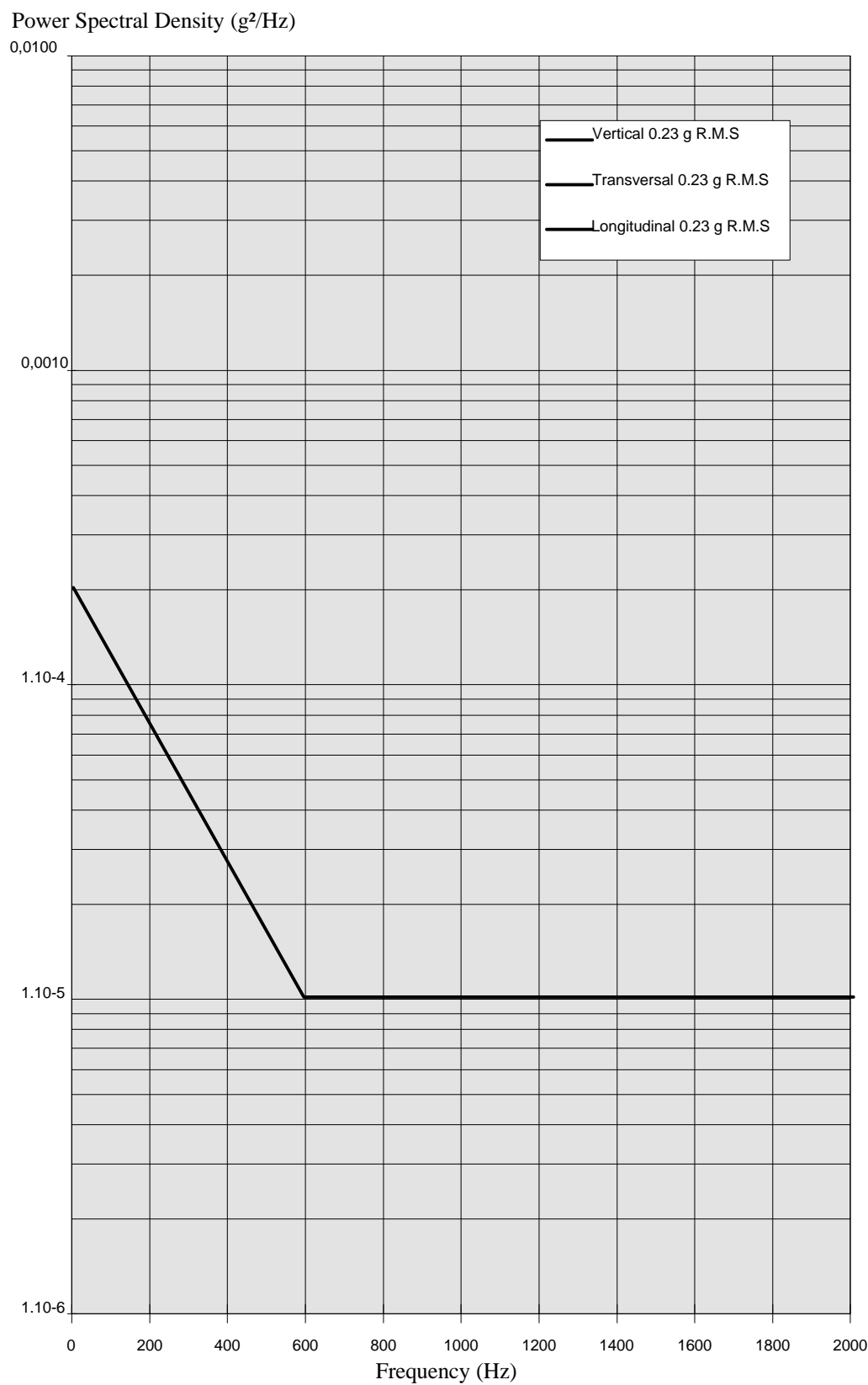


**Figure 4: Mechanical vibrations - Track (line side) Sleeper Mounted**





**Figure 5: Mechanical vibrations - Track (line side) On ballast**



**Figure 6: Mechanical vibrations - Track (line side) outside the running rail and all Track side installation locations**

### 2.8.3 Guidelines

The effect of vibrations and shocks can be reduced by the use of suitable dampers and equipment mountings. Any dampers or anti-vibration mountings shall, however, be integral with the equipment to prevent the unit being accidentally installed without them.

### 2.8.4 Test requirements

Location specific test methods for determining the suitability of a specimen shall, as a minimum, be as follows:

TEST	Track side	Track (line side)	Train External	Train Internal	Outdoor portable
EN 50155 Vibration, shock and bump test	x	x	<input type="checkbox"/>	<input type="checkbox"/>	x
IEC 68.2.27 Shock.	<input type="checkbox"/>	<input type="checkbox"/>	x	x	<input type="checkbox"/>
IEC 68.2.29 Bump.	<input type="checkbox"/>	<input type="checkbox"/>	x	x	<input type="checkbox"/>
IEC 68.2.62 Impact, pendulum hammer	x	<input type="checkbox"/>	<input type="checkbox"/>	x	x
IEC 68.2.64 Vibration - Broad-band random (digital control) and guidance	<input type="checkbox"/>	<input type="checkbox"/>	x	x	<input type="checkbox"/>
IEC 68.2.7 Acceleration, steady state.	x	x	<input type="checkbox"/>	<input type="checkbox"/>	x

**Table 16: Mechanical Tests**

#### NOTES

x denotes **not** mandatory. However, Railways may specify the test if they feel it is appropriate.

☐ denotes a mandatory test.

Railways may specify additional tests if they feel it is appropriate. Details of these tests shall be provided to the ERTMS Users Group.

In all instances performance tests shall be carried out prior to commencement of the environmental tests to ensure the item being tested is fully functional (i.e. it is not sub-standard or defective). If, upon conclusion of an environmental test, the equipment has failed and has to be modified, the associated performance and environmental tests shall be repeated. The manufacturer is responsible for developing and implementing a suitable performance test schedule. For cross-acceptance purposes these schedules shall be provided to the ERTMS Users Group.

The manufacturer shall provide a full report (to the ERTMS Users Group) on each of the tests carried out. This report shall include, but not be limited to:

- The design solutions used to fulfil the requirements.
- The performance test schedule.
- Test results.
- Any failures during testing.
- Modifications made during the testing programme.
- Any further tests which are considered necessary.
- Any unresolved problems.
- Confirmation that, in the opinion of the manufacturer, the equipment meets the requirements of this specification and those required by International Laws (e.g. EMC Regulations and CE certification).
- If, in the opinion of the manufacturer, the equipment does not meet the requirements of this specification or those required by International Laws, state why and what is required for approval.

#### 2.8.4.1 EN 50155 - Vibration, shock and bump test

All in accordance with the test procedures detailed in Section 10.2.11 of that publication, with the exception that shock severities and durations shall be in accordance with Table 14 and Section 2.8.2.1.3.

#### 2.8.4.2 IEC 68.2.27 - Shock, test Ea

TEST	Duration / Severities etc.	Final measurements / Acceptance criteria
Test Ea	In accordance with severities shown in Table 15 Actual mountings to be used Number of shocks per axis - 24	Equipment shall be fully functional both during and upon completion of the test.

#### 2.8.4.3 IEC 68.2.29 - Bump, test Eb

TEST	Duration / Severities etc.	Final measurements / Acceptance criteria
Test Eb	Pulse shape - semi-sinusoidal Peak acceleration: 2g (equipment and control rooms) 10g (on ballast) 80g (on sleeper) 250g (on rail) Pulse duration - 11 ms Directions - x, y and z Number of shocks per direction 4000 Actual mountings to be used NOTE - The above severities are non standard.	Equipment shall be fully functional both during and upon completion of the test.

**2.8.4.4 IEC 68.2.62 - Impact, pendulum hammer, test Ef**

See Section 2.6.4.2 for details of this test.

**2.8.4.5 IEC 68.2.64 - Vibration, broad band random (digital control), test Fh**

TEST	Duration / Severities etc.		Final measurements / Acceptance criteria
Test Fh	Track (line side)	Track side	Equipment shall be fully functional both during and upon completion of the test.
Initial and final vibration response investigations	Random excitation (method 2)	Random excitation (method 2)	
Vibration response investigation	Random excitation (method 2)	Random excitation (method 2)	
Frequency range	In accordance with Figures 3 to 6 as appropriate	In accordance with Figure 6	
Fixing points	Actual mountings to be used	Actual mountings to be used	
ASD level and shape	In accordance with Figures 3 to 6 as appropriate	In accordance with Figure 6	
Duration	300 minutes	100 minutes	
Pre-conditioning	Not required	Not required	
Method	2	2	
Multipoint control	Worse case (i.e. highest magnitude) check-point to be used for control	Worse case (i.e. highest magnitude) check-point to be used for control	
Axis and order of test	All 3 primary axis Order - Vertical, transverse, longitudinal	All 3 primary axis Order - Vertical, transverse, longitudinal	
Response points	A suitable number (greater than 3) to be determined by test engineer based on most likely sensitive points within the specimen	A suitable number (greater than 3) to be determined by test engineer based on most likely sensitive points within the specimen	
Multiple measurements of ASD	Every 10 minutes	Every 10 minutes	

**2.8.4.6 IEC 68.2.7 - Acceleration, steady state, test Ga**

TEST	Duration / Severities etc.	Final measurements / Acceptance criteria
Test Ga	Acceleration and Direction of acceleration - In accordance with Section 2.8.2.1.3	Equipment shall be fully functional both during and upon completion of the test.

## **2.9 ELECTRICAL (POWER SUPPLIES)**

### **2.9.1 Introduction**

Electrical requirements do not normally form part of an environmental specification. However, it has been included in this document because:

1. It is a mandatory requirement of the ERRI A200 FRS.
2. The ERRI A200 FRS is a mandatory input document for the whole ERTMS project.

### **2.9.2 Operational requirements**

Railways shall be responsible for providing suitable power supplies for ERTMS equipment that comply with the following requirements.

All ERTMS equipment shall operate without malfunction within the electrical parameters specified.

#### **2.9.2.1 Trainborne equipment**

ERTMS equipment and their associated power supplies, intended for use on board a train, shall comply in all respects with the electrical service conditions specified in CENELEC standard EN 50155 (sections 3.1 to 3.4 inclusive). In this respect equipment shall not malfunction if subjected to the following interruptions:

- Supply from an accumulator battery - 10 ms.
- Supply from alternative sources (accumulator battery/stabilised d.c. source) - 30 ms at supply change over.

#### **2.9.2.2 Track (line side) and track side equipment**

Owing to the large number of voltages and accompanying electrical tolerances used throughout Europe, it is acknowledged that mandatory requirements cannot currently be set for equipment located on or near the track. National railways shall, therefore, be responsible for specifying their own electrical requirements.

For cross-acceptance purposes these national railway specifications shall be provided to the ERTMS Users Group.

The specification must include nominal voltages, expected variations and disturbances, nominal frequencies and variations, permitted ripple, etc.

### **2.9.3 Guidelines**

#### **2.9.3.1 Trainborne equipment**

The minimum mandatory requirements of EN 50155 can be supplemented with specific national requirements if required. No reduction in these requirements will be permitted.

#### **2.9.3.2 Track (line side) and track side equipment**

Where it is possible, European Standards dealing with a.c. or d.c. power supply, such as IEC 60077, IEC 60038, IEC 60870-2-1, should be applied.

### **2.9.4 Tests requirements**

Due to the different electrical parameters and existing national test regimes that exist for each railway it is not possible to completely standardise electrical tests. Each railway shall, therefore, test ERTMS equipment in accordance with the minimum test requirements shown below, supplemented where necessary by their own national railway specifications. For cross-acceptance purposes these specifications shall be provided to the ERTMS Users Group.

The following general test requirements shall be complied with:

Test specimens shall be tested in their production configuration without the use of external devices that have been added expressly for the purpose of passing the test.

In all instances visual and performance tests shall be carried out prior to commencement of the electrical tests to ensure the item being tested is fully functional (i.e. it is not sub-standard or defective). If, upon conclusion of an electrical test, the equipment has failed and has to be modified, the associated visual, performance and electrical tests shall be repeated.

The railways/manufacturers are responsible for developing and implementing suitable visual and performance test schedules. For cross-acceptance purposes these schedules shall be provided to the ERTMS Users Group.

The manufacturer shall provide evidence of the equipment's ability to function correctly within the electrical parameters specified.

The manufacturer shall provide a full report (to the ERTMS Users Group) on each of the tests carried out. This report shall include, but not be limited to:

- The design solutions used to fulfil the requirements.
- The performance test schedule.
- Test results.
- Any failures during testing.
- Modifications made during the testing programme.
- Any further tests which are considered necessary.
- Any unresolved problems.
- Confirmation that, in the opinion of the manufacturer, the equipment meets the requirements of this specification and those required by International Laws (e.g. EMC Regulations and CE certification).
- If, in the opinion of the manufacturer, the equipment does not meet the requirements of this specification or those required by International Laws, state why and what is required for approval.

#### **2.9.4.1 Trainborne equipment tests**

Trainborne equipment electrical tests shall be carried out in accordance with CENELEC standard EN 50155, i.e:

- Visual test.
- Performance test, including (but not limited to):
  - Supply variations.
  - Supply interruptions.
- Supply related surge test.
- Transient burst susceptibility test.
- Insulation test.

#### **2.9.4.2 Fixed equipment tests**

Electrical tests for track (line side) and track side equipment shall be carried out in accordance with specific national railway specifications.

For cross-acceptance purposes these national railway specifications shall be provided to the ERTMS Users Group.



## **2.10 ELECTROMAGNETIC COMPATIBILITY (EMC)**

### **2.10.1 Introduction**

ERTMS equipment shall comply in all respects with CENELEC standard 50121, as detailed below:

- ENV 50121 - Part 1. Railway applications - Electromagnetic compatibility: General.
- ENV 50121 - Part 2. Railway applications - Electromagnetic compatibility: Emission of the whole railway system to the outside world.
- ENV 50121 - Part 3-1. Railway applications - Electromagnetic compatibility: Rolling stock - Train and complete vehicle.
- ENV 50121 - Part 3-2. Railway applications - Electromagnetic compatibility: Rolling stock - Apparatus.
- ENV 50121 - Part 4. Railway applications - Electromagnetic compatibility: Emission and immunity of the signalling and telecommunications apparatus.
- ENV 50121 - Part 5. Railway applications - Fixed power supply installations.

### **2.10.2 Operational requirements**

The location specific requirements are detailed in the following parts of CENELEC standard 50121:

- Trainborne equipment (including radio communications equipment). ENV 50121 - Part 3-2.. Railway applications - Electromagnetic compatibility: Rolling stock - Apparatus.
- Track and track side equipment (including radio communications equipment). ENV 50121 - Part 4. Standard for emission and immunity of the signalling and telecommunications apparatus.

With regard to immunity from electromagnetic disturbance of components, the limiting values laid down in ENV 50121-4 apply. Below the defined limits no disturbances of function are permitted.

The defined limits for electromagnetic compatibility are valid for all ERTMS equipment, installations, sub-systems and systems (e.g. Radio Block Centres and specific radio communications equipment such as the Balise). Furthermore, it shall be ensured that the equipment functions correctly when disturbance currents are caused by both traction units in normal operation and in the event of a failure.

Railways and manufacturers shall jointly develop an ERTMS specific EMC management plan taking into consideration the likely installation positions of ERTMS equipment on

different types of locomotive and at fixed installations. For cross-acceptance purposes these plans shall be provided to the ERTMS Users Group.

### 2.10.3 Guidelines

#### 2.10.3.1 Trainborne equipment

Emission and immunity limits for trainborne equipment depend upon the port and installation location. For the purposes of this specification, installation locations defined in ENV 50121-3-2 can be related as follows.

ERTMS Installation location	ENV 50121-3-2 equivalent (Table A1)
Train external (all locations)	1. Underframe and roof
Train internal:	
Engine room	2. Locomotive machine room
Equipment room	4. In electronics cubicle
Drivers cab	3. Drivers/Passenger cab
Coach	3. Drivers/Passenger cab

#### 2.10.3.2 Track (line side) and track side equipment

For the purposes of this specification the “Environments” detailed in ENV 50121.4 can be related to the ERTMS installation locations as follows:

ERTMS Installation location	ENV 50121-4 equivalent (Section 3.1)
Track (line side) - All locations	Trackside
Track side:	
In an exposed (non weather protected) location case	Trackside
In an enclosed (weather protected) location case	External
In an equipment room with climatic control (e.g. heating) In an equipment room without climatic control (e.g. heating) In a control room (climate controlled) In a control room (without climate controlled)	Internal

#### **2.10.4 Test requirements**

All ERTMS equipment shall be tested for both emissions and immunity in accordance with the appropriate procedures specified in the CENELEC 50121 set of standards.

Equipment shall be fully operational at all times during the tests, unless otherwise specified in the test standards.

Test specimens shall be tested in their production configuration without the use of external devices that have been added expressly for the purpose of passing the test.

In all instances performance tests shall be carried out prior to commencement of the EMC tests to ensure the item being tested is fully functional (i.e. it is not sub-standard or defective). If, upon conclusion of an EMC test, the equipment has failed and has to be modified, the associated performance and EMC tests shall be repeated. The manufacturer is responsible for developing and implementing a suitable performance test schedule.

For cross-acceptance purposes these test schedules shall be provided to the ERTMS Users Group.

ERTMS equipment shall meet the following Performance Criterion (immunity tests) and limits (emission tests):

- Trainborne equipment - Performance criterion and limits from ENV 50121-3-2.
- Track and track side - Performance criterion and limits from ENV 50121-4.

**IMPORTANT NOTE** - Where performance criteria A and B are specified in the above standards, no degradation of performance shall be allowed, i.e. the equipment shall remain fully functional either during the tests (performance criteria A) or after the tests (performance criteria B).

The manufacturer shall provide a full report (to the ERTMS Users Group) on each of the tests carried out. This report shall include, but not be limited to:

- The design solutions used to fulfil the requirements.
- The performance test schedule.
- Test results.
- Any failures during testing.
- Modifications made during the testing programme.

- Any further tests which are considered necessary.
- Any unresolved problems.
- Confirmation that, in the opinion of the manufacturer, the equipment meets the requirements of this specification and those required by International Laws (e.g. EMC Regulations and CE certification).
- If, in the opinion of the manufacturer, the equipment does not meet the requirements of this specification or those required by International Laws, state why and what is required for approval.

## **2.11 ERGONOMICS**

### **2.11.1 Introduction**

Illumination, noise and vibration are the three main factors concerning a driver's safety, health and comfort. The type of climate, solar radiation, amount of pollution, risk of and exposure to fire and possible contamination from chemical substances shall also be considered from an ergonomic point of view. These points shall also be considered for operatives of fixed equipment and maintainers of all ERTMS equipment.

The majority of this section comprises of guidelines as it is recognised that it is not always possible to dictate the ergonomic environment of existing accommodation or train drivers cabs. However, in an attempt to provide the most desirable working conditions for their staff, Railways should endeavour, where possible, to meet these guidelines.

Guidelines can be made mandatory if a Railway so desires. It is recommended that they are made mandatory for any new ERTMS purpose built buildings (e.g. Radio Block Centres). Note that national regulations on building control shall also be adhered to when designing new buildings.

Mandatory requirements are generally limited to the ergonomic environment within the drivers cab.

This section refers to two non specific installation locations, "General" and "MMI". These are defined as follows:

**General.** Buildings and cabinets in which ERTMS components are located or maintained and where personnel can work. The environment consequently has a direct influence on personal well being, e.g. In an Radio Block Centre, maintenance workshop, etc.

**MMI.** Specific to the ergonomic environment which exists in the drivers cab of a train.

## 2.11.2 General

### 2.11.2.1 Mandatory requirements

#### 2.11.2.1.1 Chemical substances

Certain airborne substances (Table 16) are known to cause cancer (i.e. carcinogens) and exposure to these substances shall be avoided at all times.

SUBSTANCE	EXAMPLE OF USE
Asbestos	Thermal insulation
Benzene (benzol)	Solvent
Chrome compounds	Pigment
Polycyclic hydrocarbons	Component of tar (diesel exhaust)
Vinylchloride	Raw material for PVC

**Table 17: Ergonomics - Examples of chemical substances that are known to produce cancer**

Certain substances which have a rapid toxic effect are covered by an internationally agreed list called the TLV-C or Threshold Limit Values - Ceiling list. These agreed values shall not be exceeded under any circumstances and the design of the ERTMS working environment shall reflect this. The TLV 8 hour (weighted) average concentration figure shall never be exceeded in any one 24 hour period.

If it is not possible to prevent the release of chemical substances, then harmful substances shall be extracted at source and released external to the work area, having paid due attention to the internationally agreed environmental laws on the emission of harmful substances into the air.

Indoor environments should be adequately ventilated even if no dangerous substances are present.

#### 2.11.2.1.2 Flammability and fire hazards - Fixed equipment

All ERTMS equipment shall be designed to:

- minimise the risk of a self igniting fire starting in an item of equipment through abnormal electrical phenomenon, such as overload, short circuit, defective contacts, premature thermal ageing, arcing, etc.
- resist failure when exposed to fire (induced ignition) through the use of flame resistant housings and connecting wires.
- minimise the release of smoke and noxious gases in the event of equipment being exposed to or catching on fire.

Railways shall clearly specify their own requirements which should, where possible, accord with internationally recognised standards. For cross-acceptance purposes these specifications shall be provided to the ERTMS Users Group.

### **2.11.2.2 Guidelines (General)**

#### **2.11.2.2.1 Fresh air**

The required volume of fresh air per person and the rate of air change depends on the degree to which the work is physically demanding. Table 18 provides details of the ERTMS recommendations.

NATURE OF WORK	VOLUME PER PERSON (m <sup>3</sup> )	FRESH AIR SUPPLY RATES (m <sup>3</sup> /hr)
Very light	10	30
Light	12	35
Moderate	15	50
Heavy	18	60

**Table 18: Ergonomics - Recommended rate of air change**

#### **2.11.2.2.2 Visual field**

The visual field in which personnel work can be divided into three zones. The task area, the immediate surroundings and the more wider environment. The requirements for their brightness are as follows:

##### *2.11.2.2.2.1 Light sources*

Light sources should be located relative to the workplace so as to prevent reflections, blinding and shadows.

- Whenever available, daylight should be used for general lighting.
- At VDU workstations, special care should be taken to prevent:
  - reflections on the screen.
  - large differences in light intensities between screen and background/surroundings.
  - dazzling sunlight.

2.11.2.2.2.2 *Light intensity*

The recommended light intensity for various tasks is shown below in Table 19.

USAGE	LIGHT INTENSITY (m <sup>2</sup> )	REMARKS
Orientation tasks	10 - 200 lux	Where visual aspect is unimportant - e.g. corridors of buildings, general activities in store rooms etc.
Normal activities	200 - 800 lux	Reading normal print, operating machines and carrying out maintenance
Special applications	800 - 3000 lux	Localised task lighting to compensate for shadows or reflections on the work surface

**Table 19: Ergonomics - Light intensity**

## NOTES

1. Small differences in light intensity should be avoided as this can make a room look too dull.
2. For readability (contrast and detail) the location height is of more importance than lighting level.

2.11.2.2.2.3 *Reflectance*

Recommended surface reflectance values and luminance ratios are given in Table 20 and Table 21 below.

SURFACE	REFLECTANCE
Ceiling	0.70 - 1.00 ("light")
Walls	0.40 - 0.60
Table tops	0.25 - 0.45
Floor	0.20 - 0.40 ("dark")

**Table 20: Ergonomics - Recommended values for the reflectance of various surfaces**

LUMINANCE RATIO	PERCEPTION IN THE TASK AREA
1	None
3	Moderate - <b>Recommended</b>
10	high
30	Too high
100	Far too high
300	Extremely unpleasant

**Table 21: Ergonomics- Luminance (contrast) ratios**



#### 2.11.2.2.3 Task area

The brightness of the task area should not:

- Be more than three times larger or smaller than that of the close surroundings.
- Differ from that of the close surroundings.
- Differ from that of the wider surroundings by more than a factor of ten.

#### 2.11.2.2.4 Vibration and shocks

Shocks and jolts often occur when equipment is vibrated. Shocks and jolts with peak intensities of more than three times higher than that of the average vibration level stress should be avoided as they will increase the total vibration.

Further requirements with respect to vibration and shock are contained in Section 2.8.

#### 2.11.2.2.5 Climate

Whether people find a climate pleasant depends very much on the individual. The aim, therefore, should be to allow people to control the climatic factors as far as possible themselves.

Table 22 provides recommended guidelines on air temperature for tasks requiring different levels of physical effort assuming that the air humidity is 30%, the air velocity is less than 0.1 m/s and that normal clothing is worn.

TYPE OF WORK	AIR TEMPERATURE (°C)
Seated, thinking task	18 - 24
Seated, light manual work	16 - 22
Standing, light manual work	15 - 21
Standing, heavy manual work	14 - 20
Heavy work	13 - 19

**Table 22: Ergonomics - Recommended air temperature for tasks requiring different levels of physical effort**

#### 2.11.2.2.6 Humidity

Humid or very dry conditions can affect thermal comfort, therefore a Relative Humidity (RH) in excess of 70% or less than 30% is to be avoided.

#### 2.11.2.2.7 Radiating surfaces

Hot and cold radiating surfaces (e.g. hot roofs and cold windows), should not differ from the air temperature by more than five degrees.

#### 2.11.2.2.8 Drafts

Drafts caused by ventilation etc., should not exceed 0.1 m/s. If this is unavoidable, then facilities should be available to increase the air temperature.

#### 2.11.2.2.9 Materials

Materials which will come into contact with the skin should be neither too cold (minimum temperature 5°C) nor too hot. Table 23 shows the maximum temperature allowed depending on the exposure duration and the type of material.

DURATION OF CONTACT	TYPE OF MATERIAL	MAXIMUM TEMPERATURE (°C)
Up to 1 min	metals	50
	glass, ceramics, concrete	55
	plastics (perspex, teflon), wood	60
Up to 10 min	All materials	48
Up to 8 hours	All materials	43

**Table 23: Ergonomics - Materials - maximum temperature**

### 2.11.3 MMI

#### 2.11.3.1 Mandatory requirements

For the purpose of this specification, the minimum MMI ergonomic requirement is that it shall meet the mandatory requirements of UIC Leaflet 651 OR.

The MMI ergonomic requirements that follow are based on the (realistic) assumption that the hardware of the MMI will consist of an information screen unit complete with touch screen facilities, a control unit and an audio unit.

The maximum allowable exposure for each of the ergonomic environmental factors is described below.

##### 2.11.3.1.1 Natural Lighting (day light)

As no specific requirements are deemed necessary for protecting the health of the driver from the effects of light, MMI environmental light requirements are mainly concerned with the driver's ability to complete a task (task effectiveness) and with the driver's comfort.

Cabs shall have built-in devices to enable crew members to protect themselves from being dazzled by sunlight or artificial lighting.

In all circumstances there shall be no direct radiation of the sun on the information screen. For existing cabs this requirement can mean that some (side) windows will have to be fitted with blinds (see Guidelines for alternative solutions).

Sunlight shall be prevented from reflecting on internal cab surfaces by the use of diffuse reflecting (not flat, not shiny, not polished, not glossy) materials for the surfaces.

The lowest reflection grades (as allowed by UIC Leaflet 651 OR), are 0.3 for doors and walls, 0.15 for the floor, 0.5 for the roof and 0.3 for the surface of the (built-in) driver's desk around the screen.

#### 2.11.3.1.2 Artificial lighting within the driver's cab

Direct beaming of light from internal cab lighting systems onto the information screen shall be prevented by use of blinds, mirror systems or positioning.

After the cab's general lighting has been switched off, there should remain sufficient light in the driver's cab for the crew to find their way around the cab. Generally, the lighting from instruments is considered adequate for this purpose.

All indicator lights shall be designed so that they can be read, without error, either using natural or artificial incidental lighting. In addition, they shall not cause reflections on the windows of the driver's cab when staff are in their normal working position.

The non-dazzle lighting of instruments and of the MMI shall be independent of the general lighting and shall be progressively adjustable. Adjustment is not obligatory for the speed-indicator lighting.

When additional lamps are provided (e.g. a lamp for the second man), these shall not dazzle the driver.

#### 2.11.3.1.3 Noise

For the driver's comfort, the noise levels inside the cabs should be as low as possible. This can be achieved by limiting the noise at source (e.g. engine, wheel/rail contact, aerodynamic noise) and (next best) by measures directed to the acoustic isolation of the cab.

Sound levels (at a maximum speed of 300 km/h and with closed windows) shall comply with the requirements of UIC Leaflet no 651 OR as shown Table 24 over.

	<b>SOUND LEVEL (MANDATORY)</b>	<b>SOUND LEVEL (RECOMMENDED)</b>
Free track	78 dB(A)	75 dB(A)
Tunnels	83 dB(A)	80 dB(A)

**Table 24: Ergonomics - Mandatory and required sound levels**

In accordance with the requirements of UIC leaflet no 651 OR, sound levels for running secondary machines (with closed windows) shall not exceed 68 dB(A).

Compliance with UIC leaflet no 651 OR [i.e. sound level with maximum speed (300 km/h) on the free track, 78 dB(A) as obligation and 75 dB(A) as target (83 dB(A) and 80 dB(A) for tunnels respectively) and 68 dB(A) for running secondary machines (all with closed windows)] will, in general, guarantee the required health protection.

The  $L_{e.g.}$  equivalent continuous noise level measured over 30 minutes shall not exceed 78 dB (A) in the driver's cabs of motive power units running at speeds of < 160 km/h. When higher speeds are involved, every effort shall be made to keep the noise level to 78 dB (A).

Measurements shall be effected under the following conditions:

- the doors and windows shall be closed.
- the track shall be in good running order with track characteristics specified by the owner-Railway.
- the hauled loads shall be equal to at least two-thirds of the maximum permissible value.
- the maximum speed shall be maintained for at least 90% of measurement time.

The measurement shall be made level with the driver's ear (in the seated position), in the centre of the horizontal plane stretching from the front window panes to the rear wall of cabs.

Audio signals originating from the audio unit shall comply with the requirements set forward in ISO 7731, namely:

- The signal/noise ratio shall be at least + 15 dB(A) when there is no frequency-orientated information available.
- For an audio system with fixed output levels this will mean a level of at least 98 dB(A) (83 + 15) for the probable worst case situation (e.g. driving at maximum speed in a tunnel).
- The audio unit shall also comply with the other requirements for the danger/safety signals as stated in ISO 7731 (i.e. minimum level of 65 dB(A), minimum duration of 2 seconds), in the 300 - 3000 Hz range, pulse repetition between 0.2 and 5 Hz, smart usage of the temporal pattern or modulation.

High frequency sounds from electronic parts (peeps, wheezy sounds etc.) in the frequency range 8000 Hz to 20,000 Hz shall be eliminated.

#### 2.11.3.1.4 Equipment design

All equipment shall be designed in such a manner that maintenance and/or repair tasks can be achieved in a safe and healthy manner, and without being physically unacceptable to the worker.

#### 2.11.3.1.5 Hand vibration

The equipment shall be designed to minimise the affect of hand vibrations when using the MMI and associated hand controls.

#### 2.11.3.1.6 Flammability and fire hazards - Trainborne equipment

All ERTMS equipment shall be designed to:

- minimise the risk of a self igniting fire starting in an item of equipment through abnormal electrical phenomenon, such as overload, short circuit, defective contacts, premature thermal ageing, arcing, etc.

- resist failure when exposed to induced fires through the use of flame resistant housings and wires.
- minimise the release of smoke and noxious gases in the event of equipment being exposed to or catching on fire.

Railways shall clearly specify their own requirements which should, where possible, accord with internationally recognised standards. For cross-acceptance purposes these specifications shall be provided to the ERTMS Users Group.

### **2.11.3.2 Guidelines (MMI)**

#### **2.11.3.2.1 Noise**

Different types of locomotive have different ambient noise levels within their driving cabs. Consequently, it is not possible to specify a single mandatory output level for the ERTMS audible warning equipment. It is strongly recommended therefore, that the audible warning device is designed to have an automatically adjusting sound output which can adapt to surrounding ambient noise levels. This will ensure that the output volume is always greater than 15 db.

#### **2.11.3.2.2 Natural lighting (day light)**

Side window panes should be constructed from dark tinted glass with a maximum light transmission factor of 60% (0.6). The use of light absorbing foils on the inside windows with a maximum light transmission factor of 35% (0.35) is preferable.

Front windows should be constructed of light-tinted glass with a light transmission factor of 80% (0.80). Where possible, there shall be no colour distortion of outside signals.

Alternatively, front windows could use an adjustable (light-reducing) screen, blinds or other devices - such as a two layer screen [i.e. one (standard) layer with no colour distortion for driving on direct sight, and one extra dark tinted (with some colour distortion) for driving on screen signals].

#### **2.11.3.2.3 Artificial lighting within the driver's cab**

It is recommended that the driver's cab incorporates a general lighting scheme guaranteeing 60 lux continuously at the level of the driver's desk.

#### **2.11.3.2.4 Vibration**

The driver should be exposed to no more than an average level of the vibration amplitude (weighted and summed over three orthogonal directions) of no more than 0.7 m/s<sup>2</sup> and preferably less than 0.5 m/s<sup>2</sup>.

#### **2.11.3.2.5 Air-conditioning facilities (in driver's cabs)**

It is recommended that air-conditioning equipment shall be installed in vehicles which are frequently operated in regions with an ambient temperatures above 30 °C and/or high

humidity levels. The rating of this system shall be designed so that the following temperatures are maintained in driver's cabs :

$$t_{\text{int}} = 20 + 0.5(t_{\text{ext}} - 20) \text{ in } ^\circ\text{C} \qquad t_{\text{ext}} = > 20 ^\circ\text{C}$$

whilst ensuring a flow of fresh air into the cab of at least 30 m<sup>3</sup> per hour.

where  $t_{\text{int}}$  = internal temperature of the cab and  $t_{\text{ext}}$  = the external air temperature.

In case of failure of the air-conditioning system, adequate ventilation of the driver's cab shall be provided.

#### 2.11.3.2.6 Information screen

The information screen itself should:

- have a maximum reflectance grade of no more than 0.02, preferably lower ( $\pm 0.005$ ), by the use of a  $\frac{1}{4}\lambda$  coating.

#### 2.11.3.2.7 General ergonomic guidelines

- The volume of air inside the driver's cab should be at least 10 m<sup>3</sup>.
- Driver's cabs should be fully enclosed on all sides.
- The doors, windows, pipe-runs and cable-runs, inspection traps and any ventilation flaps should be sealed against liquids, exhaust-gases and draughts.
- A slight over-pressure in the driver's cab is desirable.
- Driving crews should be protected against sudden and major air-pressure fluctuations that might occur - especially at high speeds - when passing other trains and/or travelling through tunnels.
- The driver's cab, and particularly the floor and roof, should be provided with heat insulation.
- Exhaust systems should be designed so that exhaust gas is not able to be recycled through the ventilation circuit.
- The available air volume may be reduced if there exists effective ventilation or air-conditioning.

#### 2.11.3.2.8 Heating

The driver should be able to regulate the temperature at will within the range 18-23 °C (measured 1.5 m above floor level around the seats). The difference in temperature between the upper and lower zones of the driver's cab should not exceed 10 °C (measured 10 cm above floor level and 10 cm below the ceiling).

When outside temperatures are low, a reduced temperature range is permissible. Heating power should, however, be designed to obtain at least 18 °C.

With the heating switched on, the installation should be capable of supplying an external airflow of at least 30 m<sup>3</sup> per hour, per person.

#### 2.11.3.2.9 Ventilation

The ventilation system should be designed to ensure that at least 30 m<sup>3</sup> per hour, per person is blown into the cab without causing unpleasant draughts. The driver should be able to adjust the airflow.

Under normal conditions of ventilation, the air velocity should not exceed 0.3 m/sec, level with the driver's head.

In order to ensure rapid evacuation of accumulated heat, the ventilation system should be designed to enable the external airflow to be increased by the driver to at least 300 m<sup>3</sup> per hour.

#### 2.11.3.2.10 Colours and surface coatings

The colour scheme used for the interior of driver's cabs should harmonise as much as possible, and not cause eyestrain.

Paint and surface coatings should not reflect light in a way that might inconvenience the crew.

Mid-grey is preferred as the basic colour for all MMI.

Components of the driver's cab, with which hands or legs come in contact continuously or repeatedly, shall not induce a "cold metal" sensation. These components should be coated with material which is pleasant to touch, or provided with surface heating.

### 2.11.4 Test requirements

It is acknowledged that changes to the existing environmental conditions within a driving cab cannot be enforced. Consequently, there is no need to test the environment within the drivers cab. However, it is necessary to prove that ERTMS equipment, intended for installation in the cab, is capable of performing within the existing environment.

All ERTMS equipment shall be tested in accordance with the standards listed in other parts of this ERTMS Environmental Specification (e.g. vibration). The following additional tests shall also be performed.

- **ISO 7731 Auditory danger signals.**

Acoustic measurements shall be taken in the drivers cab to ensure that the audible warning signal is at least 15 db above that of the ambient noise within the cab.

Measurements shall be effected under the following conditions:

- the doors and windows shall be closed.
- the track shall be in good running order with track characteristics specified by the Railway.
- the hauled loads shall be equal to at least two-thirds of the maximum permissible value.
- the maximum line speed shall be maintained for at least 90% of measurement time.

The measurement shall be made level with the driver's ear (in the seated position), in the centre of the horizontal surface stretching from the front window panes to the rear wall of cabs.

- **IEC 695 Fire hazard testing**

It is not possible to specify general fire tests as these will depend upon installation location and the physical properties of the equipment. Consequently, manufacturers shall assess each item of equipment in accordance with the guidelines of IEC 695 and carry out suitable tests to prove resistance to both self igniting and induced fires. For cross-acceptance purposes these assessments shall be provided to the ERTMS Users Group. Particular attention shall be given to testing for fire resistance, self ignition and toxicity/density of smoke emissions.

The manufacturer shall provide a full report (to the ERTMS Users Group) on each of the tests carried out. This report shall include, but not be limited to:

- The design solutions used to fulfil the requirements.
- The performance test schedule.
- Test results.
- Any failures during testing.
- Modifications made during the testing programme.
- Any further tests which are considered necessary.
- Any unresolved problems.
- Confirmation that, in the opinion of the manufacturer, the equipment meets the requirements of this specification and those required by International Laws (e.g. EMC Regulations and CE certification).
- If, in the opinion of the manufacturer, the equipment does not meet the requirements of this specification or those required by International Laws, state why and what is required for approval.



### 3. TRANSPORTATION AND STORAGE

#### 3.1 INTRODUCTION

The environmental severities associated with the transportation and storage of ERTMS equipment can, in some instances, exceed those that exist in their operational state.

#### 3.2 OPERATIONAL REQUIREMENTS

##### 3.2.1 Transport

When being transported, packaged ERTMS equipment shall be capable of resisting the following IEC 721 severity classifications.

Environmental Condition	IEC 721 Classification
Climatic	2K5L
Biological	2B2
Chemically Active Substances	2C2
Mechanically Active Substances	2S2
Mechanical	2M2

**Table 25: Transportation**

##### 3.2.2 Storage

Environmental severities during storage are the same as those for transportation, with the exception that climatic conditions shall be to the following IEC 721 classifications:

Storage environment	IEC 721 Classification
Robust equipment stored in non-weather protected storage facilities (e.g. balise stored in outdoor compounds)	1K9, 1Z1, 1Z4 & 1Z5
Sensitive equipment stored in weather protected (but <b>not</b> climate controlled) storage facilities (e.g. MMI stored in warehouses and sheds)	1K4 & 1Z5

**Table 26: Storage**

Note - No provision has been made for storage in climate controlled facilities as this form of storage may not be available in all countries and, consequently, cannot be made mandatory.

### 3.3 TEST REQUIREMENTS

Evidence of the ability of equipment to function correctly when in storage or being transported shall be provided on the basis of the following tests.

Test specimens shall be tested in their production configuration without the use of external devices that have been added expressly for the purpose of passing the test.

In all instances performance tests shall be carried out prior to commencement of the environmental tests to ensure the item being tested is fully functional (i.e. it is not sub-standard or defective). If, upon conclusion of an environmental test, the equipment has failed and has to be modified, the associated performance and environmental tests shall be repeated. The manufacturer is responsible for developing and implementing a suitable performance test schedule. For cross-acceptance purposes these schedules shall be provided to the ERTMS Users Group.

Mandatory test methods for determining the suitability of a specimen for storage and transportation shall be as follows. These tests are applicable to all installation locations.

TEST
IEC 68.2.31 Drop and topple.
IEC 68.2.32 Freefall.
IEC 68.2.48 Basic environmental testing procedures. Test to simulate the effects of storage.
IEC 68.2.50 Combined cold/sinusoidal vibration.

**Table 27: Storage and Transportation Tests**

The manufacturer shall provide a full report (to the ERTMS Users Group) on each of the tests carried out. This report shall include, but not be limited to:

- The design solutions used to fulfil the requirements.
- The performance test schedule.
- Test results.
- Any failures during testing.
- Modifications made during the testing programme.
- Any further tests which are considered necessary.
- Any unresolved problems.
- Confirmation that, in the opinion of the manufacturer, the equipment meets the requirements of this specification and those required by International Laws (e.g. EMC Regulations and CE certification).

- If, in the opinion of the manufacturer, the equipment does not meet the requirements of this specification or those required by International Laws, state why and what is required for approval.

### 3.3.1 Tests

#### 3.3.1.1 IEC 68.2.31 - Drop and topple, test Ec

TEST	Duration / Severities etc.	Final measurements / Acceptance criteria
Test Ec	Drop height - 100 mm	Equipment shall be fully functional upon completion of the test.

#### 3.3.1.2 IEC 68.2.32 - Freefall, test Ed

TEST	Duration / Severities etc.	Final measurements / Acceptance criteria
Test Ed	Procedure - 1 Height of fall - 100 mm	Equipment shall be fully functional upon completion of the test.

#### 3.3.1.3 IEC 68.2.48 - Test to simulate the effects of storage

Duration / Severities etc.	Final measurements / Acceptance criteria
<p>NOTE - Only temperature and humidity have been considered when specifying this test. Railways may wish to enlarge on the parameters.</p> <p>1. Cold test - in accordance with IEC 68.2.1 - Test Aa Temperature - lowest temp. taken from Table 26 Duration - 4 days</p> <p>2. Damp heat test - in accordance with IEC 68.2.3 - Test Ca Duration - 56 days</p>	<p>Cold test - Equipment shall be fully functional upon completion of the test (i.e. after recovery back to room temperature)</p> <p>Damp heat test - Equipment shall be fully functional upon completion of the test (i.e. after recovery back to room temperature)</p> <p>For both tests observations shall be taken on the physical condition of the equipment after completion of the tests.</p>

#### 3.3.1.4 IEC 68.2.50 Combined cold/sinusoidal vibration, test Z/AFc

TEST	Duration / Severities etc.	Final measurements / Acceptance criteria
Test Z/AFc	<p>Temperature - In accordance with lowest IEC classification stated in Sections 3.2.1 or 3.2.2</p> <p>Vibration - In accordance with the most severe IEC classifications stated in Sections 3.2.1 or 3.2.2</p> <p>Rate of change of temp - Test Ab</p> <p>Actual mountings to be used.</p> <p>Endurance by sweeping</p> <p>No. of sweep cycles - 100</p> <p>Axis of vibration - x, y and z</p>	Equipment shall be fully functional upon completion of the test.

<b>ANNEX A - Summary of IEC 721 Classifications</b>
---

A summary of the IEC 721 classifications follows. Note however, that variations and combinations of these classifications can be found within the standard. Consequently, these tables should be considered as a guide and not as a substitute for the complete standard.

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## IEC 721 GUIDANCE NOTES

## Storage

## CLIMATIC CONDITIONS

Environmental Parameter	Unit	Classification										
		1K1	1K2	1K3	1K4	1K5	1K6	1K7	1K8	1K9	1K10	1K11
Low temp. air	°C	+20	+5	-5	-25	-40	-55	-20	-33	-65	+5	-20
High temp. air	°C	+25	+40	+45	+55	+70	+70	+35	+40	+55	+40	+55
Low relative humidity	%	20	5	5	10	10	10	20	15	4	30	4
High relative humidity	%	75	85	95	100	100	100	100	100	100	100	100
Low absolute humidity	g/m <sup>3</sup>	4	1	1	0.5	0.1	0.02	0.9	0.26	0.003	6	0.9
High absolute humidity	g/m <sup>3</sup>	15	25	29	29	35	35	22	25	36	36	27
Rate of change of temperature	°C/min	0.1	0.5	0.5	0.5	1.0	1.0	0.5	0.5	0.5	0.5	0.5
Low air pressure	kPa	70	70	70	70	70	70	70	70	70	70	70
High air pressure	kPa	106	106	106	106	106	106	106	106	106	106	106
Solar Radiation	W/m <sup>2</sup>	500	700	700	1120	1120	1120	1120	1120	1120	1120	1120
Heat radiation	None	No	A suitable severity should be chosen from the Special Climatic Conditions shown on the following table.									
Movement of surrounding air	m/s	0.5	1.0	1.0	1.0	5.0	5.0	A suitable severity should be chosen from the Special Climatic Conditions shown on the following table.			50	50
Condensation	None	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Precipitation	None	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rain intensity	mm/min	None	None	None	None	None	None	6	6	15	15	15
Low rain temperature	°C	None	None	None	None	None	None	+5	+5	+5	+5	+5
Water from other sources other than rain	None	No	No	A suitable severity should be chosen from the Special Climatic Conditions shown on the following table.								
Ice and frost formation	None	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes

**IEC 721 GUIDANCE NOTES****Storage****SPECIAL CLIMATIC CONDITIONS**

Environmental Parameter	Class	Unit	Special condition Z
Heat radiation	1Z1	None	Negligible
	1Z2	None	Conditions of heat radiation e.g. near room heating systems
Movement of surrounding air	1Z3	m/s	30
	1Z4	m/s	50
Water from sources other than rain	1Z5	None	Dripping water
	1Z6	None	Water jets
	1Z7	None	Water waves

**BIOLOGICAL CONDITIONS**

Environmental Parameter	Unit	Classification		
		1B1	1B2	1B3
Flora	None	Negligible	Presence of mould, fungus, etc	Presence of mould, fungus, etc
Fauna	None	Negligible	Presence of rodents or other animals harmful to products. Excludes termites	Presence of rodents or other animals harmful to products. Including termites

## IEC 721 GUIDANCE NOTES

## Storage

## CHEMICALLY ACTIVE SUBSTANCES

Environmental Parameter	Unit	Classification					
		1C1L	1C1	1C2		1C3	
		Max	Max	Mean	Max	Mean	Max
Sea and road salt	None	No	No	Salt mist			
Sulphur dioxide	mg/m <sup>3</sup> cm <sup>3</sup> /m <sup>3</sup>	0.1 0.037	0.1 0.037	0.3 0.11	1.0 0.37	5.0 1.85	10 3.7
Hydrogen sulphide	mg/m <sup>3</sup> cm <sup>3</sup> /m <sup>3</sup>	0.01 0.0071	0.01 0.0071	0.1 0.071	0.5 0.36	3.0 2.1	10 7.1
Chlorine	mg/m <sup>3</sup> cm <sup>3</sup> /m <sup>3</sup>	0.01 0.0034	0.1 0.034	0.1 0.034	0.3 0.1	0.3 0.1	1 0.34
Hydrogen chloride	mg/m <sup>3</sup> cm <sup>3</sup> /m <sup>3</sup>	0.01 0.0066	0.1 0.066	0.1 0.066	0.5 0.33	1.0 0.66	5.0 3.3
Hydrogen flouride	mg/m <sup>3</sup> cm <sup>3</sup> /m <sup>3</sup>	0.003 0.0036	0.003 0.0036	0.1 0.012	0.03 0.036	0.1 0.12	2.0 2.4
Ammonia	mg/m <sup>3</sup> cm <sup>3</sup> /m <sup>3</sup>	0.3 0.42	0.3 0.42	1.0 1.4	3.0 4.2	10 14	35 49
Ozone	mg/m <sup>3</sup> cm <sup>3</sup> /m <sup>3</sup>	0.01 0.005	0.01 0.005	0.05 0.025	0.1 0.05	0.1 0.05	0.3 0.15
Nitrogen oxides (expressed in equivalent values of nitrogen dioxides)	mg/m <sup>3</sup> cm <sup>3</sup> /m <sup>3</sup>	0.1 0.052	0.1 0.052	0.5 0.26	1.0 0.52	3.0 1.56	9.0 4.68

## MECHANICALLY ACTIVE SUBSTANCES

Environmental Parameter	Unit	Classification			
		1S1	1S2	1S3	1S4
Sand	g/m <sup>3</sup> of air	None	30	300	1000
Dust suspension	mg/m <sup>3</sup>	0.01	0.2	5.0	15
Dust sedimentation	mg/(m <sup>2</sup> .h)	0.4	1.5	20	40

## IEC 721 GUIDANCE NOTES

## Storage

## MECHANICAL CONDITIONS

Environmental Parameter	Unit	Classification							
		1M1		1M2		1M3		1M4	
<i>Stationary sinusoidal vibration</i>									
Displacement amplitude	mm	0.3		1.5		3.0		7.0	
acceleration amplitude	m/s <sup>2</sup>		1		5		1.0		20
frequency range	Hz	2-9	9-200	2-9	9-200	2-9	9-200	2-9	9-200
<i>Non stationary vibration including shock</i>									
Shock response spectrum type L peak acceleration $\hat{a}$	m/s <sup>2</sup>	40		40		No		No	
Shock response spectrum type I peak acceleration $\hat{a}$	m/s <sup>2</sup>	No		No		100		No	
Shock response spectrum type II peak acceleration $\hat{a}$	m/s <sup>2</sup>	No		No		No		250	
<i>Static load</i>	kPa	5		5		5		5	



## IEC 721 GUIDANCE NOTES

## Transportation

## CLIMATIC CONDITIONS

Environmental Parameter	Unit	Classification								
		2K1	2K2	2K3	2K4	2K5	2K5H	2K5L	2K6	2K7
Low temp. air	°C	+5	-25	-25	-40	-65	-25	-65	+5	-20
High temp. air in unventilated enclosures	°C	No	+60	+70	+70	+85	+85	+70	+70	+85
High temp. air in ventilated enclosures or outdoor air	°C	+40	+40	+40	+40	+55	+55	+40	+40	+55
Change of temp. Air to air	°C	No	-25/+25	-25/+30	-40/+30	-65/+30	-25/+30	-65/+30	+5/+30	-20/+30
Change of temp. Air to water	°C	No	No	+40/+5	+40/+5	+55/+5	+55/+5	+40/+5	+40/+5	+55/+5
Relative humidity, not combined with rapid temp changes	%	75	75	95	95	95	95	95	95	95
	°C	+30	+30	+40	+40	+50	+50	+45	+45	+50
Relative humidity, combined with rapid temp changes: air/air at high relative humidity	%	No	No	95	95	95	95	95	95	95
	°C	No	No	-25/+30	-40/+30	-65/+0	-25/+30	-65/+30	+5/+30	-20/+30
Absolute humidity, combined with rapid temp changes: air/air at high water content	g/m <sup>3</sup>	No	No	60	60	80	80	60	60	80
	°C	No	No	+70/+15	+70/+15	+85/+15	+85/+15	+70/+15	+70/+15	+85/+15
Low air pressure	kPa	70	70	70	70	30	30	30	30	30
Change of air pressure	kPa/min	No	No	No	No	6	6	6	6	6
Movement of surrounding air	m/s	No	No	20	20	30	30	30	30	30
Precipitation	mm/min	No	No	6	6	15	15	6	15	15
Radiation, solar	W/m <sup>2</sup>	700	700	1120	1120	1120	1120	1120	1120	1120
Radiation, heat	W/m <sup>2</sup>	No	No	600	600	600	600	600	600	600
Water from other sources other than rain	m/s	No	No	1	1	3	3	3	3	3
Wetness	None	No	No	Conditions of wet surfaces						

## BIOLOGICAL CONDITIONS

Environmental Parameter	Unit	Classification		
		2B1	2B2	2B3
Flora	None	No	Presence of mould, fungus, etc	Presence of mould, fungus, etc
Fauna	None	No	Presence of rodents or other animals harmful to products. Excludes termites	Presence of rodents or other animals harmful to products. Includes termites

**IEC 721 GUIDANCE NOTES****Transportation****CHEMICALLY ACTIVE SUBSTANCES**

Environmental Parameter	Unit	Classification		
		2C1	2C2	2C3
Sea salt / Road salts	None	No	Conditions of salt mist	Conditions of salt mist
Sulphur dioxide	mg/m <sup>3</sup>	0.1	1.0 (0.3)	10.0 (0.5)
Hydrogen sulphide	mg/m <sup>3</sup>	0.01	0.5 (0.1)	10.0 (3.0)
Nitrogen oxides (expressed in equivalent values of nitrogen dioxides)	mg/m <sup>3</sup>	0.1	1.0 (0.5)	10.0 (3.0)
Ozone	mg/m <sup>3</sup>	0.01	0.1 (0.05)	0.3 (0.1)
Hydrogen chloride	mg/m <sup>3</sup>	0.1	0.5 (0.1)	5.0 (1.0)
Hydrogen flouride	mg/m <sup>3</sup>	0.003	0.03 (0.01)	2.0 (0.1)
Ammonia	mg/m <sup>3</sup>	0.3	3.0 (1.0)	35 (10)

## Notes

- Figures in brackets are expected long-term mean values
- Figures are maximum values occurring over a 30 min period per day

**MECHANICALLY ACTIVE SUBSTANCES**

Environmental Parameter	Unit	Classification		
		2S1	2S2	2S3
Sand	g/m <sup>3</sup> of air	No	0.1	10
Dust sedimentation	mg/(m <sup>2</sup> .h)	No	3.0	3.0

## IEC 721 GUIDANCE NOTES

## Transportation

## MECHANICAL CONDITIONS

Environmental Parameter	Unit	Classification								
		2M1			2M2			3M3		
<i>Stationary sinusoidal vibration</i>										
Displacement amplitude	mm	3.5			3.5			7.5		
acceleration amplitude	m/s <sup>2</sup>		10	15		10	15		20	40
frequency range	Hz	2-9	9-200	200-500	2-9	9-200	200-500	2-8	8-200	200-500
<i>Stationary vibration, random</i>										
acceleration spectral density	m <sup>2</sup> /s <sup>3</sup>	1	0.3		1	0.3		3	1	
frequency range	Hz	10-200	200-2000		10-200	200-2000		10-200	200-2000	
<i>Non stationary vibration including shock</i>										
Shock response spectrum type I peak acceleration $\hat{a}$	m/s <sup>2</sup>	100			100			300		
Shock response spectrum type II peak acceleration $\hat{a}$	m/s <sup>2</sup>	No			300			1000		
<i>Free fall:</i>										
Mass less than 20 kg	m		0.25			1.2			1.5	
Mass 20 kg to 100 kg	m		0.25			1.0			1.2	
Mass more than 100 kg	m		0.1			0.25			0.5	
<i>Toppling</i>	None									
Mass less than 20 kg					Toppling around any of the edges					
Mass 20 kg to 100 kg			No		Toppling around any of the edges					
Mass more than 100 kg			No		No					
<i>Rolling, pitching</i>										
angle	degree		No			+/- 35			+/- 35	
period	s		No			8			8	
<i>Steady state acceleration</i>	m/s <sup>2</sup>		20			20			20	
<i>Static load</i>	kPa		5			10			10	

## IEC 721 GUIDANCE NOTES

## Classifications for WEATHER PROTECTED track side equipment

## CLIMATIC CONDITIONS

Environmental Parameter	Unit	Classification												
		3K1	3K2	3K3	3K4	3K5	3K6	3K7	3K7L	3K8	3K8H	3K8L	3K9	3K10
Low temp. air	°C	+20	+15	+5	+5	-5	-25	-40	-40	-55	-25	-55	+5	-20
High temp. air	°C	+25	+30	+40	+40	+45	+55	+70	+40	+70	+70	+55	+40	+55
Low relative humidity	%	20	10	5	5	5	10	10	10	10	10	10	30	4
High relative humidity	%	75	75	85	95	95	100	100	100	100	100	100	100	100
Low absolute humidity	g/m <sup>3</sup>	4	2	1	1	1	0.5	0.1	0.1	0.02	0.5	0.02	6	0.9
High absolute humidity	g/m <sup>3</sup>	15	22	25	29	29	29	35	35	35	35	29	36	27
Rate of change of temp	°C/min	0.1	0.5	0.5	0.5	0.5	0.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Low air pressure	kPa	70	70	70	70	70	70	70	70	70	70	70	70	70
High air pressure	kPa	106	106	106	106	106	106	106	106	106	106	106	106	106
Solar Radiation	W/m <sup>2</sup>	500	700	700	700	700	1120	1120	none	1120	1120	1120	1120	1120
Heat Radiation	None	No	Select from the following special climatic conditions table											
Movement of surrounding air <sup>7</sup>	m/s	0.5	1.0	1.0	1.0	1.0	1.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Condensation	None	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Precipitation	None	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Water from other sources other than rain	None	No	No	No	See note <sup>8</sup>									
Ice and frost formation	None	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes

<sup>7</sup> If necessary a special value can be selected from the special climatic conditions table<sup>8</sup> Select from Special Climatic Conditions Table

**IEC 721 GUIDANCE NOTES****Classifications for WEATHER PROTECTED track side equipment****SPECIAL CLIMATIC CONDITIONS**

Environmental Parameter	Class	Unit	Special condition Z
High air temp.	3Z11	°C	+55
Low air pressure	3Z12	kPa	84
Heat radiation	3Z1	None	Negligible
	3Z2	None	Heat radiation e.g. near room heating systems
	3Z3	None	Heat radiation e.g. near room heating systems or commercial ovens/furnaces
Movement of surrounding air	3Z4	m/s	5
	3Z5	m/s	10
	3Z6	m/s	30
Water from sources other than rain	3Z7	none	Dripping water
	3Z8	none	Spraying water
	3Z9	none	Splashing water
	3Z10	none	Water jets

**BIOLOGICAL CONDITIONS**

Environmental Parameter	Unit	Classification		
		3B1	3B2	3B3
Flora	None	No	Presence of mould, fungus, etc	Presence of mould, fungus, etc
Fauna	None	No	Presence of rodents or other animals harmful to products. Excludes termites	Presence of rodents or other animals harmful to products. Including termites

**IEC 721 GUIDANCE NOTES****Classifications for WEATHER PROTECTED track side equipment****CHEMICALLY ACTIVE SUBSTANCES**

Environmental Parameter	Unit	Classification			
		3C1	3C2	3C3	3C4
Sea salt	None	No	Salt mist		
Sulphur dioxide	mg/m <sup>3</sup>	0.1	1.0 (0.3)	10 (5.0)	40 (13)
Hydrogen sulphide	mg/m <sup>3</sup>	0.01	0.5 (0.1)	10 (3.0)	70 (14)
Chlorine	mg/m <sup>3</sup>	0.1	0.3 (0.1)	1.0 (0.3)	3.0 (0.6)
Hydrogen chloride	mg/m <sup>3</sup>	0.1	0.5 (0.1)	5.0 (1.0)	5.0 (1.0)
Hydrogen flouride	mg/m <sup>3</sup>	0.003	0.03 (0.01)	2.0 (0.1)	2.0 (0.1)
Ammonia	mg/m <sup>3</sup>	0.3	3.0 (1.0)	35 (10)	175 (35)
Ozone	mg/m <sup>3</sup>	0.01	0.1 (0.05)	0.3 (0.1)	2.0 (0.2)
Nitrogen oxides (expressed in equivalent values of nitrogen dioxides)	mg/m <sup>3</sup>	0.1	1.0 (0.5)	9.0 (3.0)	20 (10)

## Notes

- Figures in brackets are mean values
- Figures are maximum values occurring over a 30 min period per day

**MECHANICALLY ACTIVE SUBSTANCES**

Environmental Parameter	Unit	Classification			
		3S1	3S2	3S3	3S4
Sand	g/m <sup>3</sup> of air	None	30	300	3000
Dust suspension	mg/m <sup>3</sup>	0.01	0.2	0.4	4.0
Dust sedimentation	mg/(m <sup>2</sup> .h)	0.4	1.5	15	40

## IEC 721 GUIDANCE NOTES

## Classifications for WEATHER PROTECTED track side equipment

## MECHANICAL CONDITIONS

Environmental Parameter	Unit	Classification							
		3M1	3M2	3M3	3M4	3M5	3M6	3M7	3M8
<i>Stationary sinusoidal vibration</i>									
Displacement amplitude	mm	0.3	1.5	1.5	3.0	3.0	7.0	10	15
acceleration amplitude	m/s <sup>2</sup>	1	5	5	10	10	20	30	50
frequency range	Hz	2-9 9-200	2-9 9-200	2-9 9-200	2-9 9-200	2-9 9-200	2-9 9-200	2-9 9-200	2-9 9-200
<i>Non stationary vibration including shock</i>									
Shock response spectrum type L peak acceleration $\dot{a}$	m/s <sup>2</sup>	40	40	70	No	No	No	No	No
Shock response spectrum type I peak acceleration $\dot{a}$	m/s <sup>2</sup>	No	No	No	100	No	No	No	No
Shock response spectrum type II peak acceleration $\dot{a}$	m/s <sup>2</sup>	No	No	No	No	250	250	250	250

**IEC 721 GUIDANCE NOTES****Classifications for NON WEATHER PROTECTED track (line side) and track side equipment****CLIMATIC CONDITIONS**

Environmental Parameter	Unit	Classification							
		4K1	4K2	4K3	4K4	4K4H	4K4L	4K5	4K6
Low temp. air	°C	-20	-33	-50	-65	-20	-65	+5	-20
High temp. air	°C	+35	+40	+40	+55	+55	+35	+40	+55
Low relative humidity	%	20	15	15	4	4	20	30	4
High relative humidity	%	100	100	100	100	100	100	100	100
Low absolute humidity	g/m <sup>3</sup>	0.9	0.26	0.03	0.003	0.9	0.003	6	0.9
High absolute humidity	g/m <sup>3</sup>	22	25	36	36	36	22	36	27
Rain intensity	mm/min	6	6	15	15	15	15	15	15
Rate of change of temperature	°C/min	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Low air pressure	kPa	70	70	70	70	70	70	70	70
High air pressure	kPa	106	106	106	106	106	106	106	106
Solar Radiation	W/m <sup>2</sup>	No	1120	1120	1120	1120	1120	1120	1120
Heat radiation	None	A suitable severity should be chosen from the Special Climatic Conditions shown on the following table.							
Movement of surrounding air	m/s	A suitable severity should be chosen from the Special Climatic Conditions shown on the following table						50	50
Condensation	None	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Precipitation	None	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Low rain temperature	°C	+5	+5	+5	+5	+5	+5	+5	+5
Water from other sources other than rain	None	A suitable severity should be chosen from the Special Climatic Conditions shown on the following table.							
Ice and frost formation	None	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

**SPECIAL CLIMATIC CONDITIONS**

Environmental Parameter	Class	Unit	Special condition Z
Low air pressure	4Z10	kPa	84
Heat radiation	4Z1	None	Negligible
	4Z2	None	Heat radiation due for instance to process conditions
Movement of surrounding air	4Z3	m/s	20
	4Z4	m/s	30
	4Z5	m/s	50
Water from sources other than rain	4Z6	none	Negligible
	4Z7	none	Splashing water
	4Z8	none	Water jets
	4Z9	none	Water waves



**IEC 721 GUIDANCE NOTES****Classifications for NON WEATHER PROTECTED track (line side) and track side equipment****BIOLOGICAL CONDITIONS**

Environmental Parameter	Unit	Classification	
		4B1	4B2
Flora	None	Presence of mould, fungus, etc	Presence of mould, fungus, etc
Fauna	None	Presence of rodents or other animals harmful to products. Excludes termites	Presence of rodents or other animals harmful to products. Including termites

**CHEMICALLY ACTIVE SUBSTANCES**

Environmental Parameter	Unit	Classification			
		4C1	4C2	4C3	4C4
Sea salt / Road salts	None	No	Conditions of salt mist		
Sulphur dioxide	mg/m <sup>3</sup>	0.1	1.0 (0.3)	10 (5.0)	40 (13)
Hydrogen sulphide	mg/m <sup>3</sup>	0.01	0.5 (0.1)	10 (3.0)	70 (14)
Chlorine	mg/m <sup>3</sup>	0.1	0.3 (0.1)	1.0 (0.3)	3.0 (0.6)
Hydrogen chloride	mg/m <sup>3</sup>	0.1	0.5 (0.1)	5.0 (1.0)	5.0 (1.0)
Hydrogen flouride	mg/m <sup>3</sup>	0.003	0.03 (0.01)	2.0 (0.1)	2.0 (0.1)
Ammonia	mg/m <sup>3</sup>	0.3	3.0 (1.0)	35 (10)	175 (35)
Ozone	mg/m <sup>3</sup>	0.01	0.1 (0.05)	0.3 (0.1)	2.0 (0.2)
Nitrogen oxides (expressed in equivalent values of nitrogen dioxides)	mg/m <sup>3</sup>	0.1	1.0 (0.5)	9.0 (3.0)	20 (10)

## Notes

- Figures in brackets are mean values
- Figures are maximum values occurring over a 30 min period per day

## IEC 721 GUIDANCE NOTES

## Classifications for NON WEATHER PROTECTED track (line side) and track side equipment

## MECHANICALLY ACTIVE SUBSTANCES

Environmental Parameter	Unit	Classification			
		4S1	4S2	4S3	4S4
Sand	g/m <sup>3</sup> of air	30	300	1000	4000
Dust sedimentation	mg/(m <sup>2</sup> .h)	15	20	40	80
Dust suspension	mg/m <sup>3</sup>	0.5	5.0	15	20

## MECHANICAL CONDITIONS

Environmental Parameter	Unit	Classification							
		4M1	4M2	4M3	4M4	4M5	4M6	4M7	4M8
<i>Stationary sinusoidal vibration</i>									
Displacement amplitude	mm	0.3	1.5	1.5	3.0	3.0	7.0	10	15
acceleration amplitude	m/s <sup>2</sup>	1	5	5	10	10	20	30	50
frequency range	Hz	2-9 9-200	2-9 9-200	2-9 9-200	2-9 9-200	2-9 9-200	2-9 9-200	2-9 9-200	2-9 9-200
<i>Non stationary vibration including shock</i>									
Shock response spectrum type L peak acceleration $\dot{a}$	m/s <sup>2</sup>	40	40	70	No	No	No	No	No
Shock response spectrum type I peak acceleration $\dot{a}$	m/s <sup>2</sup>	No	No	No	100	No	No	No	No
Shock response spectrum type II peak acceleration $\dot{a}$	m/s <sup>2</sup>	No	No	No	No	250	250	250	250

## IEC 721 GUIDANCE NOTES

## Classifications for train mounted equipment

## CLIMATIC CONDITIONS

Environmental Parameter	Unit	Classification							
		5K1	5K2	5K3	5K4	5K4H	5K4L	5K5	5K6
Low temp. air	°C	+5	-25	-40	-65	-25	-65	+5	-20
High temp. air - ventilated compartment (except engine compartments) or out door air	°C	+40	+40	+40	+55	+55	+40	+40	+55
High temp. air - unventilated compartment (except engine compartments)	°C	No	+70	+70	+85	+85	+70	+70	+85
High temp. engine compartments	°C	+60	+70	+70	+85	+85	+70	+70	+85
Change of temp. air to air	°C	No	-25/+30	-40/+30	-65/+30	-25/+30	-65/+30	+5/+30	-20/+30
Gradual change of temp. air to air, except engine compartments	°C	No	-25/+30	-40/+30	-65/30	-25/+30	-65/+30	+5/+30	-20/+30
	°C/min	No	5	5	5	5	5	5	5
Gradual change of temp. air to air, engine compartments	°C	No	-25/+60	-40/+70	-65/+70	-25/+70	-65/+70	+5/+70	-20/+70
	°C/min	No	10	10	10	10	10	10	10
Change of temp. air to water, except engine compartments	°C	No	No	+40/+5	+55/+5	+55/+5	+40/+5	+40/+5	+55/+5
Change of temp. air to water, engine compartments	°C	No	+60/+5	+70/+5	+85/+5	+85/+5	+70/+5	+70/+5	+85/-5
Change of temp. air to snow in engine compartments only	°C	No	+60/-5	+70/-5	+70/-5	+70/-5	+70/-5	+70/-5	+70/-5
Relative humidity not combined with rapid temp changes (except in engine compartments of vehicles powered by internal combustion engines)	%	75	95	95	95	95	95	95	95
	°C	+30	+40	+45	+50	+50	+45	+45	+50
Relative humidity not combined with rapid temp changes in engine compartments of vehicles powered by internal combustion engines	%	No	No	95	95	95	95	95	95
	°C	No	No	+70	+85	+85	+70	+85	+85
Relative humidity combined with rapid temp changes, air/air at high relative humidities. Not in close proximity to refrigerated air conditioning units	%	No	95	95	95	95	95	95	95
	°C	No	-25/+30	-40/+30	-65/+30	-25/+30	-65/+30	+5/+30	-20/+30
Relative humidity combined with rapid temp changes, air/air at high relative humidities. In close proximity to refrigerated air conditioning units	%	No	95	95	95	95	95	95	95
	°C	No	+10/+70	+10/+70	+10/+85	+10/+85	+10/+70	+10/+85	+10/+85
Absolute humidity combined with rapid temperature changes, air/air at high water content	g/m <sup>3</sup> of air	No	60	60	80	80	60	60	60
	°C	No	+70/+15	+70/+15	+85/+15	+85/+15	+70/+15	+70/+15	+85/+15
Low relative humidity	%	10	10	10	10	10	10	10	10
	°C	+30	+30	+30	+30	+30	+30	+30	+30
Low air pressure	kPa	70	70	70	70	70	70	70	70
Movement of surrounding air	m/s	No	20	20	30	30	30	30	30
Precipitation, rain	mm/min	No	No	6	15	15	6	15	15
Solar radiation	W/m <sup>2</sup>	No	700	1120	1120	1120	1120	1120	1120
Radiation, heat, not in engine compartment	W/m <sup>2</sup>	No	600	600	600	600	600	600	600
Radiation, heat, in engine compartment	W/m <sup>2</sup>	600	600	1200	1200	1200	1200	1200	1200
Water from other sources (not rain)	m/s	No	0.3	1	3	3	3	3	3
Wetness	None	No	Conditions of wet surfaces						

**IEC 721 GUIDANCE NOTES****Classifications for train mounted equipment****BIOLOGICAL CONDITIONS**

Environmental Parameter	Unit	Classification		
		5B1	5B2	5B3
Flora	None	No	Presence of mould, fungus, etc	Presence of mould, fungus, etc
Fauna	None	No	Presence of rodents or other animals harmful to products. Excludes termites	Presence of rodents or other animals harmful to products. Including termites

**CHEMICALLY ACTIVE SUBSTANCES**

Environmental Parameter	Unit	Classification		
		5C1	5C2	5C3
Sea salt	None	No	Conditions of salt mist	
Road salts	None	No	Conditions of solid salt and salt water	
Sulphur dioxide	mg/m <sup>3</sup>	0.1	1.0 (0.3)	10 (5.0)
Hydrogen sulphide	mg/m <sup>3</sup>	0.01	0.5 (0.1)	10 (3.0)
Nitrogen oxides (expressed in equivalent values of nitrogen dioxides)	mg/m <sup>3</sup>	0.1	1.0 (0.5)	10 (3.0)
Ozone	mg/m <sup>3</sup>	0.01	0.1 (0.05)	0.3 (0.1)
Hydrogen chloride	mg/m <sup>3</sup>	0.1	0.5 (0.1)	5.0 (1.0)
Hydrogen flouride	mg/m <sup>3</sup>	0.003	0.03 (0.01)	2.0 (0.1)
Ammonia	mg/m <sup>3</sup>	0.3	3.0 (1.0)	35 (10)

## Notes

- Figures in brackets are mean values
- Figures are maximum values occurring over a 30 min period per day

## IEC 721 GUIDANCE NOTES

## Classifications for train mounted equipment

## MECHANICALLY ACTIVE SUBSTANCES

Environmental Parameter	Unit	Classification		
		5S1	5S2	5S3
Sand	g/m <sup>3</sup> of air	No	0.1	10
Dust sedimentation	mg/(m <sup>2</sup> .h)	1.0	3.0	3.0

## MECHANICAL CONDITIONS

Environmental Parameter	Unit	Classification								
		5M1			5M2			5M3		
<i>Stationary sinusoidal vibration</i>										
Displacement amplitude	mm	1.5			3.3			7.5		
acceleration amplitude	m/s <sup>2</sup>		5			10	15		20	40
frequency range	Hz	2-9	9-200		2-9	9-200	200-500	2-8	8-200	200-500
<i>Stationary vibration, random</i>										
Acceleration spectral density	m/s <sup>2</sup>	0.3	0.1		1		0.3	3		1
Frequency range	Hz	10-200	200-500		10-200		200-500	10-200		200-500
<i>Non stationary vibration including shock</i>										
Shock response spectrum type I peak acceleration $\hat{a}$	m/s <sup>2</sup>	50			100			300		
Shock response spectrum type II peak acceleration $\hat{a}$	m/s <sup>2</sup>	No			300			1000		
<i>Impact from foreign bodies</i>	J	No			5			20		

## CONTAMINATING FLUIDS

Environmental Parameter	Classification		
	5F1	5F2	5F3
Motor oil	No	No	Yes
Gearbox oil	No	No	Yes
Hydraulic oil	No	Yes	Yes
Transformer oil	No	Yes	Yes
Brake oil	No	Yes	Yes
Cooling fluid	No	Yes	Yes
Grease	No	Yes	Yes
Fuel	No	No	Yes
Battery electrolyte	No	Yes	Yes

**IEC 721 GUIDANCE NOTES****Classifications for portable equipment****CLIMATIC CONDITIONS**

Environmental Parameter	Unit	Classification						
		7K1	7K2	7K3	7K4	7K5	7K6	7K7
Low temp. air	°C	+5	-5	-25	-40	-65	+5	-20
Low temp. water	°C	+40	+45	+70	+70	+85	+40	+55
Low relative humidity	%	5	5	5	5	4	30	4
High relative humidity	%	85	95	100	100	100	100	100
Low absolute humidity	g/m <sup>3</sup>	1	1	0.5	0.1	0.003	6	0.9
High absolute humidity	g/m <sup>3</sup>	25	29	48	62	78	36	27
Rapid change of air temperature	°C/°C	+5/+25	-5/+25	-25/+30	-40/+30	-65/+30	+5/+30	-20/+30
Low air pressure	kPa	70	70	70	70	30	70	70
High air pressure	kPa	106	106	106	106	106	106	106
Rate of change of air pressure	kPa/min	Negligible	Negligible	Negligible	Negligible	6	6	6
Solar radiation	W/m <sup>2</sup>	700	700	1120	1120	1120	1120	1120
Radiation, heat	None	Select from the following table						
Movement of surrounding air	m/s	Select from the following table						
Condensation	None	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Precipitation, rain	None	No	No	Yes	Yes	Yes	Yes	Yes
Rain intensity	mm/min	None	None	6	6	15	15	15
Low rain temperature	°C	None	None	+5	+5	+5	+5	+5
Water from other sources (not rain)	None	Select from the following table						
Ice and frost formation	None	No	Yes	Yes	Yes	Yes	Yes	Yes

**IEC 721 GUIDANCE NOTES****Classifications for portable equipment****SPECIAL CLIMATIC CONDITIONS**

Environmental Parameter	Class	Unit	Special condition Z
High air temperature	7Z14	°C	+55
Low air temperature	7Z15	°C	84
Heat radiation	7Z1	None	Negligible
	7Z2	None	Heat radiation e.g. near room heating systems
	7Z3	None	Heat radiation e.g. near room heating systems or commercial ovens/furnaces
Movement of surrounding air	7Z4	m/s	5
	7Z5	m/s	10
	7Z6	None	30
	7Z7	None	50
Water from sources other than rain	7Z8	None	Negligible
	7Z9	None	Dripping water
	7Z10	None	Spraying water
	7Z11	None	Splashing water
	7Z12	None	Water jets
	7Z13	None	Water waves

**BIOLOGICAL CONDITIONS**

Environmental Parameter	Unit	Classification		
		7B1	7B2	7B3
Flora	None	No	Presence of mould, fungus, etc	Presence of mould, fungus, etc
Fauna	None	No	Presence of rodents or other animals harmful to products. Excludes termites	Presence of rodents or other animals harmful to products. Including termites

**IEC 721 GUIDANCE NOTES****Classifications for portable equipment****CHEMICALLY ACTIVE SUBSTANCES**

Environmental Parameter	Unit	Classification			
		7C1	7C2	7C3	7C4
Sea salt	None	Negligible	Conditions of salt mist		
Sulphur dioxide	mg/m <sup>3</sup>	0.1	1.0 (0.3)	10 (5.0)	40 (13)
Hydrogen sulphide	mg/m <sup>3</sup>	0.01	0.5 (0.1)	10 (3.0)	70 (14)
Chlorine	mg/m <sup>3</sup>	0.1	0.3 (0.1)	1.0 (0.3)	3.0 (0.6)
Hydrogen chloride	mg/m <sup>3</sup>	0.1	0.5 (0.1)	5.0 (1.0)	5.0 (1.0)
Hydrogen flouride	mg/m <sup>3</sup>	0.003	0.03 (0.01)	2.0 (0.1)	2.0 (0.1)
Ammonia	mg/m <sup>3</sup>	0.3	3.0 (1.0)	35 (10)	175 (35)
Ozone	mg/m <sup>3</sup>	0.01	0.1 (0.05)	0.3 (0.1)	2.0 (0.2)
Nitrogen oxides (expressed in equivalent values of nitrogen dioxides)	mg/m <sup>3</sup>	0.1	1.0 (0.5)	9.0 (3.0)	20 (10)

**MECHANICALLY ACTIVE SUBSTANCES**

Environmental Parameter	Unit	Classification		
		7S1	7S2	7S3
Sand	mg/m <sup>3</sup>	30	300	10000
Dust suspension	mg/m <sup>3</sup>	0.2	5.0	20
Dust sedimentation	mg/(m <sup>2</sup> .h)	1.5	20	80



## IEC 721 GUIDANCE NOTES

## Classifications for portable equipment

## MECHANICAL CONDITIONS

Environmental Parameter	Unit	Classification								
		7M1			7M2			7M3		
<i>Stationary sinusoidal vibration</i>										
Displacement amplitude	mm	3.5			3.5			7.5		
acceleration amplitude	m/s <sup>2</sup>		10	15		10	15		20	40
frequency range	Hz	2-9	9-200	200-500	2-9	9-200	200-500	2-8	8-200	200-500
<i>Stationary vibration, random</i>										
acceleration spectral density	m <sup>2</sup> /s <sup>3</sup>	1	0.3		1	0.3		3	1	
frequency range	Hz	10-200	200-2000		10-200	200-2000		10-200	200-2000	
<i>Non stationary vibration including shock</i>										
Shock response spectrum type I peak acceleration $\ddot{a}$	m/s <sup>2</sup>	100			100				300	
Shock response spectrum type II peak acceleration $\ddot{a}$	m/s <sup>2</sup>	No			300				1000	
<i>Free fall:</i>										
Mass less than 1 kg	m		0.025			0.25			1.0	
Mass 1 kg to 10 kg	m		0.025			0.1			0.5	
Mass 10 kg to 50 kg	m		0.025			0.05			0.25	
Mass more than 50 kg	m				To be agreed between supplier and user					

**ANNEX B - Summary of IEC 529 Protection Codes**

The degree of protection (IP code) offered by an equipment enclosure/housing are classified in IEC 529 as follows:

**First digit**

Number	Protection against ingress of solid objects	Protection against access to hazardous parts with:
0	No protection	No protection
1	= 50 mm diameter	Back of hand
2	= 12.5 mm diameter	Finger
3	= 2.5 mm diameter	Tool
4	= 1.0 mm diameter	Wire
5	Dust protected	Wire
6	Dust tight	Wire

**Second digit**

Number	Protection against ingress of water
0	No protection
1	Vertical dripping
2	Dripping (15° tilted)
3	Spraying
4	Splashing
5	Jetting
6	Powerful jetting
7	Temporary immersion
8	Continuous immersion

An example of how ERTMS equipment casings can be specified is given below:

IP 67. This denotes the casing must be dust tight and capable of meeting the tests laid down for temporary immersion in water.

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