# TS400048

# GENERAL TECHNICAL SPECIFICATION OF ELECTRIC COCO LOCOMOTIVE

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## REVISION TABLE

| Rev | Date | Description | Revised By |
|---|---|---|---|
| 00 | 26/08/2025 | First release | |
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# 1. SUBJECT AND SCOPE

This technical specification defines the minimum technical requirements for the Electric (25KV ac) Co-Co Axle Arrangement Locomotive (hereinafter referred to as ELE) to be used in freight transportation and to be manufactured by Türkiye Raylı Sistem Araçları Sanayii AŞ (hereinafter referred to as TÜRASAŞ).

**The Electric Locomotive** (ELE) will also be designed to operate with the **Last Mile Module (LMM)**. This mode will enable the locomotive to pull heavy freight trains at a **maximum speed of 25 km/h** with limited power.

# 2. DEFINITIONS & REFERENCE DOCUMENTS

## 2.1. INTRODUCTION

Within this Technical Specification, the following definitions are applied:

- **End User:** Legal entities or individuals operating on the national railway lines of the Republic of Turkey
- **Administration:** Turkish Railway Vehicles Industry Inc. (TÜRASAŞ)
- **Designer:** Third legal or private entity responsible for the design of the electric and diesel-electric COCO LOCO
- **Contractor:** The company that won the tender and will supply the products covered by the relevant technical specifications.
- **Documentation:** All or any specifications, drawings, reports, networks, operating and maintenance manuals and all other information whether on paper or on magnetic or other format which is prepared by the Contractor in the course of the contract.
- **Bidder:** means the company who want to join to the tender to supply the good object of this specification
- **Traction and Auxiliary Power (APS) System Contractor:** The company which will supply the integrated drive system, which includes all electrical components and auxiliary power unit systems involved in the process of converting energy from its source or supply point into mechanical power via traction motors and transmitting it to the wheels, as well as the sub-components of these systems, for electric and diesel-electric Coco locomotives.

## 2.2. ACRONYMS AND DEFINITIONS

The acronyms and definitions used in this document are reported in the following Table.

| | |
|---|---|
| **ADMINISTRATION** | TÜRASAŞ |
| **Admin. Personnel** | TÜRASAŞ and/or Co-Co Project working groups assigned in the relevant subject |
| **AC** | Alternating Current |
| **BCU** | Brake Control Unit |
| **BP** | Brake Pipe |
| **CAD** | Computer Aided Design |
| **CPU** | Central Processing Unit |
| **DC** | Direct Current |
| **DI** | Digital Input |
| **EB** | Emergency Brake |
| **ED** | Electro Dynamic |
| **EDB** | Electro-Dynamic Brake |
| **ELE** | Electric Locomotive of Co-Co Axle Arrangement |
| **EN** | European Norm |
| **ERTMS** | European Rail Traffic Management System |
| **ESRA** | Electronic System for Railway Application |
| **FAI** | First Article Inspection |
| **FEM** | Finite Element Method |
| **FPMK** | Failure Per Million Kilometre |
| **GPRS** | General Packet Radio Service |
| **GPS** | Global Position System |
| **HV** | High Voltage |
| **HVAC** | Heating, Ventilation, & Air Conditioning |
| **HSCB** | High Speed Circuit Breaker |
| **I/O** | Input / Output |
| **IEC** | International Electro-technical Commission |
| **IP** | Protection |
| **IRIS** | International Railway Industry Standard |
| **ISO** | International Organization of Standardization |
| **LED** | Light Emitting Diode |
| **LRU** | Line Replaceable Unit |
| **MBP** | Main Brake Pipe |
| **MRP** | Main Reservoir Pipe |
| **MV** | Multiple Vehicle |
| **MVB** | Multiple Vehicle Bus |
| **N/A** | Not Applicable |
| **NoBo** | Established by the relevant commission of the European Union under the directive 2016/ 797 / EC on the "Interoperability of the rail system within the European Union" directive. "Notified Body" |
| **RAMS** | Reliability, Availability, Maintainability and Safety |
| **SI** | International System |
| **ST** | Standard |
| **SKD** | Unassembled Product |
| **TBC** | To be confirmed |
| **TBD** | To be defined |

| | |
|---|---|
| **TCDD** | Turkish State Railways General Management |
| **TCDDT** | Turkish State Railways Transportation Inc. |
| **TCMS** | Train Control & Monitoring System |
| **TCU** | Traction Control Unit |
| **TOR** | Top of Rail |
| **TSI** | Technical Specifications for interoperability |
| **TSI SRT** | Document 1303/2014 / EU of the European Commission (the technical specification for interoperability relating to 'safety in railway tunnels' of the rail system of the European Union) |
| **TSI CCS** | Document 2023/1695/EU of the European (the technical specification for interoperability relating to the control-command and signaling subsystems of the rail system in the European Union) |
| **TSI NOI** | Document 1304/2014 / EU of the European Commission (technical specification for interoperability relating to the subsystem rolling stock — noise) |
| **TÜRASAŞ** | Turkish Railway Vehicles Industry Inc. |
| **TSE** | Turkish Standards Institute |
| **UNI** | National Standards Unit |
| **UIC** | Union International Chemin de Fer |
| **VCU** | Vehicle Control Unit |
| **WSP** | Wheel Slide Protection |
| **WTB** | Wire Train Bus |
| **EMC** | Electromagnetic Compatibility |

Table 1 – Acronyms and Definition

## 2.3. REFERENCE DOCUMENTS

In the following table the documents used for reference document.

| Ref | Document | Title |
|---|---|---|
| 1 | TB50160 | Standard List |
| 2 | TB50161 | Fire Classification |
| 3 | TB50172 | Thermoacoustic Behaviour |
| 4 | TB50191 | Traction Performance Electric |
| 5 | TB50170 | SIL Level |
| 6 | TB50165 | RAMS Targets Allocation |
| 7 | 012GX0000201-000 | General Layout Electric |
| | | |

Table 2 –Reference Documents

## 3. STANDARDS TO BE COMPLIED

The design, assembly, and testing activities of the ELE Loco project will be carried out in accordance with the following nationally and internationally recognized reference standards.

- **European Standards**: TSI, EN
- **International standards:** UIC, ISO, IEC
- **Other International Standards:** DIN, NF F, UNI, CEI, etc.
- **National Standards:** Technical documents published in accordance with TSE directives and related annexes
- **Unit System to be Used:** SI (International System of Units)

Bidders and Contractors shall comply with the directives, standards, and requirements listed in the order of priority defined above in their conformity assessments and/or in other conditions that are not specified in the Technical Specifications but are relevant to the product covered by the technical specifications and the equipment and subcomponents that constitute this product.
In cases where compliance with these directives, standards, and requirements is not possible, other relevant international standards, European standards, national standards, and TCDD guidelines, as well as the conditions required by national legislation, may be used.

If a standard of a higher priority contains omissions regarding the particular matter, such omissions shall be removed by the next standard.
In case of a revision in the standards/norms referred to herein while the work is in progress, the Contractor shall:

- Inform in writing the Administration within 20 (twenty) business days after the revision has been published and put into force.
- Make the necessary processes for adaptation to the new situation no later than 1 (one) calendar month after the revision has been published and put into force and submit them to the Administration for approval. However, this approval process cannot exceed two months (60 calendar days) from the date on which the change to the standards/norms is published and enters into force.
- The Administration shall review the process within 15 (fifteen) business days and forward their decision to the Contractor.

The change of directives, standards, norms will not prevent the completion of the certification. Bidders and Contractors shall review the relevant technical specifications and annexes and confirm that the system/equipment covered by the specifications complies with the relevant standards. If in this technical specifications and its annexes, there are:

- Conflicts with or violations of international standards
- Problems to arise in case of implementation;
- Points that need to be revised technically;
- Matters that are not mentioned in the technical specifications and its annexes, but are necessary/mandatory for the manufacturing of the vehicle,

the Contractor is obligated to report these (together with the Contractor`s proposals) in writing to the Administration.

For equipment that is within the scope of the above standards, products that comply with the latest versions of the standards (or their international equivalents) will be selected.

The full list of standards to be complied with is specified in document TB50160.

# 4. ENVIRONMENTAL CONDITIONS

## 4.1. CLIMATIC CONDITION

ELE Loco will be reliable and suitable for continuous operation without being affected by any environmental and atmospheric conditions that may be encountered during service under the climate conditions specified below (temperature, rain, snow, ice, dust, wind, etc.).

General climatic conditions, following the EN 50125-1, are reported below:

| **Temperatures** | |
|---|---|
| Max. temperature inside of the car *(driver and crew constant presence, not machine room)* | + 55 °C |
| Max. external temperature (shade) | + 45 °C |
| Min. internal/external temperature | - 25 °C |
| **Precipitations** | |
| Max. Amount daily | 73 Kg/m² |
| Annual areal precipitation | 556,2 mm/m² |
| Min. areal precipitation | 380 mm |
| Max. areal precipitation | 930 mm |
| Max. snow | 100 mm |
| **Other Conditions** | |
| Monthly mean relative humidity (summer) | 50 % |
| Monthly mean relative humidity (winter) | 85 % |
| Ambient | Sand Dust |
| Weather conditions (summer) | Hot Dry |
| Weather conditions (winter) | Cold Humid |
| **Sun Radiation** | |
| Sunshine duration per year | 2986 hours |
| Radiation rate per year | 2080 kWh/m² |
| Max sun radiation | 1120 W/m² |
| Max. Sun exposition | 8 hours |

Table 3 - Climatic conditions summary

## 4.2. ALTITUDE

The maximum altitude for ELE Loco service is 1400 m above sea level (according to EN 50125-1 § 4.2 class A1).

## 4.3. HUMIDITY

ELE will operate in the following outdoor humidity levels in accordance with EN 50125-1 §4.4:

- Annual average : Relative humidity ≤ 75%
- 30 days during the year : Relative humidity 75% - 95%
- Other days, occasionally : Relative humidity 55%–100%

## 4.4. TEMPERATURE RISE

The temperature rise will be measured according to the procedure stipulated by IEC and complies with the limits specified and the ambient conditions defined in the Specification.
Specified temperature rise of equipment are calculated after taking into account at least 25% choking of air filters and radiator fins etc.

## 4.5. QUICK TEMPERATURE VARIATIONS

The considered quick outside temperature variations are of 3°C per second, with a maximum variation of 40°C, in accordance with paragraph 4.4 of standard EN 50125-1.

## 4.6. WINDS

The wind speeds to be considered in the design of ELE Loco and its sub-assemblies have been determined in accordance with clause 4.5 of the EN 50125-1 standard.
The maximum wind speed to be considered for ventilation, cooling, and similar equipment is 35 m/s.
Exceptionally, winds up to 50 m/s will be considered for locomotives in a stationary position.
Under these conditions, the performance of the equipment and/or vehicle may be temporarily affected; however, no permanent damage shall occur.

## 4.7. MAXIMUM PRECIPITATION (RAIN, SNOW, BLACK ICE)

Rain precipitation: 6 mm/min, as per EN 60721-3-5 class 5 K3.

Snow, black ice precipitation: The criteria of **class S1** of standard EN 60721-3-5 shall be applied.

To complete the indications in paragraph 4.6 and 4.7 of standard EN 50125-1, the following shall be considered for more severe condition of snow, ice and hail according to TSI RST 1302/2014 (LOC&PASS) § 4.2.6.1.2 (3):

- Snowdrift: Light snow with low water equivalent content, covering the track up to 80 cm continuously above top rail level.
- Powder snow: Snowfall of large quantities of light snow with low water equivalent content. Ice formation on vehicles due to temperature gradient, temperature and humidity changes within a single working period will be taken into account.
- Combined effects with temperature: Depending on the selected temperature zone, combined environmental conditions with the effect of low temperature will be taken into account as defined in clause 4.2.6.1.1.

In accordance with clause 4.8 of standard EN 50125-1, ice formation likely to occur on the stock or equipment, in temperatures under 0°C, shall not lead to any degradation prejudicial to the stock's or equipment's operation and to its utilisation (the nominal performances are to be maintained).

## 4.8. SOLAR RADIATION

Solar radiation: **Class R2** according to EN 50125-1 standard will be applied.
The vehicle and all sub-equipment will be designed to protect against ultraviolet (UV) rays.
The Loco shall meet requirements laid down in paragraph 4.9 of standard EN 50125-1.
Maximum exposure period to the sun is 8 (eight) hours.

## 4.9. POLLUTION

Along with the weather conditions, it is necessary to take into account the solid and gas pollutants in ambient air. Regarding above listed items, the EN 50125-1 § 4.11 and the following standards shall be considered (only for polluting substances):

- **Gas pollutants:** the levels defined by the class 5C2 of standard EN 60721-3-5.
- **Pollutant fluids:**
    - For electric power motor: EN 60721-3-5 Class 5F2
    - For thermal motor: EN 60721-3-5 Class 5F3
- **Active biological substances:** EN 60721-3-5 Class 5B2
- **Dust:** EN 60721-3-5 Class 5S2.
- **Other pollutants:** Related classes of EN 60721-3-5.
- **Marine ambient:** EN 60721-3-5:1997 Class 5C2.

## 4.10. LOCOMOTIVE STORAGE CONDITIONS

The locomotive can be stored outdoors and exposed to the elements for several weeks under the weather conditions described above.

## 4.11. CLEANING

The locomotive and its equipment are designed so as to be efficiently protected against corrosion.
In order to prevent the risk of electrolytic corrosion, special measures have been taken in cases where materials with different metal structures come into contact with each other.
Outside cleaning will be made either through a washing machine, or manually.
Any specific targets relating to cleanability shall be clearly stated in the technical specifications by the supplier of the relevant equipment, if applicable.
The carbody shell, as well as the exterior elements such as access doors, fairings, boxes, hatches, windows, are designed to not lead to any deterioration of the equipment, nor of the washing machine (e.g. bristles being pulled out).

# 5. BASIC DETAILS

## 5.1. TRACK INFORMATION

### 5.1.1. *Gauges*

The locomotive shall comply with the following gauges.

Static Gauge: TCDD Gauge

Kinetic Gauge: EN 15273-2.2013 + A1:2016; G2 + GI2

### 5.1.2. *Superelevation*

Maximum superelevation is 90 mm for operation.

### 5.1.3. *Cant Deficiency*

Maximum cant deficiency is 165mm.

Rail cant is 1:40

### 5.1.4. *Maximum Gradient*

Maximum gradient in main line is 37‰.

### 5.1.5. *Minimum Radius*

The following prescriptions for minimum radius are applicable:

- Locomotive in depot: 80 m
- Locomotive in-service Line: 150 m

### 5.1.6. *Track and Circulation Characteristics*

Concerning other information about track curves and circulation characteristics not explicitly mentioned in this document are below:

- S-Curves
  - 150 m radius, 150m radius with or without any straight portion in between
- Vertical curves
  - 2500 m on vertical

### 5.1.7. *Wheels & Track Profile*

The track rail profile: 60E1 (UIC60) with rail cant 1:40 and track gauge 1435 mm.

The nominal wheel profile: S1002.

### 5.1.8. *Applicable Routes and Traction Performances*

The applicable routes for the ELE Loco performance assessment are specified in document TB50191.

The same quotations from the documents above are provided below.

The routes that have been considered for the simulations included in the documents above are:

- Bilecik-Karaköy
- Ulukışla–Boğazköprü
- Ankara-Istanbul compatibility test
- Iskenderun-Sivas Divriği single locomotive and double locomotive coupling compatibility test

The desired performance of the ELE Loco, which has a maximum carrying capacity of 1500 tons, is shown below:

| Max Speed on 16 ‰ slope (km/h) | Starting Acceleration ($m/s^2$) | Average Acceleration 0-40 km/h ($m/s^2$) | Average Acceleration 0-120 km/h ($m/s^2$) | Bilecik-Karakoy Run time (sec) | Bilecik-Karakoy average speed (km/h) | Ulukisla – Bogazcopru Run time (sec) | Ulukisla – Bogazcopru Average speed (km/h) | Ulukisla – Bogazcopru RMS torque (Nm) |
|---|---|---|---|---|---|---|---|---|
| 61 | 0.28 | 0.26 | 0.18 | 1412 | 43 | 6066 | 82 | 4956 |

Table 4 – Electric Traction performance

## 5.2. LOCOMOTIVE CONFIGURATIONS

The main requirements for ELE Loco are listed in the table below:

| TYPE OF LOCOMOTIVE | ELECTRIC |
|---|---|
| Operation | Freight |
| Power Supply [kV] | 25 kV AC |
| Traction motor power [kW] | 6x1200 kW |
| Axles configuration | Co-Co |
| Max. Speed [km/h] | 120 |
| Max. Axle load [t] | 22,5 |
| Multi traction availability | Yes |
| Adhesion coefficient @start (min) | 0.38 |
| Adhesion force @start (min) | 500 KN |
| Continue tractive effort (min) | 350 kN |
| Pull & Buff equipment | Chain coupler + side buffers |
| Operation period [years] | 30 years, avg. 300 000 km annually |
| Max. Traction force [kN] | Min 500 |
| Additional requirements | Last Mile Module (LMM) |

Table 5 – Locomotive data

ELE Loco is powered from the catenary line; in this Locomotive all the elements which can receive power from the 25kV catenary line are installed, such as pantograph, High Speed Circuit Breaker, transformer, energy meter etc.

In addition to what above, a Last Mile Module (LMM) equipment is installed, to let the ELE Loco be moved also in absence of 25kV from a short track.

## 5.3. LOCOMOTIVE MULTI MODE

It will be possible to attach a locomotive fitted with EN 15566 coupling items (hook/buffer).

Regarding multiple locomotive configurations (same family [CoCo] of loco), more than one (max 3) locomotive can be connected to the front booster, rear booster and coupled by complying with the connection conditions defined in A.1.1, A.1.2 and A.1.3 of the neutral section specified in EN 50367 Annex A.

## 5.4. POWER SUPPLY AND USED VOLTAGE

### 5.4.1. *Power Architecture*

In the figure below is reported the power line architecture:

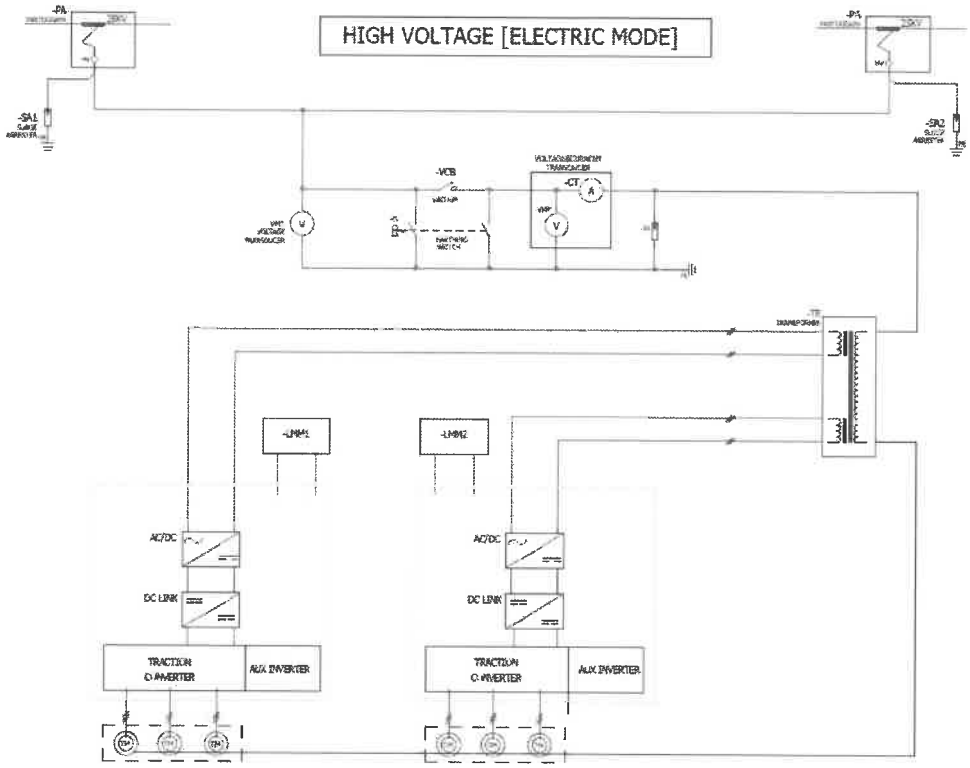


**Figure 1 – POWER ARCHITECTURE - ELECTRIC LOCO**

### 5.4.2. *Overhead Line Characteristics*

Following table reports the line power supply system characteristics.

| DESCRIPTION | VALUE |
|---|---|
| Type of Power Supply System | 25.000 V AC 50Hz |
| Nominal voltage | 25.000 V (EN 50163) |
| Minimum working voltage | 19.000 V |
| Maximum working voltage | 27.500 V |
| Minimum abnormal voltage | 17.500 V |
| Maximum Non Continuous Voltage | 30.000 V |
| Maximum Instantaneous Abnormal Voltage (10 s) | 29.000 V |

Table 6 – Overhead Data

High Speed Line Maximum Current: 1000 A

Maximum current at standstill per pantograph (A), only for Loco loads: 80A

| | |
|---|---|
| Coordination between the Substations and the Locomotive circuit breakers: | As per EN50388 Table 7<br>Sub-Station 25kV Circuit Breaker Technical Data:<br>• Nominal Voltage: 25 kV<br>• Ith: 25 kA<br>• Idyn: 2,5 x Ith<br>• Frequency: 50 Hz<br>• Control Voltage: 110 V DC<br>• 1.2/50µsn, Impact Withstand Voltage: 250 kV<br>• 1 minute Withstand Voltage: 95 kV<br>• Nominal Current: 2000 A<br>Tripping time: approximately 80 ms;<br>There is no protection and control coordination between the locomotive circuit breakers and the circuit breakers in the substation. |

Table 7 – Substation protection

### 5.4.3. *Pantograph Line Characteristics*

The pantograph will be designed and manufactured in accordance with EN 50367.

The main characteristics of the pantograph line are:

| DESCRIPTION | VALUE |
|---|---|
| Normal contact wire height in mid span | 5.75 m from Rail Level |
| Max. contact wire height | 6.2 m from Rail Level |
| Min. contact wire height | 5 m |
| Min. contact wire height (tunnel) | 4.96 m |
| Maximum lateral deviation | ± 200mm on straight track |
| Maximum lateral deviation | ± 240mm on curve |
| Permissible contact wire uplift maximum | 50 mm |
| Neutral sections | Standards: EN 50367 Annex A<br>Long neutral section D' > 400 m<br>Short neutral section D ≤ 8 m<br>Normal neutral section 30-40 m |

Table 8 – Catenary main characteristics

### 5.4.4. *Power Factor*

The ELE Loco is at all times achieved a minimum power factor of 0.98 as measured at the pantograph.

The measurement of power factor will be governed by EN 50388

## 5.5. LOCOMOTIVE PERFORMANCE

### 5.5.1. *Mission Profile*

The values foreseen for the locomotive mission profile are given below:

| | | |
|---|---|---|
| Yearly mileage | 300.000 | km/years |
| Daily average mileage | 1000 | km/day |
| Average Service Speed | 82 | Km/h |
| Carbody and Main Equipment life (years) | 30 | Years |

Table 9 – Locomotive mission profile

### 5.5.2. *Maximum Speed*

The maximum service speed is 120 km/h. The design speed, performed by locomotive during the testing, will be 135 km/h.

### 5.5.3. *Axle Load*

The maximum axle load will be 22.5 tons for each axle.

### 5.5.4. *Brake Performance*

The following braking modes are provided in the Locomotive:

- Service brake
  - Electro-Pneumatic (EP) friction
  - Electric regenerative (dynamic) service brakes (ED)
- Parking brake: spring applied and pneumatic-released
- Fail safe
  - Fully Pneumatic friction emergency brakes (Indirect brake IB)

The braking performance are listed in the following:

- Service brake (pneumatic only): min average braking deceleration: 0,8 $m/s^2$
- Emergency brake stopping distance: max. 900 m
- Parking brake permanently on slope of 40 ‰

The brake system is compliance with TSI

The EP can complete the journey without ED.

### 5.5.5. *Acceleration or Deceleration Variations (Jerk Limit)*

Under all normal operating conditions, the rate of change of the Locomotive acceleration or deceleration (jerk) is less than $1 m/s^3$.

### 5.5.6. *Structural Requirements, Shock and Vibration*

Concerning vibration and impact and relevant issues applicable to electric, electronic and pneumatic constituents, the following standards are applied:

- EN 12663-1 Railway Application Structural requirements of vehicle bodies
- EN 61373 Railway applications - Rolling stock equipment - Shock and vibration tests

## 5.6. NOISE PERFORMANCE

The following are applied:

- **The measurement of interior noise:** will be made according to EN ISO 3381.
- **The measurement of exterior noise:** will be made according to EN ISO 3095.
- **The Technical Specification of Interoperability of Noise:** TSI 1304/2014 Amended 2023/1694
- The cab noise level must comply with UIC 651 Section 2.10 and TSI LOC&PASS 1302/2014 and TSI Noise 1304/2014/EC

The requirements are resumed in the TB50172 Thermoacoustic behaviour.

All components installed on locomotives shall be designed to meet the requirements specified in the standards and documents mentioned above.

## 5.7. FIRE PERFORMANCE

The fire protection on the Locomotive is designed and constructed in accordance with TSI 1302. The vehicle is classified as freight locomotive 2N (Operation and design category) as described in TB50161 Fire Classification.

The applicable Hazard level will be HL2.

The Locomotive is designed to prevent fire propagation by use of fire barriers:

- in the floor (cab area), 15 minutes duration tested in accordance with EN1363-1 (latest editions.); refer to doc TB50161 for details
- in walls at ends of cab (division with equipment area)

The fire strategy prevention is described in TB50161 Fire Classification.

### 5.8. EMC

All components in the locomotive shall be designed and manufactured to meet all requirements specified in EN 50121-3-2.

### 5.9. RECYCLABILITY AND FORBIDDEN MATERIALS

ELE Loco shall be designed for optimal recyclability.

The equipment/systems materials shall not affect both safety and health of crews and maintainers or the environment.

Reference Norms are the following:

- The European regulation REACH RG 1907/2006
- UIC leaflet 345: Environmental specifications for new rolling stocks
- EN ISO 14025
- EN ISO 14040: Environmental management - Life cycle assessment - Principles and framework.

### 5.10. ELECTRIC GENERAL REQUIREMENT

The Low Voltage 0V level in the Loco is floating, so shall be avoided any internal connection in the equipment between metallic chassis and the 0V connection; grounding connections in the equipment shall not be connected to car Low Voltage DC power supply.

# 6. LOCOMOTIVE GENERAL DETAILS

## 6.1. LAYOUT

The layout for ELE Loco is depicted in the drawing ref. [7].

## 6.2. MAIN DIMENSIONS

In the following table are reported the main dimensions of the ELE Loco:

| Description | Values |
|---|---|
| Loco length over coupler [m] | 21,700 |
| Width [mm] | 2900 |
| Roof height of car body from top of rail [mm] | 4520 |
| Wheel Diameter (new) [mm] | 1250 |
| Bogie pivot distance [m] | 11,200 |
| Floor height from TOR [mm] | 1870 |

Table 10 – Locomotives main dimensions

## 6.3. MAIN COMPONENTS

### 6.3.1. *Main Components Distribution*

The distribution of the main components is depicted in the following table.

| Component | Quantities |
|---|---|
| Cabin HVAC | 2 |
| Pantograph + HV related devices | 2 |
| Circuit breakers | 1 |
| Traction Converter | 2 |
| Auxiliary Converter | 2 |
| Main Transformer | 1 |
| Brake Package | 1 |
| Battery Box | 2 |
| Air Production | 2 |
| Auxiliary Air Production | 2 |
| Last Mile Module (battery) | 2 |

Table 11 – Locomotive main components distribution

## 6.4. LOCOMOTIVE CAR DESIGN (BODYSHELL)

The Carbody-shell, in carbon steel, is composed by the following sub-assemblies:

- Underframe
- Cab structure
- Sidewall
- Roof

The design, the mechanical strength and the crash worthiness of the car body meets the following standard:

- EN 12663: Railway applications - Structural requirements of railway vehicle bodies
  The Locomotive category is L.
- EN 15227 Railway applications - Crashworthiness requirements for rail vehicles
  The Locomotive category is C-I.

## 6.5. DRIVER CAB DESIGN (GRP STRUCTURE)

The following norms are applied for the Locomotive driver's cab design:

- TSI RST 1302 (LOC&PASS)
- UIC 651 OR – "Layout of driver's cabs in locomotives, railcars, multiple units' trains and driving trailers"
- UIC 612 – "Driver Machines Interfaces for EMU/DMU, Locomotives and driving coaches - Functional and system requirements associated with harmonized Driver Machine Interfaces"

## 6.6. LOCOMOTIVE BOGIES

The Locomotive is fitted with two bogies each consisting of 3 powered axles.

The following scheme shows the bogies in the Locomotive with fitted components.

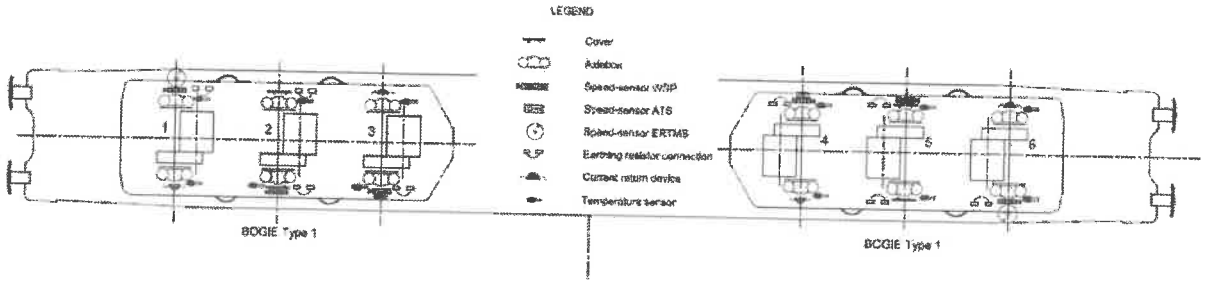


Figure 2 – BOGIE EQUIPMENT DISTRIBUTION

The bogie main characteristics:

| DESCRIPTION | VALUE |
|---|---|
| Nominal axle wheelbase 1st-2nd | 2150mm |
| Nominal axle wheelbase 2nd -3rd | 2150mm |
| Nominal Wheel Diameter | 1250 mm |
| Worn Wheel Diameter | 1170 mm |
| Track gauge | 1435 mm |
| Primary suspension | Flexi coil springs |
| Secondary suspension | Rubber-metal stick |
| Motor Bogie Brake | 6 discs bolted on wheels and 6 brake callipers |
| Bogie Weight | About 30 t |

Table 12 – Bogie Characteristics

The welded bogie frame is in S355J2+N EN 10025.
The connection with the carbody is provided by a pivot structure component made in G20Mn5 EN 10293.

## 6.7. OPERATIONAL MODES

### 6.7.1. *Stabling*

Loco stabled, battery power off, no compressed air, parking brakes applied.

### 6.7.2. *Normal Operation*

Battery power on, one driver's cab activated, all functions are available. The Loco can either operate alone or in multiple units as a master.

### 6.7.3. *Normal Operation - Slave*

Battery power on, no driver's cab activated, all functions are available. The Locomotive can operate in multiple units as a slave.

### 6.7.4. *Parking Mode*

The Loco is ready for operation, with minimum energy consumption.
Parking brakes applied, traction is inhibited, driver desk commands are enabled in Loco.

### 6.7.5. *Change of Driving Cab*

The change of cab mode is identical with the parking mode, but some steps are requested for the correct driving cab change.

### 6.7.6. *Towing*

It must be possible to tow the Locomotive using another traction vehicle.

## 6.8. SYSTEM FUNCTIONS

### 6.8.1. *Traction*

#### *6.8.1.1. Transformer*

Scope of the transformer is to transfer the energy received from the catenary line to the input of the traction converters.
The scheme for the transformer is visible in the image below:

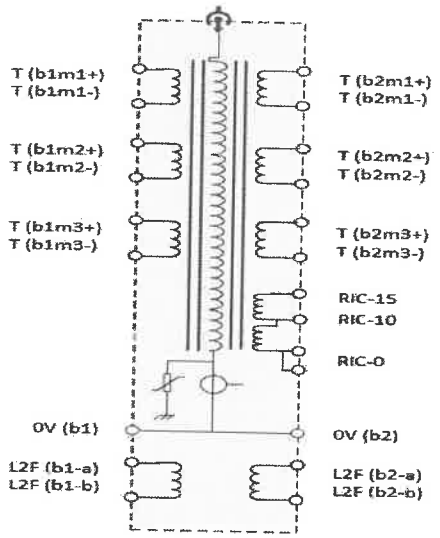


Figure 3 – Transformer scheme

### 6.8.1.2. *Traction Converter*

Two traction converters, which includes the auxiliary inverters, are present in the ELE Loco, powered by the transformer.
The traction converters supply power, each, to 3 motors on the same bogie.

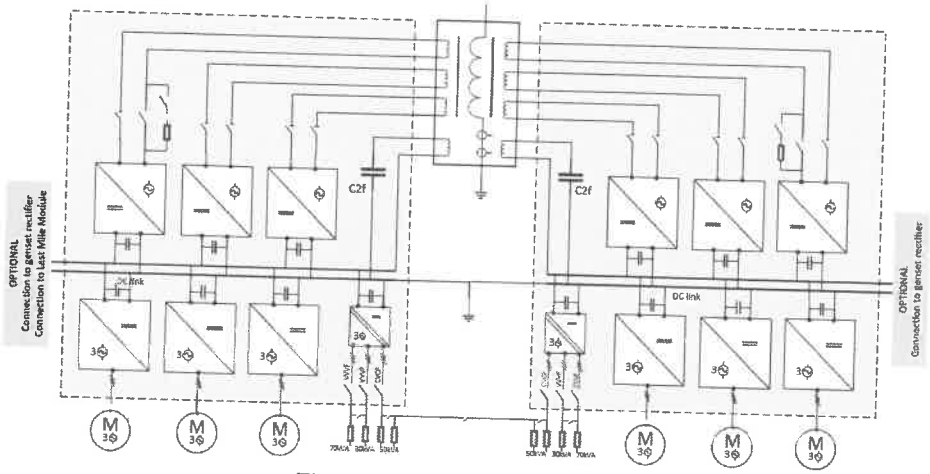


Figure 4 – Converter scheme

### 6.8.1.3. *Traction Converter and Trafo Cooling*

The cooling of the traction converters and the TRAFO is integrated in the cooling unit equipment, to optimize the space allocation.
In total there will be 2 cooling units in each Locomotive.

### 6.8.1.4. *Traction Motor*

Six traction motors are installed in the motor bogie and fed by the traction converters output.

The traction motors are cooled by opportune cooling units, installed in the Locomotive; each cooling unit is able to supply fresh air to the 3 motors on the bogies, a total of 2 cooling units is present in the Locomotive.

### 6.8.1.5. *Traction General Requirements and Redundancy Level*

The traction system shall not generate interaction with the power supply system that would result in voltage fluctuations or harmonic currents exceeding the limits of EN 50163, and it shall meet the requirements set out herein.

For an optimized weight distribution all traction system components are distributed along the Locomotive.

The traction system has some functional redundancies to completely recover or reduce as minimum as possible the effect on performances due to the failures listed hereafter:

- loss of one pantograph

- loss of one traction converter
- loss of a traction system on a bogie

In the first case, the relevant single failure will not affect in any way Locomotive performances
In the second and third cases the Loco is allowed to operate in degraded conditions; the Locomotive should reach next convenient station or service depot without assistance.

#### *6.8.1.6. Electro Dynamic Braking (Regenerative)*

The ELE Loco is equipped with the electrodynamic brake actuated by the driver using the Master Controller. The driver could use the service friction brake to improve the brake performance.
The electrical energy generated during the ED braking phase is returned to supply line, when available, when traction is via catenary.
When regenerative braking is not available, pneumatic (friction) brake shall be used.

### 6.8.2. *Auxiliary Power Supply*

#### *6.8.2.1. MV and LV Power Generation and Distribution*

Two auxiliary inverters will be installed in the Locomotive, to supply the required power to loads connected to the MV lines in variable voltage and frequency mode (VVVF) and in fixed mode (CVCF, 400V AC 3ph 50Hz).
Auxiliary Power Supply will not include Battery Charger device, which is installed in an electrical cubicle and powered from the medium voltage (fixed mode line output, CVCF).
The Auxiliary inverter is cooled by an opportune cooling system which is integrated with the cooling system of the traction converter and transformer.

#### *6.8.2.2. Battery and Battery Box*

The battery box is composed by the following main components:

- Battery box frame
- Battery elements (cells)
- Refill system
- Temperature sensor

The nominal voltage considered for the LV is 110Vdc, battery cells are configured for this voltage output and are charged by a dedicated battery charger.

#### *6.8.2.3. Energy Meter*

An energy meter device is implemented to measure the consumed and regenerated active or reactive energy; in compliance with EN50463-2.

### 6.8.3. *Braking System*

The scope of the braking system is to provide the necessary braking force to meet the performance requirements as described above.

The system is mainly composed by:

- Air production and stock components (AGTU+ Tanks)
- Brake control components (Brake control panel)
- Pneumatic distribution (piping)
- Bogie brake components (brake callipers and disks)
- Dead man and Vigilance System interfacing (according to UIC 641 and L&P TSI requirements)
- Wheel-Slide protection system

### 6.8.4. *Heating Ventilation and Cooling*

The heating, ventilation and cooling capability shall be performed by the HVAC system, with the support of independent heaters in driver cabs (in the driver desk) where deemed necessary.

There is 1 independent HVAC unit for each driver cabin.

### 6.8.5. *Fire Protection*

ELE Loco is equipped with an automatic firefighting system in order to detect a fire starting in the high-risk areas, and to take the necessary action to reduce the risk of spreading it.

Thus, a fire detection and extinction system is provided in the vehicles.

A fire detection system is provided in Electric Locomotive:

- Driver's cabs
- Traction converters + Auxiliary Converters
- Main Electrical Cabinets
- Last Mile Module

Each driver's cab is equipped with an audial and visual fire alarm system integrated with Train Control Monitoring System (TCMS).

The system indicates to the driver the detection of a possible fire and the place where this has been detected.

The fire extinction system is provided in:

- Traction converters

Fire extinguishers of the dry powder type of approximately 6 kg capacity or better system are installed one on each driver cab.

### 6.8.6. *Exterior Lights*

Head, tail and marker lights shall be in full accordance with TSI 1302 Loc&Pas 2023 section 4.2.7.1 and EN 15153-1.

### 6.8.7. *CCTV System*

The CCTV system will include pantograph cameras, side cameras, front cameras, cameras for the cabin, and a driver monitoring camera.

### 6.8.8. *Train Control and Monitoring System (TCMS)*

#### *6.8.8.1. TCMS System Overview*

TCMS shall be a smart entity which, acquiring and transmitting information and controls, manages the operation of most of devices installed on the Locomotive and to the relevant components.

- Monitor and control devices directly interfaced with the system TCMS.
- Achieve operational functions necessary to manage the train with the level of performance, safety and reliability requirements.

- Provide support for the operation of the train (crew)
- Provide support for centralized maintenance
- Implemented through design and simulation tools to optimize time and cost of design and validation
- Provide a historical data with detailed information about operating the equipment and device.

The TCMS system is directly related to the information of the subsystems connected with it.

The number of information available in the diagnostic system is very high; as a consequence, to enhance effective acquisition and use of information by personnel, a differentiated management is required.

To this purpose, three groups of information are displayed on the monitor in each driving cab (placed on driver's side of the control desk), depending on the user they are addressed to:

- Driving crew (diagnostic/control monitor and instrument monitor)
- Staff personnel (diagnostic/control monitor)
- Maintenance personnel (diagnostic/control monitor)

TCMS is developed with redundancy characteristics to increase its reliability.

#### *6.8.8.2. TCMS Main Tasks*

Main tasks of Command & Control shall be the following:

- supervise functions and manage decision at system level, by adjusting the operation of apparatuses monitored according to the general operating situation
- perform starting procedures and give controls during normal operation
- provide for proper measures and cut-offs in case of malfunctions

Main tasks of diagnostics shall be the following:

- find faulty apparatuses and sub-assemblies to reduce the repair time and increase average availability of vehicle
- provide for an operator's guide, to precisely specify operations to be performed during any malfunction on duty
- organise the collection of information to support any statistic management off-board concerning the type of malfunctions per operating hours of single apparatuses

### 6.8.9. *Event Recorder*

Event recorder is a device designed to acquire and store the status coming from other on-board devices, to record driver activities.

### 6.8.10. *Warning Horns and Whistle*

Horns (audible warning device) will be in full accordance with TSI RST 1302 (Loc&Pas) section 4.2.7.1 and EN 15153-2. Operation of the horn shall not cause noise discomfort to the driver. Warning horns shall be fed by an air pressure circuit and shall be commanded either by a push button or by a pedal.

The warning whistle will be controlled electronically and powered by the battery line.

### 6.8.11. *Windscreen Wiper and Washing System*

The Locomotive shall be fitted with a wiper and windscreen washing system in accordance with applicable standards and to assure the driver visibility as per UIC 651 and 16186-1.

The windscreen wiper system shall be electrical type and include intermittent wipe facility. It shall assure good performance and functionality in all the weather condition as specified in this document and at maximum Locomotive speed.

### 6.8.12. *Flange Lubricating System*

The Locomotive is equipped with efficient and reliable spray type flange lubricating system.

### 6.8.13. *Sanding System*

The Locomotive is equipped with efficient and reliable sanding system in according to TSI 1302. The sanding device shall be located on axles 1, 3, 4, 6.

### 6.8.14. *Signalling and Train Communications*

#### *6.8.14.1. Radio*

Locomotive adopts ASELSAN radio equipment for train infrastructure radio communication. Additionally, GSM-R radio shall be used on ETCS lines.

#### 6.8.14.2. ATS

TCDD has two different types of ATS systems on its existing signalized lines: "eastern type" and "western type." The Automatic Train Stop System, approved by the Administration and used on existing locomotives in the TCDD Taşımacılık A.Ş. fleet, uses on-board equipment. The relevant components will be installed on the Locomotive in accordance with the system supplier's requirements.

#### 6.8.14.3. ERTMS / ETCS

TCDD's new signaling systems will be equipped with systems that comply with the ERTMS/ETCS Level 2 standard on the lines. Therefore, locomotives will be equipped with onboard equipment compatible with the European Rail Traffic Management System/European Train Control System (ERTMS/ETCS, Level 0/Level 1/Level 2), Baseline 3, or Baseline 4, and will be equipped with equipment that operates in both cabs, without any forward or reverse restrictions.

END OF DOCUMENT