Gemeente Amsterdam

System Specification Traction Power Substation

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Validation and authorisation

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1 Introduction

This document describes the technical specifications and functional background for new traction power substations of GVB and Metro & Tram to be built and put into operation.

The specification describes the general requirements of the distribution network part, as well as the requirements for the traction power substation with the corresponding technical specifications.

Finally, it is a requirement that compatibility between the traction power substation and the components installed is guaranteed. This compatibility ensures the correct operation of the components in the supplied substation; in particular with regard to providing safety, maintenance, reliability and life expectancy/lifetime.

This specification is generic for traction power substations for metro or tram. Where there are differences, this is indicated in the section title. For example, "Functional Metro" refers to functional requirements that explicitly apply to Metro traction power substations, "Functional Tram" to Tram traction power substations.

1.1 Abbreviations

Abbreviation	Meaning
A	Amps
AN	Air Natural
AWI	Auto-reclose
BLVC	Accessibility, Livability, Safety and Communication
CAB	Central remote control
CBI	Central control of installations
dB	Decibel
DC	Direct Current
DO	Final Design
EBH	Electrotechnical operations manual of GVB
EBT	Auxiliary transformer
EKS	Erd Kurzschluss Schalter (Electronic short-circuit switch)
AND	European Standard
FIT	Factory Integration Test
FO	Functional Design
GOOSE	Generic Object Oriented Substation Event
GS	Traction power substation
GVI	DC switchgear assembly
HMI	Human Machine Interface
HS	High-voltage
HVI	High-voltage distribution system
Hz	Hertz
IAC	Internal Arc Classification
IEC	International Electrotechnical Commission
IED	Intelligent Electronic Device
IO	Input Output

Abbreviation	Meaning
IP	International Protection Marking
kPa	Kilo Pascal
kV	Kilovolt
kWh	Kilo Watt hour
LVI	Low-voltage switchgear
MTTF	Mean Time To Fail
MTTR	Mean Time To Repair
MVA	Mega Volt Ampère
Ni-Cad	Nickel Cadmium
NSA	Emergency power unit
OG	Client
ON	Contractor
OR	Overview Retour
PLC	Programmable Logic Controller
SA	Station Automation System
SAT	Site Acceptance Test
SCADA	Supervisory Control And Data Acquisition
SF6	Sulphur hexafluoride
SIT	Site Integration Test
(S)IV	(Strategic) Installation Manager
SSI	Sectional switchgear
TO	Technical Design
UO	Implementation design
V	Volt
VLD	Voltage Limiting Device
WCD	Socket

1.2 Binding documents

This section provides an overview of the binding documents. The deliveries must demonstrably comply with the information in these documents.

Title	Documentnumber Document number	Version	Date
Afkortingen en acroniemen	CEB\OVG\19462	1.0.0.0	15-7-2019
Elektrotechnischbedrijfsvoering Handboek voor Railinfrastructuur Metro en Tram Amsterdam	WLS\OVG\18867	3.2	10-07-2018
Netcode Elektriciteit	https://wetten.overheid.nl/BWBR0037940/2021-02-13	-	18-07-2020
VB AMS 053 Areaaldecompositie en codering van locaties, installaties, objecten en kabels	CEB\OVG\20507	3.0	20-5-2019
Opstellingstekeningen installaties Gelijkrichterstation	CEB\OVG\20587	1.1.0.0	09-12-2020
Eenlijnschema's typical Gelijkrichterstation	CEB\OVG\23037	1.0.0.1	23-12-2020
Systeemspecificatie Recovery Unit	CEB\OVG\24922	0.2	17-11-2020
Schakelmatrix Gelijkrichterstation Metro	CEB\OVG\26033	0.3.6.1	10-5-2021
Schakelmatrix Gelijkrichterstation Tram	CEB\OVG\26091	0.2.0.0	3-5-2021
Tripmatrix Gelijkrichterstation	CEB\OVG\25950	4.0	20-3-2020
Overzicht RAMS grenswaarden	CEB\OVG\24071	0.3	03-09-2020
Principe-ontwerp Minus-Aarde potentiaalbewaking volgens EN50122-1	CEB\OVG\25763	1.0	21-12-2020
Besturingsconcept o.b.v. IEC61850	CEB\OVG\23094	0.2	23-03-2020
TKF 630 mm2 kabelspecificatie	CEB\OVG\25764	-	-
Aansluitvoorwaarden NMA definitief	CEB\OVG\21512	1.0	08-10-2019
NMA Device specification form template	CEB\OVG\21512	1.0	08-10-2019-
NMA Switchpoortaanvraag template	CEB\OVG\21512	1.0	08-10-2019

Title	Documentnumber Document number	Version	Date
S8035 PvE Inkoopruimte – Extern Gebruik	Liander	1.1	Jan-2021
Richtlijnen voor toelaatbare harmonische stromen	EnergieNed	-	Juni-1997
Template I/O lijst GRS	CEB\OVG\25955	6.0	31-7-2020
Blokschema CBI Metro	CEB\OVG\25957	1.0	11-2-2020
Blokschema CBI Tram	CEB\OVG\25958	1.0	11-2020
UO CBI Tram GVB	CEB\OVG\26028	1.0	20-6-2017
Schakeltoestanden Metro	CEB\OVG\26115	0.4.0.0	7-5-2021
Operationele scenario's GRS	CEB\OVG\23093	2.7	23-4-2020
GS UHL Energie en communicatie objecten variant A en B	CEB\OVG\20590	0.6.1.0	19-9-2019
Cybersecurity-Eisenset MET OT systemen	CEB\OVG\18908	1.2	16-2-2020
Cybersecurity Voorschrift OT	CEB\OVG\21876	1.2	16-1-2020

1.3 Standards

This section provides an overview of relevant standards and guidelines.
The deliveries must comply with the Dutch laws and regulations and the Buildings Decree. In addition, the deliveries must meet all common requirements that can be set for the systems at the current state of the art. In addition, the delivery must comply with all the applicable standards, regulations and directives listed below in the prevailing order:

1. NEN (Dutch Standards)
2. GVB/MeT Specific Rules
3. EN (European Standards) and European Harmonisation Documents (HD)
4. IEC (Standards of the International Electrotechnical Commission)
5. NPR (Dutch Practice Guidelines)
6. EnergieNed Guidelines
7. VDE (guidelines of the German Association of Electrical Engineering, Electronics and Information Technology)
8. ATEX (European Directives on the danger of explosion)

The list of standards is not intended to be exhaustive. The Contractor shall include additional and/or replacement standards that are applicable in the work.

1.3.1 High-voltage distribution system

NEN-EN-IEC 60282	Hoogspanningssmeltveiligheden
NEN-EN-IEC 60376	Specificatie van zwavelhexafluoride (SF6) voor technisch gebruik bestemd, voor toepassing in elektrische uitrusting
NEN-EN-IEC 61243-1	Onder spanning werken - Spanningzoekers - Deel 1: Capacitief type voor gebruik bij spanningen boven 1 kV wisselspanning

NEN-EN-IEC 61869-1	Meettransformatoren - Deel 1: Algemene eisen
NEN-EN-IEC 61869-2	Meettransformatoren - Deel 2: Aanvullende eisen voor stroomtransformatoren
NEN-EN-IEC 61869-3	Meettransformatoren - Deel 3: Aanvullende eisen voor inductieve spanningstransformatoren
NEN-EN-IEC 62271-1	Hoogspanningsschakelmaterieel; Deel 1: Algemene specificaties
NEN-EN-IEC 62271-100	Hoogspanningsschakelmaterieel; Deel 100: Wisselstroomscheiders
NEN-EN-IEC 62271-102	Hoogspanningsschakelmaterieel; Deel 102: Hoogspannings-wisselstroomscheiders en aardingsschakelaars
NEN-EN-IEC 62271-103	Hoogspanningsschakelmaterieel - Deel 103: Schakelaars voor een spanning hoger dan 1 kV en tot en met 52 kV
NEN-EN-IEC 62271-200	Hoogspanningsschakelmaterieel; Deel 200: Metaalomsloten hoogspanningsschakelmaterieel voor nominale spanning boven 1 kV tot en met 52 kV
NEN-EN-IEC 62271-206	Hoogspanningsschakel materieel – Deel 206: Indicatiesystemen voor de aanwezigheid van spanning voor nominale spanning hoger dan 1kV tot en met 52kV
NPR-CLC-IEC/TR 62271-303	Hoogspanningsschakelmaterieel - Deel 303: Gebruik en behandeling van zwavelhexafluoride (SF6)

1.3.2 Traction rectifier

NEN-EN 50327	Railtoepassingen - Vaste inrichtingen - Harmonisatie van de toegekende waarden voor een omvormergroep en de typebeproevingen van een omvormergroep
NEN-EN 50328	Spoorwegen en soortgelijk geleid vervoer - Vaste installaties - Elektronische vermogenomzetters voor onderstations
NEN-EN 50124-1	Spoorwegtoepassingen - Isolatiecoördinatie
NEN-EN 50526-1	Spoorwegen en soortgelijk geleid vervoer - Overspanningafleiders en spanningsbegrenzers voor gebruik met gelijkspanning - Deel 1: Overspanningafleiders
NEN-EN 50526-2	Spoorwegen en soortgelijk geleid vervoer - Vaste installaties - Overspanningafleiders en spanningsbegrenzers voor gebruik met gelijkspanning - Deel 2: Spanningsbegrenzers
NEN-EN-IEC 60099	Overspanningafleiders
NEN-EN-IEC 60146-1-1	Halfgeleideromzetters - Algemene eisen en omzetters met netcommutatie - Deel 1-1: Specificatie van basiseisen

1.3.3 Traction Transformer

NEN-EN-IEC 60076-1	Energietransformatoren. Deel 1: Algemeen
NEN-EN-IEC 60076-2	Energietransformatoren. Deel 2: Temperatuurverhoging
NEN-EN-IEC 60076-3	Energietransformatoren. Deel 3: Isolatieniveaus, diëlektrische proeven en uitwendige slagwijdten in lucht
NEN-EN-IEC 60076-4	Energietransformatoren. Deel 4: Leidraad voor het uitvoeren van proeven met bliksemspanningen en schakelspanningen
NEN-EN-IEC 60076-5	Energietransformatoren. Deel 5: Kortsluitsterkte
NEN-EN-IEC 60076-8	Energietransformatoren. Deel 8: Leidraad voor de toepassing.
NEN-EN-IEC 60076-10	Energietransformatoren. Deel 10: Bepaling van geluidsniveaus
NEN-EN-IEC 60076-11	Energietransformatoren. Deel 11: Droge Energietransformatoren
NPR-IEC 60076-12	Energietransformatoren. Deel 12: Leidraad voor het belasten van droge energietransformatoren
NEN-EN 50329	Spoorwegtoepassingen - Vaste inrichtingen - Tractietransformatoren
NEN-EN 50329	Spoorwegtoepassingen - Vaste inrichtingen - Tractietransformatoren

1.3.4 DC switchgear assembly

NEN-EN 50123	Railtoepassingen – Gelijkstroomschakelinrichtingen voor vaste opstellingen
NEN-EN 50526	Spoorwegen en soortgelijk geleid vervoer – Overspanningsafleiders en spanningsbegrenzers voor gebruik met gelijkspanning
NEN-EN 50124-1	Spoorwegtoepassingen - Isolatiecoördinatie
NEN-EN 50123-1	Railtoepassingen - Gelijkstroomschakelinrichtingen voor vaste opstellingen - Deel 1: Algemeen (en)

NEN-EN 50123-2	Railtoepassingen - Gelijkstroomschakelinrichtingen voor vaste opstellingen - Deel 2: Gelijkstroomschakelaars
NEN-EN 50123-3	Railtoepassingen - Gelijkstroomschakelinrichtingen voor vaste opstellingen - Deel 3: Gelijkstroomscheiders en lastscheiders voor binnenopstelling
NEN-EN 50123-4	Railtoepassingen - Gelijkstroomschakelinrichtingen voor vaste opstellingen - Deel 4: Gelijkstroomlastscheiders, scheiders en gelijkstroomaarders voor buitenopstelling
NEN-EN 50123-6	Railtoepassingen - Gelijkstroomschakelinstallaties voor vaste opstellingen - Deel 6: Gelijkstroomschakelinrichtingen
NEN-EN 50123-7-1	Railtoepassingen - Gelijkstroomschakelinstallaties - Vaste opstellingen - Deel 7-1: Meet-, beheers- en beveiligingsinrichtingen voor specifiek gebruik in gelijkstroomtractiesystemen - Leidraad voor de toepassing
NEN-EN 50123-7-2	Railtoepassingen - Gelijkstroomschakelinstallaties voor vaste opstellingen - Deel 7-2: Meet-, beheers- en beveiligingsinrichtingen voor specifiek gebruik in gelijkstroomtractiesystemen - Isolerende stroomomzetters en andere ampèremeters
NEN-EN 50123-7-3	Railtoepassingen - Gelijkstroomschakelinstallaties voor vaste opstellingen - Deel 7-3: Meet-, beheers- en beveiligingsinrichtingen voor specifiek gebruik in gelijkstroomtractiesystemen - Isolerende spanningsomzetters en andere voltmeters
NEN-EN 50526-1	Spoorwegen en soortgelijk geleid vervoer - Overspanningsafleiders en spanningsbegrenzers voor gebruik met gelijkspanning - Deel 1: Overspanningsafleiders
NEN-EN 50526-2	Spoorwegen en soortgelijk geleid vervoer - Vaste installaties - Overspanningsafleiders en spanningsbegrenzers voor gebruik met gelijkspanning - Deel 2: Spanningsbegrenzers
NEN-EN 50526-3	Spoorwegen en soortgelijk geleid vervoer - Vaste installaties - Overspanningsafleiders en spanningsbegrenzers voor gebruik met gelijkspanning - Deel 3: Richtlijn voor de toepassing

1.3.5 Low-voltage supply

NEN 1010	Veiligheidsbepalingen voor laagspanningsinstallaties (complete versie)

1.3.6 Miscellaneous

NEN-EN 50122-1	Spoorwegen en soortgelijk geleid vervoer – Vaste installaties – Elektrische veiligheid, aarding en retourstromen – Deel 1: Eisen in verband met bescherming tegen elektrische schok.
NEN-EN 50122-2	Spoorwegen en soortgelijk geleid vervoer - Vaste installaties - Elektrische veiligheid, aarding en retourstromen - Deel 2: Maatregelen tegen de effecten van zwerfstromen veroorzaakt door met gelijkspanning gevoede tractiestelsels
NEN-EN 50124-1	Spoorwegtoepassingen - Isolatie-coördinatie – Deel 1: Basiseisen – Slagwijdten en kruipwegen voor alle elektrische en elektronische uitrusting.
NEN-EN 50124-2	Spoorwegtoepassingen - Isolatie-coördinatie – Deel 2: Overspanningen en bijbehorende bescherming.
NEN-EN 50160	Spanningskarakteristieken in openbare elektriciteitsnetten
NEN-EN 50163	Railtoepassingen – Voedingsspanningen van tractiesystemen

NEN-EN 50388	Spoorwegen en soortgelijk geleid vervoer - Energievoorziening en rollend materieel - Technische criteria voor de coördinatie tussen energievoorziening (onderstations) en rollend materieel om interoperabiliteit te bereiken.
NEN 3140	Bedrijfsvoering van elektrische installaties – Aanvullende Nederlandse bepalingen voor laagspanningsinstallaties.
NEN 3840	Bedrijfsvoering van elektrische installaties – Aanvullende Nederlandse bepalingen voor hoogspanningsinstallaties.
NEN 8012	Keuze van het leidingtype met als doel het beperken van schade als gevolg van brand van en via elektrische leidingen met inbegrip van glasvezelleidingen
NEN 3207	Geïsoleerde leidingen voor sterkstroom - Systemen voor de aanduiding van leidingtypen
NEN-EN 50110	Bedrijfsvoering van elektrische installaties – Algemene bepalingen.
NEN-EN 50522	Aarding van hoogspanningsinstallaties van meer dan 1 kV wisselspanning.
NEN-EN-IEC 61936-1	Sterkstroominstallaties met meer dan 1 kV wisselspanning – Deel 1: Algemene bepalingen.
NEN 5152	Technische tekeningen - Elektrotechnische symbolen.
IEC 60146-1-1	Halfgeleideromzetters – Algemene eisen en omzetters met netcommutatie – Deel 1-1: Specificatie van basiseisen.
IEC 61850	Communicatienetwerken en – systemen in substations
IEC 60909	Short-circuit calculation in three phase a.c. systems.
IEC 60038	IEC Standard Voltages
IEC 60050	International Electrotechnical Vocabulary
NEN-EN-IEC 60529	Degrees of protection provided by enclosures (IP Code)
EnergieNed	Richtlijnen voor toelaatbare harmonische stromen.
NEN-EN-IEC 60228	Geleiders van geïsoleerde elektrische leidingen
NEN-EN-IEC 61914	Kabelzadels voor elektrische installaties
NPR 3626	Kabels geïsoleerd met vernet polyetheen (XLPE) voor spanningen van 6 kV tot en met 30 kV - Continu toelaatbare stroom en thermisch toelaatbare kortsluitstroom.

1.3.7 Definitions

Concept	Definition
Power section Metro	A 3rd rail section that is interconnected or has fixed cable connections and can be switched on and off separately from other power supply sections
Tram supply section	An overhead contact line section which is interconnected or has fixed cable connections and can be switched on and off separately from any other overhead contact line section
Medium voltage	According to IEC 62271-200, medium voltage is defined as 1 kV-52 kV The common name for an installation with these voltage levels within GVB is High Voltage Installation. Both terms are used interchangeably in the specification. Both terms refer to the 10kV AC installation.
High speed circuit breaker	DC circuit breaker suitable for switching off DC short-circuit current. Switches very quickly.

2 Traction power substation

2.1 System description

The traction installation subsystem is primarily responsible for converting the electrical energy received from the power supply company into the voltage and current required for operation and then distributing this to the consumer, the electric tram and metro vehicles. In addition, power is supplied to the installations in the traction power substation by means of the auxiliary transformer. The control concept is shown in the figure below.

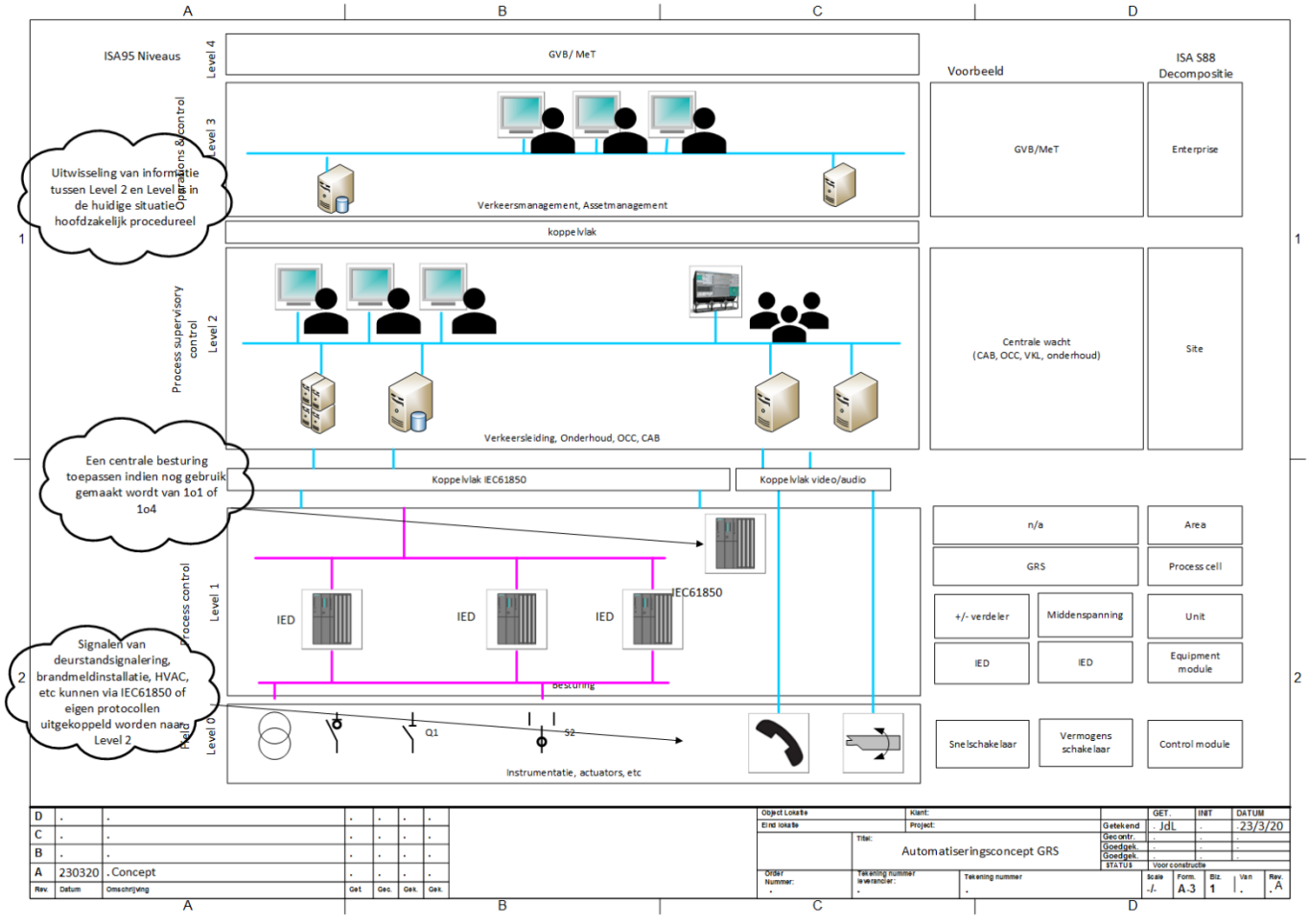

Figure 2-1 - Control concept

2.2 Functional description of the system

The system traction power substation (GS) fulfils the desired functions within the system boundaries. The desired functions are shown in Figure 2-. Table 1contains an outline functional description of the traction power substation system.

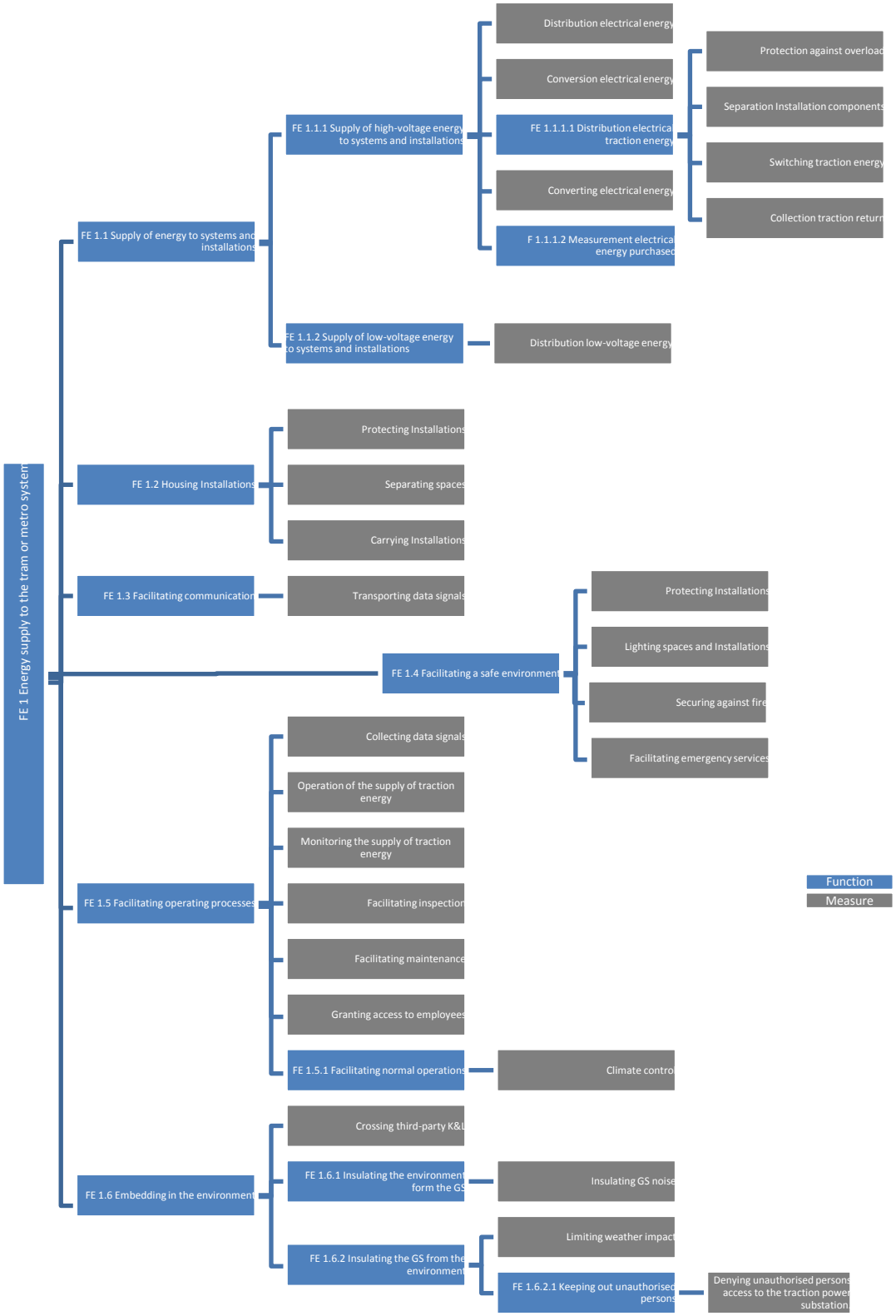

Figure 2-2 - Function tree

ID	Position	Function description
FE 1	**Energy supply to the tram or metro system**	**Supplying energy to the tram or metro system.**
FE 1.1	**Supply of energy to systems and installations.**	**Supply of high-voltage and low-voltage energy to systems and installations.**
FE 1.1.1	Supply of high-voltage energy to systems and Installations.	The conversion, distribution, transforming and supply of electrical energy.
FE 1.1.1.1	Distribution electrical traction energy	Securing against overload, separation of installation components, switching traction energy and collection traction return. Measurement electrical energy purchased.
FE 1.1.1.2	Measurement energy purchased.	kWh meter provided with a purchase/supply counter
FE 1.1.2	Supply of low-voltage energy to systems and Installations for traction power substation own operation.	Supply of low-voltage energy to systems and installations and the storage of energy for control and protection.
FE 1.2	**Housing Installations.**	**Protecting and carrying the installations.** **Separating the spaces.**
FE 1.3	**Facilitating communication**	**Transporting data signals**
FE 1.4	**Facilitating a safe environment**	**Protecting installations, lighting spaces and installations, protecting against fire and facilitating access for emergency services.**
FE 1.5	**Facilitating operating processes**	**Collecting data signals** **Operating and monitoring the supply of traction energy.** **Facilitating inspection and maintenance of the installation and systems by employees of the manager.** **Granting access to employees.**
FE 1.5.1	Facilitating normal operation	Facilitating normal operations by means of climate control.
FE 1.6	**Embedding in the environment**	**Embedding the traction power substation in the environment.** **Crossing cables and pipes owned by third parties.** **Insulating the environment and the traction power substation.**
FE 1.6.1	Insulating the environment form the	Avoiding impact of the traction power substation on the environment such as noise and other nuisance.
FE 1.6.2	Insulating the traction power substation from the environment	Limiting the impact of the weather on the traction power substation and keeping out unauthorised persons.
FE 1.6.2.1	Keeping out unauthorised persons.	Denying unauthorised persons access to the traction power substation.

Table 1- Functional analysis - System Traction power substation.

On the basis of the functional analysis, an object tree was drawn up for the traction power substation system. The objects in the object tree thus provide an initial interpretation of the required functions. The desired objects for Traction power substation are shown in Figure 2-3. They are numbered according to the chapter structure.

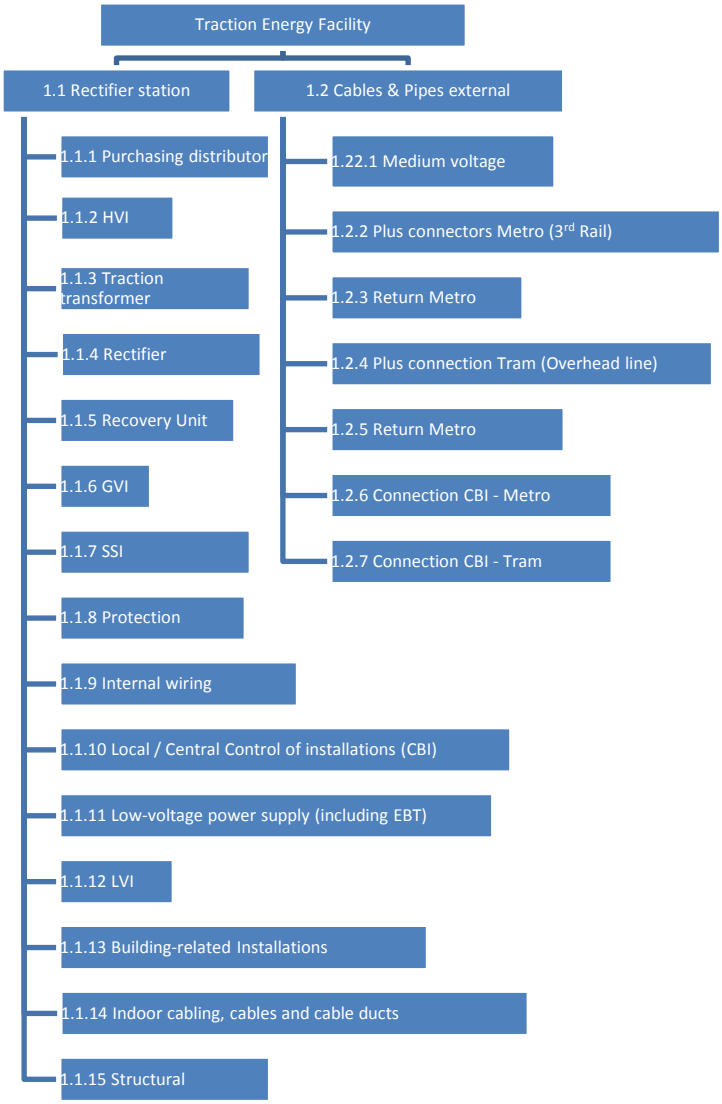

Figure 2-3 - Object tree

Table 2- Relationship between Functions and Objects shows a cross table, indicating per object which functions are fulfilled by the object.

Chapter	Object Function		FE 1.1 Supplying energy to systems	FE 1.2 Housing Installations	FE 1.3Facilitating communication	FE 1.4Facilitating safe environment	FE 1.5Facilitating business processes	FE 1.6 Embedding in the environment
4.2	1.1.1	Purchasing distributor (for traction power substation version with purchasing distributor)	X	X				
4.3	1.1.2	HVI	X					
4.4	1.1.3	Traction Transformer	X					
4.5	1.1.4	Rectifier	X					
4.6	1.1.5	Recovery Unit	X					
4.7	1.1.6	GVI	X					
4.8	1.1.7	SSI	X					
4.9	1.1.8	ProtectionProtection				X		
4.10	1.1.9	Internal wiring	X		X		X	
4.11	1.1.10	Local/central control of installations (CBI)			X		X	
4.12	1.1.11	Low voltage supply (EBT LS)	X				X	
4.13	1.1.12	LVI	X				X	
4.14	1.1.13	Building-related installations	X					
4.15	1.1.14	Internal cabling, cables and cable ducts	X		X		X	
4.16	1.1.15	Construction		X		X	X	X
4.18	1.2.1	Medium voltage	X					X
4.19	1.2.2	Plus connections Metro (Third Rail)	X					X
4.20	1.2.3	Return Metro	X					X
4.21	1.2.4	Tram Plus Connections (Overhead Line)	X					X
4.22	1.2.5	Return Tram	X					X
4.23	1.2.6	Connection CBI - Metro			X		X	X
4.24	1.2.7	Connection CBI - Tram			X		X	X

Table 2- Relationship between Functions and Objects

2.3 Typical version Traction power substation Metro/Tram

This specification uses the following typical construction of a traction power substation for Metro and Tram, distinguishing between the high-voltage power supply variants. One variant with purchase distributor and one variant without purchase distributor.

For both variants, typical single line drawings and typical arrangement drawings have been added to this specification. See the single line diagrams in section 1.2.
These concern typical drawings and not site-specific drawings; deviations are anticipated depending on the sites. The basic principle, however, is compliance with the typical drawings; deviations must be submitted to OG for approval, stating the reason.

The high voltage power supply variants listed above also apply to a traction power substation for Tram. In case of a traction power substation for Tram, the traction transformer and GVI are smaller compared to a traction power substation for Metro.

2.3.1 Traction power substation with direct input from the grid operator

In the case of a traction power substation which is fed directly from the grid operator, a separate room must be provided which is accessible to the grid operator. The grid operator places a high-voltage installation, the purchase distributor, in this room. The distribution board then feeds the High Voltage Switchgear (HVI) of the traction power substation, for a global overview see Figure 2-4- Typical traction power substation with Tram and Metro purchase distributor, at 10kV level

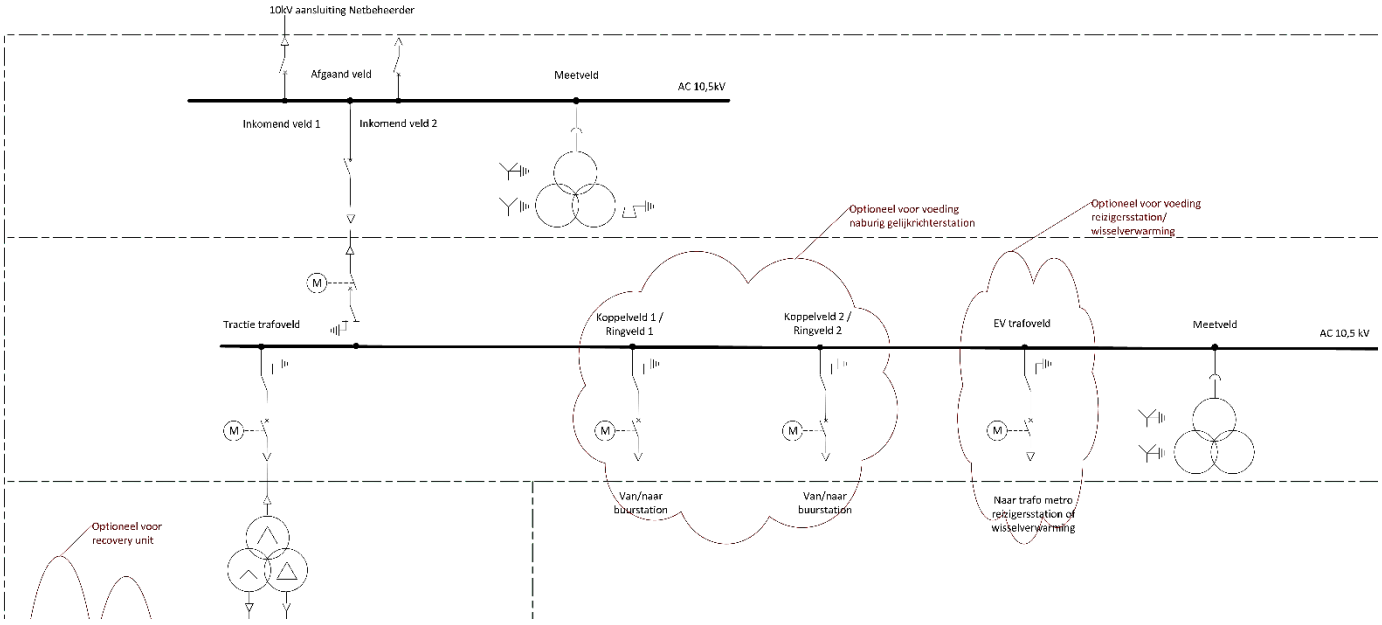

Figure 2-4- Typical traction power substation with Tram and Metro purchase distributor, at 10kV level

It should be noted that the final and exact layout of the purchase distributor is determined by the network operator.
See the Eenlijnschema's and Schedule of Requirements for the Procurement Area in section 1.2.

2.3.2 Traction power substation fed from the medium voltage distribution ring

In the case of a traction power substation fed from its own medium-voltage distribution ring, a purchase space is obviously not provided. The high-voltage distribution ring (HVI) is equipped with two ring fields with which the feed from the distribution ring is provided, see Figure 2-5.

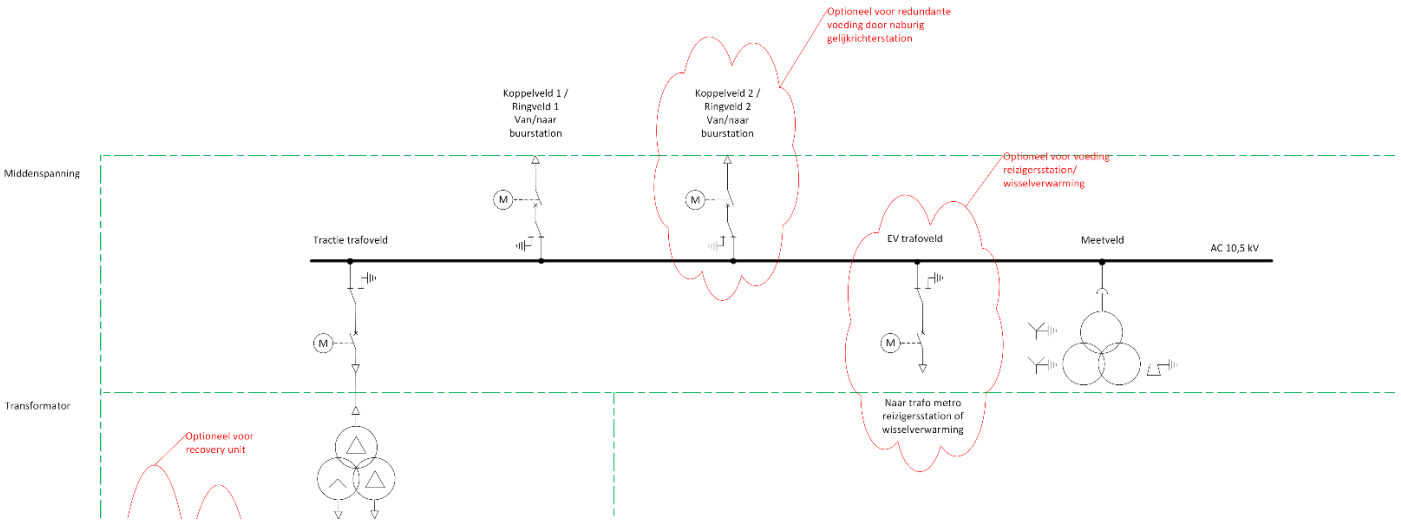

Figure 2-5- Typical traction power substation fed from distribution ring.

See the single line diagrams in section 1.2.

3 Requirements

The classification of the requirements in this specification is based on the object tree. Requirements have been set for each object. The requirements are linked to the objects named in Chapter 2. The requirements are linked to the typical version of the Traction power substation for Metro and Tram, see the typicals included in the binding documents of section 1.2.

A colour code is indicated with each requirement. This colour code indicates for which Contractor this requirement is intended.
We distinguish between the supplier of engineering and components and the installer.

Both parties receive this complete System Specification. The requirements for the Supplier Engineering and components serve as a starting point for the Installer and vice-versa. The aim is to make the context of the requirements and their coherence clear. See section 3.2for the definition of the colour codes.

3.1 Definition of requirements

Characteristic of this specification is the classification into various types of requirements and the relationship between the requirements. The requirements are divided into the following types:

- Functional requirements.
- Aspect requirements.
- Interface requirements.
- Realisation requirements.

Table 3 provides a definition for each type of requirement.

Type of requirement		Note
Functional Requirements		Functional requirements are requirements for the primary function or performance of the system and the objects of which the system is composed.
Aspect requirements	Reliability	The probability that the required function is performed under given conditions during a given time interval.
	Availability	The probability that the required function can be performed at a given arbitrary time under given conditions. This corresponds to the fraction of time that the required function can be performed under given conditions.
	Maintainability	Requirements concerning the necessary management and maintenance effort of the system or objects to be realised and the ease and speed with which a system can be restored to an operational status after failure.
	Safety	Requirements concerning the safety of the system to be realised or the objects during the usage phase, for both the user and the environment.
	Cyber security	Requirements for system resilience against cyber attacks and cyber infections.
	Design	Requirements for the aesthetic appearance of the system or objects to be realised.
	Lifetime	Requirements regarding the required lifetime of the system or objects to be realised.
	Future-proof	Requirements for making the system suitable for future use.

Type of requirement		Note
Realisation requirements		During the implementation phase, the system should meet the requirements and preconditions as described in the "BLVC framework".
Interface requirements	External interface	Requirements for interfaces of the system with the (future) environment on the outside of the system boundaries
	Internal interface	Requirements for interfaces within the system related to systems/objects to be designed or realised by third parties or for the interaction between different objects within the system.

Table 3 - Requirement types definition

3.2 Requirements tables

The requirements in this System Specification are presented in accordance with the format in Table 4- Requirement format.

ID Title of the requirement	
Demand text	
Explanation (optional)	
Verification method (optional)	Prescription/Standards (optional)

Table 4- Requirement format .

	:	Supplier of engineering and components (is also indicated by the letter L in the requirement number).
	:	Installer (is also indicated by the letter I in the requirement number).
ID	:	Unique Requirement Number.
Title of the requirement	:	: Short description of the requirement with keywords.
Requirement text	:	Description of the requirement.
Explanation (optional)	:	Explanation of requirement included for information.
Verification method (optional)	:	Prescribed verification method.
Requirement (optional)	:	Description of verification method.
Prescription/Standard (optional)	:	Applicable prescriptions and standards

3.3 Unique Requirement Number

The unique Requirement Number is composed of 9 characters, W-XX-YY-ZZZ. Whereby the characters represent the following:

W	L or I	Coding requirement applies to the supplier (L) or to the installer (I)
XX	M, T or MT	Code requirement applies to M=Metro, T=Tram or MT=Metro and Tram
YYY	000-999	Coding for system group, see Table 5.
ZZZ	001-999	Coding of requirement within system group

System group code YYY	**Group name**
000	General
001	Functionality
002	Test protocols

System group code YYY	Group name
003	single-line diagram
004	Object Architecture
005	Contact list
006	Civil Requirements/Designs
010	HVI
011	Metering
020	Traction Transformer
021	Auxiliary transformer
022	Station energy supply transformer
030	Rectifier
031	Recovery Unit
040	GVI general
041	GVI high speed circuit breaker
043	GVI-Plus-/minus circuit breaker
044	GVI Circuit breaker Recovery Unit
045	Sectional switchgear (SSI)
046	Track circuit breaker
050	Low voltage general
051	Low-voltage switchgear
052	Low-voltage UPS
060	General protection
061	Protection-HVI
062	Protection-Traction Transformer
063	Protection Auxiliary transformer
064	Protection-Rectifier
065	Protection-GVI
066	Interlocks-SSI
070	Cabling general
071	Cable paths
072	Cabling-internal
073	Cabling-external
074	Cabling - fibre optic network
075	Wiring 61850
076	Connection CBI Metro
077	Connection CBI Tram
080	General controls
081	Control-CBI Metro
082	Control-CBI Tram
083	HMI operation
084	Emergency off circuit
090	Building-related installations
091	Project management

System group code YYY	Group name
092	Interface management
093	Designs
094	Implementation
095	Testing
096	Verify/Validation
097	Completion/Delivery
098	Education/Training
099	Project Control and Project Support
100	Aftercare
101	Warranty
102	Parts supply
103	Service and maintenance

Table 5 - Coding system group

3.4 Verification

The verification method is filled in in the requirements tables. The contractor must elaborate this verification through a verification and validation plan, which can only be carried out after formal approval by OG. The interpretation of the verification method in this specification should be seen as a conceptual proposal which the contractor should complete, detail, work out and specify further.

This specification distinguishes between the following verification methods:

- Document assessment Design: In this verification method, the design must provide an explicit description, substantiation of how the requirement is implemented. It is up to the contractor how this is worked out.
- Document review Design Drawing: In this verification method, the design should provide an explicit description, substantiation of how the requirement is implemented. A specific design drawing is explicitly required.
- Document review Design Calculation: In this verification method, the design should provide an explicit description, substantiation of how the requirement is implemented. A specific design calculation is explicitly required (example: short circuit calculation).
- Document review Design specification: In this verification method, the design must provide an explicit description, substantiation of how the requirement is implemented. A specification from, for example, a supplier is explicitly required (e.g. a control circuit diagram of a high speed circuit breaker field).
- Testing/inspection report visual: In this verification method, an explicit substantiation must be provided visually of how the requirement has been implemented. This should be recorded in a report. (For example, an inspection of the cable ducts).
- Testing/functional: In this verification method, a functional test should provide evidence that the requirement has been implemented. This should be recorded in a report (e.g. an IO test).
- Testing/measurement and report: In this verification method, a measurement should provide evidence that the requirement has been implemented. This must be laid down in a report (e.g. a measurement of the frame-earth insulation).

It should be noted that tests are normally divided into FAT, SAT and iSAT tests. It is up to the contractor to give further substance to this. The above enumeration forms a basis for this.

4 Traction power substation

This specification is generic for metro and tram traction power substations. Where there are differences, specific distinctions have been made regarding the requirements for metro or tram. This is clear from the section names.
In addition, a distinction must be made between traction power substations with their own direct power supply from the grid operator and traction power substations that obtain their power from their own medium-voltage distribution ring. The difference lies particularly in whether or not a purchase distributor from the grid operator is used. This distinction is made in the requirements by means of the designation "HVI traction power substation version with feed-in distributor" and "HVI traction power substation version without feed-in distributor".

4.1 Top requirements

4.1.1 Functional Metro

I-M-001 -001 System Traction power substation - Metro 3rd rail/Minus	
The traction power substation shall supply power to the rail traffic through a connection to the third rail/ overhead line and a connection to the minus racks.	
Explanation: Requirement applies where the contact line network is third rail/overhead. See the Eenlijnschema'sin section 1.2, these are not site-specific drawings.	
Verification method Document review Design drawing	Requirement: The ON must demonstrate the connection by means of a circuit diagram.

L-M-001-002 System traction power substation - Traction power substation Metro	
The traction power substation must provide a fully functioning traction power substation with a capacity of 1x2.5 MVA.	
Explanation: See the Eenlijnschema'sin section 1.2, these are not site-specific drawings.	
Verification method Document review Design	Prescription/Standards

L-M-001-003 System Traction power substation - Traction voltage Metro	
The traction power substation shall transform the incoming high voltage to 750 VDC traction voltage (nominal) by means of transformation and rectification, in accordance with NEN-EN 50163.	
Explanation (optional)	
Verification method Document review Design Document review Design specification	Norm: NEN-EN 50163

L-M-001-004 System Traction power substation - No-load voltage Metro	
The no-load voltage shall be 825 VDC.	
Explanation (optional)	
Verification method Document review Design	Prescription/Standards

L-M-001-005 System Traction power substation - Recovery of braking energy	
The traction power substation shall be able to recover and/or store the braking energy of the system.	
Explanation (optional) If applicable.	
Verification method Document review Design	Prescription/Standards See Systeemspecificatie Recovery Unitin section 1.2

L-MT-001-006 System traction power substation - Traction power substation Group separation	
The traction power substation shall continue to supply energy to the other supply sections when one supply section is switched off (selectivity of the protective devices).	
Explanation: Each power section contains one or more high speed circuit breakers.	
Verification method Document review Design drawing	Requirement: ON must demonstrate group separation by means of the circuit diagram.

4.1.2 Functional Tram

I-T-001-007 System Traction power substation - Tram overhead line/Minus	
The traction power substation has to supply the rail traffic with energy through a connection to the overhead line and a connection to the minus cabinets.	
Explanation (optional)	
Verification method Document review Design drawing	Requirement: The ON must demonstrate the connection by means of a circuit diagram.

L-T-001-008 System Traction power substation - Traction power substation Tram	
The traction power substation shall provide a fully functioning traction power substation with a capacity of 2MVA.	
Explanation (optional)	
Verification method Document review Design	Prescription/Standards

L-T-001-009 System Traction power substation - Tram traction voltage	
The traction power substation must transform the incoming high voltage to 600 VDC traction voltage or 750 VDC traction voltage (nominal) by means of transformation and rectification, in accordance with NEN-EN 50163. In the future, it must be possible to equip trams as 750 V systems. The voltage level is specified for each traction power substation. Please refer to the site-specific Schedule of Requirements and Single Line Plan.	
Explanation: In the future, it may also be decided to implement tram as a 750V system. To this end, traction transformers are currently being requested with two secondary voltages, both for 600Vdc and 750Vdc. If Tram is also configured as a 750Vdc system in the future, this will no longer be necessary. ON must coordinate with OG whether a double secondary voltage is required.	
Verification method Document review Design Document review Design specification	Norm: NEN-EN 50163

L-T-001-010 System Traction power substation - No-load voltage tram
The no-load voltage shall be 660 VDC (at nominal 600 VDC traction voltage) and the no-load voltage shall be 825 VDC (at nominal 750 VDC traction voltage).
Explanation: In the future, it may also be decided to implement tram as a 750 V system, which has a no-load voltage of 825 V.

L-T-001-010 System Traction power substation - No-load voltage tram	
Verification method Document review Design	Prescription/Standards

4.1.3 Functional General (Metro and Tram)

L-MT-001-011 System traction power substation - Primary supply voltage	
The traction power substation shall receive a primary supply voltage at medium voltage level.	
Explanation: See the Eenlijnschema'sin section 1.2, these are not site-specific drawings. In mid-2020, we will assume 10kV supply voltage from the grid operator. In the future, 20kV may become the new standard from the grid operator.	
Verification method Document review Design	Prescription/Standards

L-MT-011-001 System Traction power substation - Metering	
The traction power substation must provide for metering of the total electrical consumption of the traction power substation.	
Explanation: See the Eenlijnschema'sin section 1.2, these are not site-specific drawings.	
Verification method Document review Design	Prescription/Standards

L-MT-011-002 System Traction power substation - Traction consumption measurement	
The traction power substation should provide for metering of the traction consumption of the traction power substation.	
Explanation: See the Eenlijnschema'sin section 1.2, these are not site-specific drawings.	
Verification method Document review Design	Prescription/Standards

4.1.4 Aspect requirement: Maintainability

I-MT-000-001 System traction power substation - Traction power substation maintainability
The traction power substation must be suitable for maintenance by the operator. The explanatory notes specify the operating aids and special tools.
Explanation: Per traction power substation: 2x 3-pole grounding kit 1x 2-pole grounding kit Number of outgoing plus fields x 1-pole grounding kit Rack for suspending earthing devices 1x earth stick 1x voltage tester (only for 20 kV installations) 10x " NIET SCHAKELEN " sign 10x sign "GEAARD" Locks to lock switches Single line drawing on the wall Warning signs high voltage First aid kit

I-MT-000-001 System traction power substation - Traction power substation maintainability	
Verification method Document review Design Testing/inspection report visual	Prescription/Standards

L-M-000-003 System Traction power substation - Platform power section Metro	
The traction power substation shall switch the feed sections according to the circuit diagram so that each platform track has a separate feed section.	
Explanation: For metro, each platform track has in general its own power supply section. With such an arrangement, each platform track can be taken out of service and/or de-energised separately. See Eenlijnschema'sin paragraph 1.2, these are not site-specific drawings. See Schedule for the circuit diagram to be used.	
Verification method Document review Design drawing	Prescription/Standards

L-T-000-004 System Traction power substation - Tramway stop section power supply	
The traction power substation shall classify the overhead contact line sections in accordance with the circuit diagram.	
Explanation: Requirement applies if Tram Traction power substation. For tram, the overhead contact line section for both stop lines is generally one and the same section. See Eenlijnschema'sin section 1.2, this does not concern location-specific drawings. See Schedule for the circuit diagram to be used.	
Verification method Document review Design drawing	Prescription/Standards

L-M-000-005 System Traction power substation - Coupling options power sections Metro	
The traction power substation shall be equipped with coupling facilities to couple adjacent traction sections in accordance with the circuit diagram.	
Explanation: With such a layout, traction sections can be fed in case of maintenance or failure of the GVI. See the Eenlijnschema'sin section 1.2, these are not site-specific drawings. See Schedule for the circuit diagram to be used.	
Verification method Document review Design drawing	Prescription/Standards

L-MT-000-006 Traction power substation - Traction power substation disconnectable	
The electrical installations (HVI and GVI) of the traction power substation must be able to be switched off independently and maintained separately.	
Explanation: See the Eenlijnschema'sin section 1.2, these are not site-specific drawings.	
Verification method Document review Design drawing	Norm: NEN-EN 50123

L-MT-000-007 System traction power substation - Installation cabinet	
All components and parts of the traction installations (with the exception of the traction transformer) in the traction power substation shall be placed in metal-enclosed cabinets where accessibility for maintenance shall be maintained in accordance with NEN-EN 50123. The direct-current distribution system and the rectifier shall be installed insulated from earth.	
Explanation (optional)	
Verification method Document review Design specification Testing/inspection report visual Testing/measurement and report	Norm: NEN-EN 50123

L-MT-000-008 System Traction power substation - Clearance for maintenance of switchgear	
The location of the switchgear in the traction power substation must allow for the switchgear to be driven out (GVI) and for (maintenance-) work to be carried out safely in front of, in and on the equipment-.	
Explanation (optional)	
Verification method Document review Design	Prescription/Standards

4.1.5 Aspect requirement: Reliability

L-MT-000-009 System Traction power substation - Traction power substation design lifetime	
The traction power substation should have a design life of at least 30 years, or otherwise if so required in referenced documents or in this demand specification. Exception for PLC's and protection relays, for which the minimum lifetime is 15 years. For batteries, a design life of 10 years should be applied.	
Explanation (optional)	
Verification method Document review Design specification	Prescription/Standards

L-MT-000-010 System traction power substation - Traction power substation operation in ambient conditions	
The traction power substation must function undisturbed in the Dutch climate. A moderate maritime climate must be assumed.	
Explanation: The KNMI forecasts of 2020 must be used as the basis for the extremes in temperature, precipitation, drought and relative humidity.	
Verification method Document review Design specification	Prescription/Standards KNMI forecast from 2020 to 2050

L-MT-000-011 System traction power substation - Traction power substation ambient temperature	
The traction power substation must be able to operate undisturbed at an outside temperature of -10°C to +40°C.	
Explanation: If the temperature extremes in Amsterdam's urban environment remain within the values given here according to the KNMI's prognosis up to 2050, then keep to these values. If not, then the KNMI's extremes should be adhered to.	
Verification method Document review Design specification	Prescription/Standards

4.1.6 Aspect requirement: Future-proofing

L-MT-000-012 System Traction power substation - Components to be supplied
The supply of applied components must be guaranteed for at least 10 years.

L-MT-000-012 System Traction power substation - Components to be supplied	
Explanation (optional)	
Verification method Testing/inspection report visual	Prescription/Standards

4.1.7 Aspect requirement: Availability

L-MT-000-001 System Traction power substation – RAMS: Availability	
The overall availability of the traction power substation must be minimal 99,95%.	
Toelichting: The not-availability of the grid is not taken into account.	
Verification method RAMS Analysis	Prescription:

L-MT-000-014 System Traction power substation - RAMS: MTTF requirements for components	
The electrical components must comply with the MTTF values shown in the Overzicht RAMS grenswaardenin section 1.2.	
Explanation: The values given may be better than those given here, not worse.	
Verification method Document review Design drawing	Prescription: Overzicht RAMS grenswaardenin section 1.2

L-MT-000-015 System Traction power substation - RAMS: MTTR requirements	
The design of the traction power substation must allow for the MTTR limits.	
Explanation: The values given may be better than those given here, not worse. The MTTR values depend on many factors.	
Verification method RAMS analysis: ON must make clear how the set values will be met.	Prescription: Overzicht RAMS grenswaardenin section 1.2

4.1.8 Aspect requirement: Nuisance

L-MT-000-015 System traction power substation - Traction power substation noise level	
The noise level of the traction power substation may not exceed 55dB(A) [LpA] at 10 m from the outside at a load of 100 % x Pnom.	
Explanation (optional)	
Verification method Testing/measurement and report in accordance with IEC 6007610	Prescription/Standard: Noise Pollution Act 01-05-2017 IEC 6007610

4.1.9 Aspect requirement: Safety

L-MT-000-016 System traction power substation - Traction power substation protections	
The installations of the traction power substation must be protected against internal faults, overloads and short circuits.	
Explanation (optional)	
Verification method Document review Protection concept design & selectivity	Prescription/Standards

I-MT-000-017 System traction power substation - Traction power substation Cable type	
The cables and wiring used in the traction power substation must be halogen-free and flame-retardant.	
Explanation (optional)	
Verification method Document review Design specification	Norm: NEN 8012

4.1.10 Aspect requirement: Cyberprotection

L-MT-000-018 System traction power substation - Traction power substation Cyberprotection	
The traction power substation must be protected against cyber attacks and cyber infections. The traction power substation must at least meet the requirements as described in the CS Requirements document. Repair work resulting from the pen test is the responsibility of ON.	
Explanation: The document Process Requirements describes how cyber protection should be embedded by ON in its operations.	
Verification method On the basis of the H&S plan approved by OG Pen test to be carried out by OG	Prescription/Standards Cyberprotection-Requirementset WITH OT Systems Cyberprotection Ordinance OT

4.2 Purchasing distributor (for traction power substation version with purchasing distributor)

I-MT-010-001 System Traction power substation - Connection of grid operator	
In order to realise a medium-voltage purchase distributor, the traction power substation must be prepared for a redundant supply from a substation of grid manager Liander. ON has a duty to coordinate with the grid manager Liander.	
Explanation: Requirement applicable if medium voltage supply comes from network operator.	
Verification method Document review Design drawing	Prescription/Standards

L-MT-010-002 System Traction power substation - Purchasing area	
The traction power substation must be equipped with a purchasing area in accordance with Liander's Schedule of Requirements. ON has a duty to coordinate with the grid manager Liander.	
Explanation: Requirement applies if medium voltage supply comes from network operator. The delivery, installation, connection and commissioning of the distribution panel of the DSO is not part of the scope of this specification, it belongs to the regulated domain and is carried out by the network operator. See typical Opstellingstekeningenin section 1.2, this does not concern a site-specific building arrangement.	
Verification method Document review Design drawing	Requirement: See binding documents para 1.2: - S8035 PvE Inkoopruimte – Extern Gebruik

L-MT-010-003 System Traction power substation - Consumption measurement	
The location of the accountable consumption measurement must be agreed with the network operator and the metering company. Two units (one measuring unit and one control measuring unit) are to be installed in the MS room of the traction power substation. ON has a duty to coordinate with the grid manager Liander and the metering company.	
Explanation: Requirement applies if medium voltage supply comes from network operator. See typical Opstellingstekeningen in section 1.2, this does not concern a site-specific building arrangement.	
Verification method Document review Design	Prescription/Standards

4.3 HVI

L-MT-010-004 System traction power substation - HVI	
The traction power substation must be equipped with a high-voltage distribution panel that supplies the underlying installation parts with high voltage.	
Explanation (optional)	
Verification method Document review Design	Prescription/Standards

L-MT-010-005 System Traction power substation - HVI switchgear version	
In the high-voltage switchgear of the GS, the switchgear must be designed in accordance with IEC 62271	
Explanation (optional)	
Verification method Document review Design specification	Norm: IEC 62271

L-MT-010-006 System traction power substation - HVI traction power substation version with purchase distributor	
The installation in the customer area should consist of: 1. One incoming field (circuit breaker) to which the incoming power supply from the grid operator's installation is connected. 2. Optional] Two ring bays (circuit breakers) to which the distribution cables from/to the neighbouring stations are connected. 3. An output field (circuit breaker) for feeding the traction transformer. 4. One measuring field. It is permissible to integrate the measuring field into the incoming cable field, for example. 5. Optional: additional outgoing field (circuit breaker) for connection of e.g. Subway station/switchgear/Installations railway sidings See sPvE for the site-specific composition of the HVI.	
Explanation: Requirement applies if medium voltage supply comes from network operator. The two ring fields mentioned under number 2 in the requirements text are optional, the site-specific required composition is specified in the sPvE. See the Eenlijnschema'sin section 1.2, these are not site-specific drawings.	

L-MT-010-006 System traction power substation - HVI traction power substation version with purchase distributor	
Verification method Document review Design drawing	Prescription/Standards

L-MT-010-007 System traction power substation - HVI traction power substation version without purchase distributor	
The HVI installation shall consist of: 1. Two ring fields (circuit breakers) to which the distribution cables from/to the neighbouring stations are connected. 2. An output field (circuit breaker) for feeding the traction transformer. 3. A measuring field for power measurement and voltage and current monitoring. 4. Optional: An outgoing field (power switch) for EV transformer of passenger station. The power supply to a neighbouring station comes from a main station or, in the event of a medium voltage cable fault with the main station, from another neighbouring station (if there is one).	
Explanation: Requirement applies if medium voltage supply comes from neighbouring station. See the Eenlijnschema's in section 1.2, these are not site-specific drawings.	
Verification method Document review Design drawing	Prescription/Standards

L-MT-010-008 System traction power substation - HVI Specifications

The HVI shall comply with the following specifications:
• Rail system
  ○ Nominal voltage: Included in sPvE
  ○ Frequency: 50Hz
  ○ Rated current rail system: 630A
  ○ Dynamic short-circuit current: to be determined by ON
  ○ Thermal short-circuit current: to be determined by ON
  ○ Internal arc classification: IAC AFL(R) classification
  ○ Degree of protection (HS): IP65
  ○ Degree of protection (LS): IP3X
  ○ Permissible ambient temperature: -5 to +40 °C
• Incoming and outgoing fields (circuit breaker)
  ○ Allocated load current: 630A
  ○ Rated tripping current in the event of a short circuit: to be determined by ON
  ○ Rated inrush current in case of short circuit: to be determined by ON
  ○ Short duration current allowed: to be determined by ON
The HVI shall be tested with regard to internal arc faults in accordance with NEN-EN-IEC 62271-200:2012

Explanation: See Schedule for the nominal voltage to be used. Explanation internal arc classification: • IAC: Internal Arc Classification • A: Switchgear installed in closed rooms with access (A) restricted to authorized personnel only • F: Accessibility from the front (F) • L: Accessibility from the sides (L = lateral) • R: Accessibility from the rear (R); R depends on the set-up. The starting point is therefore that the HVI is accessible from the front and the side.

L-MT-010-008 System traction power substation - HVI Specifications	
Verification method Document review Design specification Short circuit calculation	Prescription/Standards NEN-EN-IEC 62271-200:2012

L-MT-010-009 System Traction power substation - HVI Version	
The design of the high-voltage distribution system must comply with the following: • All controls, gauges and indicators must be carried out at the front of the cabinet. • The status messages of all switches and disconnectors must be easy to read both on the front panel and on the HMI. • The meters for current and voltage must be easy to read both on the front of the cabinet and on the HMI. • Switching the circuit breakers on and off must be done by means of push buttons in the field or on the protection unit. • It must be possible to switch the circuit breakers and phase switches on and off manually in the field at any time, even in the absence of auxiliary power. • The disabling must be carried out by means of a field reset. • When the circuit breaker is tripped, it shall be possible to read which protection has been activated and at what time. • In addition, the history of the trips up to at least 50 trips shall still be stored and easy to read and save. • Connected medium-voltage cables must be accessible for measurements for cable inspection without having to remove the end closures. • The controls and signals to and from the traction power switchgear substation must be implemented in accordance with the IO list.	
Explanation (optional)	
Verification method Document review Design specification	Prescription/Standards

L-MT-010-010-010 System traction power substation - HVI SF6 switching medium	
SF6 as a switching medium is not permitted.	
Explanation: Due to the negative environmental aspects of this gas, we do not want to use it.	
Verification method Document review Design specification	Prescription/Standards

L-MT-010-011 System Traction power substation - HVI SF6 insulation medium	
SF6 as an insulating medium is NOT allowed.	
Explanation: Due to the negative environmental aspects of this gas, we do not want to use it.	
Verification method Document review Design specification	Prescription/Standards

L-MT-010-012 System Traction power substation - HVI protection type
The HVI shall be equipped with (modern) safety relays that realise interconnection, interlocking and connection to the station automation system on the basis of IEC61850/GOOSE. The components shall support the functionality of IEC61850 version 2.0.
Explanation: Trip notifications, status and stand notifications will be linked to CBI on the basis of fibre optic connections. No hardware links will be used.

L-MT-010-012 System Traction power substation - HVI protection type	
Verification method Document review Design specification	Prescription/Standards IEC61850

L-MT-010-013 System traction power substation - HVI operation version	
The switches of the high-voltage distribution device can be operated in three ways: • Local. This means the control in the traction power substation on the HVI itself. • Remote. This means operation from the HMI in the traction power substation. • Far Away. This means the operation from the CVL/Central remote control. The selection between "Local", "Remote" or "Far" operation shall be made by means of a selector switch at the local HMI. The selector switch has to be implemented as a key switch. The selector switch shall be a three-position switch with the following design: • In the "Local" mode, only locally issued commands are to be executed on the HVI. • In the Remote mode, only the commands issued from the HMI must be executed. • In the "Far Away" mode, only the commands given by the CVL/Central remote control shall be executed. The position of the selector switches must be signalled in the field, on the HMI and to the central remote control. Switching the selector switch must not cause a change of state in the field concerned.	
Explanation (optional)	
Verification method Document review Design Testing/functional	Prescription/Standards

L-MT-010-014 System traction power substation - HVI operation	
In the high-voltage switchgear in the GS, both the load and power switches must be suitable for local operation via the HMI (Remote) and from CVL/Central (Far Away) remote control according to the IO list.	
Explanation (optional)	
Verification method Document review Design Testing/functional	Prescription/Standards

L-MT-010-015 System Traction power substation - HVI control and monitoring	
In the high-voltage switchgear in the GS, each circuit breaker must be controlled and monitored by means of its own IED.	
Explanation: The IEDs provide signalling, interlocks, and remote and distant control.	
Verification method Document review Design	Prescription/Standards

L-MT-010-016 Traction power substation - HVI 2-stage circuit breaker	
The incoming and outgoing fields of the HVI must be equipped with a 2-position circuit breaker (operating mode/grounding mode).	
Explanation: The two-position circuit breaker is manually operated and intended to separate circuit breaker and voltage rails.	
Verification method Document review Design specification Testing/functional	Prescription/Standards

L-MT-010-017 System Traction power substation - HVI control 2-position circuit breaker in earthing mode	
If the 2-position circuit breaker (operating position/earth position) of a circuit breaker in the high-voltage switchgear in the traction power substation is in the earth position, it must only be possible to operate the field in question from the local area.	
Explanation: The remote control of the relevant field must be blocked in this case.	
Verification method Document review Design specification Testing/functional	Prescription/Standards

L-MT-010-018 System Traction power substation - HVI blocking 2-position circuit breaker in earthing mode	
If the two-position circuit breaker of a circuit breaker in the high-voltage switchgear in the traction power substation is in the earthing position, no disconnection by the protective device may take place in the relevant field in the HVI.	
Explanation (optional)	
Verification method Document review Design specification Testing/functional	Prescription/Standards

L-MT-010-019 System Traction power substation - HVI blocking after trip	
If a protection device has tripped, the activation of the relevant field shall be blocked until the protection device has been RESET.	
Explanation (optional)	
Verification method Document review Design Testing/functional	Prescription/Standards

L-MT-010-020 System traction power substation - HVI kWh meter	
For GVB registration purposes, a kWh meter suitable for remote reading and the necessary measuring transformers for current and voltage must be included in the HVI, which meet the requirements of the Metering Code.	
Explanation (optional)	
Verification method Document review Design Testing/inspection report visual	Prescription/Standards

L-MT-010-021 System traction power substation - potential-free signals	
From the high voltage distribution panel of the GS, the interlocks required for the traction installations have to be carried out via the local control system.	
Explanation:	
Verification method Document review Design	Prescription/Standards

4.4 Traction Transformer

4.4.1 Metro

L-M-020-001 System traction power substation - TT power Metro	
The traction transformer of the traction power substation must have a nominal power (in accordance with NEN-EN 50329) of 1 x 2.5 MVA.	
Explanation (optional)	
Verification method Document review Design specification	Standards: NEN-EN 50329 class VI

L-M-020-002 System traction power substation - TT Overload class Metro	
The traction transformer of the traction power substation must be suitable for heavy traction operation according to NEN-EN 50329 class VI.	
Explanation (optional)	
Verification method Document review Design specification	Standards: NEN-EN 50329 class VI

L-M-020-003 System traction power substation - TT Voltages Metro	
The nominal primary voltage at medium voltage level is included in the sPvE and the secondary nominal voltage is 610 V.	
Explanation: See sPvE for the nominal voltage to be used.	
Verification method Document review Design	Prescription/Standards

L-M-020-004 System traction power substation - TT secondary voltage Metro	
The traction transformer of the traction power substation has to be equipped with two secondary windings (branch 1 and 2) with a terminal voltage of 610V with 30° phase shift for the 12-pulse rectification.	
Explanation: The 30° phase shift is achieved by switching branch 1 to triangle and branch 2 to star. The voltage of each branch should meet the above values.	
Verification method Document review Design specification	Prescription/Standards

4.4.2 Tram

L-T-020-005 System Traction power substation - TT power Tram	
The traction transformer of the traction power substation must have a nominal power (in accordance with NEN-EN 50329) of 1 x 2 MVA.	
Explanation (optional)	
Verification method Document review Design specification	Standards: NEN-EN 50329 class VI

L-T-020-006 System Traction power substation - TT Overload class Tram	
The traction transformer of the traction power substation must be suitable for heavy traction operation according to NEN-EN 50329 class VI.	
Explanation (optional)	
Verification method Document review Design specification	Standards: NEN-EN 50329 class VI

L-T-020-007 System Traction power substation - TT Primary voltages tram	
The nominal primary voltage at medium voltage level is included in the sPvE.	
Explanation: See sPVE for the nominal primary voltage to be used.	
Verification method Document review Design	Prescription/Standards

L-T-020-008 System Traction power substation - TT Secondary voltage Tram	
The traction power substation traction transformer shall be equipped with two secondary windings (branch 1 and 2) with a terminal voltage of 490 V with 30° phase shift for the 12-pulse rectifier with also a branch for 610 V with 30° phase shift.	
Explanation: The 30° phase shift is achieved by switching branch 1 to triangle and branch 2 to star. The voltage of each branch should meet the above values. In the future, it may also be decided to implement tram as a 750V system. To this end, traction transformers are currently being requested with two secondary voltages, both for 600Vdc and 750Vdc. If Tram is also configured as a 750Vdc system in the future, this will no longer be necessary. ON must coordinate with OG whether a double secondary voltage is required.	
Verification method Document review Design specification	Prescription/Standards

4.4.3 General (Metro and Tram)

L-MT-020-009 System traction power substation - TT rectifier	
The traction transformer of the traction power substation shall be suitable for feeding a 12-pulse -bridge rectifier, with silicon diodes.	
Explanation: Class VI; 150% for 2 hours or 300% for 1 minute of rated power.	
Verification method Document review Design specification	Prescription/Standards

L-MT-020-010 System traction power substation - TT switching protocol	
The traction transformer of the traction power substation must not be switched on again automatically after a power failure and a power return, but manually according to the switching protocol in accordance with the Electrical Operation Manual for Metro and Tram Amsterdam. This should be possible at the local operating level.	
Explanation: This means switching on the high voltage HVI distributor.	
Verification method Document review Design	Prescription: Electrical Management Handbook for Rail Infrastructure Metro and Tram Amsterdam

L-MT-020-011 System traction power substation - TT tap positions	
The traction transformer of the traction power substation shall have five tapping positions, with the following values -5%, -2.5%, 0%, +2.5%, +5%.	
Explanation (optional)	
Verification method Document review Design specification	Prescription/Standards

L-MT-020-012 System traction power substation - TT type	
The traction transformer should be of the dry type.	
Explanation: Dry-type transformers do not require structural facilities for oil collection, require virtually no maintenance and have a lower fire load.	
Verification method Document review Design specification	Prescription/Standards

L-MT-020-013 System Traction power substation - TT Cooling method	
The traction transformer of the traction power substation must be cooled by means of cooling method AN.	
Explanation: Take into account the room temperature in which the transformer is installed.	
Verification method Document review Design specification	Prescription/Standards

L-MT-020-014 System Traction power substation - TT Surge arresters	
Overvoltage arresters should be included on the primary side of the traction transformer to dissipate switching overvoltages.	
Explanation: High switching peaks can occur when dry traction transformers and vacuum switches are combined.	
Verification method Document review Design drawing Testing/inspection report visual	Prescription/Standards

L-MT-020-015 System Traction power substation - TT overload class	
The traction transformer of the traction power substation must be overload-proof in accordance with NEN-EN 50329 class VI.	
Explanation: Class VI; 150% for 2 hours or 300% for 1 minute of rated power.	
Verification method Document review Design specification Testing/measurement and report	Norm: NEN-EN 50329

L-MT-020-016 System Traction power substation - TT noise level	
The traction transformer of the traction power substation shall cause a noise level of not more than 55 dB(A) at full load, measured according to EN 60076-10.	
Explanation: Full load refers to the nominal load.	
Verification method Document review Design specification Testing/measurement and report in accordance with IEC 6007610	Norm: EN 60076-10

L-MT-020-017 System Traction power substation - TT Short circuit loss
The traction transformer must have a maximum short-circuit loss that complies with Class Ak in accordance with EU directive Nr. 584/2014 for dry-type transformers. The exclusion in article 1, sub 2 for transformers that are specially designed for railway supply systems is not applicable.
Explanation (optional)

L-MT-020-017 System Traction power substation - TT Short circuit loss	
Verification method Document review Design specification Testing/measurement and report	Norm: EU directive Nr. 584/2014 NEN-EN 50588-1

L-MT-020-018 System Traction power substation - TT No-load loss	
The traction transformer must have a maximum no-load loss that complies with Class Ao in accordance with EU directive Nr. 584/2014 for dry-type transformers. The exclusion in article 1, sub 2 for transformers that are specially designed for railway supply systems is not applicable.	
Explanation (optional)	
Verification method Document review Design specification Testing/measurement and report	Norm: EU directive Nr. 584/2014 NEN-EN 50588-1

L-MT-020-019 System Traction power substation - TT Winding material	
The material of the windings of the traction transformer may be copper or aluminium. The final winding material must be equivalent in terms of losses (see L-MT-020-017 and L-MT-020-018). The traction power substation windings shall be made of round wire.	
Explanation (optional)	
Verification method Document review Design specification Testing/measurement and report	Norm: EU directive Nr. 584/2014 NEN-EN 50588-1

L-MT-020-020 System traction power substation - TT coupling factor	
The coupling factor between the secondary windings of the traction transformer is not to be greater than 0.2	
Explanation: The starting point is not to install separate choke fields (in the DC distribution). Therefore, the requirement for the traction transformer is K<0.2.	
Verification method Document review Design specification Testing/measurement and report	Prescription/Standards

L-MT-020-021 System traction power substation - TT Thermal protection	
The traction transformer must be equipped with cast PT100 elements at the hotspots. Two PT100 elements per phase on the secondary side of the traction transformer. The PT100s should be connected to an IED. Temperature of each PT100 must be visible on the HMI and CBI.	
Note The measuring range of the PT100 elements must be able to measure 150% of the maximum temperature of the transformer hotspots.	
Verification method Document review Design specification	Prescription/Standards

L-MT-020-022 System traction power substation - TT Connections	
The primary connection of the traction transformer of the traction power substation must be made with Elastimold connections or equivalent, suitable for the application of a work earth.	
Note This applies only to oil-filled transformers.	
Verification method Document review Design specification Testing/inspection report visual	Prescription/Standards

I-MT-020-023 System Traction power substation - Natural ventilation Staircase room	
The climatic conditions in the transformer room in the traction power substation are preferably controlled by ventilation.	
Explanation: ON should prepare a heat load/ventilation calculation as part of the design to ensure the climate requirements for the traction transformer.	
Verification method Document review Design heat load/ventilation calculation	Prescription/Standards

L-MT-020-024 System traction power substation - TT Code plate	
The traction transformer must be provided with rating plates according to NEN-EN 50329.	
Explanation (optional)	
Verification method Document review Design drawing Testing/inspection report visual	Prescription/Standards NEN-EN 50329

I-MT-020-025 System traction power substation - TT Vibration dampers	
The traction transformer should be placed on vibration dampers.	
Explanation (optional)	
Verification method Document review Design specification Testing/inspection report visual	Prescription/Standards

I-MT-020-026 System Traction power substation - TT Exit	
The traction transformer should be placed on rails and be wheeled out.	
Explanation (optional)	
Verification method Document review Design specification Testing/inspection report visual	Prescription/Standards

4.5 Rectifier

4.5.1 Metro

L-M-030-001 System traction power substation - rectifier nominal voltage Metro	
The nominal DC voltage of the rectifier shall be 750 V.	
Explanation (optional)	
Verification method Document review Design specification	Prescription/Standards

4.5.2 Tram

L-T-030-002 Traction power substation - rectifier nominal voltage Tram
The nominal DC voltage of the rectifier should be 600V or 750V. In the future, it shall be possible to equip trams with a 750 V system. The voltage level is specified per traction power substation. Please refer to the location specific PoR and Unified Line Diagram.

L-T-030-002 Traction power substation - rectifier nominal voltage Tram	
In the future, it may also be decided to implement tram as a 750V system. To this end, traction transformers are currently being requested with two secondary voltages, both for 600Vdc and 750Vdc. If Tram is also configured as a 750Vdc system in the future, this will no longer be necessary. ON must coordinate with OG whether a double secondary voltage is required.	
Verification method Document review Design specification	Prescription/Standards

4.5.3 General (Metro and Tram)

L-MT-030-003 System traction power substation - rectifier circuit	
The rectifier circuit should be a 12-pulse bridge. Alternatively, an IGBT rectifier with a 6-pulse bridge is allowed.	
Explanation: Table 4 NEN-EN 50328 connection number 9. Suction chokes are not permitted. An IGBT rectifier produces far fewer harmonics than a diode bridge, so a 6-pulse bridge and transformer is sufficient.	
Verification method Document review Design specification	Prescription/Standards NEN-EN 50328

L-MT-030-004 System Traction power substation - Rectifier overload class	
The rectifier must comply with an overload class VI in accordance with NEN-EN 50328.	
Explanation (optional)	
Verification method Document review Design specification	Prescription/Standards NEN-EN 50328

I-MT-030-005 System Traction power substation - isolated arrangement	
The rectifier must be installed in an insulated manner with a connection to earth ground.	
Explanation: Connection to water earth via earth fault protection.	
Verification method Document review Design Testing/measurement and report	Prescription/Standards

L-MT-030-006 System traction power substation - rectifier overvoltages	
The rectifier must be protected against overvoltages on both the AC and DC sides.	
Explanation (optional)	
Verification method Document review Design specification Testing/inspection report visual	Prescription/Standards

L-MT-030-007 System traction power substation - Rectifier protection equipment	
The rectifier shall be equipped with warning and protection devices that selectively cut off the switches placed in front of it, if necessary.	
Explanation (optional)	
Verification method Document review Design drawing Testing/functional	Prescription/Standards

L-MT-030-008 System traction power substation - rectifier thermal protection	
The rectifier should be equipped with a temperature sensor. The temperature sensor has to be connected to an IED. The temperature must be visible on the HMI and CBI.	
Explanation (optional)	
Verification method Document review Design drawing	Prescription/Standards

L-MT-030-009 Traction power substation - Rectifier ground balls	
The rectifier should be equipped with earth balls on the plus and minus rails and two earth balls on ground.	
Explanation: For securing the installation during maintenance work.	
Verification method Document review Design drawing Visual inspection report	Prescription/Standards

I-MT-030-010 System Traction power substation - Connection of the auto-transformer	
The connection of the EBT is to be realised in the traction rectifier. The protection of the cable to the EBT (via fuse links) should also be realised in the rectifier in this case.	
Explanation: In this case, it is also preferable to include the EBT itself in the traction rectifier. This is optional.	
Verification method Document review Design drawing	Prescription/Standards

L-MT-030-011 System traction power substation - rectifier placement	
It shall be possible to install the rectifier directly to the wall. It shall be possible to carry out all maintenance from the front.	
Explanation: When replacing in existing traction power substations, space is often at a premium, so a free-standing arrangement is not possible.	
Verification method Document review Design drawing Visual inspection report	Prescription/Standards

L-MT-030-012 System traction power substation - rectifier Colour cabinet	
The colour of the rectifier cabinet shall be RAL5012.	
Explanation (optional)	
Verification method Document review Design drawing Visual inspection report	Prescription/Standards

4.6 Recovery Unit

L-M-030-013 System traction power substation - AC Connection Recovery Unit	
The rectifier shall provide a connection on the AC-side (branch 1) for the connection of a recovery unit of 1 MVA. See the Systeemspecificatie Recovery Unitin section 1.2.	
Explanation (optional)	
Verification method Document review Design specification	Prescription/Standards

L-M-030-014 System traction power substation - DC Connection Recovery Unit	
The GVI must provide a connection for connecting a Recovery Unit to the GVI. See the Systeemspecificatie Recovery Unitin Section 1.2.	
Explanation (optional)	
Verification method Document review Design specification	Prescription/Standards

4.7 GVI

4.7.1 Metro

L-M-040-001 System traction power substation - GVI Outgoing fields Metro	
The GVI shall be equipped with four outgoing (plus) fields. The project-specific circuit diagram included in the sPvE is leading in the final number of outbound fields.	
Explanation: The final number of outgoing fields and configuration is to be determined on the basis of the project-specific circuit diagram.	
Verification method Document review Design drawing	Prescription/Standards

L-M-040-002 System traction power substation - GVI Circuit breaker Field Recovery Unit	
The GVI must be equipped with a circuit breaker field to which a Recovery Unit can be connected, a connection to the plus rail and a connection to the minus rail.	
Explanation: Disconnector is always placed for Metro, in preparation for the future.	
Verification method Document review Design drawing Testing/inspection report visual	Prescription/Standards

4.7.2 Tram

L-T-040-003 System Traction power substation - GVI Outgoing fields Tram	
The GVI of the traction power substation shall have two outbound (plus) fields. The project-specific circuit diagram included in the sPvE is leading in the final number of outbound fields.	
Explanation: The final number of outgoing fields and configuration must be determined according to the project-specific circuit diagram.	
Verification method Document review Design drawing	Prescription/Standards

4.7.3 General

I-MT-040-004 System traction power substation - GVI classification	
The GVI must be placed in accordance with the Opstellingstekeningenin section 1.2.	
Explanation: This arrangement is used to reduce the cable distance between the traction transformer and the rectifier. This is not a site-specific building arrangement.	
Verification method Document review Design drawing Testing/inspection report visual	Prescription/Standards

L-MT-040-005 System traction power substation - GVI Installation	
It must be possible to install the GVI directly against the wall. It must be possible to carry out all maintenance from the front.	
Explanation: When replacing in existing traction power substations, space is often at a premium, so a free-standing arrangement is not possible.	
Verification method Document review Design drawing Testing/inspection report visual	Prescription/Standards

L-MT-040-006 System Traction power substation - GVI Outgoing field railway sidings	
The GVI shall be equipped with outbound fields for feeding a siding.	
Explanation: Requirement applies if sidings are present. The final number of outgoing fields and configuration is to be determined on the basis of the project-specific circuit diagram.	
Verification method Document review Design drawing Testing/inspection report visual	Prescription/Standards

L-MT-040-007 System traction power substation - GVI Minus field	
The GVI must be equipped with a minus field to which at least 4 return cables can be connected.	
Explanation: The exact number of minus cables is determined from the network analysis.	
Verification method Document review Design drawing Testing/inspection report visual	Prescription/Standards

L-MT-040-008 System traction power substation - GVI Plus & Minus circuit breakers	
The GVI must be equipped with Plus & Minus circuit breakers that allow the traction rectifier to be disconnected from the plus rail and the minus rail. In order to be able to switch the rectifier freely from the direct current distribution, isolating switches must be installed in both the plus and the minus pole.	
Explanation: Preference is given to the plus/minus circuit breakers in a combined field in the GVI.	
Verification method Document review Design drawing Testing/inspection report visual	Prescription/Standards

L-MT-040-009 System traction power substation - Locking GVI Plus & Minus circuit breakers	
Interlocks should be provided to prevent the Plus & Minus circuit breakers of the rectifier from being switched under load.	
Explanation (optional)	
Verification method Document review Design drawing Testing/functional	Prescription/Standards

L-MT-041-001 System Traction power substation - GVI switch cars	
The high speed circuit breakers must be placed on switch carts. The switch cars should have a test position where the main contacts are broken. When the switch car is deployed it shall be possible to test the switch for proper functioning (switching on, off, trips) using normal electrical operation.	
Explanation (optional)	
Verification method Document review Design drawing Testing/inspection report visual Testing/functional	Prescription/Standards

L-MT-041-002 System Traction power substation - GVI ground balls	
The GVI must be equipped with earth balls on the plus, minus and earth rail.	
Explanation: For securing the installation during maintenance.	
Verification method Document review Design drawing Iinspection report visual	Prescription/Standards

I-MT-040-010 System traction power substation - GVI insulated arrangement	
The GVI must be completely isolated from water earth. The system is connected to water earth via the system short-circuit protection, which detects the fault current in the event of a short-circuit from the DC circuit to the system. The system short-circuit protection must be demonstrably short-circuit proof.	
Explanation (optional)	
Verification method Document review Design drawing Document review Design Calculation Testing/measurement and report Testing/functional	Prescription/Standards

I-MT-040-011 System traction power substation - GVI blind diagram	
The GVI must have a single-line blind on the panel.	
Explanation: The blind diagram must be site-specific, with the correct coding and section names.	
Verification method Document review Design drawing Testing/inspection report visual	Prescription/Standards

I-MT-040-012 System Traction power substation - GVI blind design	
The blind should be mounted on the panel without glue.	
Explanation: The application of adhesive (e.g. a sticker) causes loosening of the blinds.	
Verification method Document review Design drawing Testing/inspection report visual	Prescription/Standards

L-MT-040-013 System Traction power substation - GVI Version	
Operation and monitoring of the DC switchgear assembly shall comply with: • All controls, measurements and signals must be carried out at the front of the cabinet. • All local and remote controls and position transmitters must be carried out with double poles. • The status reports of all switches and disconnectors and the current L-M-0 and voltage measurements must be easy to read, both on the front of the cabinet and on the HMI. • Switching on and off of high speed circuit breakers has to be done by means of push buttons on the field or on the protection unit. • It must be possible to switch the high speed circuit breaker on and off manually in the field at any time, even in the absence of auxiliary power. • The disabling of the blocking of the on-switching must be carried out by means of a field reset. • When the high speed circuit breaker is tripped, it shall be possible to read which protection has been activated and at what time. • The trip history shall be stored up to at least 50 trips and be easily readable. • The controls and signalling to and from the traction power switchgear substation must be in accordance with the IO list.	
Explanation: All the above requirements must be configured in the local traction power substation control system.	
Verification method Document review Design specification	Prescription/Standards

L-MT-040-014 System Traction power substation - GVI protection type	
The GVI shall be equipped with IEDs that enable interconnection and linkage to stations automation system (SA) based on IEC61850/GOOSE. The components must support version 2.0.	
Explanation: Trip notifications, interlocks, status and status notifications will be linked to CBI via fibre optic connections. No hardware links will be used.	
Verification method Document review Design specification	Norm: IEC61850/GOOSE

L-MT-040-015 System traction power substation - GVI version operation	
The switches of the GVI can be operated in three ways: • Local. This means the operation in the traction power substation on the GVI itself. • Remote. This means operation from the HMI in the traction power substation. • Remote control. This means the operation from the CVL/Central remote control. The selection between "Local", "Remote" or "Far" operation has to be made by means of a selector switch on the HMI in the traction power substation. The selector switch must be designed as a key switch. The selector switch shall be a three-position switch with the following design: • In the "Local" mode, only locally issued commands are to be executed on the GVI. • In the remote mode, only the commands issued from the HMI must be executed. • In the "remote control" mode, only the commands given by the CVL/Central remote control shall be executed. The position of the selector switches must be signalled in the field, on the HMI and to the central remote control. Switching the selector switch must not cause a change of state in the field concerned.	
Explanation (optional)	
Verification method Document review Design Testing/functional	Prescription/Standards

L-MT-040-016 System traction power substation - GVI Cabinet colour	
The colour of the cabinet of the GVI shall be RAL5012.	
Explanation (optional)	
Verification method Document review Design drawing	Prescription/Standards

4.7.4 High speed circuit breakers Metro

L-M-041-003 System Traction power substation - GVI interlock high speed circuit breakers	
The control of the Metro high speed circuit breakers is described in the Switch and Trip Matrix.	
Explanation: See the Schakelmatrix and the Tripmatrix in section 1.2.	
Verification method Document review Design Testing/functional	Prescription/Standards

4.7.5 High speed circuit breakers Tramway

L-T-041-004 System Traction power substation - GVI interlock high speed circuit breakers	
The control of the Tram High speed circuit breakers is described in the Switch and Trip Matrix.	
Explanation: See the Schakelmatrix and the Tripmatrix in section 1.2.	
Verification method Document review Design Testing/functional	Prescription/Standards

4.7.6 High speed circuit breakers General

L-MT-041-005 System Traction power substation - GVI switching on and off contact line network	
The switch-on and switch-off of the voltage in the contact line network is carried out by means of the high speed circuit breakers. For this purpose, the high speed circuit breakers must be equipped with safety devices that cut off the power supply to the contact line network in the event of an excessive current load.	
Explanation: For each section of the contact line network, a high speed circuit breaker is included in the switch and distribution unit.	
Verification method Document review Design	Prescription/Standards

L-MT-041-006 System traction power substation - GVI high speed circuit breaker per section	
The switchgear and distribution system must include a high speed circuit breaker for each section of the contact line system.	
Explanation (optional)	
Verification method Document review Design drawing	Prescription/Standards

L-MT-041-007 System traction power substation - GVI high speed circuit breaker specifications	
The high speed circuit breakers must be capable of carrying the nominal operating current that occurs, taking into account the permissible overload of the rectifier, and also of switching on and off the short-circuit currents that occur.	
Explanation (optional)	
Verification method Document review Design Calculation Document review Design specification	Prescription/Standards

L-MT-041-008 System traction power substation - GVI high speed circuit breakers	
The high speed circuit breakers must be equipped with a unit for disconnection within 25 msec (shunt trip, capacitor disconnection with thyristor and additional trip coil on the high speed circuit breaker)	
Explanation: The aim is to prevent extreme short-circuit currents. The tripping time of the selected high speed circuit breaker should be taken as the basis for the short-circuit calculation.	
Verification method Document review Design specification	Prescription/Standards

4.7.7 Plus & Minus circuit breakers

L-MT-043-001 System traction power substation - Plus & Minus circuit breaker version	
The Plus & Minus circuit breaker of the plus and minus pole of the rectifier must be double-pole and motor-operated.	
Explanation (optional)	
Verification method Document review Design drawing	Prescription/Standards

L-MT-043-002 System traction power substation - Plus & Minus circuit breakers specifications and interlock
The motorised Plus- & Minus-Circuit breaker must be suitable for carrying the largest locally occurring short-circuit current. Measures must be taken to prevent this circuit breaker from switching under load (interlocking).

L-MT-043-002 System traction power substation - Plus & Minus circuit breakers specifications and interlock	
Explanation: The plus and minus circuit breakers must be locked with the outgoing field to the traction transformer.	
Verification method Document review Design Calculation Document review Design specification	Prescription/Standards

L-MT-043-003 System traction power substation - Plus- & Minus circuit breakers control	
The Plus- & Minus circuit breakers should only be operated locally.	
Explanation (optional)	
Verification method Document review Design Testing/inspection report visual	Prescription/Standards

4.7.8 Circuit breakers for Recovery Unit Metro

L-M-044-001 System traction power substation - circuit breaker version	
The circuit breakers of the Recovery Unit must be motor-operated.	
Explanation: The circuit breaker is for connecting a recovery unit.	
Verification method Document review Design drawing Testing/inspection report visual	Prescription/Standards

L-M-044-002 System traction power substation - circuit breaker specifications and interlock	
The motor-driven disconnectors of the Recovery Unit shall be suitable for carrying the largest locally occurring short-circuit current.	
Explanation (optional)	
Verification method Document review Design Calculation Document review Design specification	Prescription/Standards

L-M-044-003 System Traction power substation - circuit breaker specifications and interlock	
Measures must be taken to prevent the motor-operated disconnectors of the Recovery Unit from switching under load (locking).	
Explanation (optional) See also the switching conditions at	
Verification method Document review Design Calculation Document review Design specification	Prescription/Standards

L-M-044-004 System traction power substation - circuit breaker operation	
It must be possible to operate the circuit breakers locally, remotely and by remote control.	
Explanation (optional)	
Verification method Document review Design Testing/functional	Prescription/Standards

4.8 SSI

4.8.1 Metro

L-M-045-001 System traction power substation - SSI	
The traction power substation shall be equipped with a section switch system which shall make it possible to connect the 3rd rail from the traction power substation to minus/neutral/plus.	
Explanation: The final number of outgoing fields and configuration is to be determined on the basis of the project-specific circuit diagram.	
Verification method Document review Design drawing	Prescription/Standards

L-M-045-002 System traction power substation - SSI Metro outgoing fields	
The SSI of the traction power substation shall be equipped with four outgoing (plus) fields and two (longitudinal) coupling fields for coupling fields 1 and 3 and for coupling fields 2 and 4. The project-specific circuit diagram included in the sPvE is leading in the final number of outbound fields.	
Explanation: The SSI must be equipped with (longitudinal) coupling fields that make it possible to interconnect supply sections when a plus field or the DC power supply rail in the GVI is out of operation. This interconnection makes N-1 operation possible. The final number of outgoing fields and configuration is to be determined on the basis of the project-specific circuit diagram.	
Verification method Document review Design drawing	Prescription/Standards

I-M-045-003 System traction power substation - SSI classification	
The arrangement and layout of the SSI must comply with the Opstellingstekeningenin Section 1.2.	
Explanation: Specific adjustments may be required per location, especially in the numbers of outbound fields.	
Verification method Document review Design drawing Testing/inspection report visual	Prescription/Standards

L-M-045-004 System Traction power substation - SSI Outgoing field siding	
The SSI shall be equipped with outgoing fields to supply a railway siding.	
Explanation: Requirement applies if sidings are present. The final number of outgoing fields and configuration is to be determined on the basis of the project-specific circuit diagram.	
Verification method Document review Design drawing Testing/inspection report visual	Prescription/Standards

L-M-045-005 System traction power substation - Lock SSI	
The outbound high speed circuit breakers and longcoupling switches must be locked. The switching conditions of the high speed circuit breakers and longitudinal switches are listed in the Schakelmatrixin Section 1.2.	
Explanation: Purpose: The low-current switch must be able to switch on and off without current. This can only be done by short-circuiting the longcircuit switch prior to the switching action via the high speed circuit breakers and the GVI.	
Verification method Document review Design drawing Testing/functional	Prescription/Standards

L-MT-045-006 System Traction power substation - control version	
All switching components in the traction power substation can be operated in three ways: • Local. This means the control in the traction power substation on the SSI itself. • Remote. This means operation from the HMI in the traction power substation. • Remote control. This means the operation from the CVL/Central remote control.	
Explanation (optional)	
Verification method Document review Design Testing/functional	Prescription/Standards

L-MT-045-007 System Traction power substation - key switch operation	
The choice between operation "Local", "Remote" or "Distant" shall be made by means of a selector switch on the HMI in the traction power substation. The selector switch shall be a key switch. The selector switch shall be a three-position switch with the following design: • In the "Local" mode, only locally issued commands are to be executed on the SSI. • In the remote mode, only the commands issued from the HMI must be executed. • In the "remote control" mode, only the commands given by the CVL/Central remote control shall be executed. The position of the selector switches must be signalled in the field, on the HMI and to the central remote control. Switching the selector switch must not cause a change of state in the field concerned.	
Explanation (optional)	
Verification method Document review Design Testing/functional	Prescription/Standards

4.8.2 Switch-disconnectors (longitudinal) coupling field

L-M-045-008 System traction power substation - SSI Metro (longitudinal) coupling field
The SSI shall be equipped with a (longitudinal) coupling field, so that the traction power substation can be operated as a traction power switchgear substation where it is possible to connect two adjacent 3rd rail sections. The switching conditions for switching the switch-disconnectors on and off are listed in the Schakelmatrix in section 1.2.

L-M-045-008 System traction power substation - SSI Metro (longitudinal) coupling field	
Explanation: The coupling of two adjacent 3rd rail sections enables the N-1 operation of a part of an metro route. The coupling is usually made in the traction power substation where the supply of traction energy is not possible. The final number of outbound fields and configuration should be determined on the basis of the project-specific circuit diagram and sPvE.	
Verification method Document review Design drawing	Prescription/Standards

L-M-045-009 System Traction power substation - Switch-disconnectors (longitudinal)	
Each (longitudinal) coupling field must be fitted with a switch-disconnector. It must be possible to switch the switch-disconnector on and off. The circuit breaker must be motor-operated.	
Explanation (optional)	
Verification method Document review Design Document review Design specification Testing/functional	Prescription/Standards

L-M-045-010 System Traction power substation - Switching on and off switch-disconnectors (longitudinal)	
The switch-disconnector may be switched under load, but may not switch short-circuit currents. Provisions must also be made to ensure that it is not possible to switch on a 3rd rail that is connected to the minus. The switching conditions for switching the switch-disconnectors on and off are listed in the Schakelmatrix in section 1.2.	
Explanation (optional)	
Verification method Document review Design Document review Design specification Testing/functional	Prescription/Standards

4.8.3 3-way position circuit breakers

L-M-045-011 System traction power substation - SSI Metro 3-position circuit breaker section switch field	
The SSI shall be equipped with a 3-way disconnector, so that the 3rd rail can be disconnected or connected to the minus. The switching conditions for switching the 3-position circuit breaker are listed in the Schakelmatrix in section 1.2.	
Explanation: The final number of outbound fields and configuration should be determined on the basis of the project-specific circuit diagram and sPvE.	
Verification method Document review Design drawing	Prescription/Standards

L-M-045-012 Traction power substation - 3-position circuit breaker section switch field	
Each 3-position circuit breaker is positioned between a high speed circuit breaker and the cable to the 3rd rail. The 3-position circuit breaker has 3 positions: • Enabled; • Neutrally switched; • Switched to minus. In the position switched to minus, the 3rd rail section is at minus. The 3-position circuit breaker must be motor-operated.	
Explanation: The switching conditions of the 3-way disconnector section are listed in the Schakelmatrix in section 1.2.	
Verification method Document review Design Document review Design specification Testing/functional	Prescription/Standards

4.9 Protection

4.9.1 General

L-MT-060-001 System Traction power substation - Selectivity study	
ON shall carry out a selectivity study and submit it to OG for approval. The selectivity study must include at least the following aspects: • Expected maximum operating and design currents (10kV and DC side) • Short-circuit calculations medium voltage and DC side • Safety settings medium voltage and DC side • Protection settings on the network operator side • Intermediate scaling in scaling diagrams • Thermal and dynamic short-circuit resistance of cables and installation parts in relation to short-circuit currents and tripping times should also be considered. • The above must be explained and described in a separate report.	
Explanation: Collecting and retrieving the necessary input data to elaborate the above is part of the job.	
Verification method Document review Design Calculation	Prescription/Standards Connection conditions grid operator Grid code

L-MT-060-002 System traction power substation - trip functionality	
The trip function of all safety devices must be realised in accordance with the Trip Matrix.	
Explanation: See the Tripmatrix in section 1.2.	
Verification method Document review Design Testing/functional	Prescription/Standards

4.9.2 Emergency off

L-MT-060-003 System traction power substation - emergency off traction power substation	
On the inside of the GS, at each access door, an emergency pushbutton must be installed which can switch off the entire traction power substation.	
Explanation: The purpose of this emergency off is to promote the safety of personnel, and to switch off immediately if a fire is detected. All high speed circuit breakers and the incoming and outgoing fields of the HVI switch off.	
Verification method Document review Design drawing Testing/functional	Prescription/Standards

4.9.3 Protection HVI

L-MT-061-001 System traction power substation - HVI Type fields	
From a protection point of view, the HVI should be equipped with the following types of fields: • Incoming field for grid connection: Circuit-breaker field (only traction power substation with purchase distributor) • Ring-fields for connection to the distribution network: Circuit-breaker field (only at traction power substation included in a ring) • Transformer field for traction transformer connection: Circuit-breaker field	
Explanation: See Eenlijnschema's in section 1.2	
Verification method Document review Design drawing Testing/inspection report visual	Prescription/Standards

4.9.3.1 HVI Incoming field

L-MT-061-002 System traction power substation - HVI Incoming field fuses	
The HVI Incoming field shall be provided with the following protections: • Short-circuit protection I>/I> • Earth fault protection • Thermal protection • Undervoltage detection • Short-circuit detection	
Explanation: The undervoltage detection should be equipped with a trip capability on an adjustable undervoltage measurement on the cable side. The actions that should follow as a result of the above protections are shown in the Tripmatrix.	
Verification method Document review Design Document review Design specification Testing/inspection report visual Testing/functional	Prescription/Standards

4.9.3.2 HVI Ring field

L-MT-061-003 System Traction power substation - HVI Safety devices ring field	
The HVI Ring field must be equipped with the following protections • Short-circuit protection I>>/I> • Earth fault protection • Thermal protection • Current measurement cable side If one or more of these protections are triggered, this field must be disabled.	
Explanation: This only applies to a traction power substation with medium voltage connection from the grid operator. The actions that should follow as a result of the above protections are shown in the Tripmatrix in section 1.2.	
Verification method Document review Design Document review Design specification Testing/inspection report visual Testing/functional	Prescription/Standards

4.9.3.3 HVI Transformer field

L-MT-061-004 System Traction power substation - HVI Protections Transformer field	
The HVI transformer field must be equipped with the following protections: • Short-circuit protection I>>/I> • Earth fault protection • Thermal protection (see note) • Asymmetry protection • External trip (see explanation) If one or more of these protections are triggered, this field must be disabled.	
Explanation: The thermal protection must be provided with a protection relay with a thermal function. In addition, a transformer field must be equipped with external trip functionality. This external trip functionality concerns trip by: • Temperature protection of traction transformer triggered (trip) • Temperature protection of the traction rectifier triggered (trip) • Diode fault traction rectifier addressed (only if parallel diodes are used in the rectifier) • Position locking device triggered • Overvoltage protection devices for the traction rectifier triggered The actions that should follow as a result of the above protections are shown in the Tripmatrix in section 1.2.	
Verification method Document review Design Document review Design specification Testing/inspection report visual Testing/functional	Prescription/Standards

4.9.4 Traction Transformer

L-MT-062-001 System traction power substation - TT protections	
The traction transformer must be equipped with the following protections: • Thermal pre-notification via thermal module traction transformer • Thermal trip (external trip on the respective circuit breaker HVI) via the thermal module traction transformer. The thermal module has to be implemented via two PT100 elements per phase on the secondary side of the traction transformer. The PT100 signals must be connected to the GS control unit via the IED.	
Explanation: The actions that should follow as a result of the above protections are shown in the Tripmatrix in section 1.2.	
Verification method Document review Design Document review Design specification Testing/inspection report visual Testing/functional	Prescription/Standards

4.9.5 Medium Voltage Auto-transformer (if applicable)

L-MT-063-001 System traction power substation - EBT safety devices	
The auto-transformer must be equipped with the following protection devices: • Thermal pre-announcement via thermal module own operating transformer • Thermal trip via the thermal module own operating transformer.	
Explanation: Also add HVI field if applicable.	
Verification method Document review Design Document review Design specification Testing/inspection report visual Testing/functional	Prescription/Standards

4.9.6 Traction rectifier

L-MT-064-001 System traction power substation - GR protections	
The traction rectifier must be equipped with the following protections: • Thermal pre-notification via thermal module traction rectifier • Thermal trip (external trip on the respective circuit breaker HVI) via thermal module traction rectifier • Trip (external trip on the respective circuit breaker HVI) overvoltage protection AC side tripped • Trip (external trip on the respective circuit breaker HVI) overvoltage protection DC side tripped • Trip (external trip on the respective circuit breaker HVI) diode fault called upon (only when parallel diodes are used in the rectifier) The thermal module must be connected to the GS control unit via the IED.	
Explanation: The actions that should follow as a result of the above protections are shown in the Tripmatrix in section 1.2.	
Verification method Document review Design Document review Design specification Testing/inspection report visual Testing/functional	Prescription/Standards

L-MT-064-002 System Traction power substation - Overvoltage GR AC side	
The rectifier is equipped with overvoltage protection to protect against overvoltages from the supplying high-voltage grid.	
Explanation: This particularly affects the transients due to switching operations of vacuum switches.	
Verification method Document review Design Document review Design specification Testing/inspection report visual	Prescription/Standards

L-MT-064-003 System Traction power substation - Overvoltage GR DC side	
The rectifier is equipped with overvoltage protection to protect against overvoltages from the contact line network.	
Explanation: This particularly affects transients resulting from switching operations or lightning strikes.	
Verification method Document review Design Document review Design specification Testing/inspection report visual	Prescription/Standards

L-MT-064-004 System Traction power substation - GR Diode error/fuse message	
If the rectifier is equipped with several parallel diodes per branch, a fuse must be included in series with each diode to eliminate a defective diode.	
Explanation: This does not apply to a rectifier with a few diodes.	
Verification method Document review Design Document review Design specification Testing/inspection report visual Testing/functional	Prescription/Standards

L-MT-064-005 System Traction power substation - GR Diode error/fuse message	
Provide a collective report whereby a broken fuse is reported to the GS control system.	
Explanation: This does not apply to a rectifier with a few diodes.	
Verification method Document review Design Document review Design specification Testing/inspection report visual Testing/functional	Prescription/Standards

4.9.7 GVI

4.9.7.1 Protection plus fields

L-MT-065-001 System traction power substation - GVI safety devices	
The outbound (plus) fields (direct current contactors) must be equipped with the following safety devices: • I> mechanical: directly on the high speed circuit breaker, should work without auxiliary voltage • I> electronic: via protection relay in combination with shunt trip/ capacitor switch-off • I thermal (pre-alarm): alarm op 80% via protection relay • I thermal (trip): via protection relay • dI/dt (trip): via protection relay in combination with shunt trip/ capacitor trip • Cable protection: via protection relay • External trip (see relevant section) • Line test functionality The protection relay shall have the possibility of automatically switching between two settings/ parameter sets (high and low settings) with regard to the maximum current time (I> electronic) protection.	
Explanation: A distinction is made between trips with Auto-reclose (AWI) and without (see §44.9.7.2Auto-reclose). See the Tripmatrixin section 1.2.	
Verification method Document review Design Document review Design specification Testing/inspection report visual	Prescription/Standards

4.9.7.2 Auto-reclose

L-MT-065-002 System traction power substation - Auto-reclose (AWI)	
The outgoing (plus) fields (direct current circuit breakers) must be equipped with Auto-reclose, AWI applies to the following trips: • I> mechanical • I> electronic • I thermal (trip) (after cooling below 80%) • dI/dt	
Explanation: When a trip with auto-reclose occurs, the reclose procedure may be activated a maximum number of times (1 to 10 times). This procedure means that the switch receives an IN command after which the line test is started. If the line test is successful, the switch is re-entered and the counter is reset. If the line test is not successful, the procedure is started again. If the settable number of times has been reached and the switch has still not entered, it shall be blocked against switching on. It shall be possible to reset the lock on remote control (switching watch).	
Verification method Document review Design Document review Design specification Testing/inspection report visual	Prescription/Standards

4.9.7.3 Line test

L-MT-065-003 System traction power substation - Line test functionality	
The outbound (plus) fields (DC high speed circuit breakers) shall be provided with line test functionality. The line test should work both ways. The key current shall be adjustable, as well as the number of attempts before the switch locks.	
Explanation: After an IN command for an outgoing plus field, the line test must be performed. With a line test, the resistance of the circuit to be fed is measured. The line test must work both ways to prevent switching on from an electrified overhead line or power supply rail to an earthed plus rail in the GVI. When the current is too high (e.g. a short circuit) the line test is unsuccessful and the switch will not come on. When the current is sufficiently low, the switch is switched on. If there is already voltage on the power section when switching on, do not test. A pause must be maintained between tests to prevent the heat dissipation of the test resistors from becoming too great.	
Verification method Document review Design Document review Design specification Testing/inspection report visual	Prescription/Standards

4.9.7.4 External trips

L-MT-065-004 System traction power substation - External trips	
The outgoing (plus) fields (DC high speed circuit breakers) must be equipped with external trip functionality.	
Explanation: External trip means a trip of the high-speed switch not by its "own" protection relay but by trips of protection relays of other installations or by protection of neighbouring traction power substations. As with "internal" trips, a distinction is made for external trips: • External trip without AWI • External trip with AWI <u>The external trips without AWI are:</u> • Trip surge arrester device • Trip Minus Earth Potential Monitoring • Trip surge arrester device of neighbouring importing HS • Trip cable protection of neighbouring importing GS • Line test error of neighbouring importing HS <u>The external trips with AWI are:</u> • I> trip of neighbouring importing HS • dI/dt trip of neighbouring importing HS Neighbouring feeder in this context means the high speed circuit breaker that feed into the same supply section. <u>The external trips are received and transmitted from/to the neighbouring traction power substation via the so-called "carrier circuit". This is done via the Central Control of Installations (CBI).</u>	
Verification method Document review Design Document review Design specification Testing/functional	Prescription/Standards

4.9.7.5 Anti-pump protection

L-MT-065-005 System traction power substation - Anti-pump protection	
The outgoing (plus) fields (high speed circuit breakers) must be equipped with anti-pump protection.	
Explanation: The control circuit of the high speed circuit breaker must be equipped with an anti-pump protection. The anti-pump protection prevents a switch from being switched on again if, within 1 second of being switched on, the switch is switched off again for any reason. This can occur, for example, during an automatic restart where the low-energy line test voltage does not detect an error and the switch is wrongly switched on. Subsequently, a trip of the fast-start switch will immediately take place, now that the error has manifested itself. The anti-pump protection then blocks the automatic reactivation, so that the high-speed switch remains switched off.	
Verification method Document review Design Document review Design specification Testing/functional	Prescription/Standards

4.9.8 Recovery Unit

L-M-031-001 System traction power substation - Recovery Unit	
The optional Recovery Unit must be installed in accordance with the specification in Systeemspecificatie Recovery Unit in section 1.2	
Explanation: If applicable	
Verification method Document review Design Document review Design specification Testing/functional	Prescription/Standards

4.9.9 Interlocks SSI: GS with SSI and paired traction power substation with SSI

4.9.9.1 Switch-disconnectors (longitudinal) coupling field

L-M-066-001 System Traction power substation - Enablement conditions longitudinal coupling field with coupled traction power substation with SSI	
In order to switch on the switch-disconnector, the following condition(s) must be fulfilled. See the Schakelmatrix in section 1.2. Pre-condition(s): • The switch-disconnector in the (longitudinal) coupling field in the relevant traction power substation must be in the "OFF" position; • The supplying high speed circuit breakers in the relevant traction power substation must be in the "IN" position; Post condition(s): • Switch-disconnector (longitudinal) coupling field in relevant traction power substation switched on; • Load break feedback (longitudinal) = Enabled. Fault situation(s): If the switch-disconnector cannot (fault) or is not allowed to (interlock) switch on, the traction unit sends a message. The status message indicates which pre-condition prevented the switching action. The fault message indicates which object did not perform its action correctly.	
Explanation: The (longitudinal) coupling field is switched on/off while the high speed circuit breakers are in the "IN" position. Here, a momentary non-selection of the circuit breaker protection is accepted to prevent other problems such as tripping of a neighbouring traction power substation due to overload or tripping of a vehicle due to undervoltage.	
Verification method Document review Design Document review Design specification Testing/functional	Prescription/Standards

L-M-066-002 System Traction power substation - trip conditions longitudinal coupling field when coupled traction power substation with SSI	
To switch off the switch-disconnector, the following condition(s) must be fulfilled. See the Schakelmatrix in par 1.2. Pre-condition(s): • The switch-disconnector in the (longitudinal) coupling field in the relevant traction power substation must be in the "IN" position; • The supplying high speed circuit breakers in the relevant traction power substation must be in the "IN" position; Post condition(s): • Switch-disconnector (longitudinal) coupling field in relevant traction power substation switched off; • Switch-disconnector feedback (longitudinal) = switched off. Fault situation(s): • If the switch-disconnector cannot or is not allowed to switch, the traction unit sends a fault message. The fault message indicates which pre-condition prevents the switching action.	
Explanation (optional)	
Verification method Document review Design Document review Design specification Testing/functional	Prescription/Standards

4.9.9.2 Switching conditions for 3-position circuit breaker to 3rd rail

L-M-066-003 System Traction power substation - switching conditions 3-position circuit breaker when coupled to traction power substation with SSI
The 3-position circuit breaker can be switched in 3 ways: - IN; - NEUTRAL; - MINUS. In order to switch the 3-position circuit breaker to the above positions, the following condition(s) must be fulfilled. See the Schakelmatrix in Section 1.2. Pre-condition(s) for "NEUTRAL" to "IN": (objective: disconnection) • The 3-position circuit breaker must be in the "NEUTRAL" position; • The supplying high speed circuit breaker in the relevant traction power substation must be in the "OFF" position; • The switch-disconnector in the (longitudinal) coupling field in the relevant traction power substation must be in the "OFF" position. Pre-condition(s) for "NEUTRAL" to "MINUS": (objective: disconnection) • The 3-position circuit breaker must be in the "NEUTRAL" position; • The power supply high speed circuit breaker in the coupled traction power substation must be in the "OFF" position; • The switch-disconnector in the (longitudinal) coupling field in coupled traction power substation must be in the "OFF" position. Pre-condition(s) for "IN" to "NEUTRAL": (objective: disconnection of power) • The 3-position circuit breaker must be in the "IN" position; • The supplying high speed circuit breaker in the relevant traction power substation must be in the "OFF" position;

L-M-066-003 System Traction power substation - switching conditions 3-position circuit breaker when coupled to traction power substation with SSI	
• The switch-disconnector in the (longitudinal) coupling field in the relevant traction power substation must be in the "OFF" position. Pre-condition(s) for "MINUS" to "NEUTRAL": (objective: switch off power) • The 3-position circuit breaker must be in the "MINUS" position; • The feeding high speed circuit breaker in coupled traction power substation must be in the "OFF" position; • The switch-disconnector in the (longitudinal) coupling field in coupled traction power substation must be in the "OFF" position. Post condition(s): • After the 3-position switch has been switched, it reports its current switching position. Fault situation(s): • If the 3-position circuit breaker cannot or should not switch, the traction unit sends a fault message. The fault message indicates which pre-condition is preventing the switching action.	
Explanation: The 3-position circuit breaker may only be switched during no-load operation, i.e. when no current can flow. Voltage from the 3rd rail, while the coupled high speed circuit breakers are switched off, is permitted. However, when switching to minus, no voltage must be present at the 3-position circuit breaker. In this case, there must be no voltage from either the high-speed switch to the 3-position circuit breakers or the outgoing cable side to the 3-position circuit breaker.	
Verification method Document review Design Document review Design specification Testing/functional	Prescription/Standards

4.9.10 Interlocks SSI: GS with SSI and paired traction power substation without SSI

4.9.10.1 Switch-disconnectors (longitudinal) coupling field

L-M-066-004 System Traction power substation - Enablement conditions longitudinal coupling field with coupled traction power substation without SSI
To switch on the switch-disconnector, the following condition(s) must be fulfilled. See the Schakelmatrixin par 1.2. Pre-condition(s): • The switch-disconnector in the (longitudinal) coupling field in the relevant traction power substation must be in the "OFF" position; • The supplying high speed circuit breakers in the relevant traction power substation must be in the "IN" position; Post condition(s): • Switch-disconnector (longitudinal) coupling field in relevant traction power substation switched on; • Load break feedback (longitudinal) = Enabled. Fault situation(s): • If the switch-disconnector cannot or is not allowed to switch, the traction unit sends a fault message. The fault message indicates which pre-condition prevents the switching action.
Explanation: The (longitudinal) coupling field is switched on while the high speed circuit breakers are in the "IN" position. Here, momentary non-selection of switches is accepted to avoid other problems such as tripping of a neighbouring traction power substation due to overload or tripping of a vehicle due to undervoltage.

L-M-066-004 System Traction power substation - Enablement conditions longitudinal coupling field with coupled traction power substation without SSI	
Verification method Document review Design Document review Design specification Testing/functional	Prescription/Standards

L-M-066-005 System Traction power substation - trip conditions longitudinal coupling field with coupled traction power substation without SSI	
To switch off the switch-disconnector, the following condition(s) must be fulfilled. See the Schakelmatrixin par 1.2. Pre-condition(s) • The switch-disconnector in the (longitudinal) coupling field in the relevant traction power substation must be in the "IN" position; • The supplying high speed circuit breakers in the relevant traction power substation must be in the "IN" position; Post condition(s): • Switch-disconnector (longitudinal) coupling field in relevant traction power substation switched off; • Load break feedback (longitudinal) = Disabled. Fault situation(s): • If the switch-disconnector cannot or is not allowed to switch, the traction unit sends a fault message. The fault message indicates which pre-condition prevents the switching action.	
Explanation (optional)	
Verification method Document review Design Document review Design specification Testing/functional	Prescription/Standards

4.9.10.2 3-position circuit breaker to 3rd rail

L-M-066-006 System Traction power substation - switching conditions 3-position circuit breaker with coupled traction power substation without SSI	
The 3-position circuit breaker can be switched in 3 ways: - IN; - NEUTRAL; - MINUS. In order to switch the 3-position circuit breaker to the above positions, the following condition(s) must be fulfilled. See the Schakelmatrixin Section 1.2. Pre-condition(s) from "NEUTRAL" to "IN": • The 3-position circuit breaker must be in the "NEUTRAL" position; • The supplying high speed circuit breaker in the relevant traction power substation must be in the "OFF" position; • The switch-disconnector in the (longitudinal) coupling field in the relevant traction power substation must be in the "OFF" position. Pre-condition(s) from "NEUTRAL" to "MINUS": • The 3-position circuit breaker must be in the "NEUTRAL" position; • The power supply high speed circuit breaker in the coupled traction power substation must be in the "OFF" position; • The switch-disconnector in the (longitudinal) coupling field in coupled traction power substation must be in the "OFF" position. Pre-condition(s) from "IN" to "NEUTRAL": • The 3-position circuit breaker must be in the "IN" position; • The supplying high speed circuit breaker in the relevant traction power substation must be in the "OFF" position; • The switch-disconnector in the (longitudinal) coupling field in the relevant traction power substation must be in the "OFF" position. Pre-condition(s) from "MINUS" to "NEUTRAL": • The 3-position circuit breaker must be in the "MINUS" position; • The power supply high speed circuit breaker in the coupled traction power substation must be in the "OFF" position. • The switch-disconnector in the (longitudinal) coupling field in coupled traction power substation must be in the "OFF" position. Post condition(s): • After the 3-position switch has been switched, it reports its current switching position. Fault situation(s): • If the 3-position circuit breaker cannot or should not switch, the traction unit sends a fault message. The fault message indicates which pre-condition is preventing the switching action.	
Explanation (optional)	
Verification method Document review Design Document review Design specification Testing/functional	Prescription/Standards

4.9.11 Interlocks SSI: GS with SSI and coupled with SS

4.9.11.1 Switch-disconnectors (longitudinal) coupling field

L-M-066-007 System Traction power substation - activation conditions longitudinal coupling field with coupled SS	
To switch on the switch-disconnector, the following condition(s) must be fulfilled. See the Schakelmatrix in par 1.2. Pre-condition(s): • The switch-disconnector in the (longitudinal) coupling field in the relevant traction power substation must be in the "OFF" position; • The supplying high speed circuit breakers in the relevant traction power substation must be in the "IN" position; Post condition(s): • After the switchover, the switch-disconnector switches on. Fault situation(s): • If the switch-disconnector cannot or is not allowed to switch, the traction unit sends a fault message. The fault message indicates which pre-condition prevents the switching action.	
Explanation: The (longitudinal) coupling field is switched on while the high speed circuit breakers are in the "IN" position. Here, momentary non-selection of switches is accepted to avoid other problems such as tripping of a neighbouring traction power substation due to overload or tripping of a vehicle due to undervoltage.	
Verification method Document review Design Document review Design specification Testing/functional	Prescription/Standards

L-M-066-008 System Traction power substation - trip conditions longitudinal coupling field with coupled SS	
To switch off the switch-disconnector, the following condition(s) must be fulfilled. See the Schakelmatrix in par 1.2. Pre-condition(s) • The switch-disconnector in the (longitudinal) coupling field in the relevant traction power substation must be in the "IN" position; • The supplying high speed circuit breakers in the relevant traction power substation must be in the "IN" position; Post condition(s): • After the switchover, the switch-disconnector switches off. Fault situation(s): • If the switch-disconnector cannot or is not allowed to switch, the traction unit sends a fault message. The fault message indicates which pre-condition prevents the switching action.	
Explanation (optional)	
Verification method Document review Design Document review Design specification Testing/functional	Prescription/Standards

4.9.11.2 3-position circuit breaker to 3rd rail

L-M-066-009 System Traction power substation - switching conditions 3-position circuit breaker with SS coupled	
The 3-position circuit breaker can be switched in 3 ways: - IN; - NEUTRAL; - MINUS. In order to switch the 3-position circuit breaker to the above positions, the following condition(s) must be fulfilled. See the Schakelmatrixin Section 1.2. Pre-condition(s) from "NEUTRAL" to "IN": • The 3-position circuit breaker must be in the "NEUTRAL" position; • The supplying high speed circuit breaker in the relevant traction power substation must be in the "OFF" position; • The switch-disconnector in the (longitudinal) coupling field in the relevant traction power substation must be in the "OFF" position. Pre-condition(s) from "NEUTRAL" to "MINUS": • The 3-position circuit breaker must be in the "NEUTRAL" position; • The power supply high speed circuit breaker in coupled SS must be in the "OFF" position; Pre-condition(s) from "IN" to "NEUTRAL": • The 3-position circuit breaker must be in the "IN" position; • The power supply high speed circuit breaker in the relevant traction power substation must be in the "OFF" position; • The switch-disconnector in the (longitudinal) coupling field in the relevant traction power substation must be in the "OFF" position. Pre-condition(s) from "MINUS" to "NEUTRAL": • The 3-position circuit breaker must be in the "MINUS" position; • The power supply high speed circuit breaker in coupled SS must be in the "OFF" position. Post condition(s): • After the 3-position circuit breaker has been switched, it reports its current switching position. Fault situation(s): • If the 3-position circuit breaker cannot or should not switch, the traction unit sends a fault message. The fault message indicates which pre-condition is preventing the switching action.	
Explanation (optional)	
Verification method Document review Design Document review Design specification Testing/functional	Prescription/Standards

4.9.11.3 Communication SSI via CBI

L-M-066-010 System traction power substation - Status information via CBI	
Status information of coupled/neighbouring stations (traction power substations or traction power switchgear substations) such as status reports of switches/isolators for switching operations in the relevant traction power substation must be realised via the CBI.	
Explanation (optional)	
Verification method Document review Design Document review Design specification Testing/functional	Prescription/Standards

4.9.12 Frame short-circuit protection

L-MT-065-006 System Traction power substation – Frame short-circuit protection	
The DC switchgear assembly and the sectional switchgear must be equipped with a system of short-circuit protection. A combined frame short-circuit protection relay is to be used for the GVI and SSI.	
Explanation: The cabinets of the rectifier, DC switchgear assembly, section switchgear and other components of the DC traction power supply circuit must be installed in an insulated manner. The cabinets of these parts of the installation must be electrically interconnected and connected to earth via a single contactor. In this way, closures between the DC installation and the cabinets are detected and eliminated. When the current through the frame short-circuit protection exceeds a certain adjustable value, it shall send a trip command to all outgoing plus fields of the station and to the circuit breakers of the traction transformers. In addition, only the input plus fields of the traction section(s) from neighbouring traction power substations are to be switched off via the "carrier circuit".	
Verification method Document review Design Document review Design specification Testing/functional	Prescription/Standards

4.9.13 Minus earth potential (rail-to-ground voltage)

L-MT-065-007 System Traction power substation - Minus earth potential monitoring	
The DC distribution unit must be equipped with a minus earth potential monitoring device according to the binding document: Basic design of minus earth potential monitoring device according to EN 50122-1. The minus earth potential signalling device shall be installed in the traction power substations and shall be designed as a low-voltage limiting device between the minus rail and earth. The low voltage limiter shall ensure that an overvoltage on the minus rail is diverted to earth. The conducted current shall be monitored and signalled in the SCADA system with a pre-alarm and an alarm. The signals shall be automatically cancelled if the induced current falls below the monitoring levels. If the overvoltage has not dropped below the standard value after 1 second, the high speed circuit breakers of the outbound plus fields and the circuit breakers of the traction fields shall be switched off: - External trip outgoing plus field(s) GVI without auto-reclose (AWI) - Trip circuit breaker in the traction field HVI Minus earth potential monitoring must be carried out with a VLD-O. The threshold values for the various reports are listed in the following table. Values must be in accordance with NEN-EN 50122: • Minus earth pre-alarm: 90V • Minus ground trip: 120V • Mini-rail current to earth alarm: 20A • Mini-rail current to earth alarm: 200A	
Explanation: The potential difference between minus and earth must always comply with the safety standard (the potential difference must not exceed the standard value). The minus earth potential monitoring monitors the minus earth potential and intervenes when the potential threatens to exceed the safety standard. The protective device has a response value for a pre-notification and a trip value.	
Verification method Document review Design Document review Design specification Testing/functional	Standards: NEN-EN 50122-1

4.9.14 Asymmetry monitoring

L-MT-065-008 System Traction power substation - Asymmetry protection	
The return cables in the minus field must be equipped with asymmetrical protection. The protection is to be activated when the total current traction power substation exceeds the rated current of one return cable. An alarm should be generated if there is a current difference of 500A between the lowest and highest value of the currents through the return cables.	
Explanation: The protection system must give an alarm on the HMI Remote Control. The limit value shall be adjustable.	
Verification method Document review Design Document review Design specification Testing/functional	Prescription/Standards

4.9.15 Carrier circuit

L-MT-065-009 System Traction power substation - Carrier circuit	
The external trips between the neighbouring traction power substations are to be communicated between the traction power substations by the carrier circuit. This carrier circuit must be implemented via the Central Control of Installations (CBI).	
Explanation: See the Schakelmatrix and the Tripmatrix in section 1.2.	
Verification method Document review Design Document review Design specification Testing/functional	Prescription/Standards

4.10 Internal wiring

I-MT-072-001 System traction power substation - internal wiring	
Internal wiring must be halogen-free, low-smoke and flame-resistant.	
Explanation (optional)	
Verification method Document review Design specification	Prescription/Standards

I-MT-072-002 System traction power substation - coding	
Internal wiring must be coded.	
Explanation (optional)	
Verification method Document review Design Testing/inspection report visual	Prescription/Standards VB AMS 053 Area composition and coding of sites, installations, objects and cables JOIN: CEB/OVG/20507)

I-MT-072-003 System Traction power substation - Internal wiring sleeves filling degree	
Internal wiring should be housed in flame-retardant and halogen-free ducts. Fill level should not exceed 60%.	
Explanation (optional)	
Verification method Document review Design Testing/inspection report visual	Prescription/Standards

I-MT-072-004 System Traction power substation - internal wiring sleeves covers	
The lids of the wiring sleeves must be easy to remove and replace.	
Explanation (optional)	
Verification method Testing/inspection report visual	Prescription/Standards

I-MT-072-005 System Traction power substation - Wiring connections	
The installation of two or more wires under one terminal is not permitted.	
Explanation (optional)	
Verification method Testing/inspection report visual	Prescription/Standards

I-MT-072-006 System traction power substation - 600/750 VDC cabling	
For 600 VDC and 750 VDC cables, double-insulated special wire should be used and placed in separate conduits where no other wires run.	
Explanation (optional)	
Verification method Testing/inspection report visual	Prescription/Standards

I-MT-070-001 System traction power substation - mechanical protection	
When wiring is connected to parts that are movable in relation to the fixed part, this wiring must be bundled and flexible and mechanically protected.	
Explanation (optional)	
Verification method Testing/inspection report visual	Prescription/Standards

4.11 Local/central control of installations (CBI)

4.11.1 Control (Station automation)

As the requirements for HVI and GVI in particular show, the various protection relays will be interconnected according to the standard IEC61850/GOOSE. The intelligence will be implemented as much as possible in the decentralised safety relays (IED). There are, however, functions that must be realised from a more centralised IED (for example, a frame short-circuit fault that must be transmitted to both the medium voltage switches and the high speed switches). In addition, a central unit must be provided with which the link with the Central Control of Installations can be realised. This concerns the local control (the station automation unit of the GS). The coupled components must support version 2.0 of the IEC61850 standard.

L-MT-080-001 System traction power substation - Station automation unit traction power substation	
The traction power substation shall be equipped with a local station automation unit that provides the necessary control interfaces between the various installations, plus the interface to the Central Control of Installations (CBI) of the GVB. The local station automation unit must be an industrial PLC. ON may offer alternatives at the discretion of OG. It is required that the local control unit is accommodated in a separate cabinet or separately lockable compartment. A site-specific block diagram specifying the various interfaces is a required part of the design. For station automation, modern IEC61850 couplers must be used.	
Explanation: Coordination with party for interface with CBI is part of the work and scope ON.	
Verification method Document review Design	Prescription/Standards

L-MT-080-002 System Traction power substation - Switching power sections on/off	
Each traction power supply section of the traction power substation must be capable of being shut down locally (at the installation level), remotely (from the HMI in the GS) and by remote control (via the CBI) and, if required, must be able to be put back into operation.	
Explanation (optional)	
Verification method Document review Design Testing/functional	Prescription/Standards

L-MT-080-003 System traction power substation - CBI	
The traction power substation must be equipped with remote control and signalling, for all commands, position transmitters, alarms and measurements necessary for proper operation. This information must be transmitted to the CAB of the GVB. A connection to the existing CBI system must be realised.	
Explanation: This is based on the site-specific IO list approved by OG, which must be prepared by ON based on the template IO list (see section 1.2).	
Verification method Document review Design Testing/functional	Prescription/Standards

L-MT-080-004 System traction power substation - IO list	
ON shall prepare a site-specific I/O list based on the template/generic I/O list (typicals) and submit it to OG for approval.	
Explanation: See the template IO list in section 1.2.	
Verification method Document review Design	Prescription/Standards

4.11.2 Controls Metro

I-M-081-001 System traction power substation - Local control traction power substation	
ON must install a local control box (Control GS) in the traction power substation. The local control box must house the local central control components. For the basic principle, see the Besturingsconcept o.b.v. IEC61850oblock diagram in section 1.2.	
Explanation (optional)	
Verification method Document review Design	Prescription/Standards

L-M-081-002 System Traction power substation - Block diagram	
ON should provide the Besturingsconcept o.b.v. IEC61850 in section 1.2. to be specific and up to date and further elaborated as part of the design process.	
Explanation (optional)	
Verification method Document review Design drawing	Prescription/Standards

L-M-081-003 System Traction power substation - Interface underlying installations
The local controls must be linked to the underlying installations on the basis of the interfaces specified in the Besturingsconcept o.b.v. IEC61850 block diagram in section 1.2.

L-M-081-003 System Traction power substation - Interface underlying installations	
Explanation (optional)	
Verification method Document review Design drawing Testing/functional	Prescription/Standards

L-M-081-004 System traction power substation - Track controller interface	
The local control should be linked to the NMA for the purpose of linking the traction power substation and the higher-level SCADA system. The tuning of the interface and the interface with the SCADA system is part of the scope of this specification.	
Explanation (optional)	
Verification method Document review Design Testing/functional	Prescription/Standards

I-M-081-005 Traction power substation system -Reservation of space	
The contractor must take account of the space reserved in the traction power substation for placing a wall cabinet (60x60cm) for the NMA network connection.	
Explanation (optional)	
Verification method Document review Design drawing Testing/inspection report visual	Prescription/Standards

4.11.3 Tram controls

I-T-082-001 System traction power substation - local control traction power substation	
ON must install a local control box (Control GS) in the traction power substation. The local control box must house the local central control components. For the basic principle, see the Besturingsconcept o.b.v. IEC61850 block diagram in section 1.2.	
Explanation (optional)	
Verification method Document review Design	Prescription/Standards

L-T-082-002 System Traction power substation - Block diagram	
ON should provide the Besturingsconcept o.b.v. IEC61850 block diagram in section 1.2. to be specific and up-to-date and further elaborated as part of the design process.	
Explanation (optional)	
Verification method Document review Design drawing	Prescription/Standards

L-T-082-003 System Traction power substation - Interface underlying installations
The local controls must be linked to the underlying installations on the basis of the interfaces specified in the Besturingsconcept o.b.v. IEC61850 block diagram in section 1.2.
Explanation (optional)

L-T-082-003 System Traction power substation - Interface underlying installations	
Verification method Document review Design drawing Testing/functional	Prescription/Standards

L-T-082-004 System traction power substation - Interface Remote Terminal Unit	
The local control must be linked to the higher-level Remote Terminal Unit (RTU) on the basis of the interface specified in the Besturingsconcept o.b.v. IEC61850 block diagram in section 1.2. Matching the interface, specific IO list with the party providing the operations with the RTU is part of the scope of this specification. The RTU itself, the data connection to the central control unit and all associated work on the SCADA system are not within the scope of this specification.	
Explanation (optional)	
Verification method Document review Design Testing/functional	Prescription/Standards

L-T-082-005 System Traction power substation - space reservation	
ON should take into account space reservation in the traction power substation for the following components: • Third-party installation of RTU • Installation of a wall box (60x60cm) for the data connection to CBI Tram. An RTU will not be placed in the traction power substation in all cases. ON must request this from the client on a site-specific basis.	
Explanation (optional)	
Verification method Document review Design drawing Testing/inspection report visual	Prescription/Standards

4.11.4 HMI

L-MT-083-001 System traction power substation - HMI remote control
Operation and monitoring of the traction power substation should be possible at three levels: • Local service • Local Remote control • Remote control
Explanation: • Local control refers to the control and monitoring of the installations/panels themselves. This can be done via push buttons on the panel, status lights, but also via operation and reading of (touch) screens of protective relays. The switching of disconnectors/earthers by means of switch bars also falls under local control. For the purpose of local control, the panels must be provided with up-to-date blind diagrams on the panels. • Local Remote control refers to the operation and monitoring of the traction power substation via a display system installed centrally in the traction power substation. Only the traction power substation in which the display system is located can be operated and monitored. • Remote control means: operation and monitoring of the traction power substation via the CVL/Central remote control.

L-MT-083-001 System traction power substation - HMI remote control	
Verification method Document review Design Testing/functional	Prescription/Standards

L-MT-083-002 System traction power substation - HMI remote control -- Status display	
The status of all switches (medium voltage, Plus/Min circuit breaker, outgoing plus fields, circuit breakers, earths) must be indicated: • Open • Closed • Ground state (if applicable) • Carry out (if applicable) It must not be possible to override locks in the primary circuit via remote control or remote operation.	
Explanation (optional)	
Verification method Document review Design Testing/functional	Prescription/Standards

L-MT-083-003 System traction power substation - HMI Remote control -- Operation	
It must be possible to operate the following components (after taking over remote control): • Switching medium-voltage circuit breakers on and off • Switching medium-voltage switch-disconnectors on and off • Switching on and off outbound plus fields • Switching plus/minus circuit breakers on and off • Switching longitudinal coupling fields on and off • Resetting of error messages / acknowledgement of alarms	
Explanation (optional)	
Verification method Document review Design Testing/functional	Prescription/Standards

L-MT-083-004 System traction power substation - HMI remote control - Analogue values	
The following analogue values shall be displayed: • Incoming medium voltage • Secondary AC voltages • Secondary AC currents • Voltage on the DC rail • Minus earth voltage • Rectifier current (total current) • Current per outgoing plus field (both positive and negative) • Current per outgoing minus cable • Temperature transformer windings	
Explanation (optional)	
Verification method Document review Design Testing/functional	Prescription/Standards

L-MT-083-005 System traction power substation - HMI remote control - signalling/alarms	

The following signals/alarms must be readable:
• Fault messages/alarms of medium-voltage protection relays
• Error messages/alarms of protective relays outbound plus fields including at least:
  ○ Line test failed;
  ○ Imax;
  ○ dI/dt;
  ○ Cable jacket fault.
• Error messages/alarms of the transformer protection system including at least:
  ○ Over-temperature transformer alarm;
  ○ Trip transformer overtemperature.
• Rectifier error messages/alarms include at least:
  ○ Pre-alarm temperature rectifier;
  ○ Trip temperature rectifier.
• Frame short-circuit protection
• Short-circuit switch
• Error message/alarm high minus earth potential
  ○ High minus earth potential alarm;
  ○ Trip high earth-minus potential.
• Emergency off
• Take-off (external trip)
The signalling/alerting must be visualised in an alarm list which is logged.	

Explanation (optional)	
Verification method Document review Design Testing/functional	Prescription/Standards

L-MT-083-006 System traction power substation - HMI Remote control - General	
Display visualisation after activating the HMI. Access to switching operations should only be possible after login with user name and password of switching authorised persons.	
Explanation: After activating the screen, due to burn-in / service life / energy consumption.	
Verification method Document review Design Testing/functional	Prescription/Standards

L-MT-083-007 System traction power substation - HMI access rights	
The HMI should have different authorisation levels: • Basic level: Visualisation of the status of switches and disconnectors as well as error messages/alarms is available to anyone who has access to the traction power substation without a user name/password; • Second level: Access to control and reset functions should only be possible after login with user name and password by switchgear authorised persons; • Third level gives access to change parameters/settings under a (different) user name/password.	
Explanation (optional)	
Verification method Document review Design Testing/functional	Prescription/Standards

I-MT-083-008 System traction power substation - HMI placement	
The hardware of the HMI consists of a screen that is built into a control panel; preferably the panel that also houses the traction control of the traction power substation to avoid unnecessary wiring.	
Explanation (optional)	
Verification method Document review Design Testing/functional	Prescription/Standards

L-MT-083-009 System traction power substation - HMI screen	
Schermeisen: • Touchscreen; • Colour TFT screen minimum 15 inches (widescreen); • Resolution at least 1024×768. Displays should switch off after a settable period of time due to burn-in / service life / energy consumption. Switch on by touching the touch screen.	
Explanation: After activating the screen because of burn-in/life expectancy/energy consumption.	
Verification method Document review Design Testing/functional	Prescription/Standards

L-MT-083-010 System traction power substation - HMI screen layout	
It must be possible to display various images on the screen, including at least: • A login screen; • Single-line diagram of the installation in the traction power substation with the current status of the switches and disconnectors; • Current measured values of voltage/current are displayed in the single-line diagram of the installations. • An overview of the supply sections fed by the traction power substation; • An overview of the last 50 error messages and alarms. If a component is in an alarm/error situation, this must be made visible on the screen for the component: • Alarm: Orange; • Fault: Red. Operation (for level 2 and 3 users): • Switching of disconnectors and switches via touch screen and after answering an additional confirmation question; • Resetting of error messages / acknowledgement of alarms. Parameters: • Clicking on a component opens a frame with the set values (for all login levels); • Changing parameters only by level 3 users. Logging of parameter change: • The logging indicates when, by whom and the change in the parameter. The symbols on the screen must be in accordance with NEN 5152/IEC 60617 'Graphical symbols for diagrams'. Display switches as switch symbols and not as green or red squares due to lack of standardisation.	
Explanation: After activating the screen because of burn-in/life expectancy/energy consumption.	
Verification method Document review Design Testing/functional	Prescription/Standards

I-MT-083-011 System traction power substation - HMI placement	
The HMI should be placed in the Low Voltage area.	
Note: See the Opstellingstekeningenin section 1.2. This is not a site-specific building arrangement.	
Verification method Document review Design Testing/functional	Prescription/Standards

4.12 Low voltage supply (EBT LS)

The Auxiliary transformer (EBT LS) supplies the LS power for the auxiliary systems of the traction power substation. This includes lighting, climate control systems, WCDs, secondary DC auxiliary voltages for relays, etc. (approx. 15kVA). It is therefore permissible to feed a relatively small auxiliary transformer (EBT) from the secondary side of the traction transformer and transform this voltage to 400Vac with earthed star point. This EBT then feeds a Low Voltage Switchgear (LVI) for further distribution to the underlying consumers.

L-MT-021-001 System traction power substation - LS power balance	
A site-specific LS power balance should be prepared to determine the EBT's capacity.	
Explanation: All consumers should be included in the LS balance sheet, taking into account realistic simultaneity factors.	
Verification method Document review Design Calculation	Prescription/Standards

L-MT-021-002 System traction power substation - power supply EBT LS	
The EBT LS is to be powered from the secondary voltage of the traction transformer.	
Explanation: Due to the maximum asymmetric load of the 2 branches of the traction transformer, the power of the EB transformer is < 16 kVA.	
Verification method Document review Design drawing	Prescription/Standards

L-MT-021-003 System traction power substation - EBT LS Secondary voltage	
The EBT LS should transform the secondary voltage of the traction transformer to a three-phase voltage (400V/230V) suitable for the secondary systems.	
Explanation (optional)	
Verification method Document review Design specification	Prescription/Standards

L-T-021-004 System Traction power substation - EBT LS Primary voltage	
The EBT LS should transform the secondary voltage of the traction transformer to a three-phase voltage (400V/230V) suitable for the secondary systems. The secondary voltage of the traction transformer (= primary voltage EBT LS) is: - 490 V AC for 600 VDC - 610 V for 750 VDC	
Explanation: For the future conversion of the tram network from 600 VDC to 750 VDC, the EB transformer must be equipped with extra flags for the connection of the 2 mentioned voltages.	
Verification method Document review Design specification	Prescription/Standards

I-MT-021-005 System traction power substation - EBT LS placement	
The EBT LS is preferably positioned separately, but may also be incorporated into the traction rectifier. However, the connection and the protection of the LS cable to the EBT LS must always be located in the traction rectifier. It is not permissible to connect the EBT LS to the secondary side of the traction transformer.	
Explanation: See the Opstellingstekeningenin section 1.2. This is not a site-specific building arrangement.	
Verification method Document review Design Testing/inspection report visual	Prescription/Standards

4.13 LVI

4.13.1 Low-voltage distributor

I-MT-051-001 System traction power substation - LVI	
The traction power substation must be equipped with a low-voltage installation 230/400 V.	
Explanation (optional)	
Verification method Document review Design	Prescription/Standards

L-MT-051-002 System traction power substation - LVI emergency power connection option	
The LVI must be fitted with a connection option for an external power supply. For connecting an NSA.	
Explanation (optional)	
Verification method Document review Design Testing/inspection report visual	Prescription/Standards

L-MT-051-003 System traction power substation - LVI Specifications	
The low-voltage distributor must comply at least with the following points: 1. In accordance with NEN-EN-IEC 61439 parts 1 and 2. 2. Construction form 2b. 3. Operating voltage 400/230 V - 50Hz. 4. Earthing regime: TN-S. 5. External protection class IP 54. 6. Insulation value class II. 7. Design: surface-mounted wall mounting. 8. Connection type: top side with screw terminals. 9. Enclosure material: Galvanised sheet steel of at least 1.5 mm thickness. 10. Outside lying doors. 11. Locking system (if casing is used): three-point espagnolette. 12. Lock: handle/lever to be operated without key or tools. 13. Surface treatment: powder coating. 14. Colour: standard manufacturer-dependent (light grey/greyish white o.g.). 15. Plastic gland plates with membranes.	
Explanation (optional)	
Verification method Document review Design specification	Standards: NEN-EN-IEC 61439 part 1 and 2 / NEN1010

L-MT-051-004 System traction power substation - LVI protection and reserve	
All necessary equipment is connected to the low-voltage distribution. The end groups must be protected by circuit breakers. The low-voltage distribution should also be equipped with 20% built-in reserve groups.	
Explanation: The total power must not exceed the maximum power of the EB transformer.	
Verification method Document review Design drawing	Prescription/Standards

L-MT-051-005 System traction power substation - LVI operation and signalling	
The controls and signalling to and from the traction power switchgear substation must be in accordance with the IO list.	
Explanation (optional)	
Verification method Document review Design Testing/functional	Prescription/Standards

L-MT-051-006 System traction power substation - LVI power supply for the distribution board purchase room	
The LVI must be equipped with a descending group to supply the installations in the purchasing area; this must be connected to the distribution board in the purchasing area in accordance with Liander's Schedule of Requirements.	
Explanation: Requirement applicable if supply for medium voltage comes from the grid operator. See the Opstellingstekeningenin section 1.2. This is not a site-specific building arrangement.	
Verification method Document review Design Testing/functional	Prescription/Standards - S8035 Schedule of Requirements for the purchasing space v1.0 - External use

4.13.2 Auxiliary voltage

L-MT-052-001 System traction power substation - auxiliary voltage power balance	
The DC auxiliary power supply must be able to provide sufficient power to supply all consumers with the corresponding autonomy time.	
Explanation: All consumers must be included in the power balance, taking into account realistic simultaneity factors. It must be demonstrated that the rectifiers and batteries used are sufficiently dimensioned in relation to autonomy time and rectifier failure. This involves total capacity, base load and peak load.	
Verification method Document review Design Calculation	Prescription/Standards

L-MT-052-002 System traction power substation - auxiliary power supply	
In order for the various protection, control and transmission devices in the station to operate independently of mains voltage, a battery buffered auxiliary power supply 48VDC must be present in the traction power substation. The emergency lighting should also be powered from the energy supply. Autonomy time: 4 hours.	
Explanation: The emergency lighting must be powered if no emergency lighting with built-in batteries is used. The autonomy time of 4 hours is based on the assumption that all switches can also be switched once within this period.	
Verification method Document review Design	Prescription/Standards

L-MT-052-003 System traction power substation - auxiliary power supply	
The auxiliary power supply must be supplied by a separate 3 phase group from the low voltage distribution system (LVI).	
Explanation (optional)	
Verification method Document review Design	Prescription/Standards

L-MT-052-004 System traction power substation - auxiliary voltage cabinet supplies	
The cabinet (one piece) of the auxiliary power supply must accommodate two rectifiers for indoor installation and is the connecting link between rectifiers, battery and consumer(s). Switches and fuse-switch disconnectors must be included in the cabinet in order to be able to switch, separate and protect the various parts of the installation. The rectifiers must be able to operate independently of each other; in the event of a defective rectifier, the other must be able to supply the entire load while retaining its autonomy.	
Explanation (optional)	
Verification method Document review Design specification	Prescription/Standards

L-MT-052-005 System Traction power substation - Cabinet construction	
The construction of the cabinet and rack on which the batteries are placed must be resistant to battery leakage.	
Explanation (optional)	
Verification method Document review Design specification	Prescription/Standards

L-MT-052-006 System Traction power substation - auxiliary power supplies	
The auxiliary power supply shall be provided: - a ground fault detection relay: adjustable between 0 and 100 kΩ - for each outbound group, a maximum current safety device with signalling contact in the plus and the minus circuits - Marked shielding made of flame retardant material of plus and minus rail	
Explanation (optional)	
Verification method Document review Design specification	Prescription/Standards

L-MT-052-007 System traction power substation - Cooling auxiliary power supply	
The auxiliary power supply must be provided with natural cooling; forced cooling is not permitted.	
Explanation (optional)	
Verification method Document review Design specification	Prescription/Standards

L-MT-052-008 System Traction power substation - Supply requirements auxiliary voltage	
The auxiliary power supply must meet the following power supply requirements: - Input voltage: 400V AC/ 3 phase - System: TN-S - Frequency: 50 Hz - Voltage and frequency variation: according to NEN-EN 50160 - Tolerances: according to ACM Netcode Elektriciteit	
Explanation (optional)	
Verification method Document review Design specification	Standards: NEN-EN 50160

L-MT-052-009 System Traction power substation - auxiliary output voltage	
The auxiliary power supply must meet the following values as a minimum: - Rated output voltage 48VDC - Output voltage limits +/-15% - Spare capacity: 20%.	
Explanation (optional)	
Verification method Document review Design specification	Prescription/Standards

L-MT-052-010 System traction power substation - Power supply without batteries	
The rectifiers for auxiliary voltage must be laid out in such a way that the load can also be supplied without batteries without exceeding the required tolerances.	
Explanation (optional)	
Verification method Document review Design specification Testing/functional	Prescription/Standards

L-MT-052-011 System Traction power substation - auxiliary power reserve groups	
The size of the distributor required must be determined by the contractor, taking into account at least 20% reserve groups for future expansion.	
Explanation: The Contractor shall determine the arrangement of the auxiliary power supply groups according to the specific situation.	
Verification method Document review Design Calculation	Prescription/Standards

L-MT-052-012 System traction power substation - Controller auxiliary voltage	
The auxiliary power supply must be equipped with a controller for protection, monitoring, signalling, operation and service/maintenance. This controller monitors the rail voltage, regulates the charging voltage and current of the batteries.	
Explanation (optional) Pass status and fault messages from this controller to HMI and CBI.	
Verification method Document review Design Testing/functional	Prescription/Standards

L-MT-052-013 System Traction power substation - selectivity auxiliary voltage	
The tripping of monitoring and protection relays in the auxiliary power supply must not lead to a tripping of the circuit breakers and circuit breakers.	
Explanation (optional)	
Verification method Testing/functional	Prescription/Standards

L-MT-052-014 System Traction power substation - Selectivity of auxiliary power protection	
The protective devices used must be selective with the upstream and downstream safety devices. The protective devices used must be suitable for detecting and switching off DC fault currents.	
Explanation (optional)	
Verification method Document review Design Calculation	Prescription/Standards

L-MT-052-015 System Traction power substation - Batteries auxiliary voltage	
The batteries of the auxiliary power supply must comply with the following points: - Ni-Cad - Closed and maintenance-free - Time period during which full operability and accessibility should be ensured (calculation to be added): 4 hours. - Guaranteed lifetime: 10 years. - Capacity should be determined from the installed power balance.	
Explanation: The autonomy time of 4 hours is based on the assumption that all switches can also be switched once within this period.	
Verification method Document review Design specification Document review Design Calculation	Prescription/Standards

L-MT-052-016 Traction power substation - room conditions auxiliary voltage	
It must be possible to install the auxiliary power supply in an indoor environment with a temperature variation between 0 °C and 40 °C.	
Explanation: The cabinet may be provided with cooling/ventilation so that the 48VDC No-break system is not adversely affected by excessive internal temperature caused by a room temperature of up to 40 °C.	
Verification method Document review Design specification	Prescription/Standards

L-MT-052-017 System Traction power substation - auxiliary voltage messages	
The auxiliary power supply must be equipped with messages for the CBI. The following messages must be provided as a minimum, with local readout also possible on the auxiliary power supply: • Rectifier malfunction • AC voltage failure • Low DC voltage • DC voltage too high • Ground fault	
Explanation: See the template IO list in section 1.2. Readout of messages on local HMI and CBI.	
Verification method Document review Design Testing/functional	Prescription/Standards

4.14 Building-related installations

4.14.1 Climate

I-MT-090-001 System traction power substation - Climate control	
The building-related mechanical engineering installations should control and regulate the climate in the traction power substation.	
Explanation: Climate control means ventilating, cooling and heating the building to ensure the required climatic conditions in the rooms. For the cable cellar, only ventilation applies.	
Verification method Document review Design Calculation	Prescription/Standards

I-MT-090-002 System traction power substation - room thermostat	
The climate control system in the low-voltage room and the traction transformer room must be controlled by means of a room thermostat.	
Explanation: Climate control means ventilating, cooling and heating the building to ensure the required climatic conditions in the rooms.	
Verification method Document review Design Testing/inspection report visual	Prescription/Standards

I-MT-090-003 System traction power substation - Air conditioning application	
The use of air conditioning is only permitted if cooling by means of ventilation is not sufficient.	
ExplanationCondensation in the rooms due to the cooling air from the air conditioning system is not permitted. The air conditioning may not be located above live parts of the traction system.	
Verification method Document review Design Calculation	Prescription/Standards

I-MT-090-004 System Traction power substation - climatic conditions	
In connection with the operation of various components of the equipment to be installed, the climatic conditions should be • Maximum room temperature +40 °C • Average room temperature over a period of 24hrs < +35 °C • Minimum room temperature +5 °C • Average relative humidity over 24hr period not more than 90%.	
Explanation (optional)	
Verification method Document review Design	Prescription/Standards

I-MT-090-005 System traction power substation - Heating	
The traction power substation must be fitted with electric heating. It must be possible to keep the inside temperature above 5°C at all times.	
Explanation (optional)	
Verification method: Location-specific heat load calculation, with the heat loads of the applied system components as input.	Prescription/Standards

I-MT-090-006 System Traction power substation - ventilation method	
The traction power substation shall be equipped with mechanical ventilation to keep the interior temperature below 40°C at all times.	
Explanation: Mechanical ventilation applies to the DC voltage & low voltage area.	
Verification method: Location-specific heat load calculation, with the heat loads of the applied system components as input.	Prescription/Standards

4.14.2 Lighting & WCD

I-MT-090-007 System Traction power substation - lighting installation	
A lighting system must be provided in each room of the traction power substation.	
Explanation (optional)	
Verification method Document review Design Calculation	Prescription/Standards

I-MT-090-008 System traction power substation - illuminance	
The illuminance should be at least 400 lux at 80 cm above floor level.	
Explanation (optional)	
Verification method Document review Design Calculation Testing/measurement and report	Standards: NEN-EN 12464-1

I-MT-090-009 System traction power substation - Lighting version	
The lighting should be carried out with LED lighting.	
Explanation: Application of energy-efficient lighting	
Verification method Document review Design specification Testing/inspection report visual	Prescription/Standards

I-MT-090-010 System traction power substation - Lighting switches	
Each room of the traction power substation shall have separately switchable lighting.	
Explanation: A light switch should be placed on the lock side of each entrance door.	
Verification method Document review Design drawing Testing/inspection report visual	Prescription/Standards

I-MT-090-011 System traction power substation - WCD	
Each individual room shall be equipped with at least two double earthing sockets.	
Explanation (optional)	
Verification method Document review Design drawing Testing/inspection report visual	Prescription/Standards

I-MT-090-012 System traction power substation - Emergency lighting	
Emergency lighting should be installed in all rooms. The emergency lighting should be powered from the auxiliary power supply.	
Explanation (optional)	
Verification method Document review Design drawing Testing/inspection report visual	Regulations and Standards: Emergency lighting systems - Central power supply systems: NEN-EN 50171; Emergency lighting (projection, cabling and equipment): NEN-EN1838; Escape route lighting (projection, cabling and equipment): NEN-EN1838, NEN-EN 50172 and NPR 2576;

I-MT-090-013 System traction power substation - Escape route indication	
The traction power substation should be fitted with escape route pictograms.	
Explanation: The escape route pictograms are part of the emergency lighting.	
Verification method Document review Design drawing Testing/inspection report visual	Regulations and Standards: Escape route lighting (projection, cabling and equipment): NEN-EN1838, NEN-EN 50172 and NPR 2576; Escape route symbols: NEN-6088 and NEN-EN1838.

I-MT-090-014 Traction power substation - Lighting control cabinets	
Control cabinets must be fitted with cabinet lighting.	
Explanation: The cabinet lighting switches on when the control cabinet door is opened.	
Verification method Document review Design drawing Testing/inspection report visual	Prescription/Standards

I-MT-090-015 System traction power substation - Lighting cable cellar	
The cable cellar must be equipped with sufficient working lighting: 10 lux for the crawlspace lighting. The switch for the lighting shall be located in the switch room, near the access hatch, and shall be equipped with a light indicator showing that the lighting in the cellar is on.	
Explanation (optional)	
Verification method Document review Design drawing Document review Design Calculation Testing/inspection report visual Testing/measurement and report	Prescription/Standards

I-MT-090-016 System Traction power substation - Shading/replacement	
In order to avoid shadows and to make it easier to replace elements, lighting fixtures should not be placed above appliance cabinets.	
Explanation (optional)	
Verification method Document review Design drawing Testing/inspection report visual	Prescription/Standards

I-MT-090-017 System Traction power substation - Door position indicator	
All entrance doors, except those of the purchasing area, must be equipped with door position indicators for reporting to the CBI. The door position indicator should only react to the actual opening of the door in question, and not to movement of the door due to wind, vibration, etc. See the template IO list in section 1.2.	
Explanation: This concerns all access doors to the traction power substation and the individual areas of the traction power substation except for the purchasing area.	
Verification method Document review Design Testing/functional	Prescription/Standards

4.14.3 Firefighting facilities

I-MT-090-018 System traction power substation - Fire extinguishers	
The rooms of the traction power substation shall be equipped with portable fire extinguishers.	
Explanation (optional)	
Verification method Document review Design Testing/inspection report visual	Standards: NEN-EN2 / NEN-EN3/NEN4001

4.14.4 Fire alarm

I-MT-090-019 System traction power substation - fire alarm	
The rooms in the traction power substation must be equipped with fire alarms.	
Explanation (optional) The fire detectors shall not be located above live parts of the traction installation.	
Verification method Document review Design drawing Testing/functional	Prescription/Standards

I-MT-090-020 System traction power substation - fire detectors collective notification	
The various fire detectors must generate a collective alarm that is connected to the SCADA system.	
Explanation: This means that only one message must be provided to the SCADA.	
Verification method Document review Design Testing/functional	Prescription/Standards

I-MT-090-021 System traction power substation - fire alarms projection
The fire detectors shall not be located above live parts of the traction installation.

I-MT-090-021 System traction power substation - fire alarms projection	
Note No switching actions are then required for maintenance of the fire detectors.	
Verification method Document review Design Testing/inspection report visual	Prescription/Standards

4.15 Internal cabling, cables and cable ducts

I-MT-071-001 System traction power substation - cable routes	
In the traction power substation, all cables should be enclosed in cable trays, cable racks or cable ways or a combination thereof.	
Explanation (optional)	
Verification method Document review Design Testing/inspection report visual	Prescription/Standards

I-MT-071-002 System Traction power substation - Cable tray design	
The cable ducts of the cable ways shall be made of galvanised steel.	
Explanation (optional)	
Verification method Document review Design Testing/inspection report visual	Prescription/Standards

I-MT-071-003 System Traction power substation - Equipotential bonding	
The steel cable routing systems are connected to each other by means of potential equalisation. They must also be connected to the water earth.	
Explanation (optional)	
Verification method Document review Design Testing/inspection report visual	Prescription/Standards

I-MT-071-004 System Traction power substation - Electrical connection	
A cable tray consisting of several parts must be electrically unified. The parts should be electrically connected with an earth wire of sufficient diameter and green/yellow insulation.	
Explanation (optional)	
Verification method Document review Design Testing/inspection report visual	Standards: NEN 1010

I-MT-071-005 System traction power substation - fixing	
The cable routes in the traction power substation must be mounted on the ceiling, the wall and/or in the cellar compartment.	
Explanation (optional)	
Verification method Document review Design Testing/inspection report visual	Prescription/Standards

I-MT-071-006 System traction power substation - Sharp edges	
Cable paths may not have any sharp edges that could cause damage to cables and/or pipes. The edges should have a protective rubber that does not come loose when cables are removed or installed.	
Explanation (optional)	
Verification method Document review Design Testing/inspection report visual	Prescription/Standards

I-MT-071-007 System traction power substation - disconnection	
The cable routes should be provided with a separation between power cables and signal cables, which will limit the influence as much as possible.	
Explanation: The power supply cables are those for 400/230 VAC.	
Verification method Document review Design Testing/inspection report visual	Prescription/Standards

I-MT-071-008 System Traction power substation - degree of filling	
A cable tray or ladderway should have a maximum fill level of 60%.	
Explanation (optional)	
Verification method Document review Design Testing/inspection report visual	Prescription/Standards

I-MT-071-009 System Traction power substation - Internal wall penetrations	
Cable passages through a fire-resistant wall must be permanently fireproofed. It must be possible to make changes later.	
Explanation (optional)	
Verification method Document review Design Testing/inspection report visual	Prescription/Standards

I-MT-071-010 System Traction power substation - Passages through outer wall	
Cable passages through an outer wall must be permanently sealed. It must be possible to make changes later.	
Explanation (optional)	
Verification method Document review Design Testing/inspection report visual	Prescription/Standards

I-MT-071-011 System traction power substation - Cable blocks	
Traction and medium-voltage cables should be mounted in cable blocks in the cable cellar of the traction power substation. The cable blocks must ensure that the relevant cables are not short-circuited.	
Explanation (optional)	
Verification method Document review Design Calculation Testing/inspection report visual	Norm: NEN-EN-IEC61914

I-MT-071-012 System Traction power substation - Cable blocks Version	
The cable blocks must be made of plastic. In addition, the material should be non-combustible and low-smoke.	
Explanation: Wooden cable blocks are not allowed.	
Verification method Document review Design specification Testing/inspection report visual	Norm: NEN-EN-IEC61914

I-MT-071-013 System Traction power substation - Low voltage cables	
The low-voltage cables must be laid and anchored in the cable ducts provided.	
Explanation (optional)	
Verification method Document review Design Testing/inspection report visual	Prescription/Standards

I-MT-072-007 System traction power substation - cable sleeves	
The use of cable joints in the traction power substation is not permitted.	
Explanation (optional)	
Verification method Document review Design Testing/inspection report visual	Prescription/Standards

I-MT-072-008 System Traction power substation - Low voltage cables	
Low-voltage cables must be UV-resistant, low-smoke, flame-retardant and halogen-free.	
Explanation (optional)	
Verification method Document review Design specification Testing/inspection report visual	Prescription/Standards

I-MT-072-009 System Traction power substation - Shielding low voltage cables	
Low voltage cables (control cables) must be shielded.	
Note Connect EMC-compliant cable.	
Verification method Document review Design specification Testing/inspection report visual	Prescription/Standards EN 61000-3, 4 and 6

I-MT-072-010 System traction power substation - Low voltage cables	
Low-voltage cables must be printed per metre with a sheathing stamp. Labels are to be provided at the ends of low voltage cables and on both sides of wall penetrations.	
Explanation: The sheathing stamp for the indication: "cable type", "cross-section", "voltage".	
Verification method Document review Design Testing/inspection report visual	Prescription/Standards

L-MT-072-011 System Traction power substation - coding and numbering	
All wiring in cabinets must be coded. All components must be provided with component coding.	
Explanation (optional)	
Verification method Document review Design Testing/inspection report visual	Prescription/Standards

L-MT-072-012 System Traction power substation - Coding and numbering of cabinets	
All control cabinets, traction cabinets must be provided with a unique box code.	
Explanation (optional)	
Verification method Document review Design Testing/inspection report visual	Prescription/Standards

4.16 Construction

I-MT-006-001 System Traction power substation - Construction	
There is a separate contract document for the construction aspects. See the sPVE for this.	
Explanation (optional)	
Verification method Document review Design Testing/inspection report visual	Prescription/Standards

4.17 Cables & Pipelines External

Not applicable

4.18 Medium voltage

4.18.1 GS version with purchasing distributor

I-MT-072-013 System traction power substation - Cable traction power substation	
The cable between the Purchase Distributor and the HVI (Incoming Field) is part of the scope of this specification. Supply, lay, measure and connect to the HVI (Incoming Field) by ON of this specification. Connecting to the Purchase Exchanger by the grid operator.	
Explanation: Coordination with the grid operator is part of the scope of this specification. The Liander spec S8035 of 1-4-2020 states that the cable between purchase distributor HVI (incoming field) will be delivered and assembled by ON, whereby this cable must meet the specifications of Liander and must be installed by a certified company/person.	
Verification method Document review Design	Prescription/Standards

4.18.2 GS Version without purchasing distributor

I-MT-073-001 System Traction power substation - Connection to the distribution network	
The traction power substation is fed from the medium-voltage distribution network. The scope of this specification does not include the supply and laying of these cables. The scope of this specification does include the (measuring and) connection of the relevant cables to the ring fields.	
Explanation: An XLPE 1x3x240mm2 AL per ring field must be taken into account for connection.	
Verification method Document review Design	Prescription/Standards

4.19 Plus connections Metro (Third Rail)

I-M-073-002 System Traction power substation - Third rail connection	
Every outbound high speed circuit breaker field for supplying the third rail must be connected to the third rail (in accordance with the circuit diagram) using the following type of cable BMz1Kas 1x630 mm2 Cu, conductor class 5, earth shield 70 mm2. The sPvE is leading for the number of cables.	
Explanation: See TKF 630 mm2 kabelspecificatiein section 1.2See sPvE for the number of plus connections to be made.	
Verification method Document review Design drawing Testing/measurement and report	Prescription/Standards

I-M-073-003 System Traction power substation - Demarcation	
Scope of work for plus cables is described in the sPVE.	
Explanation: See sPvE for scope demarcation.	
Verification method N/A	Prescription/Standards

4.20 Return Metro

I-M-073-004 System traction power substation - Minus rack Metro	
A minus rack must be provided per track for the return connection. The minus rack has to be placed next to the track. The sPVE is leading for the number of minus racks.	
Explanation: See sPvE for the number of mini racks to be installed.	
Verification method Document review Design Testing/inspection report visual	Prescription/Standards

I-M-073-005 System traction power substation - traction power substation connection - Minus rack
Each minus rack for the return must be connected to the minus field in the traction power substation (in accordance with the circuit diagram) using the following type of cable BMz1Kas 1x630 mm2 Cu, conductor class 5, earth screen 70 mm2. It must be possible to connect at least 4x630mm2 to the minus rack. The sPvE is leading for the number of minus connections.

I-M-073-005 System traction power substation - traction power substation connection - Minus rack	
Explanation: See TKF 630 mm2 kabelcable specification in section 1.2. See sPvE for the number of minus connections to be made.	
Verification method Document review Design drawing Testing/measurement and report	Prescription/Standards

I-M-073-006 System Traction power substation - Minus rack connection - track	
Each minus stretch for the purpose of return shall be connected to the track via n. t. b. number of BMqK 1x150 mm2 Al or 1x120 mm2 Cu. The sPvE is leading for the number of minus connections.	
Explanation: ON has to request the OR sheets (OverzichtRetourbladen) from OG. See sPvE for the number of minus connections to be made.	
Verification method Document review Design drawing Testing/measurement and report	Standards: NEN 3207

I-M-073-007 System Traction power substation - demarcation	
Scope of work for return cables is described in the SPR.	
Explanation: See sPvE for scope demarcation.	
Verification method N/A	Prescription/Standards

4.21 Tram Plus Connections (Overhead Line)

I-T-073-008 System Traction power substation - overhead line connection	
Every outbound high speed circuit breaker field for supplying the overhead line must be connected to the overhead line (in accordance with the circuit diagram) by means of the following type of cable BMz1Kas 1x630 mm2 Cu, conductor class 5, earth shield 70 mm2. The Schedule is leading for the number of cables.	
Explanation: See TKF 630 mm2 kabelspecificatiein section 1.2. See Schedule for the number of plus connections to be made.	
Verification method Document review Design drawing Testing/measurement and report	Prescription/Standards

I-T-073-009 System Traction power substation - demarcation	
Scope of work for plus cables is described in the SPR.	
Explanation: See sPvE for scope demarcation.	
Verification method N/A	Prescription/Standards

4.22 Return Tram

I-T-073-010 System Traction power substation - Minus box tram
For each return cable, one minus box must be provided for the return connection.

I-T-073-010 System Traction power substation - Minus box tram	
Explanation (optional)	
Verification method Document review Design Testing/inspection report visual	Prescription/Standards

I-T-073-011 System traction power substation - traction power substation connection - Minus box	
Each minus box serving the return must be connected to the minus field in the traction power substation (in accordance with the circuit diagram) using the following type of cable BMz1Kas 1x630 mm2 Cu, conductor class 5, earth screen 70 mm2. The sPvE is leading for the number of cables.	
Explanation: See TKF 630 mm2 kabelspecificatiein section 1.2. See sPvE for the number of minus connections to be made.	
Verification method Document review Design drawing Testing/measurement and report	Prescription/Standards

I-T-073-012 System Traction power substation - Junction box - track	
Each return minus box shall be connected to the track by a number of cables of type BMqK 1x120 mm2 Cu to be specified.	
Explanation: ON should request the OR sheets from OG. See sPvE for the number of minus connections to be laid. At locations where there is a risk of theft, the cables may be replaced by 1x150 mm2 Al. This is then indicated in the sPvE.	
Verification method Document review Design drawing Testing/measurement and report	Standards: NEN 3207

I-T-073-013 System Traction power substation - demarcation	
Scope of work for return cables is described in the SPR.	
Explanation : See sPvE for scope demarcation.	
Verification method N/A	Prescription/Standards

4.23 Connection CBI - Metro

I-M-076-001 System Traction power substation - NMA connection	
The traction power substation should provide a connection to the NMA (Network Metro Amsterdam) fibre optic network of Metro and Tram.	
Explanation: Coupling in the nearest fibre optic coupling point	
Verification method Document review Design Testing/functional	Prescription: Aansluitvoorwaarden NMA definitief in para 1.2

4.24 Connection CBI - Tram

I-T-076-002 System Traction power substation - TETRA/NMA connection	
The traction power substation should provide a connection to the NMA/4G network of Metro and Tram. The connection to the NMA network is realised via the RTU and is not part of the scope of this specification.	
Explanation: Coupling in the nearest fibre optic coupling point	
Verification method Document review Design Testing/functional	Prescription:

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