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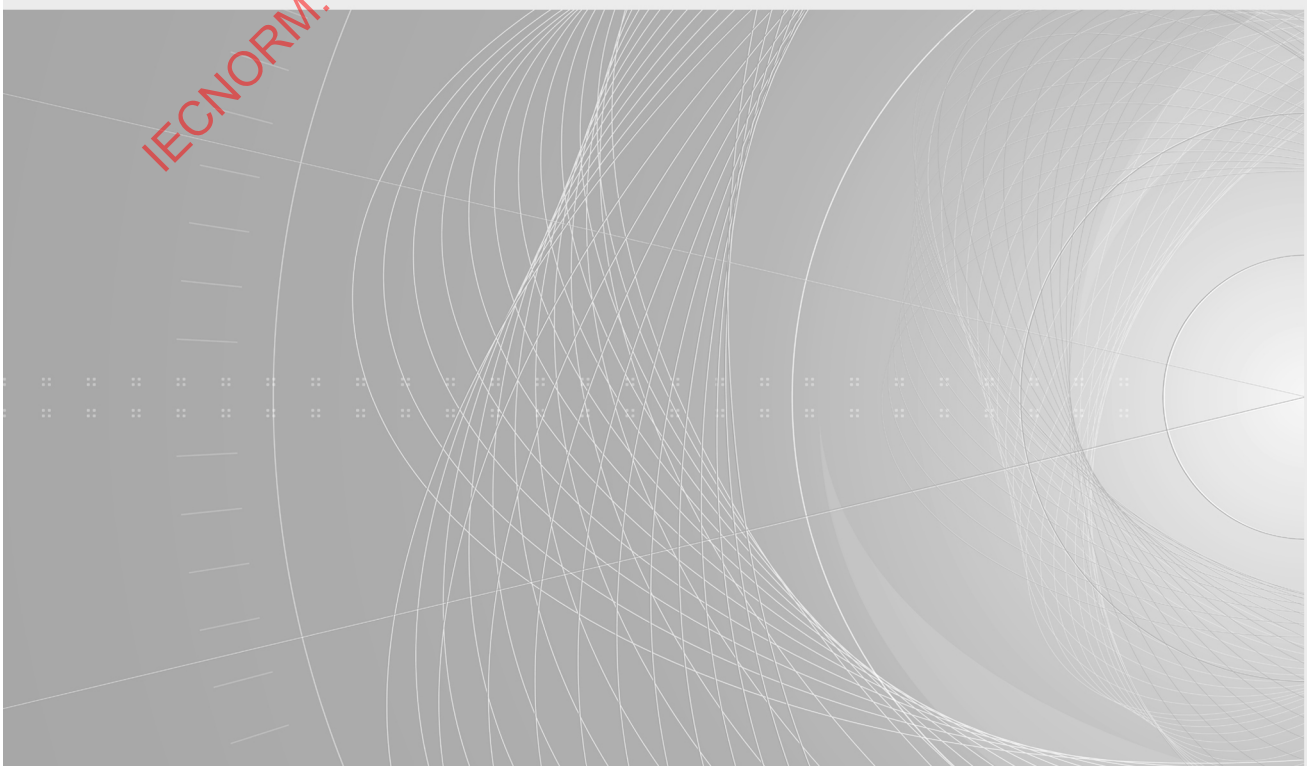
Edition 1.0 2016-12

TECHNICAL REPORT

Railway applications – Specification and demonstration of reliability, availability, maintainability and safety (RAMS) –
Part 4: RAM risk and RAM life cycle aspects



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Railway applications – Specification and demonstration of reliability, availability, maintainability and safety (RAMS) – Part 4: RAM risk and RAM life cycle aspects

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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Part 4: RAM risk and RAM life cycle aspects

FOREWORD

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IEC TR 62278-4, which is a technical report, has been prepared by IEC technical committee 9: Electrical equipment and systems for railways.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
9/2184/DTR	9/2204A/RVC

Full information on the voting for the approval of this technical report can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 62278 series, published under the general title *Railway applications – Specification and demonstration of reliability, availability, maintainabilty and safety (RAMS),* can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

INTRODUCTION

IEC 62278 series *Railway applications – Specification and demonstration of reliability, availability, maintainability and safety (RAMS)* is issued for demonstration of the RAMS aspects. It is based on the European Norm EN 50126:1999 that was prepared by Technical Committee CENELEC TC 9X: Electrical and electronic applications for railways. It was submitted to the National Committees for voting under the Fast Track Procedure. This standard is widely used for safety requirements for the safety within the railway field, with relevant safety standards for railway applications such as IEC 62425 and IEC 62279.

For rolling stock, the guidance on applying the RAM requirements in IEC 62278 is issued as IEC TR 62278-3, which is aimed at the customers/operators and main suppliers of rolling stock. The RAM aspects are important for the whole railway systems, not limited to rolling stock. This means that the RAM aspects need to be elaborated upon in the current version of IEC 62278.

IEC technical committee 9 set up Ad-hoc group 9 (AHG 9) with remit to study the possibilities to develop a Technical Report giving input in order to allow the introduction of RAM risk and RAM life cycle aspects in a future revision of EN 50126 by CENELEC TC 9X or of IEC 62278 by IEC TC 9. This technical report is the result of the study in AHG 9 in order to achieve suitable RAM aspects in the future version of IEC 62278.

RAILWAY APPLICATIONS – SPECIFICATION AND DEMONSTRATION OF RELIABILITY, AVAILABILITY, MAINTAINABILITY AND SAFETY (RAMS) –

Part 4: RAM risk and RAM life cycle aspects

1 Scope

This part of IEC 62278 provides an idea for the expansion of the requirements relating only to RAM aspects in IEC 62278.

This document is intended to be used as an input to the revision for the next edition of IEC 62278. This technical report is entirely informative in nature and does not contain normative aspects.

This document details the idea by means of referring to and revising the related clauses of the current edition of IEC 62278.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 62278:2002, *Railway applications – Specification and demonstration of reliability, availability, maintainability and safety (RAMS)*

3 Terms, definitions and abbreviated terms

For the purposes of this document, the terms and definitions given in IEC 62278 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1 Terms and definitions

3.1.1
impact on operation, comfort or maintenance
IOCM
combination of impact on operational capability, impact on passenger's comfort or impact on maintenance

Note 1 to entry: examples of IOCM can be:

- for operational capability: delay, cancelation, stop on the line,
- for passenger comfort: degradation or loss of passenger information, air conditioning, lighting,
- for maintenance: failure without direct impact on operation or comfort, loss of diagnostic system.

3.1.2
potential impact on operation, comfort or maintenance
PIOCM
physical situation with a potential impact on operational capability, passenger's comfort or maintenance

3.1.3
PIOCM Log
document in which all reliability, availability and maintainability management activities, PIOCM identified, decisions made and solutions adopted are recorded or referenced

3.1.4
RAM risk
probable rate of occurrence of a PIOCM causing IOCM and the degree of severity of IOCM

Note 1 to entry: See Annex B for an example of the relation between PIOCM and IOCM.

3.2 Abbreviated terms

IOCM Impact on Operation, Comfort or Maintenance

PIOCM Potential Impact on Operation, Comfort or Maintenance

4 Railway RAM

4.1 General

This clause is about RAM risk. The purpose of this clause is to show that descriptions after 4.2 are intended to be added to Clause 4 in IEC 62278:2002.

The concepts, methods, tools and techniques (e.g. FMEA, FTA, etc.) described in IEC 62278 are considered also applicable for this document.

4.2 RAM risk

4.2.1 RAM risk concept

The concept of RAM risk is the combination of two elements:

- the probability of occurrence of an event or combination of events leading to a PIOCM, or the frequency of such occurrences;
- the consequence of the PIOCM.

4.2.2 RAM risk analysis

4.2.2.1 The bodies or entities in charge should choose whether RAM risk analysis is carried out. RAM risk analysis should be started at the phase 4, and then may need to be updated or repeated at several stages of the life cycle and should be documented by responsible and/or involved bodies or entities for these phases. The documentation should contain:

a) analysis methodology;

b) assumptions, limitations and justification of the methodology;

c) PIOCM identification results;

d) RAM risk estimation results and their confidence levels;

e) results of trade-off studies;

f) data, their sources and confidence levels;

g) references.

4.2.2.2 Table 1 provides, in qualitative terms, typical categories of probability or frequency of occurrence of a PIOCM event and a description of each category for a railway system. The categories, their numbers, and their numerical scaling to be applied should be defined or approved by bodies responsible for the overall railway system, appropriate to the application under consideration.

Table 1 – Example of categories of frequency of occurrence of PIOCM events

Category	Description
Frequent	Likely to occur frequently. The PIOCM will be continually experienced
Probable	Will occur several times. The PIOCM can be expected to occur often
Occasional	Likely to occur several times. The PIOCM can be expected to occur several times
Remote	Likely to occur sometime in the system life cycle. The PIOCM can reasonably expected to occur
Improbable	Unlikely to occur but possible. It can be assumed that the PIOCM may exceptionally occur
Incredible	Extremely unlikely to occur. It can be assumed that the PIOCM may not occur

4.2.2.3 Consequence analysis should be used to estimate the likely impact. Table 2 describes typical PIOCM severity levels and the consequences associated with each PIOCM severity level.

The number of PIOCM severity levels and the consequences for each PIOCM severity level to be applied and the standard which defines PIOCM severity level should be defined or approved by bodies responsible for the overall railway system, appropriate to the application under consideration.

Table 2 – Example of PIOCM severity levels

Example for operation

Severity level	Consequence to service
Significant	Impact on passengers/freight greater than a specified significant level. Examples of events that have such an impact on passengers/freight are: – a specific intolerable delay – train cancellation – line interruption (impact on other trains' operation) – skip operation (e.g. failure of station equipment)
Major	Impact on passengers/freight greater than a specified major level and less than a specified significant level. Examples of events that have such an impact on passengers/freight are: – a specific undesirable delay – line disturbance (impact on other trains' operation)
Minor	Impact on passengers/freight less than a specified major level (possibly greater than a specified minor level).

Example for comfort

Severity level	Consequence to service
Significant	Impact on passengers greater than a specified significant level. Examples of events that have such an impact on passengers are: – loss of ventilation – loss of air conditioning when needed – loss of lighting (e.g. more than 50 %) when needed – loss of passenger information (e.g. loss of announcement function in a whole station or in a whole train) – failure of toilet for people with reduced mobility
Major	Impact on passengers greater than a specified major level and less than a specified significant level. Examples of events that have such an impact on passengers are: – partial loss or degradation of ventilation – partial loss or degradation of air conditioning when needed – partial loss or degradation of lighting when needed – partial loss or degradation of visual passenger information – failure of toilet (e.g. half of toilets in train)
Minor	Impact on passengers less than a specified major level (possibly greater than a specified minor level). Examples of events that have such an impact on passengers are: – loss of one speaker, one screen, one light, etc.

Example for maintenance

Severity level	Consequence to service
Significant	Impact on maintenance greater than a specified significant level. Examples of events that have such an impact on maintenance are: – restoration which needs important time (e.g. more than 5 days) – re-scheduling the maintenance schedule or inspection schedule (e.g. shorten the inspection interval) – restoration which needs important amount of resources or specific resources with limited capacity
Major	Impact on maintenance greater than a specified major level and less than a specified significant level. Examples of events that have such an impact on maintenance are: – restoration which could not be finished until the beginning of next operation period – necessity of more resources without changing maintenance scheme – restoration with logistic issues
Minor	Impact on maintenance less than a specified major level (possibly greater than a specified minor level). Examples of events that have such an impact on maintenance are: – maintenance which may be postponed if necessary (e.g. operational constraint) and does not require important/specific time/tools/installations

The number and definition of PIOCM severity levels should be scaled depending on the specific application.

4.2.3 RAM risk evaluation and acceptance

4.2.3.1 This subclause deals with the formation of a "frequency – consequence" matrix for evaluation of the results of RAM risk analysis, RAM risk categorisation, actions for RAM risk reduction or elimination of intolerable RAM risks, and for RAM risk acceptance.

4.2.3.2 RAM risk evaluation should be performed by combining the frequency of occurrence of a PIOCM event with the severity of its consequence to establish the level of

RAM risk generated by the PIOCM event. A "frequency – consequence" matrix is shown in Table 3.

Table 3 – Example of frequency – consequence matrix

Frequency of occurrence of a PIOCM event	RAM risk levels		
Frequent			
Probable			
Occasional			
Remote			
Improbable			
Incredible			
	Minor	Major	Significant
	Severity levels of PIOCM consequence		

4.2.3.3 Table 4 defines qualitative categories of RAM risk and the actions to be applied against each category. The bodies or entities responsible for the overall railway system should define or approve principle to be adopted and the tolerability level of a RAM risk and the levels that fall into the different RAM risk categories.

Table 4 – Example of qualitative RAM risk categories

RAM risk category	Actions to be applied against each category
Intolerable	Shall be eliminated. (Some drastic measures shall be required)
Undesirable	Some measures should be considered by the bodies or entities in charge.
Tolerable	Acceptable with adequate control or toleration by the bodies or entities in charge
Negligible	Acceptable

4.2.3.4 Table 5 shows an example of RAM risk evaluation and RAM risk reduction/controls for RAM risk acceptance.

Table 5 – Example of RAM risk evaluation and acceptance

Frequency of occurrence of a PIOCM event *	RAM risk levels		
Frequent	Undesirable	Intolerable	Intolerable
Probable	Tolerable	Undesirable	Intolerable
Occasional	Tolerable	Undesirable	Undesirable
Remote	Negligible	Tolerable	Undesirable
Improbable	Negligible	Negligible	Tolerable
Incredible	Negligible	Negligible	Negligible
	Minor	**Major**	**Significant**
	Severity levels of PIOCM consequence		

* Scaling for the frequency of occurrence of PIOCM events will depend on the application under consideration (4.2.2.2).

5 RAM life cycle

5.1 General

This clause describes requirements related to RAM through the entire life cycle. Based on the concept of RAM performance, requirements for RAM activity in some phases of the life cycle are stated after 5.2. The entries after 5.2 are intended to be added to Clause 6 of IEC 62278:2002.

The concepts, methods, tools and techniques (e.g. FMEA, FTA, etc.) described in IEC 62278 are considered also applicable for this document.

5.2 Requirements to be considered in phase 1

5.2.1 Requirement of this phase should be to identify sources of PIOCM which could affect the RAMS performance of the system.

5.2.2 Requirement of this phase should be to obtain information about:

- RAM policy of responsible and/or involved bodies or entities.

5.3 System requirements for RAM in phase 4

5.3.1 Objectives

The objectives of this phase are to:

a) identify PIOCM associated with the system;

b) identify the events leading to the PIOCM;

c) determine the RAM risk associated with the PIOCM.

RAM risk analysis should be started at the phase 4, and then may need to be updated or repeated at several stages of the life cycle.

5.3.2 Inputs

The input to this phase shall include all relevant information, and where appropriate, data, necessary to meet the requirements of the phase, and in particular the deliverables produced in phase 2 and phase 3.

5.3.3 Requirements

5.3.3.1 Requirement of this phase shall be to:

a) systematically identify and prioritise all reasonably foreseeable PIOCM associated with the system in its application environment, including PIOCM arising from:
   - system normal operation;
   - system fault conditions;
   - system emergency operation;
   - foreseeable system misuse;
   - system interfaces;
   - system functionality;
   - system operation, maintenance and support issues;
   - mechanical environment;
   - electrical environment;

– natural environment to cover such matters as snow, floods, storms, rain, landslides, etc.;

b) identify the sequence of events leading to PIOCM;

c) evaluate the frequency of occurrence of each PIOCM;

d) evaluate the likely severity of the consequences of each PIOCM;

e) evaluate the RAM risk to the system for each PIOCM.

5.3.3.2 Requirement of this phase should be to determine and classify the acceptability of the RAM risk associated with each identified PIOCM, having considered associated RAM risk in terms of any conflicts with safety. Possible conflicts among Reliability, Availability and Maintainability should be considered as well.

5.3.3.3 Requirement of this phase should be to establish a PIOCM Log as the basis for on-going RAM risk management. It should be updated, whenever a change to any identified PIOCM occurs or a new PIOCM is identified, throughout the lifecycle. The PIOCM Log should include details of:

a) the aim and purpose of the PIOCM Log;

b) each PIOCM event and contributing components;

c) likely consequences and frequencies of the sequence of events associated with each PIOCM;

d) the RAM risk of each PIOCM;

e) RAM risk tolerability criteria for the application;

f) the measures taken to reduce RAM risks to a tolerable level, or remove, the RAM risk for each PIOCM event;

g) a process to review RAM risk tolerability;

h) a process to review the effectiveness of RAM risk reduction measures;

i) a process for on-going RAM risk and RAM reporting;

j) a process for management of the PIOCM Log.

5.3.4 Deliverables

5.3.4.1 The results of this phase shall be documented, along with any assumptions and justifications made during the phase.

5.3.4.2 The results of the RAM risk analysis should be recorded within the PIOCM Log.

5.4 Requirements to be considered in phase 7

Requirements of this phase may, if appropriate, be to:

a) start Failure Reporting Analysis and Corrective Action System (FRACAS);

b) update PIOCM Log according to the result of FRACAS.

Annex A
(informative)

Examples of reliability, availability and maintainability parameters for railway applications

Examples of typical reliability, availability and maintenance parameters and symbols, suitable for use in railway applications, are shown in Tables A.1 to A.5 below.

Table A.1 – Examples of reliability parameters

PARAMETER	SYMBOL	DIMENSION
Failure rate	Z(t), λ	$Time^{-1}$
Mean Up Time	MUT	Time, distance, cycle, volume
Mean Time To Failure Mean Distance To Failure (for non-repairable items)	MTTF MDTF	Time, distance, cycle, volume
Mean Time Between Failure Mean Distance Between Failure (for repairable items)	MTBF MDBF	Time, distance, cycle, volume
Mean Time Between Service Failure	MTBSeF	Time, distance, cycle, volume
Failure probability	F(t)	Dimensionless
Reliability (success probability)	R(t)	Dimensionless
NOTE 1 Schedule adherence is not to be mixed with transportation availability (see Table A.3). NOTE 2 Service failure means any failure has an impact on the operation. e.g. delay, loss of comfort, impact of staff on site.		

Table A.2 – Examples of availability parameters

PARAMETER	SYMBOL	DIMENSION
Availability inherent achieved operational	A(.) = MUT/(MUT+MDT) Ai Aa Ao	Dimensionless
Fleet availability	FA (= available vehicles/Fleet)	Dimensionless
Schedule adherence	SA (= 1 – number of delays/number of missions)	Dimensionless
NOTE Schedule adherence is not to be mixed with transportation availability (see Table A.3).		

Table A.3 – Examples of transportation service parameters

PARAMETER	SYMBOL	DIMENSION
Transportation availability (time)	At = (Tt – Ta)/Tt	Dimensionless
Total transportation time	Tt	Time
Affected transportation time	Ta	Time
Transportation availability (volume)	Atv = (Vt – Va)/Vt	Dimensionless
Total transportation volume	Vt	Volume (person, ton)
Affected transportation volume	Va	Volume (person, ton)
Transportation availability (time and volume)	Attv = (Tt×Vt – Ta×Va)/(Tt×Vt)	Dimensionless
Total time and volume	Tt×Vt	Time×volume
Affected time and volume	Ta×Va	Time×volume

Table A.4 – Examples of comfort service parameters

PARAMETER	SYMBOL	DIMENSION
Comfort availability (time)	Ac = (Tct – Tca)/Tct	Dimensionless
Total comfort function time	Tct	Time
Affected comfort function time	Tca	Time

Table A.5 – Examples of maintenance parameters

PARAMETER	SYMBOL	DIMENSION
Repair rate	μ	$Time^{-1}$
Mean Down Time	MDT	Time, distance, cycle
Mean Time/Distance Between Maintenance	MTBM/MDBM	Time, distance, cycles
MTBM/MDBM, corrective or preventive	MTBM(c)/MDBM(c), MTBM(p)/MDBM(p)	Time, distance, cycles
Mean Time to Maintain	MTTM	Time
MTTM, corrective or preventive	MTTM(c), MTTM(p)	Time
Mean Time To Restore	MTTR	Time
False Alarm Rate	FAR	$Time^{-1}$