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TECHNICAL REPORT

colour inside

Railway applications – Specification and demonstration of reliability, availability, maintainability and safety (RAMS) –
Part 3: Guide to the application of IEC 62278 for rolling stock RAM

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Railway applications – Specification and demonstration of reliability, availability, maintainability and safety (RAMS) – Part 3: Guide to the application of IEC 62278 for rolling stock RAM

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IEC 62278-3, which is a technical report, has been prepared by IEC technical committee 9: Electrical equipment and systems for railways.

This technical report is based on EN 50126-3.

This technical report is to be read in conjunction with IEC 62278 (2002).

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

Enquiry draft	Report on voting
9/1284/DTR	9/1315A/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 publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

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

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
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A bilingual version of this publication may be issued at a later date.

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INTRODUCTION

IEC 62278 is likely to enhance the general understanding of the issues involved in achieving RAMS characteristics within the railway field. It defines a comprehensive set of tasks for the different phases of a generic life cycle for a total rail system. Although some of the examples given in the annexes of IEC 62278 are for rolling stock, the standard is essentially aimed as a top level railway system document.

RAMS characteristics for rolling stock (i.e. its long-term operating behaviour performance), as for any other system, form an important part of its overall performance characteristics. But the consideration of RAMS, in contractual terms, between a customer / operator and a main supplier for the procurement of rolling stock has been problematic. Also, in rolling stock contracts, there is now a greater emphasis on the impact on end customers of service failures and on the economic and risk considerations of RAMS (i.e. the business perspective).

Consequently, Life Cycle Cost is being used as a measure of satisfying customer needs and providing a wider perspective of RAMS importance in terms of the business economics.

Life cycle cost approach represents a holistic, total cost of ownership philosophy for addressing economic considerations. The contribution of RAMS to the LCC (Life Cycle Cost) of rolling stock could be used to allow economic considerations to be addressed.

This application guide focuses mainly on the tasks and issues from procurement, engineering and maintenance, from the tender to the operation/maintenance phase, and is intended to help in establishing a common approach for capturing the different, time dependant, performance requirements of rolling stock from an operator/business perspective.

IEC 62278 is a standard, which treats the overall aspects of RAMS in railway applications.

This guide deals with the application of RAM part of IEC 62278 to rolling stock only, as stated in the scope and clarifies areas where IEC 62278 could be misinterpreted.

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

Part 3: Guide to the application of IEC 62278 for rolling stock RAM

1 Scope

This part of IEC 62278 provides guidance on applying the RAM requirements in IEC 62278 to rolling stock and for dealing with RAM activities during the system life cycle phases from invitation to tender to demonstration in operation only. All references to IEC 62278 concern the 2002 issue.

The guide is aimed at the customers/operators and main suppliers of rolling stock. The main purpose of the guide is to:

- enable a customer/operator of rolling stock:
  - to specify the RAM requirements addressing the type of operation in terms of the end customer needs, considering service availability and economic considerations;
  - to evaluate different tenders, in terms of RAM requirements, on a common basis with the aid of specific RAM documents;
  - to gain assurance, during design/development phase, that the rolling stock being offered is likely to satisfy the RAM contractual requirements by examining step by step detailed and specific RAM documents as an output of the RAM activities performed during the development phase;
  - to validate that the rolling stock, as delivered, satisfies the specified RAM requirements;
- to enable the main supplier of rolling stock;
  - to understand the customers/operators RAM requirements;
  - to provide substantive information/visibility in a tender to show that the product offered is likely to satisfy the RAM requirements by performing preliminary RAM analysis;
  - to provide substantive information during design/development phase to show that the product offered is likely to satisfy the RAM requirements by performing detailed RAM analysis;
  - to demonstrate that the product delivered satisfies the RAM requirements.

Regarding LCC, this application guide is restricted to providing only the key RAM parameters necessary to be incorporated into an LCC model.

This application guide excludes:

- RAM values connected to the different RAM requirements (however, it contains a simple guideline of actions for supporting the decision making process and choosing appropriate values, see 5.4);
- specific RAM documents to be produced and activities to be performed. However, it provides, only as an example, typical data and document templates for recording the output of a RAM analysis).

2 Terms and definitions

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

2.1
part number
the alphanumeric code, generally assigned by the main supplier, to represent a family of items with the same characteristics of form, fit and function

3 Approach adopted for the guide

3.1 General

The approach adopted is to raise the following questions, for each phase of the Life Cycle, in order to successively set up the requirements of IEC 62278 and the basis for satisfying them:

- WHAT: what activities / tasks are to be performed and the supporting documents to be produced?
- WHO: who has the responsibility for these activities / tasks?
- HOW: which type of method or tool should be used?

This process is adopted for the development of the guide and should be applied in accordance with the structure of the application guide.

3.2 Entities involved in the life cycle phases of rolling stock

Depending on the organisational and management structure of the railway system concerned, a number of entities, performing different functions, may be involved within the life cycle phases of rolling stock. For the purpose of guidance on contractual relations, the entities are divided into 2 main categories, i.e. customer and supplier.

It is therefore advisable, to identify all the entities that can be a part of this relationship and to examine how the responsibilities of dealing with these entities are shared between the customer and supplier relationship. Table 1 gives some typical examples only.

Table 1 – Possible sharing of responsibility

Entity	Supplier responsibility	Customer responsibility
Main supplier of the rolling stock	X	
Sub-supplier of the rolling stock	X	
Operator of the rolling stock		X
Owner of the rolling stock		X
Maintainer of the rolling stock	X	X

4 Application of this guide

4.1 Object of the application

This guide is applicable to rolling stock (train, coach, locomotive, etc.) and to all the subsystems, assemblies and parts belonging to the rolling stock, according to their boundary limits.

Referring to 1.2 of IEC 62278, the guide is for use by Railway Authorities and the railway support industry and is applicable to:

- new rolling stock,
- modification/refurbishment of existing rolling stock.

For use in this document only, the above two bullet point items should be referred to by the generic term “system”, comprising the complete sequence “system, sub-system, component” of a rolling stock or the whole rolling stock itself breakdown structure.

4.2 Application of IEC 62278

4.2.1 Assessment of the application of IEC 62278

Referring to 5.3 of IEC 62278 and taking into account the responsibilities of the different entities involved in the life cycle phases, the following subclause gives a synthesis of the main actions required to meet the requirements.

According to 5.3.2 of IEC 62278, the assessment of the application of the requirements of IEC 62278 to rolling stock (system under consideration) shall be defined by the Railway Authority and according to 5.3.4 of IEC 62278, the assessment shall:

a) Specify phases applicable, and for each one of these:
   - Justify and demonstrate the compliance with the principles of the requirements of the standard.
   - Specify the mandatory activities/requirements, with respect to rolling stock (system under consideration), including:
     1) The scope of each requirement,
     2) The methods, tools and techniques required against each requirement and the scope and depth of their application,
     3) The verification/validation activities required against each requirement and the scope of their application,
     4) Input/output documentation.

b) Justify any deviation from the activities and requirement of the standard.

c) Justify the adequacy of the tasks chosen for the system under consideration.

Both the customer and the main supplier should provide documented evidence for the above specifications and justifications that are within their responsibility.

Where main supplier introduces limitations, they should be discussed and agreed with the customer.

These documents are considered as part of the RAM programme.

4.2.2 Mandatory requirements for the application of IEC 62278

The correct application of IEC 62278 is effected through several requirements.

The following is a synthesis of the mandatory requirements in 5.3.5 of IEC 62278 regarding RAM only:

- define and agree the responsibilities for carrying out all RAM tasks within each phase chosen;
- ensure the competence of the personnel involved within RAM tasks;
- establish and implement a RAM programme, where the following should be identified and managed:

  – conflicts between RAM and safety tasks,
  – details of all RAM analysis, including the depth of analysis activities;
- ensure that the requirements of IEC 62278 are implemented within business processes, supported by a Quality Management System (QMS) compliant with the requirements of ISO 9000 series;
- establish and implement an adequate and effective configuration management system including, at least:
  – all system documentation,
  – all other system deliverables.

Both the customer and the main supplier should provide evidence by documents about the fulfilment of these mandatory requirements, within their responsibility.

These documents are considered as part of the RAM programme.

5 Specifying RAM requirements

5.1 Introductory remarks

The purpose of this clause is to establish the process to define RAM requirements for rolling stock and for all the subsystems, assemblies and parts belonging to the rolling stock according to its boundary limits.

This clause gives detailed information on phases 1, 2, 4 and 5 of system life cycle requirements described in 6.1, 6.2, 6.4 and 6.5 of IEC 62278.

To start with, as part of the system definition process, all available data and relevant information about the rolling stock under consideration should be collected.

The final goal is the derivation of RAM targets through the appropriate analysis of all the information collected and organised in a structured way.

5.2 Preliminary RAM analysis

5.2.1 General

This subclause complements 6.1.3.4, 6.2.3.1, 6.2.3.2, 6.4.3.1 and Clause A.2 of IEC 62278 and gives further details.

The purpose of the preliminary RAM analysis is to identify the application environment and the operating conditions of the rolling stock, in order to recognise the fundamental concepts for basing the overall RAM requirements.

The analysis involves undertaking the following activities:

- similar system review:
  – a list of similar existing rolling stock is created, suitable for extracting relevant RAM-related information;
- preliminary system analysis:
  – all available and relevant rolling stock documentation is reviewed in order to define, at a preliminary level, the overall system structure and its mission profile and to recognise the system failure conditions.

Deliverables of the preliminary RAM-related activities constitute the necessary background for defining the overall RAM requirements specification in terms of:

– RAM requirements.
– Demonstration and acceptance criteria.
– RAM programme requirements.

5.2.2 Preliminary RAM analysis activities

5.2.2.1 General

Preliminary RAM-related activities consist of investigating all the relevant available documentation in order to recognise all the functional requirements, which may affect the RAM performance of the rolling stock.

The resultant deliverables of the preliminary RAM-related activities are:

- System identification: where the rolling stock has to be identified in terms of its boundary limits, operational conditions, functions, interfaces, system breakdown structure, logistics and maintenance conditions.
- Failure conditions: where the failures of the rolling stock have to be identified and categorised in order to define appropriate requirements.

5.2.2.2 System identification

This subclause provides a general overview of the main features identifying a rolling stock (see IEC 62278, Clause A.2).

The identification process is carried out to gain assurance that the rolling stock is correctly analysed and all the factors influencing its RAM performance have been identified.

These characteristics define the conditions under which the rolling stock is required to accomplish its mission and constitute the reference conditions for:

- defining the rolling stock RAM requirements;
- demonstrating, by analysis and tests, that each specific implementation fulfils the RAM requirements in all relevant lifecycle phases.

The main characteristics and features necessary to describe a rolling stock are its mission profile, route profile, operating conditions, environmental conditions and maintenance conditions (including logistics). Items contained in each of these are listed below:

a) Mission profile:
   - Reference route,
   - Commercial speed (mission duration / mission length),
   - Mean length of a run,
   - Mean distance between train stops,
   - Operating time or distance per year,
   - Revenue operating time or distance per year,
   - Stand-by time per day,
   - Idle time per day (i.e. time when the rolling stock is neither in operation nor stand-by),
   - Planned total time of use (life expectancy in years).

b) Route profile:
   - Number of tunnels related to reference route,
   - Number of viaducts related to reference route,
   - Cumulative distance in tunnels,

- Cumulative distance on surface, including viaducts,
- Gradients and curves on the route with their lengths.

c) Operating conditions:

- Equivalent speed related to the time the equipment is powered during a given calendar period (cumulated distance / Time the equipment is powered over the period),
- Time an equipment is powered over a given calendar period (this parameter could be defined for each equipment, but is generally defined for categories of equipment),
- Time during which traction is activated,
- Time or percentage of time during which electric braking is activated,
- Operating time of the compressor,
- Number of compressor startups,
- Time of presence of catenary power, for each voltage,
- Time during which a trainset is awake (i.e. in operation or standby),
- Operating time for Heating Ventilation and Air Conditioning, in heating mode and in air conditioning mode,
- Average speed and maximum speed,
- Potential use in multiple units,
- Total time of coupled operation,
- Frequency of coupling and de-coupling,
- Internal temperature range of the rolling stock,
- Mechanical (shock and vibration),
- Electrical (power supplies),
- Electromagnetic compatibility (e.g. EMC – train to train or system to system),
- Signalling interfaces (e.g. on-board and way-side),
- Ergonomics.

d) Environmental conditions:

- Outside air temperatures (OAT),
- Maximum height above the sea level,
- Solar radiation,
- Humidity,
- Wind and pressure pulses,
- Water and precipitation,
- Pollutants and contaminants,
- Resistance to corrosion.

e) Maintenance conditions:

- Indicative maintenance plan (i.e. minimum preventive maintenance interval, maximum contemporary number of personnel required for maintenance interval tasks, maximum standstill time to complete maintenance interval tasks, etc.),
- Number, location and description of the sites for maintenance,
- Description of the standard equipment, tools and resources at the maintenance sites.

5.2.2.3 Breakdown structure and boundary limits

5.2.2.3.1 General

Breakdown structure of the rolling stock is the most important baseline of the identification process. Establishing a breakdown structure of the rolling stock, gives a clear reference outline for all the activities and analyses for supporting RAM programme through the life cycle.

Generally, the scope of the breakdown structure is to set up the borders of a system by listing all the items belonging to that system and, by using an appropriate number of discrete breakdown levels for the system, to draw out the relationships existing between the different items of the rolling stock.

There are two categories of structures to support RAM analyses:

- Functional breakdown structure,
- Physical breakdown structure.

The functional breakdown is used to perform preliminary criticality analyses. The last functional level allows consequences of functional failure modes to be developed and the next physical level allows the critical item list to be developed.

The physical breakdown is used to perform maintainability analyses. The last level of this breakdown is the LRU (Line Replaceable Unit), as defined in 5.5.4.4. This breakdown is sometimes called the logistic breakdown structure.

5.2.2.3.2 Common rules to set up a physical breakdown structure

For setting up a breakdown structure, a decomposition process is carried out starting from the first level to the other levels identified and being able to represent all the items and their functional relationships.

The decomposition process is based on a hierarchical breakdown in a top down process commencing with the rolling stock as the system under consideration.

At each level identified in the hierarchy, every system identified becomes the next system under consideration and can be further decomposed into lower levels, as necessary.

There are several methods and tools to set up a breakdown structure. The following are recommendations to be followed in order to develop an appropriate and suitable breakdown structure for RAM purposes:

- Avoid the use of "large number of levels" and limit these to a reasonable number (three or four are suggested),
- Last item identified along a branch shall be a LRU,
- Force the use of the same terms and definitions for identical items,
- Ensure that the terms and definitions used for every item are the same in all the design documents (drawings, outlines, diagrams, specifications, etc.),
- After the first issue of the structure avoid continuous modifications,
- Avoid the use of vague or unclear definitions.

The definition used for LRU is well explained in 5.5.4.4.