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Systemspecification Recovery Unit

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1 Introduction

This document describes the technical specifications and functional backgrounds, for the realization and commissioning of new Recovery Units to supply superfluous braking energy of traction vehicles into the distribution grid.

The specification describes the requirements for the Recovery Unit with the according specifications.

Finally, it is a requirement that the Recovery Unit is compatible with other installed components in the substation. This compatibility ensures the correct operation of the components in the substation, especially with respect to safety, maintenance, reliability and life esteem/lifespan.

This is a generic specification for a Recovery Unit applied for Metro.

1.1 Abbreviations

A complete list of the used abbreviations and acronyms Metro & Tram is included in appendix 4.

Abbrevation	Meaning
A	Ampère
AWI	Automatic Reclosing (Automatische Weder Inschakeling)
CAB	Central Remote Control (Centrale Afstand Bediening)
CBI	Central Control Installation (Centrale Besturingsinstallatie)
dB	Decibel
DC	Direct Current
DO	Final/Detailed Design Design (Definitief Ontwerp)
EN	European Standard (Europese Norm)
FIT	Factory Integration Test
FO	Functional Design (Functioneel Ontwerp)
GOOSE	Generic Object Oriented Substation Event
GVI	DC Distribution panel (Gelijkstroomverdeelinrichting)
HMI	Human Machine Interface
HVI	HV distribution panel (Hoogspannings Verdeel Inrichting)
Hz	Hertz
IEC	International Electrotechnical Commission
IED	Intelligent Electronic Device
IO	Input Output
IP	International Protection Marking
kPa	Kilo Pascal
kV	Kilovolt
kWh	Kilo Watt hour

LVI	Low Voltage Distribution panel (Laagspanningsverdeelinrichting)
MVA	Mega Volt Ampère
Ni-Cad	Nikkel Cadmium
NSA	Emergency Power (Noodstroomaggregaat)
OG	Client (Opdrachtgever)
ON	Contractor (Opdrachtnemer)
PLC	Programmable Logic Controller
RU	Recovery Unit
SAT	Site Acceptance Test
SCADA	Supervisory Control And Data Acquisition
SIT	Site Integration Test
SS	Switching Station (Schakelstation)
TO	Technical Design (Technisch Ontwerp)
UO	Execution Desigd (Uitvoeringsontwerp)
V	Volt
VLD	Voltage Limiting Device
WCD	Wall Socket (Wandcontactdoos)

1.2 Reference documents

Reference	Document description
[]	Systeemspecificatie Gelijkrichterstations_v7.0

1.3 Standards

This paragraph gives an overview of the relevant standards and guidelines.
The supplies have to fulfil the Dutch law and Building code.

In addition, the delivery has to fulfill all applicable standards, regulations and guidelines, in the prevailing order:

1. GVB/MeT Specific Regulations
2. NEN (Dutch standards)
3. EN (European Standards) en European harmonisation documents (HD)
4. IEC (Standards of the International Elektrotechnical Commission)
5. NPR (Dutch practice guideline)
6. EnergieNed Guidelines
7. VDE (guidelines of the German Verband der Elektrotechnik, Elektronik und Informationstechnik)
8. ATEX (European guideline about explosion danger)

The overview of standards doesn't pretend to be complete. Contractor has to include applicable additional and/or replacing standards.

1.3.1 Specific Standards

NEN-EN 50122-1	Railway applications - Fixed installations - Electrical safety, earthing and the return circuit - Part 1: Protective provisions against electric shock
NEN-EN 50122-2	Railway applications - Fixed installations - Electrical safety, earthing and the return circuit - Part 2: Provisions against the effects of stray currents caused by d.c. traction systems
NEN-EN 50122-3	Railway applications - Fixed installations - Electrical safety, earthing and the return circuit - Part 3: Mutual Interaction of a.c. and d.c. traction systems
NEN-EN 50123-1	Railway applications - Fixed installations - D.C. switchgear - Part 1: General
NEN-EN 50123-2	Railway applications - Fixed installations - D.C. switchgear - Part 2: D.C. circuit breakers
NEN-EN 50123-3	Railway applications - Fixed installations - D.C. switchgear - Part 3: Indoor D.C. disconnectors and switch-disconnectors
NEN-EN 50123-4	Railway applications - Fixed installations - D.C. switchgear - Part 4: Outdoor d.c. in-line switch-disconnectors, disconnectors and d.c. earthing switches
NEN-EN 50123-6	Railway applications - Fixed installations - D.C. switchgear - Part 6: D.C. switchgear assemblies
NEN-EN 50123-7-1	Railway applications - Fixed installations - D.C. switchgear - Part 7-1: Measurement, control and protection devices for specific use in d.c. traction systems - Application guide
NEN-EN 50123-7-2	Railway applications - Fixed installations - D.C. switchgear - Part 7-2: Measurement, control and protection devices for specific use in d.c. traction systems - Isolating currenttransducers and other current measuring devices
NEN-EN 50123-7-3	Railway applications - Fixed installations - D.C. switchgear - Part 7-3: Measurement, control and protection devices for specific use in d.c. traction systems - Isolating voltage transducers and other voltage measuring devices
NEN-EN 50124-1	Railway applications - Insulation coordination - Part 1: Basic requirements - Clearances and creepage distances for all electrical and electronic equipment
NEN-EN 50124-2	Railway applications - Insulation coordination – Part 2: Overvoltages and related protection.
NEN-EN 50160	Voltage characteristics of electricity supplied by public electricity networks
NEN-EN 50163	Railtoepassingen – Railway applications - Supply voltages of traction systems
NEN-EN 50328	Railway applications - Fixed installations – Electronic power converters for substations
NEN-EN 50388	Railway Applications - Power supply and rolling stock - Technical criteria for the coordination between power supply (substation) and rolling stock to achieve interoperability
NEN-EN 50526-1	Railway applications - Fixed installations - D.C. surge arresters and voltage limiting devices - Part 1: Surge arresters
NEN-EN 50526-2	Railway applications - Fixed installations - D.C. surge arresters and voltage limiting devices - Part 2: Voltage limiting devices
NEN-EN 50526-3	Railway applications - Fixed installations - D.C. surge arresters and voltage limiting devices - Part 3: Application Guide
IEC 60146-1-1	Semiconductor converters - General requirements and line commutated converters - Part 1-1: Specification of basic requirements
IEC 61850	Communication networks and systems for power utility automation

1.3.2 General Standards

NEN 1010	Electrical installations for low-voltage - Dutch implementation of the HD-IEC 60364-series
NEN 3140	Operation of electrical installations - Low voltage
NEN-EN 50110	Operation of electrical installations - Part 2: National annexes
NEN 5152	Technical drawings - Electrotechnical symbols (Dutch version of IEC 60617 'Graphical symbols for diagrams')
IEC 60038	IEC Standard Voltages
IEC 60050	International Electrotechnical Vocabulary
NEN-EN-IEC 60529	Degrees of protection provided by enclosures (IP Code)
IEC 60909	Short-circuit calculation in three phase a.c. systems.
EnergieNed	Guidelines for permissible harmonic currrents.
Netcode Elektriciteit	Regulations for grid operators and clients about functioning, connection of clients and transport of electricity.
Meetcode Elektriciteit	Regulations for grid operators and clients about measuring the amount of electricity transported and consumed.

2 Recovery Unit System

2.1 System description

The function of the subsystem Recovery Unit is to supply superfluous electrical braking energy of metro vehicles that cannot be received by other vehicles back into the distribution grid.

2.2 Functional description of the system

The system Recovery Unit (RU) fulfills the required functions within in the system boundaries.
The required functions are shown in Figure 2-1 (enlarged in Appendix 1). Table 1 contains a functional description of main features of the system ‘RU’

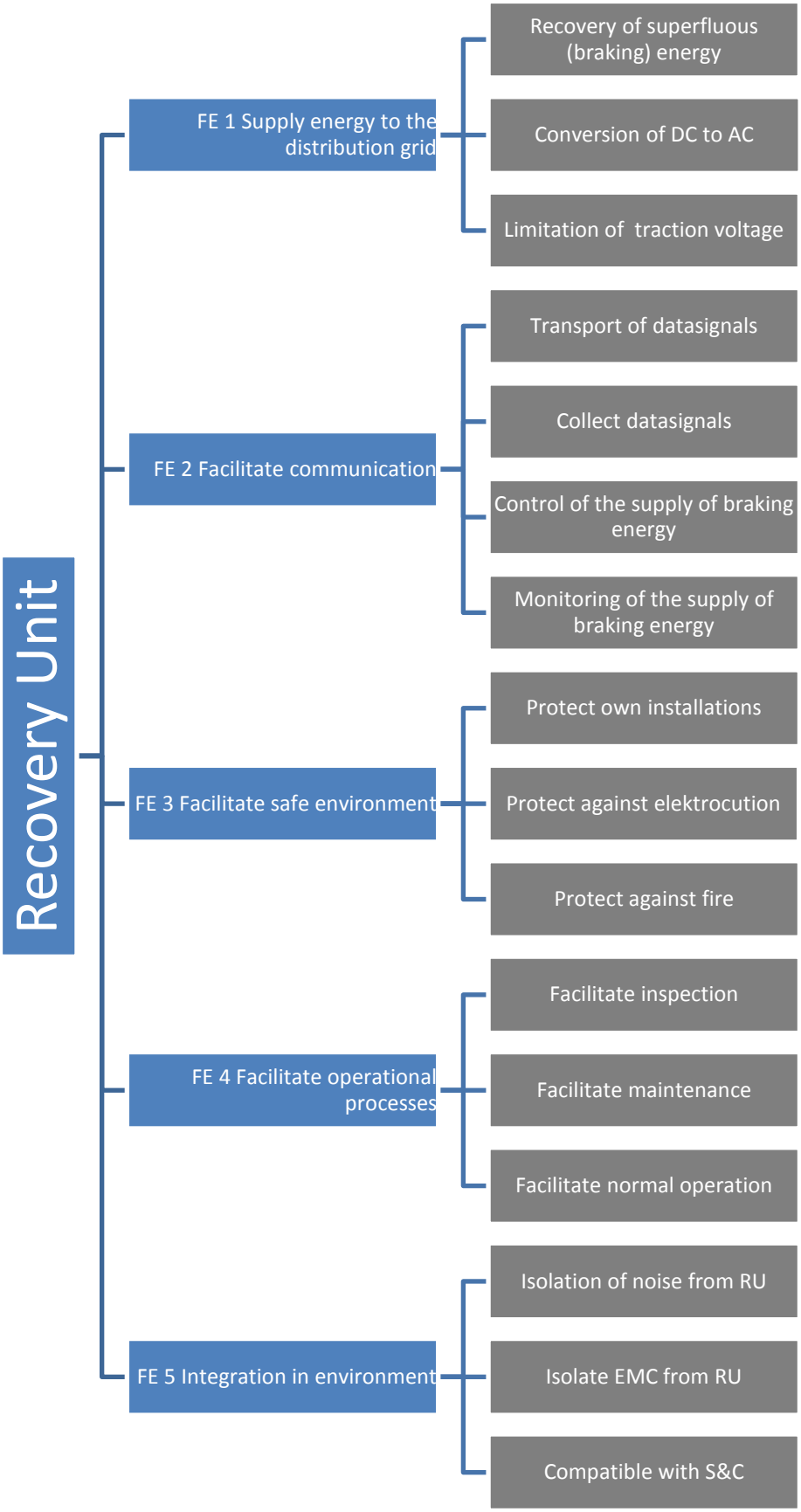


Figure 2-1 – Function tree (enlarged in appendix 4.1).

ID	Function	Functional description
FE 1	Supply energy to the distribution grid	Supply of braking energy from the DC metro grid tot he AC distribution grid.
FE 2	Facilitate communication	Collection and transportation of data signals Control and monitoring of the recovery of braking energy.
FE 3	Facilitate safe environment	Protection of the installation against fire and electrocution and to prevent the installation become defective by external circumstances.
FE 4	Facilitate operational processes	Facilitating inspection and maintenance of the installation by service personnel. Facilitating normal exploitation.
FE 5	Integration in environment	Prevent influence on the environment by noise and other nuisance.

Table 1 – Functional analysis – Recovery Unit System.

Figure 2-2 shows the location of the Recovery Unit within the substation.

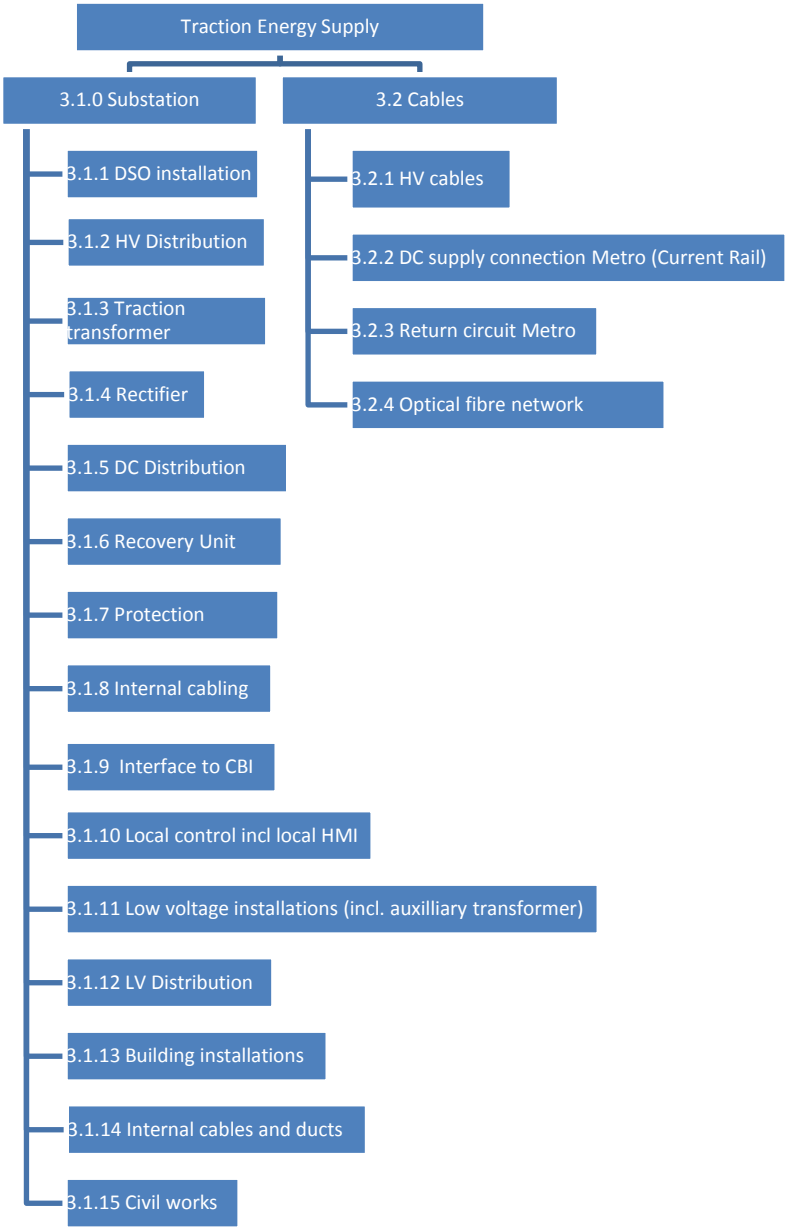


Figure 2-2 – Object tree Substation (enlarged in appendix 4.2).

In Table 2 an X-table shows for each object the interfaces with the Recovery Unit.

Object\Function		FE 1 Supply energy to the	FE 2 Facilitate communication	FE 3 Facilitate safe environment	FE 4 Facilitate operational processes	FE 5 Integration in environment
3.1.1	DSO installations					
3.1.2	HV Switchgear	X				
3.1.3	Traction transformer	X				
3.1.4	Rectifier	X				
3.1.5	DC Distribution	X				
3.1.6	Recovery Unit	X	X	X	X	X
3.1.7	Protection	X		X		
3.1.8	Internal cabling	X	X			
3.1.9	Interface CBI		X		X	
3.1.10	Local control and HMI				X	
3.1.11	Low voltage installations					
3.1.12	LV Switchgear	X				
3.1.13	Building installations					
3.1.14	Internal cabling and ducts	X	X		X	
3.1.15	Civil			X	X	X
3.2.1	HV cables	X				
3.2.2	DC supply connection Metro (Current Rail)	X				
3.2.2	Minus cables (return circuit)	X				
3.2.4	Optical fiber network		X		X	

Table 2 – X-table Recovery Unit interfaces.

2.3 Integration in Metro Substation

Intended locations for the installation of Recovery Units are the Metro substations. In the typical for new substations a space of 1600x1800 mm is reserved. The structure of the substation is shown in the single line diagram and the arrangement drawing. These drawings are added to this specification in H4 appendices, this are the GS_Grondschema and GS_Opstellingstekening respectively. This are general drawings and not location specific drawings, depending on the location modifications will be necessary.

The GVI contains a disconnector to connect the Recovery Unit to the plus rail and a connection to the minus rail. Also a connection to the AC-side (secondary side of the traction transformer) is prepared.

In existing substations those extra connections are not present and an additional disconnector needs to be added to connect the RU with the DC-rail. Also it is location dependent if there is enough space available for installation of the Recovery Unit.

3 Recovery Unit Requirements

This chapter describes the requirements of the Recovery Unit.

Requirement Definitions

Characteristic for this specification is the division in different types of requirements and the cohesion between the requirements. The requirements can be divided in the following types:

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

In Table 3 for each type of requirement the definition is given.

Requirement type		Clarification
Functional requirements		Functional requirements concern requirements of the primary function i.e. the performance of the system and the breakdown of the system in objects.
Aspect requirements	Reliability	The probability that the required function will be executed under given circumstances during a determined interval.
	Availability	The probability that the required function can be executed under given circumstances. This corresponds with the fraction of time that the required function can be executed under given circumstances.
	Maintainability	Requirements with respect to the necessary management and maintenance effort of the system to be realized c.q. the objects and ease and speed the system can be restored to a operational status after a failure.
	Safety	Requirements with respect to safety of the system c.q. the objects during the usage phase, fort he user and the environment.
	Design	Requirements with respect to the esthetic appearance of the system c.q. objects.
	Lifespan	Requirements with respect to the required lifetime of the system c.q. objects.
	Future-proofness	Requirements with respect to the suitability of the system for future use.

Requirement type		Clarification
Realisation requirements		The system shall in the realisation phase fulfill the requirements and boundaries als described in the Electrotechnical Safety Handbook (Elektrotechnisch Veiligheidshandboek) of GVB.
Interface requirements	External interface	Requirements with respect to interfaces of the system with (future) environment at the outside of the system border.
	Internal interface	Requirements with respect to the interfaces within the system related to systems/objects that will be designed or realized by third parties or interaction between different objects within the system.

Table 3 – Requirement type definition

Requirement tables

The requirements in this system specification are described according the format in Table 4 – Requirements format.

ID Title of the requirement	
Requirement text	
Explanation (optional)	
Verification method (optional)	Guidelines/Standards (optional)

Table 4 – Requirements format.

ID	:	Unique requirement number.
Title of the requirement	:	Short description in keywords.
Requirement text	:	Description of the requirement.
Clarification (optional)	:	Extra information, explanation.
Verification method (optional)	:	Prescribed verification method.
Guidelines/Standards (optional)	:	Description of verification method.

3.1 Recovery Unit Requirements

This specification is generic for Recovery Units applied for metro.

3.1.0 Top requirement

3.1.0.1 Functional Requirements

3.1.0.1.1.1 Recovery Unit System – Electrical specifications	
The RU shall fulfill the electrical specifications EN 50328 and EN 50163 as escribed in Appendix 4.1 Electrical specifications.	
Clarification (optional):	
Verification method: Document review	Standards: NEN-EN 50328, NEN-EN 50163

3.1.0.1.1.2 Recovery Unit System – Recovery of braking energy	
When the RU is active, superfluous energy generated by braking vehicles and cannot be used by other vehicles nearby, will be supplied from the DC traction grid tot he AC distribution grid.	
Clarification: This superfluous energy would otherwise be converted into heat on breaking resistors and is lost.	
Verification method: (optioneel)	Guidelines/Standards (optional)

3.1.0.1.1.3 Recovery Unit System – Threshold voltage	
When the voltage of the traction grid (Ud) exceeds the threshold voltage of the Recovery Unit (Ud,th), the unit shall operate with an almost constant voltage curve until the maximum current is reached. At that moment, the current shall kept constant and the voltage will increase.	
Clarification: The recovery unit should not obstruct the exchange of braking energy between vehicles.	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.0.1.1.4 Recovery Unit System – Maximum operational voltage	
The maximum operational voltage of the recovery unit is determined by the maximum braking voltage Ud,max1 according EN 50163.	
Clarification: Braking vehicles limit the voltage on the supply; when there is a threat of exceedance, superfluous energy will be converted into heat.	
Verification method: (optional)	Standard: NEN-EN 50163

3.1.0.1.1.5 Recovery Unit System – Coupling and decoupling	
Coupling of the recovery unit with a passive rectifier should not interfere with the functionality of the rectifier. Also, it should be possible to decouple the recovery from the rectifier without influencing the rectifier.	
Clarification (optional):	

3.1.0.1.1.5 Recovery Unit System – Coupling and decoupling	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.0.1.1.6 Recovery Unit System – Adjustable threshold voltage	
The threshold voltage $U_{d,th}$ (=U_{Nd}) that activates the recovery unit should be adjustable to gain an optimal energy recovery.	
Clarification: The recovery unit should only be activated above the local zero-load voltage and should make exchange of energy between vehicles possible	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.0.1.1.7 Recovery Unit System – Duty Cycle	
The maximum duty cycle: I_L = 1000 A during 30 s every 3 minutes.	
Clarification: Starting point is that every 3 minuten a metro stops and a braking lasts 30 seconds	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.0.1.1.8 Recovery Unit System – Efficiency	
The efficiency of the recovery unit shall be 98% minimum.	
Clarification: High efficiency is favorable for the recovery of energy and less heat has to be abducted.	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.0.1.1.9 Recovery Unit System – Overload Protection	
Overload protection: The recovery unit shall detect overload situations, deactivate temporarily and activate automatically after a cool down period. De-activation and activation should be reported tot the CBI.	
Clarification: Overload may occur when duty cycle or other electrical specifications are exceeded.	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.0.1.1.10 Recovery Unit System – Overcurrent Protection	
Overcurrent protection: The recovery unit shall have an overcurrent protection on both the AC as the DC-side. Triggering of the overcurrent protection should be reported to the CBI.	
Clarification (optional):	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.0.1.1.11 Recovery Unit System – Stability	
The recovery unit may not cause stability problems with control systems on the vehicle.	
Clarification: The metro vehicles have a braking chopper (rheostat) that is activated when the voltage on the overhead line or current rail becomes too high. The control of the Recovery Unit will also be dependent of the traction voltage. They should not influence each other in such a way that instability occurs. Also the on-board auxiliary supply can fall out due to this instability.	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.0.1.1.12 Recovery Unit System – Interface Signalling & Control	
The recovery unit shall not influence the signaling & control system.	
Clarification: The Recovery Unit may not produce frequency components that influence the signaling & control system.	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.0.2 Requirement Aspect: Maintainability

3.1.0.2.1.1 Recovery Unit System – Tooling	
The RU shall be suitable for maintenance by service personnel. All necessary tooling, documentation, software and applications shall be supplied to do the maintenance in-house.	
Clarification: This concerns earthing gear and software for change or read settings, fault reports, loggings etc.	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.0.2.1.2 Recovery Unit System – Documentation	
An Installation and Maintenance Manual and a separate User Manual shall be provided. All user documentation shall be delivered in the Dutch language; specific technical documentation may be delivered in the English language.	
Clarification (optional):	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.0.2.1.3 Recovery Unit System – Training
The supplier of the Recovery Unit shall give training to installation and maintenance personnel.
Clarification (optional):

3.1.0.2.1.3 Recovery Unit System – Training	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.0.2.1.4 Recovery Unit System – Selfdiagnosis	
If possible, self diagnosis functions shall be built in to indicate the necessity of (preventive) maintenance instead a fixed maintenance interval.	
Clarification (optional):	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.0.2.1.5 Recovery Unit System – Accessibility	
It shall be possible for first line maintenance personnel to inspect all diagnosis indicators (e.g. wear indication of switchgear) without dismantling the equipment.	
Clarification (optional):	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.0.2.1.6 Recovery Unit System – Connection of cables	
Connection of cables shall be possible without special tools.	
Clarification (optional):	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.0.2.1.7 Recovery Unit System – Earthing balls	
All live parts shall have grounding balls of 20 mm according EN 50328 section 3.8.2 (Earthing) for easy grounding.	
Clarification (optional):	
Verification method: (optional)	Standards: EN 50328

3.1.0.2.1.8 Recovery Unit System – Rating plate	
The RU shall have a rating plate and other markings as required by EN 50328 section 3.9.	
Clarification (optional):	
Verification method: (optional)	Standards: EN 50328

3.1.0.3 Requirement Aspect: Reliability

3.1.0.3.1.1 Recovery Unit System – Levensduur
The technical lifetime of the ARU shall be at least 30 years. Components of the ARU with a shorter technical life time shall be identified and be replaceable.
Clarification: During the technical lifetime, the system can be maintained and upgraded to keep it a reliable operational system.

3.1.0.3.1.1 Recovery Unit System – Levensduur	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.0.3.1.2 Recovery Unit System – Climate	
The RU shall function properly in the Dutch climate, which is a moderate maritime climate.	
Clarification (optional):	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.0.3.1.3 Recovery Unit System – Storage and transport	
The RU shall comply with the storage and transport conditions according to EN 50328 section 2.2.2.1: • Storage and transport temperature: -25°C ≦ Tstg ≦ +55°C.	
Clarification (optional):	
Verification method: (optional)	Standards: EN 50328

3.1.0.3.1.4 Recovery Unit System – Environment	
The ARU shall be designed to operate in the environmental conditions of a traction substation, according to EN 50328 section 2.2.	
Clarification (optional):	
Verification method: (optional)	Standards: EN 50328

3.1.0.3.1.5 Recovery Unit System – Environmental conditions	
The ARU shall be designed to operate within the following ambient (cooling) air conditions: Temperature, according to EN 50328 section 2.2.2.2.1: • Extreme air temperature: -5°C _ TA _ 40°C; • Maximum daily average air temperature: +35°C; • Yearly average air temperature: +25°C. Humidity, according to EN 50328 section 2.2.2.2.2: • Relative humidity: minimum 15 %, maximum 80% (noncondensing). Pollution, according to EN 50328 section 2.2.2.2.3: • Pollution degree PD3A (dust with low conductivity, humidity: damp with long time condensation), see EN 50124-1 Table A.4.	
Clarification (optional):	
Verification method: (optional)	Normen: EN 50328, EN 50124

3.1.0.3.1.6 Recovery Unit System – Cooling	
The ARU shall be designed ideally with natural air cooling, but practically with indirect cooling with identification code AFAN, according to EN 50328 section 2.1: • heat transfer agent: AF (air with forced circulation by means of incorporated moving device); • cooling medium: AN (air with natural circulation).	
Clarification: Water cooling or cooling with fluids that can cause greenhouse effect are not allowed.	
Verification method: (optional)	Standards: EN 50328

3.1.0.3.1.7 Recovery Unit System – Vibrations	
The RU shall be capable to operate when subjected to vibrations according to EN 50328 section 2.2.2.2.4: 10 Hz sinusoidal vibration in vertical and/or horizontal direction during 30 s and with a peak acceleration of 5 m/s^2.	
Clarification: Mounting near the track can cause vibrations.	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.0.3.1.8 Recovery Unit System – EMC	
As stated in EN 50328 section 3.6, the emission and immunity aspects of electro-magnetic compatibility (EMC) of the RU shall comply with EN 50121 and especially EN 50121-5.	
Clarification (optional):	
Verification method: (optional)	Standards: EN 50328

3.1.0.3.1.9 Recovery Unit System – Dangerous materials	
The RU shall not contain any materials prohibited by applicable law. Where substances are known to be hazardous to health and suitable alternatives exist, these substances shall not be used.	
Clarification (optional):	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.0.3.1.10 Recovery Unit System – Dangerous waste	
The RU product shall contain a list of the components or parts of the RU that are to be considered as dangerous waste according to the European Waste Catalog. The list shall be esp. the data format) conforming IEC 62474.	
Clarification (optional):	
Verification method: (optional)	Normen: IEC 62474

3.1.0.3.1.11 Recovery Unit System – Grid blackout
The ARU shall be able to handle fall out of the main grid voltage.

3.1.0.3.1.11 Recovery Unit System – Grid blackout	
Clarification (optional): Blackout of the utility grid may not cause dangerous situations or damage to components.	
Verification method: (optional)	Standards: IEC 62474

3.1.0.3.1.12 Recovery Unit System – Typetest	
A type test report according to EN 50328 section 4 has to be delivered.	
Clarification (optional):	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.0.3.1.13 Recovery Unit System – Routinetest	
A Routine Test according to EN 50328 section 4 shall be performed on each installation to verify that the implementation meets its requirements.	
Clarification (optional):	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.0.4 Requirement Aspect: Future-proofness

3.1.0.4.1.1 Recovery Unit System – Tooling and accessories	
All necessary tooling and accessories necessary for proper operation shall be supplied.	
Clarification: Tooling will consist of at least: test sticks, earthing gear, software for readout of data and change of settings etc.	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.0.5 Requirement Aspect: Availability

3.1.0.5.1.1 Recovery Unit System – Availability	
The RU system shall have an availability of at least 99.9% per year.	
Clarification (optional):	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.0.5.1.2 Recovery Unit System – Maintenance interval	
Preventive maintenance must be very limited and shall only be necessary maximum once in 2 years per RU.	
Clarification (optional):	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.0.5.1.3 Recovery Unit System – Preventive maintenance duration	
Preventive maintenance on the RU shall take a maximum of 2 hours.	
Clarification (optional):	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.0.5.1.4 Recovery Unit System – MTBF	
The MTBF should be … minimum.	
Clarification (optional):	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.0.5.1.5 Recovery Unit System – MTTR	
The ARU shall have a MTTR of maximum 4 hours.	
Clarification: Based on the direct availability of spare parts. I.e. travel time etc. is not taken into account. This means that the effective MTTR may be higher on the level of the customer criteria.	
Verification method: (optional)	Normen: IEC 62474

3.1.0.6 Requirement Aspect: Hinder

3.1.0.6.1.1 Recovery Unit System – Noise	
The average sound level during 8 hours measured at a distance of 1 m and at a height of 1.50 m above ground level should not exceed 80 dB(A).	
Clarification: Below this level ear protection is not required.	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.0.7 Requirement Aspect: Safety

3.1.0.7.1.1 Recovery Unit System – CE Certificate	
The RU shall be CE certified.	
Clarification (optional):	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.0.7.1.2 Recovery Unit System – Short-circuit proof	
The RU shall be thermically and dynamically short-circuit proof.	
Clarification (optional):	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.0.7.1.3 Recovery Unit System – Insulated mounting	
The RU shall be mounted completely insulated from earth. The installation is connected to earth by means of an earth-leakage protection, which detects a short circuit current from the DC-circuit to the frame. The earth leakage protection shall be short-circuit proof.	
Clarification (optional):	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.0.7.1.4 Recovery Unit System – Emergency shut off	
Optionally, the ARU shall have an emergency shut off button in a (dust) protective housing. After use, it should only be resettable with a key (Ronis 455).	
Clarification (optional):	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.0.7.1.5 Recovery Unit System – Cable type	
The applied cabling and wiring in the RU shall be halogen free, low-smoke and difficult to burn.	
Clarification (optional):	
Verification method: (optional)	Standard: NEN 8012

3.1.0.7.1.6 Recovery Unit System – Voltage neutral enclosure	
The RU shall be enclosed in a protected, voltage neutral enclosure, in accordance with EN 50328 section 3.8.1.	
Clarification (optional):	
Verification method: (optional)	Standard: EN 50328

3.1.0.8 General

3.1.0.8.1.1 Recovery Unit System – Single-line scheme	
The RU will be provided with a single-line scheme on the front panel.	
Clarification: The scheme has to has to be location specific, with the right encoding.	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.0.8.1.2 Recovery Unit System – Setting of control parameters	
All control parameters of the RU can be set either directly on the RU and/or via a Personal Computer or the HMI.	
Clarification (optional):	

3.1.0.8.1.2 Recovery Unit System – Setting of control parameters	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.0.8.1.3 Recovery Unit System – Signalling trips	
Any activation of built-in protection, or any other malfunction of the RU that results in a reduced operation, shall be signalled locally, and remote (type, start time, duration).	
Clarification (optional):	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.0.8.1.4 Recovery Unit System – Station automation	
The RU shall make a coupling with the station automation system based on IEC61850/GOOSE version 2.0. The recovery unit communicates with a fieldbus and the IEC 61850 protocol with the rest of the control system. Only standard IEC 61850 codes are permitted.	
Clarification: Trips, status and switching states will be coupled with fiber optics tot he CBI. No hardwired connections will be used.	
Verification method: (optional)	Norm: IEC61850/GOOSE

3.1.0.8.1.5 Recovery Unit System – Operational Status	
The RU shall provide an output signal for each relevant signal regarding the operation of the RU, namely: • Operation status: Disconnected, Connected, Ready; • Error status: None, Warning, Fault, TripFault; • Individual signals for each fault indication; • Feedback status: Inactive, Active; • States of the switching devices: Disconnected, Connected. • Control mode: Local, Remote.	
Clarification (optional):	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.0.8.1.6 Recovery Unit System – Status switches	
De status of the coupling switches at the AC and DC-side shall be displayed on the HMI.	
Clarification (optional):	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.0.8.1.7 Recovery Unit System – Indication actual DC-current
De recovery unit indicates the recovered DC-current (I_d). This information is also supplied to the fieldbus.
Clarification (optional):

3.1.0.8.1.7 Recovery Unit System – Indication actual DC-current	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.0.8.1.8 Recovery Unit System – Indication actual DC-voltage	
De recovery unit indicates the measured DC-voltage (U_d). This information is also supplied to the fieldbus.	
Clarification (optional):	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.0.8.1.9 Recovery Unit System – Indication actual power	
De recovery unit indicates the actual recovered power. This information is also supplied to the fieldbus.	
Clarification (optional):	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.0.8.1.10 Recovery Unit System – Registration recovered energy	
The recovery unit measures and counts the amount of recovered energy: • The total amount of recovered energy • The amount of recovered energy per quarter • The amount recovered energy per day • The amount recovered energy per month This information is also supplied to the fieldbus.	
Clarification (optional):	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.0.8.1.11 Recovery Unit System – Switching	
The recovery unit can be switched on and off local and remote.	
Clarification (optional):	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.0.8.1.12 Recovery Unit System – Reset of faults	
The recovery unit can be reset local and remote.	
Clarification (optional):	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.0.8.1.13 Recovery Unit System – Logging	
The RU shall provide automatic logging and presentation of RU signals and data via an internal or external tool. Downloading the logging should be simple.	
Clarification (optional):	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.0.8.1.14 Recovery Unit System – HMI	
Signals and data can be presented on a local display and on the HMI.	
Clarification: New substations will be equipped with a HMI to show statuses and data.	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.0.8.1.15 Recovery Unit System – Timestamp	
Logged and presented data shall have a timestamp, accurate within 0.001% per year.	
Clarification (optional):	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.0.8.1.16 Recovery Unit System – Dashbord	
A daily overview, or more frequent, shall be available for the CBI.	
Clarification (optional):	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.0.8.1.17 Recovery Unit System – Location controls and indication	
Controls and indicating devices on the enclosure shall be located between 450 mm and 1800 mm from ground level.	
Clarification (optional):	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.0.8.1.18 Recovery Unit System – Auxilliary supply voltage	
The auxiliary power supply that powers the ARU itself shall be 24 V DC +10% / -15%.	
Clarification (optional):	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.0.8.1.19 Recovery Unit System – Power consumption auxiliary supply	
Power consumption shall be below 1000 W.	
Clarification (optional):	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.0.8.1.20 Recovery Unit System – Blackout	
At power interruptions the recovery unit shall shut off safely.	
Clarification (optional):	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.0.8.1.21 Recovery Unit System – UPS	
The RU shall use the substation's UPS for coping with auxiliary power supply interruptions, unless its power consumption exceeds the available power. In that case the capacity of the substation's UPS will be expanded.	
Clarification (optional):	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.0.8.1.22 Recovery Unit System – Cooling system power supply	
If a separate auxiliary power supply for the cooling system is required; it shall be AC 50 Hz and: • 230 V +10%/-14% for single-phase installations • 400 V +10%/-14% for three-phase installations	
Clarification: The cooling system may not be supplied from the 48V auxilliary supply of the substation.	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.0.8.1.23 Recovery Unit System – Real Time Clock	
The real-time clock function can overcome an 8 hour power cut.	
Clarification: During activities or short power interruptions the real-time clock must stay active.	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.0.8.1.24 Recovery Unit – Control locations	
Control of the Recovery Unit can be done in three ways: • Local. This means control in the substation on the RU itself. • Remote. This means control from the HMI in the substation. • Distance-control. This means control from the command centre (CVL/Schakelwacht) The choice between "Local", "Remote" or "Distance-control" shall be made by a selector switch on the RU. The selector switch shall be implemented as a key switch. De selector switch shall be a threestate switch with the following implementation: • In the position "Local" only local given commands should be executed on the RU. • In the position "Remote" only commands given from the HMI should be executed. • In the position "Distance-control" only given commands from the CVL/Schakelwacht should be executed. The position of the selector switch shll be indicated on the RU, the HMI and the CBI/schakelwacht. Changing the position of the selector switch may not change the status of the RU.	
Clarification (optional):	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.0.8.1.25 Recovery Unit – Disconnectors and switchgear	
The disconnectors Recovery Unit shall be motor controlled.	
Clarification: The disconnector is for the benefit of connection of the recovery unit.	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.0.8.1.26 Recovery unit – Disconnector control	
The disconnectors shall be able to be controlled remote and on distance.	
Clarification (optional):	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.0.9 Frame leakage protection

3.1.0.9.1.1 Recovery Unit System – Frame leakage protection
In compliance with EN 50328 section 3.8.2, the RU shall be protected against frame leakage (gestelsluiting, IEC 60050 IEV 488-14-21

3.1.0.9.1.1 Recovery Unit System – Frame leakage protection	
Clarification (optional): As specified in EN 50123-7-1 section 6.5.7 (Frame fault protection of the switchboard) this can be done in several ways. If a frame protection is present on the rectifier, the RU shall be placed on insulating material and its enclosure shall be electrically interconnected with the enclosure of the rectifier. If no existing frame leakage protection present, the RU shall include one.	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.1 Internal wiring

3.1.1.1.1.1 Recovery Unit System – Internal wiring	
The applied cabling and wiring in the RU shall be halogen free, low-smoke and difficult to burn.	
Clarification (optional):	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.1.1.1.2 Recovery Unit System – Coding	
Internal wiring needs to be coded.	
Clarification (optional):	
Verification method: (optional))	Guidelines/Standards (optional)

3.1.2 Local/ Central control of the Recovery Unit (CBI)

3.1.2.1 Control (Station automation)

The different protection relays are coupled according the standard IEC61850/GOOSE. The intelligence is as much as possible implemented in distributed protection relais IED). There are functions that need to be realized in a more central IED. Also a central unit is available for communication with the Central Besturings Installatie (CBI). This is the local control unit (the station automation unit for the substation).

3.1.2.1.1.1 Recovery Unit System – RU in and out of service	
De RU shall be able to local (on installation level), remote (from HMI) and by means of distance control (from the CBI) switched off and back to service if desired.	
Clarification (optional):	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.2.1.1.2 Recovery Unit System – CBI	
The RU shall be equipped with remote control and signalling for all commands, states, alarms and measurements that are necessary for a proper operation. This information shall be communicated with the CAB of the GVB. A connection with the existing CBI-system shall be forseen.	
Clarification (optional):: Based on the by OG agreed location specific IO-list, compiled by ON on the template IO-list in appendix **Fout! Verwijzingsbron niet gevonden.**.	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.2.1.1.3 Recovery Unit System – IO-list	
ON shall present a location specific IO-list for approval in the UO phase. The IO-list shall be made location specific based on the template IO-list.	
Clarification (optional):: See template IO-lijst in appendix **Fout! Verwijzingsbron niet gevonden.**.	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.2.2 HMI

The HMI is located in the DC & Low voltage compartment.

3.1.2.2.1.1 Recovery Unit System – HMI Remote control	
Control of the Recovery Unit can be done on three levels: • Local • Remote • Distance-control	
Clarification: • With local control is meant : control and monitoring on the RU itself. This can be by push buttons on the panel, indication lamps, but also by control and readout of (touch)-screens of protection relays. Also switching of disconnectors/earthers by means of switching handles belongs to local control. On behalf of local switching, one-line schemes will be applied on the panels. • With remote control is meant: control and monitoring of the RU via a central located screen in the substation. • With distance-control is meant: control and monitoring of the RU via the CVL/Schakelwacht.	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.2.2.1.2 Recovery Unit System – Remote control – State indication	
The status of all present main switches in the RU (DC-coupling, AC-coupling, disconnectors, earthers), the status shall be shown: • Open • Closed • Earthed (if applicable) It shall not be possible to bridge lockings in the primary circuit by remote or distance-control.	
Clarification (optional):	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.2.2.1.3 Recovery Unit System – Remote control – Control	
Control of the following functions shall be possible (after switching to local control): • Switching the RU on and off • Resetting failures/ accepting alarms	
Clarification (optional):	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.2.2.1.4 Recovery Unit System – Remote control – Analogue values	
De next analogue values can be displayed • Voltage on the DC-rail • Current from the DC-rail • Current to the AC-grid • Power to the AC-grid	
Clarification (optional):	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.2.2.1.5 Recovery Unit System – Remote control – Signalling/Alarms	
De next signals/alarms can be displayed: • Faults/alarms of the RU The signalling/alarms shall be visualized in an alarmlist and logged.	
Clarification (optional):	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.2.3 Auxilliary Supply

3.1.2.3.1.1 Recovery Unit System – AC auxiliary supply	
The AC supplied secundary installations of the RU shall be suitable to be fed from the auxilliary AC supply from the substation with the following specifications: - Input voltage: 400V AC/ 3 phase - System: TN-S - Frequency: 50 Hz - Voltage- and frequency variation: according NEN-EN-50160 - Tolerances: according ACM Netcode Elektriciteit	
Clarification (optional):	
Verification method: (optional)	Standards: NEN-EN-50160

3.1.2.3.1.2 Recovery Unit System – DC auxiliary supply	
The DC supplied secondary installations of the RU shall be suitable to be fed from the auxilliary DC supply from the substation with the following specifications: - Nominal output voltage 48VDC - Output voltage tolerance +/-15% - Spare capacity: 20%.	
Clarification (optional):	
Verification method: (optional)	Guidelines/Standards (optional)

3.1.2.3.1.3 Recovery Unit System – Cabinet lighting	
Control cabinets shall be equipped with lighting.	
Clarification (optional):	
Verification method: (optional)	Guidelines/Standards (optional)

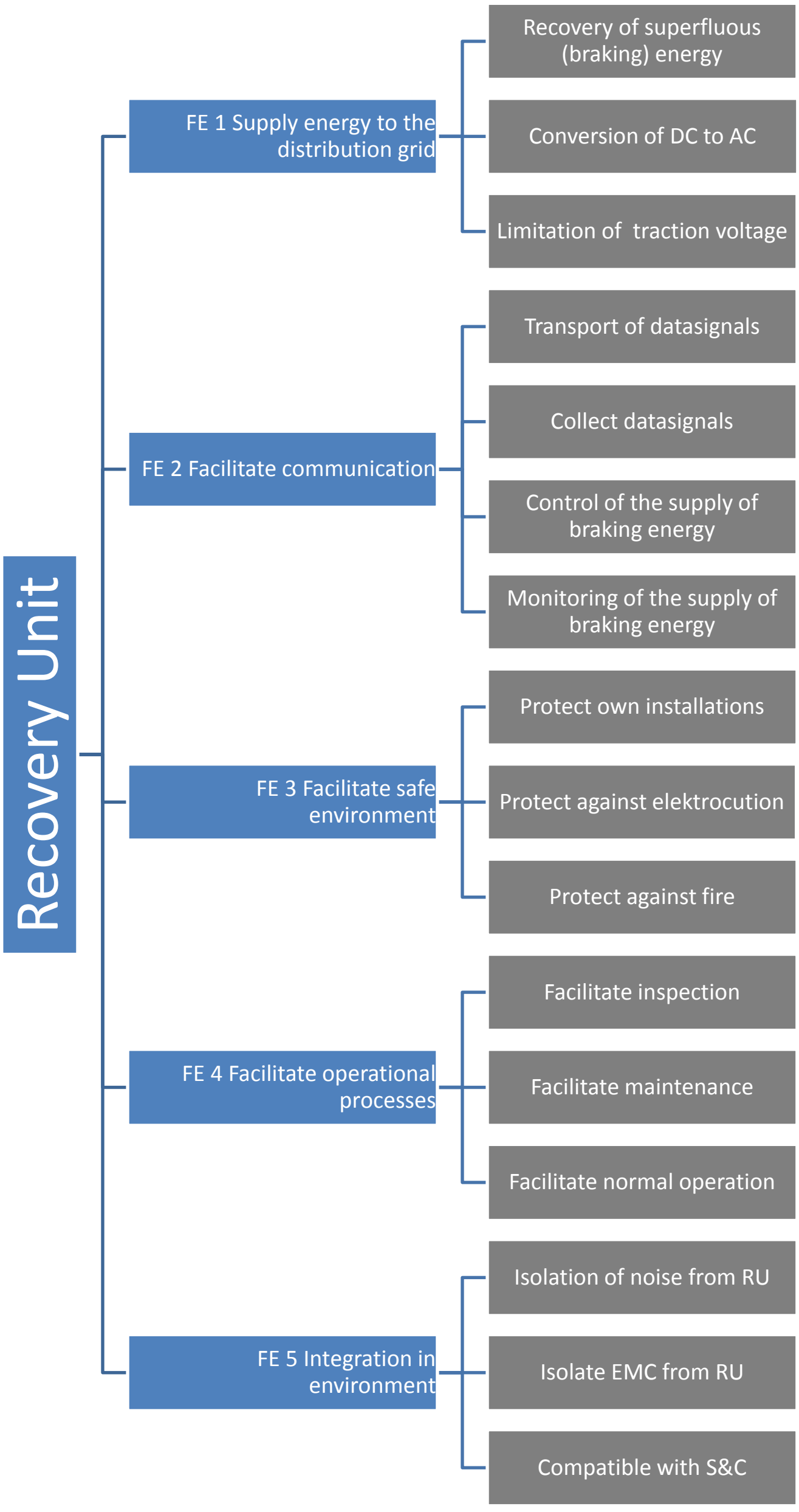
4 Appendices

4.1 Electrical Specifications
4.2 Function tree
4.2 Object tree
4.3 GS_Grondschema
4.4 GS_Opstellingstekening
4.5 Template IO-lijst
4.6 Abbrevations and acronyms Metro en Tram

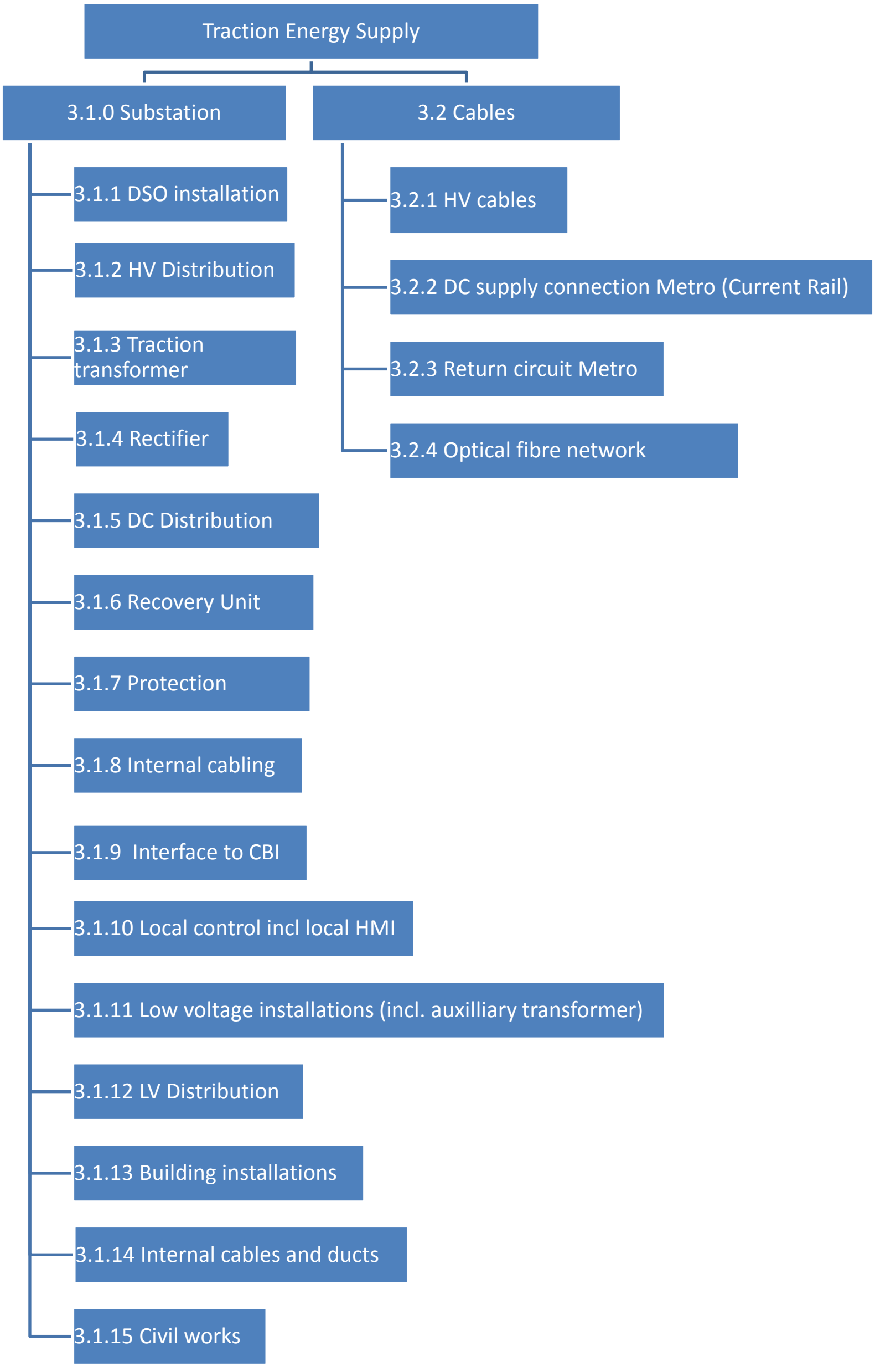
4.1 Electrical specifications

#	Eis	Waarde
1	Nominal direct voltage Un	750 V
2	Direct voltage variation steady state	+20%/-33% van U_n
3	Direct voltage variation short time (1 .. 5 s)	+30%/-33% van U_n
4	Rated direct voltage UNd (feedback activation threshold direct voltage Ud,th)	750 .. 900 V
5	Highest permanent direct voltage Ud,max1 (breaking resistors active)	900 V
6	Highest non-permanent direct voltage Ud,max2 (at most for 5 min)	1000 V
7	Highest long-term overvoltage Ud,max3 (duration 0.02 .. 1 s)	1270 V
8	Lowest permanent direct voltage Ud,min1	900 V
9	Rated impulse voltage UNi (EN 50124-1, overvoltage category OV2: circuits with normal transient overvoltages, and normal availability requirements)	5 kV
10	Lowest permanent direct voltage Ud,min1	500 V
11	Lowest non-permanent direct voltage Ud,min2	500 V
12	Basic direct current IBd	1111 .. 1333 A
13	DC Power Pd	1 MW
14	Nominal primary alternating voltage Umain	10 kV
15	Rated AC frequency fN	50 Hz
16	Frequency range	±2% van f_N
17	Frequency rate of change	±1%/s
18	Rated (secondary) alternating voltage ULN	615 V
19	Alternating voltage variation steady state	+10%/-10% van U_{LN}
20	Alternating voltage variation short time (0.5 .. 30 cycles)	+15%/-15% van U_{LN}
21	Rated alternating current ILN	940 A @ 615 V

4.2 Function tree



4.3 Object tree



5 Additional projectspecifications/changes

Paragraaf	Eisnr	Eistekst origineel	Eistekst gewijzigd	Motivatie