Gemeente Amsterdam

Recovery Unit system specification

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Validations and authorisation

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Contents

List of images

1 Introduction

This document sets out the technical specifications and functional backgrounds for the Recovery Units to be newly realised and commissioned intended to be able to supply excess brake energy of traction vehicles back to the power grid in the Metro and Tram rectifier stations.

The specification sets out the requirements applicable to the Recovery Unit including the related technical specifications.

And finally, it is required in connection with the components inside the station that compatibility is guaranteed between the Recovery Unit and the other components that have been installed in the rectifier station. This compatibility guarantees the proper operation of the components in the station that has been delivered; in particular with respect to the provision of safety, maintenance, reliability and the expected service life.

This is a generic specification for Recovery Unit for Metro.

1.1 Abbreviations

A full list of the abbreviations used and the Metro and Tram acronyms has been included as a schedule in paragraph 1.2.

Abbreviation	Meaning
A	Ampère
AWI	Automatic Re-engagement
BLVC	Accessibility, Quality of Life, Safety and Communication
CAB	Central Remote Control
CBI	Central Control Installation
dB	Decibel
DC	Direct Current
DD	Definitive Design
EN	European Standard
FIT	Factory Integration Test
FD	Functional Design
GOOSE	Generic Object Oriented Substation Event
GVI	Direct Current Distribution System
HMI	Human Machine Interface
HVI	High-voltage Distribution System
Hz	Hertz
IEC	International Electrotechnical Commission
IED	Intelligent Electronic Device

Abbreviation	Meaning
IO	Input Output
IP	International Protection Marking
kPa	Kilo Pascal
kV	Kilovolt
kWh	Kilo Watt hour
LVI	Low-voltage distribution system
MVA	Mega Volt Ampère
Ni-Cad	Nickel Cadmium
NSA	Emergency power generator
OG	Client
ON	Contractor
PLC	Programmable Logic Controller
RU	Recovery Unit
SAT	Site Acceptance Test
SCADA	Supervisory Control And Data Acquisition
SIT	Site Integration Test
SS	Switching station
TDD(I)	Total Current Demand Distortion
UO	Implementation Design
V	Volt
VLD	Voltage Limiting Device
WCD	Wall socket

1.2 Binding documents

Title	Document number	Version	Date
Afkortingen en acroniemen	CEB\OVG\19462	1.0.0.0	15-7-2019
Elektrotechnisch Bedrijfsvoering Handboek voor Railinfrastructuur Metro en Tram Amsterdam	WLS\OVG\18867	3.2	10-07-2018
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
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
Richtlijnen voor toelaatbare harmonische stromen	EnergieNed	-	Juni-1997
Template I/O lijst Recovery unit	CEB\OVG\26092	1.0	3-5-2021
Blokschema CBI Metro	CEB\OVG\25957	1.0	11-2-2020
Schakelmatrix Gelijkrichterstation Metro	CEB\OVG\26033	0.3.6.1	10-5-2021
Schakeltoestanden Metro	CEB\OVG\26115	0.4.0.0	7-5-2021

1.3 Standards

This paragraph provides an overview of relevant standards and guidelines.
Deliveries must comply with Dutch Legislation and Regulations and the Buildings Decree.

In addition, the delivery must comply with all applicable standards, regulations and guidelines set out below, in the prevailing order set out below:

1. GVB/MeT Specific Regulations
2. NEN (Dutch Standards)
3. EN (European Standards) and European harmonisation documents (HD)
4. IEC (Standards of the International Electrotechnical Commission)
5. NPR (Netherlands Code of Practice)
6. EnergieNed Guidelines

7. VDE (guidelines of the German Verband der Elektrotechnik, Elektronik und Informationstechnik)
8. ATEX (European Directives in the area of the danger of explosion)

The overview of standards does not aim to be exhaustive. The contractor is required to include additional and/or replacement standards that apply to the work.

1.3.1 Specific standards

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 50122-3	Spoorwegen en soortgelijk geleid vervoer - Vaste installaties - Elektrische veiligheid, aarding en retourstromen - Deel 3: Wederzijdse beïnvloeding van met wisselspanning gevoede tractiestelsels en met gelijkspanning gevoede tractiestelsels
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 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 50328	Railtoepassingen – Vaste inrichtingen –Elektronische vermogensomzetters voor onderstations
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-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
IEC 60146-1-1	Halfgeleideromzetters – Algemene eisen en omzetters met netcommutatie – Deel 1-1: Specificatie van basiseisen.
IEC 61850	Communicatienetwerken en – systemen in substations.

1.3.2 General standards

NEN 1010	Veiligheidsbepalingen voor laagspanningsinstallaties (complete versie)
NEN 3140	Bedrijfsvoering van elektrische installaties – Aanvullende Nederlandse bepalingen voor laagspanningsinstallaties.
NEN-EN 50110	Bedrijfsvoering van elektrische installaties – Algemene bepalingen.
NEN 5152	Technische tekeningen - Elektrotechnische symbolen.
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	Richtlijnen voor toelaatbare harmonische stromen.
Netcode Elektriciteit	Voorschriften voor netbeheerders en netgebruikers over het functioneren, het aansluiten van klanten en het transporteren van elektriciteit.
Meetcode Elektriciteit	Voorschriften voor netbeheerders en netgebruikers over het meten van de hoeveelheid elektriciteit die vervoerd en verbruikt wordt.

2 System Recovery Unit

2.1 System description

The Recovery Unit subsystem is required to supply back to the electricity network electrical brake energy of metro vehicles that cannot be taken up by another vehicle or user.

2.2 Functional description of the system

The Recovery Unit (RU) system implements the desired functions within the system limits. The desired functions are shown in Image 2-1. Table 1 contains an outline functional description of the 'RU' system.

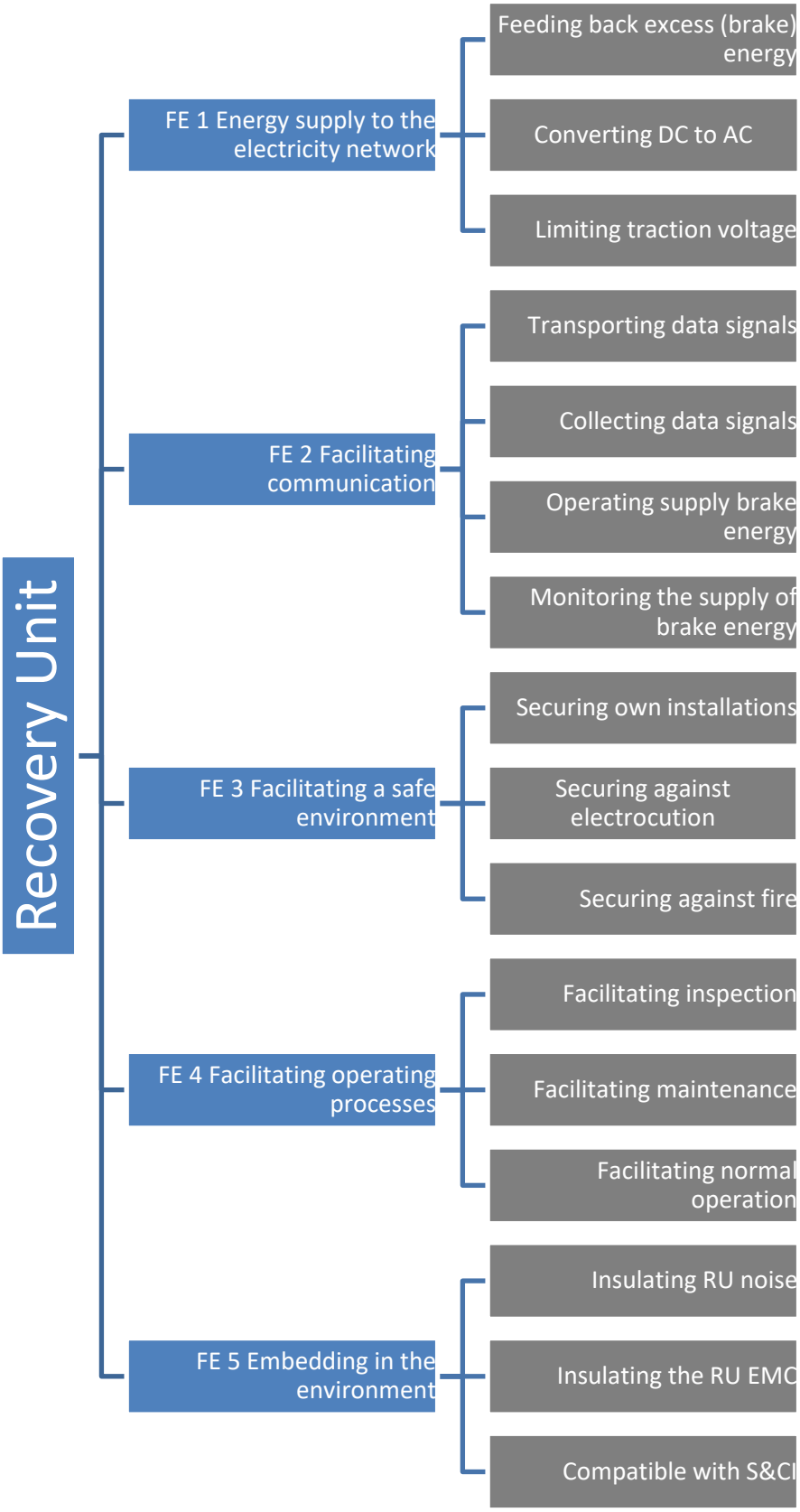

Image 2-1 – Function tree

ID	Function	Function description
FE 1	Energy supply to the electricity network.	The supply of brake energy from the DC metro network to the AC distribution network.
FE 2	Facilitating communication	Collecting and transporting data signals. Operating and monitoring the supply back of traction energy.
FE 3	Facilitating a safe environment	Securing the installation against fire and electrocution and preventing the installation from become defective as a result of external circumstances.
FE 4	Facilitating operating processes	Facilitating inspection and maintenance of the installation by employees of the manager. Facilitating normal operations (operation)
FE 5	Embedding in the environment	Avoiding impact of the RU on the environment such as noise and other nuisance.

Table 1 – Functional analysis – System Recovery Unit.

Image 2-2 - Objects Traction Power substation indicates the place of the Recovery Unit within the rectifier station.

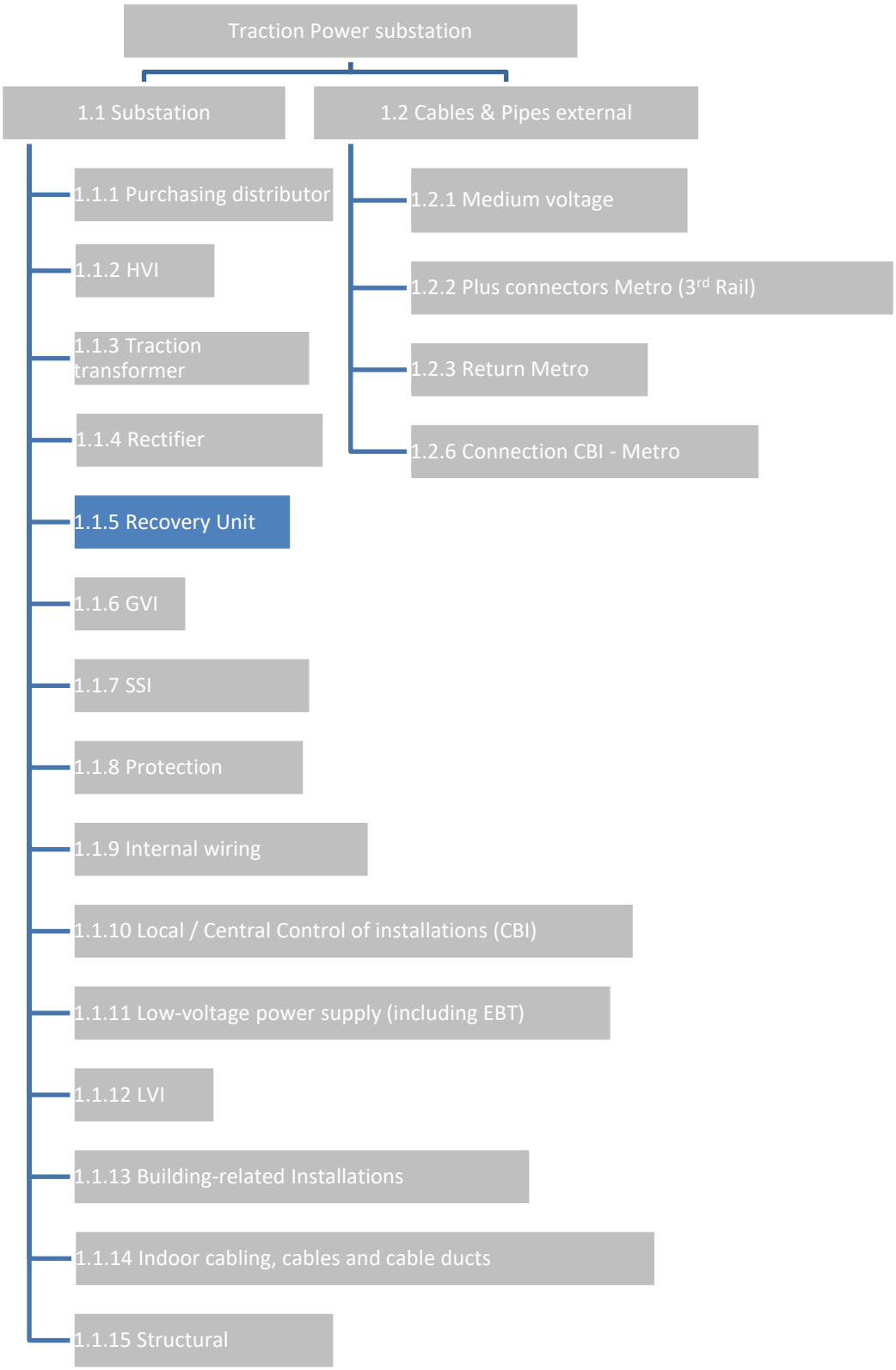

Image 2-2 - Objects Traction Power substation

Table 2 – Relationship between functions Recovery Unit and Objects Shows a cross table which indicates; per object which interfaces the object has with the functions of the Recovery Unit.

Object\Function		FE 1 Energy supply to E-net	FE 2 Facilitating communication	FE 3 Facilitating a safe environment	FE 4 Facilitating operating processes	FE 5 Embedding in the environment
1.1.1	Purchasing distributor					
1.1.2	HVI	X				
1.1.3	Traction transformer	X				
1.1.4	Rectifier	X				
1.1.5	GVI	X				
1.1.6	Recovery Unit	X	X	X	X	X
1.1.7	Protection	X		X		
1.1.8	Internal wiring	X	X			
1.1.9	Interface CBI		X		X	
1.1.10	HMI				X	
1.1.11	Low-voltage power supply					
1.1.12	LVI	X				
1.1.13	Building-related installations					
1.1.14	Indoor cabling, cables and cable ducts	X	X		X	
1.1.15	Structural			X	X	X
1.2.1	High-voltage cables	X				
1.2.2	Plus connectors Metro (3rd Rail)	X				
1.2.2	Minus cables (return)	X				
1.2.4	Fibreglass network		X		X	

Table 2 – Relationship between functions Recovery Unit and Objects

2.3 Embedding in Metro Rectifier Station

Intended locations for installing the Recovery Unit are the Metro Recovery stations. Installation space has been reserved in the typical implementation of Metro rectifier stations measuring 3000x1600 mm and 500x1400 mm for a disconnector with the plus/min rail. The structure of the rectifier station can be seen in the single line diagram and the installation drawing. These drawings have been added to this specification as schedules, they being this Rectifier Station Single Line Diagram and the Rectifier Station Installation Drawing (see paragraph 1.2). These are drawings in principle and not location-specific drawings. Deviations are anticipated depending on the location.

The assumption is that the Recovery Unit is placed parallel to the rectifier and linked on the AC and DC sides. A direct link to the medium-voltage network requires an additional medium-voltage field and a medium-voltage transformer.
In case of new construction or complete replacement, it is also allowed to place a Bidirectional Unit, in which the rectifier and the Recovery Unit have been integrated.

The GVI is provided with a circuit breaker field to which the Recovery Unit can be connected with a connection to the plus rail and a connection to the minus rail. A connection possibility is also provided for in the connection on the AC side (secondary side traction transformer).

The existing traction power substations do not have additional connections and a circuit breaker field will have to be added in order to link the RU to the DC rail. It also depends on the location whether sufficient space is available to place the Recovery Unit.

3 Requirements Recovery Unit

This chapter sets out the requirements imposed on the Recovery Unit.

3.1 Definition of requirements

Characteristic of this specification is the classification into the various types of requirements and the coherence between the requirements. The requirements can be distinguished by the following types of requirements:

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

A definition per type requirement is provided in Table 3.

Type requirement		Explanation
Functional requirements		Functional requirements are requirements concerning the primary function or performance of the system and the objects that make up the system.
Aspect requirements	Reliability	The probability that the required function is carried out in the given circumstances during a certain period.
	Availability	The probability that the required function may be carried out at a given random moment in the given circumstances. This corresponds to the faction of time in which the required function can be carried out in the given circumstances.
	Maintainability	Requirements with respect to the required management and maintenance efforts of the system or objects to be realised and the ease and speed with which a system can be restored to operational status following a failure.
	Safety	Requirements with respect to the safety of the system or objects to be realised during the use phase, for both the user and the environment.
	Design	Requirements with respect to the aesthetic appearance of the system or objects to be realised.
	Service life	Requirements with respect to the required service life of the system or objects to be realised.
	Future-proofness	Requirements with respect to making the system suitable for future use.
Realisation requirements.		The system must satisfy and preconditions set out in the GVB Electrotechnical Safety Manual during the realisation phase.
Interface requirements.	External interface	Requirements with respect to the system's interfaces with the (future) environment outside the system limits.
	Internal interface	Requirements with respect to interfaces within the system in connection with the systems/objects that must be designed or realised by third parties or that are imposed with respect to the interaction between the various objects within the system.

Table 3 – Types of requirements definition

3.2 Tables of requirements

The requirements in this System specification are represented in accordance with the format in Table 4 – Requirement format.

ID Title of the requirement	
Text of the requirement	
Explanation (optional)	
Verification method (optional)	Regulation/Standards (optional)

Table 4 – Requirement format.

	:	Supplier of engineering and components (also called indicated by the letter L in the requirement number).
	:	Delivery/Implementation Installer (also called 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.
Regulation/Standards (optional)	:	Applicable regulations 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
003	single line diagram
004	Object Architecture
005	Interface list

System group code YYY	Group name
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 disconnector
044	GVI-disconnector 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-EB 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 Stop circuit
090	Building-related installations
091	Project management
092	Interface management

System group code YYY	Group name
093	Designs
094	Implementation
095	Testing
096	Verification/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– System group coding

4 Requirements Recovery Unit

This specification is generic for Recovery Units for Metro

4.1 Functional Requirements

L-M-31-001 System Recovery Unit – Electrical specifications	
The Recovery Unit must satisfy the electrical specifications in accordance with EN 50328 and EN 50163 set out in par. 1.3.	
Explanation (optional)	
Verification method: Document assessment	Standards: NEN-EN 50328, NEN-EN 50163

L-M-31-002 System Recovery Unit – Brake energy recovery	
If the Recovery Unit is active, the excess energy generated by braking vehicles that cannot be used by other vehicles in the environment is fed back from the DC traction network to the AC electricity network.	
Explanation: This excess energy is otherwise converted into heat in the breaking resistor and is lost.	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-003 System Recovery Unit – Threshold voltage	
In the event the voltage of the traction network (Ud) exceeds the threshold voltage of the recovery unit ((Ud,th), the unit will operate with a near-constant voltage curve, until maximum power has been reached. Power is kept constant until that moment and the voltage will increase.	
Explanation: The recovery unit must obstruct the exchange of brake energy between vehicles as little as possible.	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-004 System Recovery Unit – Maximum operating voltage	
The maximum operating voltage of the recovery unit is determined by the maximum voltage when braking, Ud,max1 in accordance with EN 50163.	
Explanation: Braking vehicles limit the voltage at which they feed back; excess energy is converted into heat in case of an imminent breach of the limit.	
Verification method (optional)	Standard: NEN-EN 50163

L-M-31-005 System Recovery Unit – Connecting and disconnecting	
Connecting the recovery unit to a passive rectifier must not affect the functionality of the rectifier. It must also be possible to disconnect the recovery unit from the rectifier without affecting the functionality of the rectifier.	
Explanation (optional)	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-006 System Recovery Unit – Threshold voltage adjustable	
The threshold value at which the recovery unit is activated $U_{d,th}$ (=U_{Nd}) must be adjustable in order to obtain optimal feedback.	
Explanation: The recovery unit must not be activated until above the no-load voltage and must enable the exchange of energy between vehicles.	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-007 System Recovery Unit – Duty Cycle	
The maximum duty cycle assumes delivery of 1 MW at a voltage between 750 and 900VDC for a period of 30 seconds every 3 minutes.	
Explanation: The assumption is that a metro stops every 3 minutes and braking takes 30 seconds.	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-008 System Recovery Unit – Efficiency	
The yield of the recovery unit must be at least 97.5%.	
Explanation: A high yield is favourable for recovered energy and less heat needs to be discharged.	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-009 System Recovery Unit – Harmonics	
The power fed back must satisfy a TDD(I) of less than 5%. The individual harmonic components must satisfy the EnergieNed guideline.	
Explanation: Injected harmonic components may cause failures at other clients.	
Verification method (optional)	Regulation/Standards: Guidelines for permissible harmonic currents, EnergieNed.

L-M-31-010 System Recovery Unit – Overload Protection	
Overload protection: the recovery unit must be able to detect an overload situation, deactivate it temporarily and reactivate automatically after a cooling-down period. Deactivation and activation must be reported to the CBI.	
Explanation: Overload may occur if duty cycle requirements or other electrical specifications are exceeded.	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-011 System Recovery Unit – Overcurrent Protection	
Overcurrent protection: the recovery unit must have overcurrent protection both on the AC and on the DC side. Activation of the overcurrent protection must be reported to the CBI.	
Explanation (optional)	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-012 System Recovery Unit – Stability	
The recovery unit must cause stability problems involving the control systems in the vehicles.	
Explanation: The braking chopper in the metro vehicles intervenes at the moment the voltage on the overhead cable/third rail. The control of the Recovery Unit also depends on the traction voltage. These must not affect each other in such a manner that instability arises. The onboard network also monitors the traction power and may therefore fail.	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-013 System Recovery Unit – Rail security interface	
The recovery unit must not affect the rail security system.	
Explanation: The Recovery Unit must not produce frequency components that affect the rail security system.	
Verification method (optional)	Regulation/Standards (optional)

4.2 Aspect requirement: Maintainability

L-M-31-014 System Recovery Unit – Resources
The RU must be suitable for maintenance by service personnel. All auxiliary materials, tools, documentation, software and applications required must be delivered for the purpose of being able to conduct the maintenance under our own management.
Explanation: This concerns among other things earthing sets and software for the purpose of setting/reading parameters, errors, loggings etc.

L-M-31-014 System Recovery Unit – Resources	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-015 System Recovery Unit – Removing power	
The RU must be able to de-energize after the installation has been switched off.	
Explanation: Components that have a load in operating conditions, such as capacitors remain powered also after they have been switched off.	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-016 System Recovery Unit – Documentation	
An Installation and Maintenance Manual and a separate User Manual must be delivered. All user documentation must be delivered in the Dutch language; specific technical documentation may be delivered in the English language.	
Explanation (optional)	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-017 System Recovery Unit – Training	
The supplier of the Recovery Unit must provide training to the assembly and maintenance mechanics.	
Explanation (optional)	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-018 System Recovery Unit – Self-diagnosis	
If possible, self-diagnosis functions must be embedded in order to indicate the need for (preventative) maintenance instead of a fixed interval maintenance regime.	
Explanation (optional)	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-019 System Recovery Unit – Accessibility	
It must be possible for first-line maintenance staff to inspect all diagnostics indicators (e.g. wear and tear indication on switch mechanisms) without dismantling equipment.	
Explanation (optional)	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-020 System Recovery Unit – Connecting cables	
It must be possible to connect cables without special tools.	
Explanation (optional)	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-021 System Recovery Unit – Grounding balls	
All live components must be provided with 20-mm grounding balls in accordance with EN 50328 section 3.8.2 (Grounding).	
Explanation (optional)	
Verification method (optional)	Standards: EN 50328

L-M-31-022 System Recovery Unit – Type plate	
The recovery unit is provided with a type plate and other markings as required in EN 50328 section 3.9	
Explanation (optional)	
Verification method (optional)	Standards: EN 50328

4.3 Aspect requirement: Reliability

L-M-31-023 System Recovery Unit – Service life	
The technical service life of the recovery unit is at least 30 years. Components with a shorter service life are identified and can be replaced.	
Explanation: It must be possible to maintain and upgrade the system during the technical service life in order to maintain a reliable, operational system.	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-024 System Recovery Unit – Climate	
The RU must operate without interruption in the Dutch climate. A moderate maritime climate must be assumed.	
Explanation (optional)	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-025 System Recovery Unit – Storage and transport	
The recovery unit satisfies the storage and transport requirements in accordance with EN 50328 section 2.2.2.1 Storage and transport temperature: -25°C ≦ Permitted ≦ +55°C.	
Explanation (optional)	
Verification method (optional)	Standards: EN 50328

L-M-31-026 System Recovery Unit – Environment	
The recovery unit must be able to operate in the environmental requirements of a traction rectifier station in accordance with EN 50328 section 2.2	
Explanation (optional)	
Verification method (optional)	Standards: EN 50328

L-M-31-027 System Recovery Unit – Environmental conditions	
The recovery unit must be able to operate in the following (cooled) air conditions: Temperature, in accordance with EN 50328 section 2.2.2.2.1: • Extreme air temperature: -5°C ≦ Permitted ≦ +40°C. • Maximum average day temperature: +35 °C • Average annual temperature: +25 °C Humidity, in accordance with EN 50328 section 2.2.2.2.2: • Relative humidity: at least 15%, at most 80% (uncondensed) Pollution, in accordance with EN 50328 section 2.2.2.2.3: • Pollution level PD3A (dust with conductivity, humidity: damp with long-term condensation), see EN 50124-1 Table A.4.	
Explanation (optional)	
Verification method (optional)	Standards: EN 50328, EN 50124

L-M-31-028 System Recovery Unit – Cooling	
Naturally, it is preferred that the recovery unit is air-cooled, but indirect cooling with identification code AFAN, in accordance with EN 50328 section 2.1, is also permitted. • Heat transfer medium: AF (air, with forced circulation by means of an integrated ventilator); • Cooling medium: AN (air with natural circulation)	
Explanation: Water cooling or cooling using fluids that could cause greenhouse gases when released are not allowed.	
Verification method (optional)	Standards: EN 50328

L-M-31-029 System Recovery Unit – Vibrations	
The recovery unit must be suitable for operating at vibrations in accordance with EN 50328 section 2.2.2.2.4: 10 Hz sinusoidal vibrations in vertical and/or horizontal direction during 30 seconds and with a peak acceleration of 5 m/s^2.	
Explanation: Vibrations may occur when installation near the track.	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-030 System Recovery Unit – EMC	
As set out in EN 50328 section 3.6, the emission and immunity with respect to electro-magnetic compatibility (EMC) of the recovery unit must satisfy EN 50121 and EN 50121-5 in particular.	
Explanation (optional)	
Verification method (optional)	Standards: EN 50328

L-M-31-031 System Recovery Unit – Hazardous materials	
The recovery unit must not contain materials prohibited by law. Substances known to be hazardous to public health and for which suitable alternatives exist must not be used.	
Explanation (optional)	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-032 System Recovery Unit – Hazardous waste	
A list of components or parts of the unit that are designated as hazardous waste in the European Waste Catalogue must be delivered with the recovery unit. The list must be in accordance with IEC 62474 as regards the data format.	
Explanation (optional)	
Verification method (optional)	Standards: IEC 62474

L-M-31-033 System Recovery Unit – Electricity network failures	
The recovery unit must be able to handle interruptions in the electricity network.	
Explanation: Failure of the electricity network must not cause dangerous situations or cause components to become defective.	
Verification method (optional)	Standards: IEC 62474

L-M-31-034 System Recovery Unit – Type test	
A type test report concerning the recovery unit in accordance with EN 50328 section 4 must be delivered in order to demonstrate that the design meets the requirements.	
Explanation (optional)	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-035 System Recovery Unit – Routine test	
The recovery unit must have undergone a routine test in accordance with EN 50328 section 4 in order to demonstrate that the design meets the requirements.	
Explanation (optional)	
Verification method (optional)	Regulation/Standards (optional)

4.4 Aspect requirement: Future-proofness

L-M-31-036 System Recovery Unit – Subsequent delivery components	
The delivery of applied components must be guaranteed for at least 10 years.	
Explanation (optional)	
Verification method Test/inspection report visual	Regulation/Standards

4.5 Aspect requirement: Availability

L-M-31-037 System Recovery Unit – Availability	
The availability of the recovery unit must be at least 99.9%.	
Explanation (optional)	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-038 System Recovery Unit – Maintenance interval	
Preventative maintenance must be limited and must be necessary at most once every 2 years.	
Explanation (optional)	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-039 System Recovery Unit – Duration preventative maintenance	
Preventative maintenance may take at most 2 hours.	
Explanation (optional)	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-040 System Recovery Unit – MTBF	
The MTBF must be at least 100,000 hours.	
Explanation (optional)	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-041 System Recovery Unit – MTTR	
The MTTR of the recovery unit is at most 4 hours.	
Explanation: Based on immediate availability of spare parts. This does not include travel time, etc. This means that the *effective* MTTR may be higher.	
Verification method (optional)	Standards: IEC 62474

4.6 Aspect requirement: Nuisance

L-M-31-042 System Recovery Unit – Noise	
The average noise level over 8 hours over a distance of 1 metre and at a level of 1.50 metres above ground level must not exceed 80 dB(A).	
Explanation: No hearing protection is required below this level.	
Verification method (optional)	Regulation/Standards (optional)

4.7 Aspect requirement: Safety

L-M-31-043 System Recovery Unit – Short-circuit-proof	
The recovery unit must be short-circuit-proof in a thermal and dynamic sense.	
Explanation (optional)	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-044 System Recovery Unit – Insulated installation	
The RU must be installed entirely insulated from water grounding. The installation is connected to water grounding by means of the frame short-circuit protection, which detects the fault current in case of a short circuit from the DC circuit to the frame. The frame short-circuit protection must be demonstrably short-circuit-proof.	
Explanation (optional)	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-045 System Recovery Unit – Emergency outlet	
The recovery unit must be fitted with an emergency shut off button in the (dust) protected housing that can be connected to the GRS emergency circuit.	
Explanation (optional)	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-046 System Recovery Unit – Cable type	
The cables and wiring used in the RU must be free from halogens, low-smoke and flame-retardant.	
Explanation (optional)	
Verification method (optional)	Standard: NEN 8012

L-M-31-047 System Recovery Unit – Voltage-Neutral Housing
The recovery unit is placed in a protective voltage-neutral housing in accordance with EN 50328 section 3.8.1
Explanation (optional)

L-M-31-047 System Recovery Unit – Voltage-Neutral Housing	
Verification method (optional)	Standard: EN 50328

4.8 General

L-M-31-048 System Recovery Unit – Blind diagram	
The RU must be provided with a single-line blind diagram on the panel.	
Explanation: The blind diagram must be location-specific with the correct coding.	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-049 System Recovery Unit – Setting control parameters	
It must be possible to set the control parameters of the recovery unit directly on the unit itself or using a PC or the HMI.	
Explanation (optional)	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-050 System Recovery Unit – Reporting trips	
All trips or internal interventions of the recovery unit that result in a limitation of the operation must be registered locally and remotely (type, start moment, duration).	
Explanation (optional)	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-051 System Recovery Unit – Station automation	
The RU must enable connection to station automation on the basis of IEC61850/GOOSE. The recovery unit communicates with the other parts of the operating system with the aid of a fieldbus and the IEC 61850 protocol. Only standard IEC 61850 codes are allowed.	
Explanation: Trip reports, status and position indications will be connected to CBI by means of fibreglass connections. Hardware-based connections are not used.	
Verification method (optional)	Standard: IEC61850/GOOSE

L-M-31-052 System Recovery Unit – Operational Status	
The recovery unit issues the following status signals: • Operational status: disconnected, connected, ready • Error status: None, Alarm, Trip (resettable), Defect (not resettable) • Recovery status: Stand-by, Active • Operation: Local, remote	
Explanation (optional)	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-053 System Recovery Unit – Switch Status	
The statuses of the separators on the AC and DC side must be shown on the HMI	
Explanation (optional)	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-054 System Recovery Unit – Indication instantaneous DC current	
The recovery unit indicates the DC current (I_d) delivered. This information is also delivered to HMI and CBI via the fieldbus (IEC 61850).	
Explanation (optional)	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-055 System Recovery Unit – Indication instantaneous DC voltage	
The recovery unit indicates the DC voltage (U_d) measured. This information is also delivered to HMI and CBI via the fieldbus (IEC 61850).	
Explanation (optional)	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-056 System Recovery Unit – Indication instantaneous power	
The recovery unit indicates the instantaneous power fed back. This information is also delivered to HMI and CBI via the fieldbus (IEC 61850).	
Explanation (optional)	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-057 System Recovery Unit – Registration energy fed back	
The recovery unit measures and counts the quantity energy delivered back: • The total quantity of energy fed back (kWh). • The quantity energy fed back per fifteen minutes • The quantity energy fed back per day • The quantity energy fed back per month This information is also delivered to the fieldbus.	
Explanation (optional)	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-058 System Recovery Unit – Switching	
The recovery unit can be switched on or off locally, remotely and from a great distance.	
Explanation (optional)	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-059 System Recovery Unit – Resetting errors
The recovery unit can be reset locally, remotely and from a great distance.
Explanation (optional)

L-M-31-059 System Recovery Unit – Resetting errors	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-060 System Recovery Unit – Logging	
The recovery unit is provided with automatic logging and presentation of the signals and data via an internal or external tool. The history must cover a period of at least 1 year. It must be easy to download the logging.	
Explanation (optional)	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-061 System Recovery Unit – HMI	
The signals and data can be shown on a local display on the device and on the HMI.	
Explanation: New rectifier stations are provided with an HMI to show the statuses and data.	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-062 System Recovery Unit – Timestamp	
Logged and displayed data are provided with a timestamp with an accuracy of at least 1 ms. The internal clock is synchronised with the NMA NTP server.	
Explanation (optional)	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-063 System Recovery Unit – Dashboard	
An overview of the energy fed back is available for the CBI system on a daily or more frequent basis.	
Explanation (optional)	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-064 System Recovery Unit – Placement operation/indication	
Operating and indication devices on the housing must be placed between 450 mm and 1800 mm from the ground level.	
Explanation (optional)	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-065 System Recovery Unit Voltage Auxiliary Supply	
The auxiliary supply for the recovery unit is fed from: 48 V DC +10%/ -15%	
Explanation (optional)	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-066 System Recovery Unit – Energy consumption Auxiliary supply	
The energy consumption of the auxiliary supply must remain below 1000 W.	
Explanation (optional)	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-067 System Recovery Unit – Mains failures	
In the event the mains fail, the recovery unit must switch itself off safely.	
Explanation (optional)	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-068 System Recovery Unit – UPS	
The UPS of the rectifier stations may be used to handle mains interruptions, provided it does not exceed the power of the UPS. The capacity of the UPS must be expanded in such cases.	
Explanation (optional)	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-069 System Recovery Unit – Cooling system power supply	
In the event a separate power supply for the cooling system is required, it will be fed with an alternating current of 50 Hz and: • 230 V +10%/-10% for single-phase installations • 400 V +10%/-10% for three-phase installations	
Explanation: The cooling system must not be fed from the 48 V auxiliary supply of the rectifier station.	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-070 System Recovery Unit – Real Time Clock	
The real-time clock installed must be able to bridge a non-voltage period of 8 hours.	
Explanation: The real-time clock must continue in case of activities or short power interruptions.	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-071 System Recovery Unit – Operating locations	
The Recovery Unit can be operated in three ways: • Locally. This refers to operation inside the rectifier station on the RU itself. • Remotely. This refers to operation from the HMI inside the rectifier station. • Operation from far away. This refers to operation from the CVL/Switchboard. The choice between "Local", "Remote" of "far away" operation must be made by means of a selector switch on the RU. The selector switch must be implemented as a key switch. The selector switch must be a three-position switch implemented as follows: • In the "Local" setting, only the commands issued locally must be carried out on the RU. • In the "Remote" setting, only the commands issued from the HMI must be carried out. • In the "Far away" setting, only the commands issued from the CVL/Switchboard must be carried out. The position of the selector switches must be identified on the RU, the HMI and communicated to the switchboard. Changing the selector switch must not cause a position change of the RU.	
Explanation (optional)	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-072 System Recovery Unit – Separators and switches	
The disconnector switches of the Recovery Unit must be motor-operated switches.	
Explanation: The separator is intended for the connection of a recovery unit.	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-073 System Recovery Unit – Separator operation	
It must be possible to operate separators locally, remotely and from far away.	
Explanation (optional)	
Verification method (optional)	Regulation/Standards (optional)

4.9 Frame short-circuit protection

L-M-31-074 System Recovery Unit – Frame short-circuit protection
The RU must be fitted with frame short-circuit protection. A combined frame short-circuit relay must be used for the frame short-circuit protection for the RU and the GVI.

L-M-31-074 System Recovery Unit – Frame short-circuit protection	
Explanation: The cabinets of the Recovery Unit must be connected electrically and connected to the earthing via the central frame short-circuit protection. This detects and switches off short-circuits between the direct current installation and the cabinets. In the event power becomes higher than a certain settable value as a result of the frame short-circuit protection it will issue a trip command. This switches off all outbound plus fields of the rectifier station and all incoming plus fields from neighbouring rectifier stations (via the "interlocking switch").	
Verification method (optional)	Regulation/Standards (optional)

4.10 Internal wiring

L-M-31-075 System Recovery Unit – Internal wiring	
Internal wiring must be halogen-free, low-smoke and flame-retardant.	
Explanation (optional)	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-076 System Recovery Unit – Coding	
Internal wiring must be coded.	
Explanation (optional)	
Verification method (optional)	Regulation/Standards (optional)

4.11 Local / Central Control of the Recovery Unit (CBI)

4.11.1 Operation (Station automation)

The various protection relays are connected in accordance with the IEC61850/GOOSE standard. Intelligence is implemented in the decentralised protection relay (IED) as much as possible. However, there are functions that have to be realised from a more centralised IED. A central unit has been envisioned as well, which makes it possible to realise the Central Operating Installation. This concerns the local operation (the station automation unit of the GR).

L-M-31-077 System Recovery Unit – Commissioning and decommissioning the RU	
It must be possible to switch off the RU locally (at installation level), remotely (from HMI) and by means of far operation (via the CBI) and thereafter recommissioned again if so desired.	
Explanation (optional)	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-078 System Recovery Unit – CBI	
The RU must be fitted with remote operation and identification for all commands, position reports, alarms and measurements that are necessary for correct operations. This information must be transferred to the CAB of GVB. A connection to the existing CBI system must be realised.	
Explanation: All of the above on the basis of the location-specific IO list approved by the Client that must be drawn up by the Contractor on the basis of the IO list template in paragraph 1.2.	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-079 System Recovery Unit – IO list	
The Contractor is required to submit a location-specific IO list in the UO for approval. The IO list must be made location specific on the basis of the IO list template.	
Explanation: See the IO list template in paragraph 1.2.	
Verification method (optional)	Regulation/Standards (optional)

4.11.2 HMI

The HMI has been placed in the DC current & low-voltage space.

L-M-31-080 System Recovery Unit – HMI Remote operation	
Operation and monitoring of the RU must be able to take place at the three levels: • Local operation • Remote operation • Operation from far away.	
Explanation: • Local operation means: operation and monitoring on the RU itself. This can take place by means of push buttons on the panel, status lights, but also by means of operation and reading of (touch) screens of protection relays. Switching separators/earthing devices by means of selector rods comes under local operation. The panels must be fitted with current blind diagrams on the panels for the purpose of local operation. • Remote operation means: operation and monitoring of the RU via a screen system, which is installed centrally at the Rectifier station. • Operation from far away means: operation and monitoring of the RU via the CVL/switchboard.	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-081 System Recovery Unit – Remote operation – Status indication	
The status must be indicated of all main power switches (DC circuit breaker, AC circuit breaker) present in the RU. • Open • Closed • Earthed (if applicable) It must not be possible to bridge locks in the primary circuit using remote operation or operation from far away.	
Explanation (optional)	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-082 System Recovery Unit – Remote operation – Operation	
It must be possible to operate the following components (after taking over local operation): • Switching the RU on and off • Resetting errors/clearing alarms	
Explanation (optional)	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-083 System Recovery Unit – Remote operation – Analogue values	
It must be possible to read the following analogue values: • Voltage on the DC rail • Current from the DC rail • Current to the AC network • Power to the AC network	
Explanation (optional)	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-084 System Recovery Unit – Remote operation – Signals/Alarms	
It must be possible to read the following signals/alarms on the HMI and the CBI: • Switching the RU on and off The signals/alarms must be visualised in an alarms list, which will be logged.	
Explanation (optional)	
Verification method (optional)	Regulation/Standards (optional)

4.11.3 Auxiliary voltage

L-M-31-085 System Recovery Unit – AC auxiliary voltage	
The RU's AC-fed secondary installations must be suitable for being fed from the AC auxiliary voltage of the rectifier station with the following specifications: - Input voltage: 400V AC/ 3 phase - System TN-S - Frequency: 50 Hz - Voltage and frequency variation: in accordance with NEN-EN-50160 - Tolerances: in accordance with the ACM Electricity Network Code	
Explanation (optional)	
Verification method (optional)	Standards: NEN-EN-50160

L-M-31-086 System Recovery Unit – DC auxiliary voltage	
The RU's DC-fed secondary installations must be suitable for being fed from the DC auxiliary voltage of the rectifier station with the following specifications: - Nominal output voltage 48VDC - Limits output voltage +/- 15%	
Explanation (optional)	
Verification method (optional)	Regulation/Standards (optional)

L-M-31-087 System Recovery Unit – Lighting control cabinets	
Operating cabinets must be fitted with cabinet lighting.	
Explanation (optional)	
Verification method (optional)	Regulation/Standards (optional)

5 Electrical specifications

L-M-031-001 Systeem Recovery Unit – Electrical specifications

The recovery unit shall be designed and operated in accordance with the following electrical specifications:

#	Requirement	Value	Standard
1	Nominal DC voltage U_n	750 V	NEN-EN 50163
2	DC voltage variation steady state	+20%/-33% of U_n	NEN-EN 50163
3	DC voltage variation short time (1..5 s)	+30%/-33% of U_n	NEN-EN 50163
4	Rated DC voltage U_n	750 .. 900 V	NEN-EN 50163
5	Highest permanent DC voltage $U_{d,max1}$ (in case of engaged brake resistors)	900 V	NEN-EN 50163
6	Highest non-permanent DC voltage $U_{d,max2}$ (at most 5 minutes)	1000 V	NEN-EN 50163
7	Highest short overvoltage $U_{d,max3}$ (lasting 0.02 .. 1 s)	1270 V	NEN-EN 50163
8	Nominal isolation voltage U_{Nm}	900 V	EN 50124-1
9	Rated impulse voltage U_{Ni} (EN 50124-1, overvoltage category OV2: circuits with normal transient overvoltage and normal availability requirements)	5 kV	EN 50124-1
10	Lowest permanent DC voltage $U_{d,min1}$	500 V	NEN-EN 50163
11	Lowest non-permanent DC voltage $U_{d,min2}$	500 V	NEN-EN 50163
12	Basic DC I_{Bd}	1111 .. 1333 A	
13	DC power P_d	1 MW	
14	Nominal primary AC voltage U_{net}	10 kV	
15	Rated AC frequency f_N	50 Hz	
16	Frequency range	±2% of f_N	
17	Frequency change	±1%/s	
18	Rated secondary AC voltage U_{LN}	615 V	
19	AC voltage variation steady state	+10%/-10% of U_{LN}	NEN-EN 50160
20	Short AC voltage variations (0.5 … 30 periods)	+15%/-15% of U_{LN}	NEN-EN 50160
21	Rated alternating current I_{LN}	940 A @ 615 V	

Explanation (optional)

Verification method (optional)	Regulation/Standards (optional)

6 List of requirements