



TECHNOLOGY MANAGEMENT STANDARD

PHYSICAL CHARACTERISTIC OF THE RAILWAY ENVIRONMENT IN SOUTH AFRICA

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PREFACE

The objective of developing the standard for Transnet is to establish the guidelines for building either a new system or redevelop the existing system deployed in the physical railway environment across the South Africa. This standard will help to provide guidance to present and future system developers to build the required system or equipment suitable for the physical environment of South Africa.

The standard has been prepared with the aim to use it during the stage of development of a system or equipment to comply with this standard. This standard shall be used for testing and evaluation processes to ensure that systems acquired compliance with the environmental characteristics.

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1 SCOPE

1.1 Background

This document is an updated version of the current environmental specification CSE-1154-001 Category E48 Issue 1. The purpose of this standard is to provide the accepted test requirements of the physical environmental parameters to ensure that systems acquired comply with the environmental characteristics of Transnet railways. This standard also presents environmental profiles which can be used as guidelines during the development of systems or equipment.

1.2 Scope

This standard details the environmental parameters which signalling equipment, on-board equipment and wayside equipment systems have to be tested against, in order to demonstrate the compatibility with their intended environment. Some of the environmental test parameters and conditions are taken from international standards and are adopted for the development of systems or equipment. This standard also specifies the requirements for testing trackside equipment, track mounted equipment and equipment in tunnels as well as in/on railway vehicles.

2 APPLICABLE DOCUMENTS

The following international standards reference shall be used to determine the applicable parameters suitable for test requirements.

EN 50125-1	Railway application-Environmental conditions for equipment - Part 1: Rolling stock and on-board equipment
EN50125-2	Railway application. Environmental conditions for equipment - Part 1 : Fixed electrical installations
EN 50125-3	Railway application. Environmental conditions for equipment - Part 3: Equipment for signalling and telecommunications
IEC 61373	Railway application. Rolling stock equipment. Shock and vibration tests
EN 50155	Railway application: Electronic equipment used on rolling stock
EN 60529	Degrees of protection provided by enclosures (IP code)
IEC 61000	Electro Magnetic Compatibility
IEC 61000-4-4	Electromagnetic Compatibility (EMC) Part 4: Testing and measurement techniques – Section 4: Electrical fast transient/burst

	immunity test .Basic EMC publication
IEC 61000-4-6	Electromagnetic compatibility (EMC) Part 4-6: Testing and measurement techniques. Immunity to conducted disturbances, induced by radio-frequency fields
IEC 60068-2-27.	Electromagnetic compatibility (EMC) Part 4-16: Testing and measurement techniques. Test for immunity to conducted, common mode disturbances in the frequency range 0 Hz to 150 kHz
EN 50124-2	Railway applications. Insulation coordination - Part 2: Overvoltages and related protection
EN 50124-1	Railway applications. Insulation coordination - Part 1: Basic requirements. Clearances and creepage distances for all electrical and electronic equipment
BBH 0101	Signalling power system and back up supply
BBF 3862	Low-voltage power supply devices, ac to dc converter with 110V output. For use in railway signalling application

3 TERMS, DEFINITION AND ABBREVIATIONS

3.1 Terms and definitions

3.1.1 **Cubicle** is an enclosure with ventilation openings with or without direct air flow into the enclosure

3.1.2 **Covered area** means it is protected against rainfall but open to effects of humidity and wind

3.1.3 **Environmental conditions** means the conditions which are brought around because of the environment

3.1.4 **Environment** means the surrounding region that may influence the behaviour of the system and/or may be influenced by the system

3.1.5 **Grade** is a grouping or classification type of the environment

3.1.6 **Case** is the equipment housing usually provided by OEM to mount or protect equipment against environmental conditions

3.1.7 **Rocla** is reinforce concrete enclosure used to protect signalling equipment or systems.

3.2 Abbreviations

3.2.1 TM – Technology Management

3.2.2 TFR – Transnet Freight Rail

3.2.3 OEM – Original Equipment Manufacturer

3.2.4 NaCl – Sodium Chloride (Table salt)

3.2.5 EMI – Electro-Magnetic Interference

3.2.6 EMC – Electromagnetic Compatibility

3.2.7 TBD – To be determined

4 EQUIPMENT CLASSIFICATION

This document categorises environment types in grades with the aim to specify the requirements for testing equipment intended for use on Transnet railway infrastructure and rolling stock. This equipment is subsequently subjected to any environmental conditions owing to the nature of railways operational environment.

Table 1 – Represent the equipment classification of grade and their environment conditions

Environmental Grade	Environment type	Equipment examples
A	Air conditioned Office ,Trackside indoor air conditioned	Battery chargers, Personal Computers
B	Trackside Building, ship container, Rocla	Mimic diagrams, computers, embedded systems, communication equipment.
C	Trackside-Cased	Track circuits units, equipment within cases
D	Trackside-Outdoor	Signalling equipment, points and platform information displays, fixed electrical installations
E	Track Mounted	Axle counter heads, transducers, wheel sensors
F	Rolling Stock-Locomotive (Driver cab, equipment compartment)	On-board computer, train radio
G	Rolling Stock-bogies	Tacho generators
H	Rolling Stock-body frame	Transponders
I	Tunnel	Signalling equipment

All signalling systems and equipment shall be classified to operate in one or more of the grades of environment, and shall be tested for conformance to the requirements of that profile.

5 GENERAL REQUIREMENTS

The below requirements are applicable to all signalling systems and equipment used in the railway environment.

5.1 Functionality of the system or equipment

The system shall be tested before, after or during manufacturing to ensure the system meets the relevant parts of this standard. Test documents, which entail the exact method of testing, shall be provided to ensure that product features of the system and its operation shall comply with this standard.

5.2 Transporting requirements

The following paragraphs present environmental profiles against which all equipment and spare parts shall be tested. It is based on typical environment profiles which can be experienced during transportation thereof.

5.2.1 Altitude

This test is performed in order to simulate transportation of the system by air freight. The system operation shall be demonstrated after completing of the tests.

5.2.2 Temperature

The effect of heat during the transportation of equipment and other parts shall also be taken into consideration. Packaging systems shall be qualified before used. The shipper or transporter is responsible for ensuring product temperature complies during transport. Equipment can be transported in aeroplanes where temperatures are not in control.

5.2.3 Humidity

Equipment package shall be designed to provide resistance to humidity and moisture during transportation.

5.2.4 Shock and vibration

5.2.4.1 Equipment vibration

This test is used to simulate transportation by a common carrier to the site where equipment is to be installed. During this test the system have to be packed ready for transporting. The equipment operation shall be confirmed before commencing with the test as well as after completion of the test.

Transportation and handling test shall be done in accordance with IEC 60068-2-27.

5.2.4.2 Component vibration

The system shall be dismantled into subassemblies normally used by the maintenance staff to repair a faulty installed system. This could be in the form of P.C. boards, power supply units etc. After the vibration test, subassemblies shall be tested for functionality against the product specification.

Component vibration tests shall be performed in accordance with EN 61373.

5.2.5 Wind speed

Wind speed shall not affect any equipment during transportation where packaging of equipment is in the closed shell.

5.2.6 Solar radiation

Equipment exposed to the effects of solar radiation shall be designed to ensure that it continues to operate and comply with the parameters of the design specifications.

5.2.7 Corrosive environment

Not applicable during transportation

5.2.8 Pollution

Equipment or systems may be expected to be exposed to various pollutant conditions. The effects of pollution shall be reduced by providing the appropriate protection specified using the protection degree definition of EN 60529.

5.2.9 Surge and electrostatic discharge

Equipment shall not be affected by electrostatic discharge during transportation since the equipment is not connected to any forms of power.

5.2.10 Electromagnetic compatibility

All electronic components shall be packed well to provide protection against electromagnetic interference (EMI)

6 ENVIRONMENTAL PARAMETERS

6.1 Altitude

This test is used to determine if the equipment can withstand and /or operate in an environment from sea level up to **2500** m above sea level

6.1.1 Altitude for railway vehicles and equipment (F, G, H)

Systems and equipment shall perform as specified for the different classes of altitude range relative to sea level given in the following Table 2 which are taken from par.4.2 of EN 50125-1:2014. Systems and equipment for Transnet railways shall be tested against class AX to meet the full performance specification requirement for environmental grade **F**, **G** and **H** as stated in Table 1.

Table 2 – Classes of altitude range for railway vehicle systems and equipment

Classes	Altitude range relative to sea level (m)
A1	Up to 1400
A2	Up to 1000
A3	Up to 1200
AX	More than 1400

6.1.2 Altitude for fixed electrical installation (D, I)

All fixed electrical installations at altitudes above sea level in open air for the different classes as given in Table 3, shall perform as specified. Altitude test values related to sea level for air pressure shall be considered in accordance to par.4.2 of EN 50125-2. All fixed electrical installations for Transnet railways shall be tested against class AX to meet the full performance specification requirement for environmental grade **D** and **I**.

Table 3 – Altitude relative to sea level for fixed electrical installations, signalling and telecommunications equipment

Classes	Altitude range relative to sea level (m)
A1	Up to 1400
A2	Up to 1000
AX	Above 1400
NOTE In class A2 installation under sea level are included.	

6.1.3 Altitude of equipment for signalling and telecommunications (C, D, E, I)

Altitude values for environmental grade C, D, E and I shall be tested against class AX given in Table 3.

6.2 Temperature

6.2.1 Temperature for rolling stock and on-board equipment (F, G, H)

The railway vehicle systems and equipment shall operate as specified for different classes of temperatures given in **Table 4**. These test values are the guideline in accordance with EN 50155 for rolling stock and on-board equipment.

Temperatures for the environmental grade F, G and H shall be tested against that of class T3 temperatures given in Table 4. Where different operational temperatures are considered in the design and manufacturing due to local environmental knowledge, or where operational temperature ranges are limited by heating or cooling systems, the operating limits shall be agreed and stated in the specification requirements of Transnet.

Table 4 – Classes of air temperatures for vehicles and equipment

Class	Column 1	Column 2	Column 3	Column 4
	Ambient temperature outside vehicle (EN 50125-1, Table 2, Column 1) °C	Internal cubicle temperature °C	Internal cubicle overtemperature during 10 min °C	Air temperature surrounding the printed board assembly °C
T1	-25 +40	-25 +55	+15	-25 +70
T2	-40 +35	-40 +55	+15	-40 +70
T3	-25 +45	-25 +70	+15	-25 +85
TX	-40 +50	-40 +70	+15	-40 +85

6.2.2 Temperature for fixed electrical installations (D)

Temperature values for environmental grade D shall be tested against class TX (column1) given in Table 4 to ensure the successful operation of the system meet the requirements.

6.2.3 Temperature for signalling and telecommunications equipment

Table 5 below shows test measurements for open air temperatures measured 2 m above ground. This measurements specified represent all classes to allow for installation of signalling and telecommunications equipment at the ground level in accordance with par.4.3 of EN 50125-3. Temperature values for environmental grade B, D and I shall be tested against climatic class TX temperatures.

Table 5 – Temperature ranges at different sites

Climatic classes	External ambient	In cubicle ^{ab}	In shelter ^{ab}		In building	
			N.T.C. ^c	T.C. ^c	N.C.C. ^c	C.C. ^e
T1	(-25 +40) °C	(-25 +70) °C	(-5 +55) °C	(+15 +30) °C	(0 +45) °C	(+18 +27) °C
T2	(-40 +35) °C	(-40 +65) °C	(-20 +50) °C	(+15 +30) °C	(-5 +40) °C	(+18 +27) °C
TX	(-55 +40) °C	(-55 +70) °C	(-35 +55) °C	(+15 +30) °C	(-5 +45) °C	(+18 +27) °C
a The temperatures inside cubicle, shelter or building are values measured in free air not directly adjacent to heat emitting elements. b The maximum temperatures inside a cubicle, a shelter N.T.C. and a building N.C.C. are higher than max. ambient temperatures because of the effects of solar radiation and power dissipation of installed equipment c The higher values of lowest temperatures compared to those for external ambient are due to heat emitting equipment. d 3K2 of EN60721-3-3 e 3K1 of EN60721-3-3						
C.C.: with climatic control.			T.C.: with temperature control.			
N.C.C. : without climatic control			N.T.C. : without temperature control			

6.3 Humidity

Humidity of environment can vary extensively from location to location in South Africa and therefore it has been categorised into three levels, i.e.

- | | | |
|----|-----------------|--------------------------------|
| H1 | High humidity | for railway lines on the coast |
| H2 | Medium humidity | for coastal regions |
| H3 | Low humidity | inland and dry areas |

The following tests shall be conducted in accordance with EN 50155 par. 12.2:

- Dry heat test
- Dry cold test
- Damp heat test

6.3.1 Humidity for rolling stock and on-board equipment

Humidity tests for environmental grade F, G and H shall be measured against climatic class TX (in cubicle) described in Table 6.

6.3.2 Humidity for fixed electrical installations

Humidity in open air for environmental grade D and I shall be tested against climatic class TX (external ambient) defined in Table 6 to ensure that system or equipment will survive the specified life cycle under service conditions.

6.3.3 Humidity for signalling and telecommunications equipment

The equipment shall be designed to withstand the humidity levels for different ranges of the air temperature defined in 6.2.3 above as shown in climatogram of figures A.1 to A.6 of

annex A of EN 50125-3 which gives the relationship between humidity and temperature variations for different climate classes.

Table 6 below provides the minimum and maximum values of relative and absolute humidity for different climatic classes as stated in EN 50125-3.

Table 6 – Humidity ranges at different sites for signalling equipment and telecommunications

Climatic classes	Humidity	External ambient		In cubicle		In shelter				In building			
		Min.	Max.	Min.	Max.	N.C.C.		C.C. ^a		N.C.C.		C.C. ^b	
						Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
T1	R %	15	100	5	100	5	100	10	75	5	95	20	75
	A g/m ³	0,55	25 °	0,55	25 °	0,55	25 °	2	22	0,55	25 °	4	15
T2	R %	20	100	5	100	5	100	10	75	5	95	20	75
	A g/m ³	0,12	22 °	0,12	22 °	0,12	22 °	2	22	0,12	22 °	4	15
TX	R %	15	100	5	100	5	100	10	75	5	95	20	75
	A g/m ³	0,02	25 °	0,02	25 °	0,02	25 °	2	22	0,02	25 °	4	15
^a 3K2 of EN 60721-3-3													
^b 3K1 of EN 60721-3-3													
^c 30 g/m ³ for tunnel													
C.C. : with climatic control.								R : Relative humidity.					
N.C.C. : without climatic control.								A: Absolute humidity.					
NOTE Table 3 has been derived from HD 478.2.1 for calculations, from EN 60721-3-3 and EN 60721-3-4 for values.													

6.4 Shock and vibration

The system or equipment is subjected to experience vibration, mechanical shock and impact caused by either moving trains which interact with the surface of railway as well as the wind. The equipment shall be able to withstand vibrations and shocks that occur in operation.

6.4.1 Shock and vibration for rolling stock equipment

In order to ensure that a system or equipment maintain its intended function over the specified period of time shall be able to meet the vibration, shock and bump test described in par. 12.2.11 of EN 50155. For typical test values of shock and vibration for environmental grade F, G and H in service, reference shall be made to EN 61373.

6.4.2 Shock and vibration for signalling and telecommunications equipment

The systems or equipment installed next to railway tracks experience vibrations due to interaction between the railway tracks and moving rolling stock. These systems shall be designed to operate within the specified environment parameters. The values of acceleration at track side positions provided below Table 7 are the test criteria taken from par.4.13.1 of EN 50125-3 and shall be used for all equipment of environmental grade C,D,E and I unless more requirements are specified.

Table 7 – Represents acceleration at track side positions

Position	r.m.s. Vertical Acceleration m/s ²	r.m.s. Transversal Acceleration m/s ²	r.m.s. Longitudinal Acceleration m/s ²	Figure (Annex C)
On rail	280	140	50	C.1
On sleeper	130	50	90	C.2
On ballast	10	10	10	C.3
Outside the track (from 1 m to 3 m from the rail)	2,3	2,3	2,3	C.4

The values of shock shown in Table 8 below specify the test measurement results which shall be used for shock requirement for environmental grades C, D, E and I. These test values are taken from par.4.13.2 of EN 50125-3.

Table 8 - Represents shocks at different track side positions

Position	Acceleration (in m/s²) / Duration (in ms)	
	Mean	Peak
On rail	420 / 6	2 500 / 1
On sleeper	300 / 8	800 / 2
On ballast	50 / 11	100 / 8
Into a box upon post, outside the track (from 1 m to 3 m from the rail)	20 / 11	20 / 11

6.5 Wind speed

Systems or equipment exposed to air movement shall be designed to withstand the pressure caused by wind. This air pressure could be caused by natural wind and or the air movement produced by passing trains on the track.

6.5.1 Operating of the systems or equipment at the maximum wind speed of 35 m/s at standstill for environmental grade F, G and H shall be assumed.

6.5.2 In order to ensure that the equipment meet the requirements for environmental grade D, E,G,H and I in Table 1, tests or calculations shall be performed in accordance with par.4.5 of EN 50125-3.

6.6 Power supply

The power supply specification shall include nominal voltages, expected variations and disturbances, nominal frequencies and variations, permitted ripple to ensure that all equipment and systems operate safely and reliably when equipment is supplied from a variety of different suppliers.

6.6.1 The nominal voltage of equipment for environmental grade F, G shall be selected from amongst the following values:

Table 9 – nominal voltage for rolling stock equipment

Grade	Nominal voltage
A1	24V d.c.
A2	48V d.c.
A3	74 V d.c.
A4	96V d.c.
A5	110V d.c.

6.6.1.1 Variations of voltage supply (dc)

Electronic equipment supplied by accumulator batteries without a voltage stabilizing device shall operate satisfactorily for all the values of the supply voltage within the range defined below (measured at the input terminals of the equipment).

- Minimum voltage: $0,7 U_n$
- Nominal voltage: U_n
- Rated voltage: $1,15 U_n$
- Maximum voltage: $1,25 U_n$

Voltage fluctuations (e.g. brownout, during start-up of auxiliary equipment or voltage oscillations of battery chargers) lying between $0,6 U_n$ and $1,4 U_n$ and not exceeding 100ms shall not cause deviation of function. Transnet Freight Rail Locomotives have a maximum Nominal voltage of 110V (U_n) in Electric locomotives and a minimum of 74V (U_n) in Diesel locomotives.

6.6.1.2 Brownout

In the case of equipment supplied with power alternatively from accumulator battery and a stabilised source (dc), equipment shall operates fully and continuously when the input

voltage drops to 44.4V. Equipment and its components shall not fail at the specified limits of 100ms brownout stipulated in the applicable documents.

6.6.1.3 Blackout

Equipment shall not fail at the specified power interruption limits of 30ms.

6.6.1.4 Supply over voltages

All connection to electronic equipment capable of being connected to the control system voltage supply shall withstand:

- The supply overvoltages as specified in 6.6.1.1
- The application of supply overvoltages in accordance with 12.2.6 of EN 50155.

Additional requirements shall be defined between Transnet and the supplier to ensure compliance.

All the electrical service conditions for rolling stock shall be done in accordance with par.5.1 of EN 50155.

6.6.2 The nominal voltage of signalling installations shall be selected from amongst the following grades in Table 10 below.

Table 10 – Nominal voltages for signalling installations

Grade	Nominal voltages
A	110V ac, 230V ac, 12V dc
B	60V d.c., 110V dc, 110V ac, 12V dc, 400V three phase A.C
C	110V ac
D	110V ac, 24V ac, 12V ac
E	110V ac, 230V ac, 400V ac three phase

All ac voltage shall have a frequency variation of +/- 5% of 50 Hz and voltage variation of +/- 15%.

6.7 Solar radiation

Equipment exposed to the effects of solar radiation shall be designed to ensure that it continues to operate and comply with the parameters of the design specifications. The maximum level of solar radiation is 1 120 W/m² for equipment directly exposed in accordance with par.4.9 of EN50125-3.

Table 11 below specify the classes of radiation for rolling stock, fixed electrical installations, signalling and communications equipment which shall be considered for solar radiation requirements. Environmental grade C, D, E, F, G, H, and I (Table 1) shall be tested against class R2 given below Table 9 to ensure that equipment meets the specification of Transnet railways requirements.

Table 11 – Solar radiation

Classes	Solar radiation W/m²
R1 (low)	700
R2 (high)	1120

Care shall be taken to minimise the effects of UV radiation on equipment exposed to solar radiation.

6.8 Corrosive environment

All the equipment intended for use in environmental grade C, D, E, G and H (Table 1) on coastal line shall be tested against the effect of salt spray for at least 48 hours with a 5% NaCl solution. The tests for corrosive environment of environmental grade G and H shall be done in accordance with par.12.2.10 of EN 50155 standard.

6.9 Pollution

Equipment or systems may be expected to be exposed to various pollutant conditions. This pollutant conditions can be (but not limited to) oil, mist, salt spray, conductive dust, chromic acid and sulphur dioxide. The effects of pollution shall be reduced by providing the appropriate protection specified using the protection degree definition of EN 60529.

The external ambient pollution levels defined below Table 12, are those normally found on equipment housing situated in open air as described in par.4.11 of EN 50125-3. This levels of pollution shall be taken into considerations especially for environmental grade C, D, E and I where the systems or equipment is exposed into a known environment.

Table 12 – External ambient pollution levels

Pollution levels	Pollution type		
	Chemical active Substances	Biological active substances	Mechanical active substances
Low	4 C 1	4 B 1	4 S 1
Medium	4 C 2 *	4 B 1	4 S 2
High	4 C 3 *	4 B 1	4 S 3

* Coastal areas are excluded from these classes. The customer must specify to the designer where protection from salt mist is required, in which case protection to a minimum 4 C 2 should be provided.

6.10 Surge and electrostatic discharge

All electronic equipment for applicable environmental grades shall withstand electrical surges, supply over voltages and electrostatic discharge such that no damage or failure occurs during operation. In order to ensure that system or equipment will survive the specified life cycle under service conditions, the electronic equipment shall be capable of meeting the surges and electrostatic discharge tests described in par.12.2.7 of EN 50155 and or par.10.2.6 of EN 60571.

6.11 Lightning

6.11.1 Consideration shall be given to the effect of lightning on environmental grade F, G and H. For protection against lightning on railway vehicle refer to EN 50124-1 and EN 50124-2.

6.11.2 Protection against lightning for environmental grade C, D, E and I shall be referred to

6.12 Electromagnetic compatibility (EMC)

Electromagnetic compatibility conditions are very complex and many are transient in nature. In order to ensure that the system or component function safely and reliably in its electromagnetic environment without any intolerable electromagnetic disturbance, the tests shall be conducted for successful operation in accordance with **IEC 61000** standards.

6.12.1 All electronic systems and equipment installed under environmental grade F, G and H shall be tested in order to conform to EMC requirements in accordance with EN 50121-3-2. These tests requirements include electrical fast transient, surge immunity, radiated, radio-frequency, electromagnetic field immunity and emission standard for industrial environments.

6.12.2 All electronic equipment installed under environmental grade B, C, D, E and I shall be tested for EMC in accordance with IEC 61000-4-16. The system or equipment that operate in the specified environment shall meet the limit parameters given by TFR or the user of that equipment.

6.13 Tunnel

All signalling equipment intended for use on railway environment within tunnels shall be proved and tested for successful operation against the environmental conditions. These tests are performed to demonstrate compliance with the environment conditions that can experienced by the system or equipment in the railway environment.

6.13.1 Wind speed

TBD

6.13.2 Humidity and temperature

TBD

6.13.3 Shock and vibration

TBD

6.13.4 Dampness

TBD

6.13.5 Shock waves

TBD