

[TD-GZ.28.0038]
[Rev. 00]

Gaziray Commuter Train Project
**RAMS ANALYSIS REQUIREMENTS
FOR HVAC SYSTEM**

Issued Date : 15/04/2021

Revision Date : .././....

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Form No: TAGF-10	Issued Date: 15.04.2021	Rev. No: 00	Form Name: TECHNICAL DOCUMENT
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1 SUBJECT

This document provides the requirements to be applied to the HVAC (Heating and Air-Conditioning) systems RAMS analysis for the Gaziray Commuter Train (EMU) produced by TÜRASAŞ for urban passenger management.

1.1 DEFINITIONS

Within this document, the following definitions are applied to the words reported below:

- “the Company” means the Turkish Wagon Industry Co. (hereafter called TÜRASAŞ)
- “the Designer” means BLUE Engineering that is the company responsible for the design EMU set
- “the Supplier” means the company who wins the tender to supply the good object of this specification

1.2 LIST OF ACRONYMS & ABBREVIATIONS

EMU	Electrical Multiple Unit
EN	European Norm
FMECA	Failure Mode and Effects Critical Analysis
IEC	International Electrotechnical Commission
LCC	Life Cycle Cost
LRU	Line Replaceable Unit
MTBF	Mean Time Between Failure
MTSBF	Mean Time Between Service Failure
NoBo	Notified Body
PRM	Persons with Reduced Mobility
RAMS	Reliability, Availability, Maintainability, Safety
SIL	Safety Integrity Levels
TCDD	General Directorate of Turkish State Railways
TSI	Technical Specification for Interoperability
TÜRASAŞ	Turkish Railway Vehicle Industry Inc.

2 STANDARDS

RAMS activities will be improved in compliance with applicable STI (Specifications for Technical Interoperability).

In particular, RAMS assurance shall be controlled through the standard:

- EN50126-1/2:2017 – Railway applications - The specification and demonstration of Reliability, Availability, Maintainability and Safety.

This standard shall be used as guideline in the development of all the analyses following the methodological approach reported.

Following standards shall be followed when applicable:

- IEC 61508:2010 - Functional safety of electrical/electronic/programmable electronic safety-related systems
- EN 50129:2018 - Railway applications. Communication, signalling and processing systems. Safety related electronic systems for signalling
- EN 50128:2011/A1-2:2020 - Railway applications – Software for railway control and protection system

3 REFERENCE DOCUMENTS

The reference documents are the following.

- [R1] TŞ-01.139 - Gaziray Commuter Train Project - General Technical pecification
- [R2] TŞ-28.034 - Gaziray Commuter Train Project - Passengers and Driver Cab HVAC System & Electric Heaters Technical Specification
- [R3] TD-GZ.01.0062 - Gaziray Commuter Train Project – RAMS guidelines

4 EMU BASIC REQUIREMENTS

4.1 EMU CONFIGURATIONS

The EMU will be built in 4 cars configuration:

SKA, OA, OA, SKA

There are 2 types of car:

- SKA = Head Car with driver cab, PRM area, multifunction area
- OA = Intermediate Car

The SKA vehicles will be interchangeable, and the OA vehicles will be interchangeable.

The EMU will be fixed configuration train: the orientation of the different type of cars within a unit is fixed.

The train traction layout will be selected between the following versions:

- Bo'Bo'+2'2'+2'2'+Bo'Bo'

The trainset and HVAC systems details are described in documents [R1] and [R2].

5 EMU MISSION PROFILE

In the following tables are reported the EMU foreseen mission.

Yearly mileage	240.000	km/years
Operating days per year	330	day/year
Daily average time under power	19,0	hrs/day
Daily average running time	18,0	hrs/day
Daily average mileage	730	km/day
Average speed (powered -up time)	38,30	kph
Average speed (running time)	40,40	kph
Yearly time under power	6.270	h/year
Yearly running time	5.940	h/year
Operating days per month	29	day/month
Carbody and Main Equipments life (years)	30	years
Interior trims and equipment	15	years
Maximum Service Speed	120	Km/h

Table 5-1 - EMU mission profile

6 RELIABILITY, AVAILABILITY, MAINTAINABILITY & SAFETY (RAMS)

6.1 GENERALITY

The following sections detail the requirements for the implementation of Reliability, Availability, Maintainability and Safety (RAMS) activities to be undertaken by the Supplier of HVAC systems for Driver Cab and passenger compartment.

6.2 RAMS PROGRESS AND REVIEW MEETINGS

RAMS progress and review meetings shall be held on the frame of established Design Reviews between the Supplier and TÜRASAŞ to ensure that targets are respected, to provide a formally review the content of the RAMS activities undertaken by the Supplier.

6.3 RAMS TARGETS

The Supplier shall demonstrate that the system/equipment supplied fulfils the following RAMS requirements and targets by means of analyses during the project development and verification on the final product.

The mission profile described in this document has to be used as reference during the design development.

6.4 RELIABILITY TARGETS

Minimum MTBF (Mean Time Between Failure) and MTBSF (Mean Time Between Service Failure) values of complete system and sub-assemblies shall be submitted by the Supplier.

Data which will be the basis of MTBF and MTBSF calculations shall be collected during a 6-month period in the commercial operations after the provisional acceptance of the last vehicle.

At the end of this duration, required measures shall be taken to ensure the values determined for the train sets exceeding the limit values mentioned above.

For the calculations, fleet of 8 electrical multiple units with 4 cars shall be taken as 240.000 km / train in total annually and the duration of passenger operations of the train shall be taken as 6000 hours/year.

The classification of failure rate reported hereafter helps to identify the type of failure.

Classification of the Malfunctions

- **1st Class Malfunctions:** Major and important malfunction. Train cannot move, they are the malfunctions which require train to be coupled with another train and to be pulled by it.
- **2nd Class Malfunctions:** Influent and permanent malfunction. They are the malfunctions which require evacuation of the passengers but allow train to move to the depot with its own power.
- **3rd Class Malfunctions:** Permanent malfunction. They are specific malfunctions which do not require evacuation of the passengers but the train cannot continue giving services at the end of the run.
- **4th Class Malfunctions:** Temporary malfunction. They are the malfunctions which allow train to real-ise its scheduled runs and to continue giving services.

1st class, 2nd class, 3rd class and 4th class malfunctions described below shall be considered in MTBF calculations.

On the other hand, MTBSF calculations shall only consider 1st and 2nd class malfunctions.

The targets to be respected for the systems are the following:

PARAMETER	TARGET [HVAC system for one coach]	REMARKS
MTBF	16.670 [hours]	Failures Class 1, 2, 3, 4
MTBSF	100.000 [hours]	Failures Class 1, 2

Table 6-1 – Passenger HVAC reliability targets

PARAMETER	TARGET [HVAC system for one Cab]	REMARKS
MTBF	50.000 [hours]	Failures Class 1, 2, 3, 4
MTBSF	400.000 [hours]	Failures Class 1, 2

Table 6-2 – Driver HVAC reliability targets

6.5 MAINTENANCE TARGETS

The Supplier shall submit a LCC analysis describing maintenance activities, maintenance types, maintenance intervals, machinery/bench requirements, tool requirements, maintenance kilometer of each maintenance starting from the first periodic maintenance, list of materials consumed for the mentioned maintenance, its cost and labour hours (man x hour).

In its LCC analysis the Supplier shall submit the labour hours for the corrective maintenance works of sub-assemblies by indicating them in man x hour.

The Supplier shall consider that all maintenance works defined by himself would be performed for a vehicle life of **30 years** (30 x 240.000 = 7.200.000 km).

In the calculations, labour price shall be taken as 10 (ten) Euro for man x hour price.

The Supplier shall submit to TÜRASAŞ the values described in the following table, either for passenger HVAC system and for Driver cab system.

TÜRASAŞ shall test the accuracy of the indicated values within the warranty period.

Description	Target [At train level]	Remarks
Preventive total cost per 1000 km [€/1000 km]	<i>To be declared by Supplier</i>	
Corrective total cost per 1000 km [€/1000 km]	<i>To be declared by Supplier</i>	
Total maintenance cost per 1000 km [€/1000 km]	<i>To be declared by Supplier</i>	

Table 6-3 – Maintenance targets (30 years period)

6.6 PREVENTIVE MAINTENANCE REGIME

The Supplier shall give periodic maintenance intervals on the basis of kilometers.

These intervals shall be optimized on vehicle basis.

- ✓ 18.000 km maintenance interval minimum in kilometer
- ✓ 180.000 km maintenance interval minimum in kilometer
- ✓ 720.000 km maintenance interval minimum in kilometer

The Supplier shall agree with TÜRASAŞ upon possible different frequency keeping into account particular needs of its scope of supply.

The overhauls interval can be proposed by Supplier, as a multiple of previous intervals.

6.7 MATERIAL AND LABOUR COST

The material prices to be inserted for preventive and corrective maintenance calculation shall be after market ex works price and the same of the Spare Parts List.

The “after market ex works price is the price of spares parts without transport cost when purchased by TÜRASAŞ or by Final User for preventive or corrective maintenance during the whole life of the system/sub-system/component (after production phase).

In the calculations, labour price shall be taken as 10 (ten) Euro for man x hour price.

The maintenance task times to be counted shall be the so called “technical times” as specified in the following table.

Technical times include:	Technical times do not include:
Set-up time – Technical cleaning	
Diagnosis and trouble-shooting time	Logistic and organisation time
Accessibility time to components	Accessibility time to supplied equipment
Change or repair time	Unproductive time
Functional check time	Event recording time

Table 6-4 – Technical Time

6.8 LRU POLICY AND SPARE PARTS

It is highly recommended to perform LRUs (Line Replaceable Unit) revision or the main repair operations (corrective maintenance) off-Train.

Consequently LRUs involved in the task, will be replaced with its ready spares from the depot. All that to save time and cost as already written.

To follow this approach the Supplier shall supply a spares parts list including the list of spares used for preventive and corrective maintenance analysis, with additional information for Stock calculation purposes:

- Break down structure
- Spare description
- Quantity per “upper” equipment (sub-system quantity per each “father” system and not quantity at system/sub-system/component level)
- Serial price (1)
- After market ex works price
- Delivery time on site
- Economical buy quantity
- Life time
- Minimum buy quantity
- Obsolescence time

(1) Serial price (capital spare): new build price applied to spares in order to build the maintenance stock "capital spares" at the beginning of commercial service. TÜRASAŞ will choose within this list the equipment and quantity to be purchased.

All the reference used by the Supplier to identify the spare parts shall be the same used in all the documentation provided (design documentation, first and second level maintenance manuals, spare parts catalogue, various instructions for personnel, etc.).
Spare part production guarantee should be 10 years.

6.9 SPECIAL TOOLS LIST

Generally, the usage of special tools shall be avoided to perform preventive and corrective maintenance.

As special tool is intended either a tool (hardware and/or software) that is exclusively produced by the Supplier and is essential for system/equipment maintenance, either a tool available on market but expensive, sophisticated, with long lead time and so on.

If this is not possible, the Supplier shall provide 2 complete sets of special tools free of charge.
The list to be supplied shall be consistent with the Special Tools mentioned into the preventive and corrective maintenance analysis.

6.10 RESPECT OF RAMS TARGETS

Declared RAMS targets shall be to be demonstrated and evaluated, during the development of the project.

In particular the Supplier shall demonstrate that all reliability and maintainability requirements and levels of repair have been considered and satisfactorily introduced into design.

Maintainability analysis and Maintenance targets shall be monitored, reviewed and controlled by formal processes to be advised by TÜRASAS.

The Maintenance Plan derived from preventive analysis and the relevant tasks shall be consistent with maintenance manuals (see dedicated paragraphs).

In case of missed fulfilment the Supplier has to perform all necessary modifications at no costs for TÜRASAS, in order to fulfil all RAMS targets.

6.11 RAMS DOCUMENTATION (DELIVERABLES)

The Supplier must provide to TÜRASAS the following RAMS documentation.

The instructions for improving documentation are described in doc. [R3], which includes also the templates to be fulfilled by Supplier.

Documentation
Functional breakdown + inherent failure analysis
Mission (critical) reliability calculation/analysis
System Hazard Analysis and Operating and Support Hazard Analysis
Failure Mode Effects and Criticality Analysis (FMECA)
Hazard Log
List of critical components (single failure leads to serious accident)
Preventive and corrective maintenance analysis (LCC)
Spare parts list
Special tools list (if necessary)

Table 6-5 – RAMS documentation deliverables

END of DOCUMENT