ELES, d.o.o.

Dokumentacija za razpis

ŠT.:	NAČRT:	ŠT. NAČRTA:
3	NAČRT S PODROČJA ELEKTROTEHNIKE	
3/1	SSSC	R4PO01-6E/01A

RTP 400/220/110 kV Podlog / Sistem za regulacijo moči (SSSC) v RTP Podlog

NOVOGRADNJA - NOVOZGRAJEN OBJEKT

ŠT. PROJEKTA:	ŠT. MAPE:	IZVOD:	KRAJ IN DATUM:
R4PO01-A025/597	R4PO01-6E/M01A	1	Ljubljana, maj 2024

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NASLOVNA STRAN NAČRTA

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naslov ali poslovni naslov družbe		**Hajdrihova ulica 2,1000 LJUBLJANA**
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naziv gradnje		**RTP 400/220/110 kV Podlog / Sistem za regulacijo moči (SSSC) v RTP Podlog**
kratek opis gradnje		**/**
VRSTE GRADNJE	☒	**NOVOGRADNJA - NOVOZGRAJEN OBJEKT**
	☐	**NOVOGRADNJA - PRIZIDAVA**
	☐	**REKONSTRUKCIJA**
	☐	**SPREMEMBA NAMEMBNOSTI**
	☐	**ODSTRANITEV CELOTNEGA OBJEKTA**
	☐	**LEGALIZACIJA**
	☐	**MANJŠA REKONSTRUKCIJA**
	☐	**VZDRŽEVANJE OBJEKTA**
	☐	**VZDRŽEVALNA DELA V JAVNO KORIST**
PODATKI O PROJEKTNI DOKUMENTACIJI		
vrsta dokumentacije		**Dokumentacija za razpis (DZR)**
številka projekta		**R4PO01-A025/597**
PODATKI O NAČRTU		
strokovno področje načrta	**3**	**NAČRT S PODROČJA ELEKTROTEHNIKE**
naziv načrta	**3/1**	**SSSC**
številka načrta		**R4PO01-6E/01A**
datum izdelave		**maj 2024**
datum spremembe		**/**
PODATKI O PROJEKTANTU NAČRTA		
projektant načrta (naziv družbe)		**IBE, d.d., svetovanje, projektiranje in inženiring**
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odgovorna oseba projektanta načrta		**dr. Franc Sinur**
podpis odgovorne osebe projektanta načrta	IBE, d.d., svetovanje, projektiranje in inženiring Hajdrihova ulica 4 • 1001 Ljubljana • Slovenija 2	Digitalno podpisal ELVIS ŠTEMBERGER Datum: 2024.05.09 14:15:17 +02'00'
PODATKI O IZDELOVALCU NAČRTA		
ime in priimek pooblaščenega arhitekta, poobl. inženirja		**mag. Marko Testen, univ. dipl. inž. el.**
identifikacijska številka		**IZS E-1293**
podpis pooblaščenega arhitekta, pooblaščenega inženirja		

IBE, d.d., svetovanje, projektiranje in inženiring
Uprava družbe

Naš znak: FS
Zap. številka: 5/2/2022

Kraj in datum: Ljubljana, 01. 01. 2022

P O O B L A S T I L O

Dr. Franc Sinur, glavni direktor družbe IBE, d.d., svetovanje, projektiranje in inženiring, Hajdrihova 4, 1001 Ljubljana,

pooblaščam

Elvisa Štembergerja, univ. dipl. inž. el., pomočnika glavnega direktorja družbe,

da v skladu s predpisi s področja graditve objektov in Poslovnikom kakovosti družbe odobrava predajo projektne dokumentacije in druge dokumentacije naročnikom ter da to dokumentacijo in vse potrebne izjave v zvezi s tem podpisuje v imenu družbe.

dr. Franc Sinur
Glavni direktor

IBE, d.d., svetovanje, projektiranje in inženiring
Hajdrihova ulica 4 • 1001 Ljubljana • Slovenija 2

Sprejemam pooblastilo

Elvis Štemberger
Pomočnik glavnega direktorja

DODATNI PODATKI IBE

SKLADNOST ELEKTRONSKEGA IN FIZIČNEGA IZVODA	
podpis	datum 08.05.2024

KONTROLA PROJEKTA	
V skladu s Pravilnikom o kontroli projektov je bila imenovana komisija za kontrolo projekta. Kontrola projekta v skladu s sistemom vodenja kakovosti IBE d.d. je bila opravljena.	
predsednik komisije za kontrolo projekta	**mag. Marko Smole, univ. dipl. inž. el.**
podpis predsednika komisije	

OZNAČEVANJE DOKUMENTACIJE PO INTERNEM STANDARDU IBE D.D.	
IBE številka projekta	**R4PO01-A025/615**
IBE številka načrta	**R4PO01-6E/01A**
IBE številka mape	**R4PO01-6E/M01A**

KAZALO VSEBINE NAČRTA

INVESTITOR			
INVESTITOR 1			
ime in priimek ali naziv družbe		**ELES, d.o.o.**	
naslov ali poslovni naslov družbe		**Hajdrihova ulica 2,1000 LJUBLJANA**	
PODATKI O GRADNJI			
naziv gradnje		**RTP 400/220/110 kV Podlog / Sistem za regulacijo moči (SSSC) v RTP Podlog**	
PODATKI O PROJEKTNI DOKUMENTACIJI			
vrsta dokumentacije		**Dokumentacija za razpis (DZR)**	
številka projekta		**R4PO01-A025/597**	
strokovno področje načrta	**3**	**NAČRT S PODROČJA ELEKTROTEHNIKE**	
naziv načrta	**3/1**	**SSSC**	
številka načrta		**R4PO01-6E/01A**	

TEHNIČNO POROČILO

INVESTITOR		
INVESTITOR 1		
ime in priimek ali naziv družbe		**ELES, d.o.o.**
naslov ali poslovni naslov družbe		**Hajdrihova ulica 2,1000 LJUBLJANA**
PODATKI O GRADNJI		
naziv gradnje		**RTP 400/220/110 kV Podlog / Sistem za regulacijo moči (SSSC) v RTP Podlog**
PODATKI O PROJEKTNI DOKUMENTACIJI		
vrsta dokumentacije		**Dokumentacija za razpis (DZR)**
številka projekta		**R4PO01-A025/597**
strokovno področje načrta	**3**	**NAČRT S PODROČJA ELEKTROTEHNIKE**
naziv načrta	**3/1**	**SSSC**
številka načrta		**R4PO01-6E/01A**

/	/	/	
Revision:	Revision note:	Revision date:	Signature:

Investor: ELES	Facility: RTP 400/220/220 kV Podlog Sistem za regulacijo moči (SSSC) v RTP Podlog
Design engineer: IBE, svetovanje, projektiranje in inženiring Ljubljana, Slovenija	Part of facility/system: VOLUME 1 - Supply and Erection of Flexible Serial Compensation – SSSC in Podlog SS
/	Type of design: TECHNICAL SPECIFICATION

	First name/Name:	Id. No.:
Approved by:	mag. Marko Testen, univ. dipl. inž. el.	E-1293
Confirmed by:	mag. Marko Testen, univ. dipl. inž. el.	E-1293
Checked by:		
Designed by:	mag. M. Testen, univ. dip. in.e., D. Lenarčič, univ. dip. in. el.	E-1293, E-0076
11.2023		

Title of document:

1. INTRODUCTION

Design doc. No.:	R4PO01-A025/597	Type of documentation:	DZR
Classification No.:	C D	Page/ pages:	1/12
Identification No.:	R 4 P O 0 1 - 6 E 1 0 0 1	Spr.:	

VSEBINA:

1 INTRODUCTION

1.1 INTRODUCTION AND PURPOSE

Slovenia's high-voltage transmission network consists of three different voltage levels: 400 kV, 220 kV and 110 kV. The most powerful generation units in Slovenia are connected to the 400 kV level. Through the 400 kV and 220 kV voltage level connections Slovenia is inter-connected with all the neighbouring countries: Austria, Italy, Hungary and Croatia.

The transmission network of ELES consists of:

- 400 kV overhead transmission lines in total length of 828 km),
- 220 kV overhead transmission lines in the length of 328 km,
- 110 kV overhead transmission lines in the length of 1926 km,
- 110 kV underground cable lines in the length of 31 km.

Nodal points of the 400 kV network are located in seven substations:

- 400/110 kV Maribor SS,
- 400/110 kV Cirkovce SS,
- 400/110 kV Krško SS,
- 400/110 kV Okroglo SS,
- 400/220/110/35 kV Divača SS,
- 400/220/110 kV Podlog SS,
- 400/220/110 kV Beričevo SS.

Nodal points of the 220 kV network, besides in the mentioned ones of Divača SS, Podlog SS and Beričevo SS is located also in Kleče SS. Currently the power transmission network of ELES on the 400 kV and 220 kV levels looks as shown in the figure below.

Remarks: 400 kV (in red), 220 kV (in green), 110 kV not displayed.

Figure 1.1-1: High-voltage transmission network of ELES

In the mentioned substations, constructed up to now, ELES has 12 300 MVA, 400/110 kV grid transformers, two 400 MVA, 400/220 kV transformers and 8 150 MVA, 220/110 kV transformers. Besides the above given, in the Divača SS, there is also a 1200 MVA, 400 kV phase shifting transformer while ELES owns also some transformers on the 110/xx kV level of minor power.

Slovenia has its own electricity generation units of 3605 MW total power output connected to the transmission network. 696 MW are generated in the Krško NPP (half of production is in the Slovenian ownership), 1778 MW in thermal power plants, 951 MW in hydropower plants and 180 MW in pumped storage plant. Dispersed sources (small HPPs, solar power plants, wind power plants and similar) with installed power of around additional 15 % represent an important energy source as well. These additional sources are connected to the electricity distribution network of several power distribution companies.

According to the ELES plans, the 400 kV and 220 kV power grids will be further enhanced in near future and in 2026 they will look as follows:

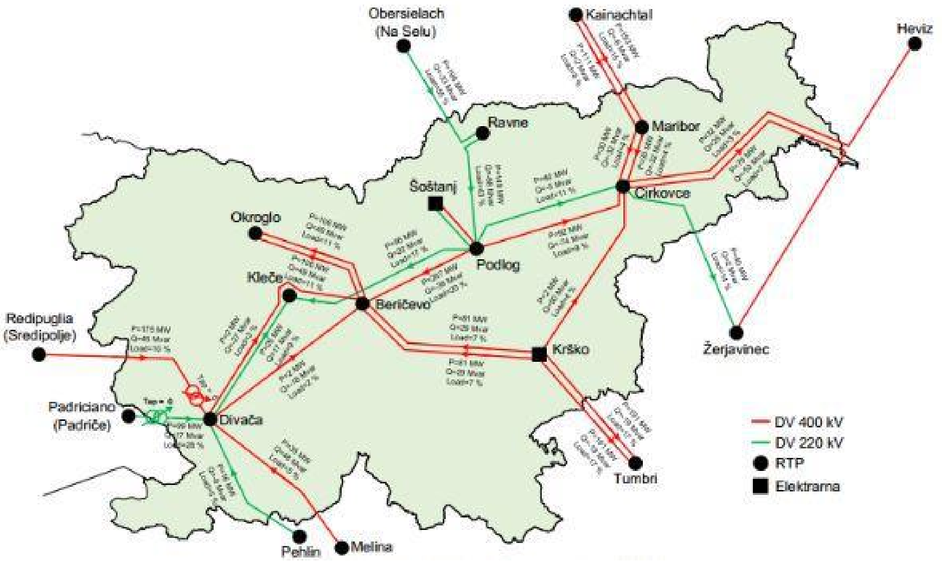

Figure 1.1-2: Power transmission network of ELES in the year 2026

Configuration of the Slovenian power transmission network as well as electricity generation, consumption and transmission characteristics cause relatively large voltage oscillations in the transmission system which shall be even enhanced by the development projections in future. This is why ELES installed recently the following plants to mitigate such problems:

- In the Beričevo SS, a SVC/STATCOM plant of ±150 Mvar,
- In the Divača SS, a 150 Mvar VSR and a 100 Mvar MSCDN devices,
- In the Cirkovce SS, a 150 Mvar VSR.

Apart of above plants, ELES intend to solve problems with interconnection connection between Austria and Slovenia on 220 kV level with installation of static synchronous series compensator (SSSC) in the 220 kV connection Podlog – Obersielach

This specification covers supply and installation of a SSSC plant only that shall be installed in the existing 400/220/110 kV Podlog SS.

The Podlog SS was constructed more than sixty years ago as SS with 110 kV level as highest, fifty years aro it has been upgraded with 220 kV level and later with 400 kV level. In the meantime, the equipment was refurbished once or even several times while the basic single line diagram of all three voltage levels has been preserved. On the 400 kV voltage level, the switchyard is constructed in the system of two main and one auxiliary busbars while the 220 kV and 110 kV switchyards are built in a system of two main busbars with one bus tie coupler and a measurement/bus-grounding bays. All switchyards are of air-insulated type while their control and protection are provided by numerical terminals. The C&P equipment is installed in relay kiosks and partialy in control building. Auxiliary supply equipment is mostly situated in the separate structure. The facility is controlled from four levels – normally remotely, but due control is provided also from the control building, from the relay kiosk or from the device itself.

The Podlog SS single line diagram in the existing state is given in enclosed drawing.

Main reason for erection of SSSC in Podlog Substation is to perform steady state current control and to enhance power damping during transient conditions in the 220 kV line Podlog – Obersielach.

1.2 CONFIGURATION OF PLANT

Detailed requirements for new plant and description of existing equipment is listed in the following Chapters:

1. Introduction	R4PO01—6E1001
2. Site Conditions and Site arrangement	R4PO01—6E1002
3. General Requirements	R4PO01—6E1003
4. HV-MV equipment and Serial Transformer	R4PO01—6E1004
5. SSSC	R4PO01—6E1005
6. Control and Protection Systems	R4PO01—6E1006
7. Design requirements and Civil Works	R4PO01—6E1007
8. Implementation	R4PO01—6E1008
9. Drawings	R4PO01—6E1009

If the Employer is not satisfield for any reason, at any stage during the negotiation stage of signing the contract for facilities and works in this Tender, he has the right to request changes or amendments to the technical solutions of the Tederer.

1.3 SCOPE OF WORKS

This is a turnkey specification for the Contractor to install a fully operational SSSC (Static Synchronous Series Compensator) plant at the Podlog substation in accordance with this specification. The Contractor will be responsible for all aspects of the project, including design, engineering, fabrication, delivery, erection, installation, testing, commissioning, and field verification of the SSSC, except for the equipment, materials, and services provided by the Employer as specified in other sections of this tender document.

The Contractor shall perform studies, design, engineering, design verification/validation, material procurement, type testing, quality management, factory inspection/testing, transport and delivery to site, civil works, construction, site inspection, trainings, testing and commissioning, project management and interface management with Other Parties and all associated Works and services until final handing over of the SSSC systems in a satisfactory working and operating condition to the Employer as specified.

All equipment shall be designed as needed to meet the requirements in this specification. All deviations from the requirements in the specification shall be clearly stated by the Tenderer in a separate List of Deviations in the Tender documentation.

Any equipment and/or function of the SSSC not specifically specified herein should be designed as required by the overall design of the SSSC system in order to ensure the satisfactory operation of the same.

For the avoidance of doubt, any deliverables which are submitted for the approval of the Employer or the Employer's Representative pursuant to those Employer's Requirements and any review or failure to review or any approval, comment or rejection of such deliverables by the Employer or the Employer's Representative, shall not relieve the Contractor from any obligation or responsibility under the Contract.

The Contractor's Scope of Works will cover all equipment up to SSSC, including a 220/xx kV serial transformer and 220 kV equipment (e.g.: for transformer bypassing and transformer protection purposes) if necessary.

1. Equipment:
   a) HV equipment in the 220 kV part of the Switchyard:
      - 220/xx kV serial power transformer, if necessary,
      - Any equipment (HV and LV) necessary for operation of SSSC and not included in obligations as specified in other lots of this tender document,
      - Contractor is obliged to verify and confirm the characteristics of HV equipment as it is shown on SS single line diagram in the new state (AD03 feeder):
        - Circuit breaker,
        - Disconnectors and earthing switches,

- Instrument Transformers,
- 220 kV cable connections with a cable terminals and all the necessary cable equipment,
- Surge arresters.

b) SSSC plant equipment including:
- SSSC,
- 220 kV equipment including serial transformer and corresponding HV equipment (if necessary)
- MV equipment including MV surge arresters, if any,
- Auxiliary supply systems (connection to existing and future substation AC and DC sources),
- Control and supervision systems,
- Protection systems,
- Other systems, necessary for continuous, safety and trouble less operation of SSSC plant.

c) Spare parts,

d) Auxiliary systems as electrical installations for illumination and small power, fire protection and supervision installations, access supervision, all necessary communications (including voice communications, video surveillance, etc…)..,

e) Apart of items listed above Contractor is obliged to supply and erect all the materials and works as listed in this tender document.

2. Services:

a) Erection works:
- SSSC plant,
- Provisional electricity supply systems,
- cable connections to existing systems,
- Grounding in the points above, the following is considered: systems within the system (connected to existing SS grounding grid),
- 220 kV equipment (if any necessary additionaly to HV equipment provided and erected in the scope of other lots,
- 220/xx kV serial transformer (if any necessary),
- and other connection to third party equipment (e.g. communications, auxiliary power supply, etc..).

b) Civil works:
- Demolition of any existing structures existing in the area reserved for erection of all equipment supplied within this tender,
- Foundations, buildings and all the necessary underground structures and cable ducts/conduits necessary for the installation of the equipment supplied in the scope of this tender,
- Noise protection barriers to achieve requested noise level (if necessary),
- Steel supports for all equipment supplied in the scope of this tender.

c) Training of customer's professional staff for independent parameterization, configuration, adjustment, testing, operation and maintenance of devices within the scope of the supply, active cooperation with Employer and Employer's consultants during production of different types of technical documentation (as required by Slovenian authorities) and during implementation of new plant to existing systems,

d) Testing (FAT's, SAT).

3. Documentation:
   a) QA project manual,
   b) QC plan,
   c) Studies,
   d) Producer's documentation, technical documentation of installations and equipment that is part of the supply, documentation for testing (FAT's, SAT),
   e) Documents, necessary for the design approval and technical documentation and for equipment where documentation is produced by a third party,
   f) Manuals for parameterizing, configuring, installing and commissioning devices (in Slovene or English) in paper and electronic form,
   g) Certificates, type tests documents of devices, etc.,
   h) Other documents as necessary to follow Slovenian legislation and regulations for such facilities, reliability certificate and participation in partial and final technical inspections, if necessary.

1.3.1 Scope of work to be performed under other tender documents

The construction of the SSSC at the Podlog S/S will be divided to:

LOT	**ELECTRICAL DESIGN**	**Št. načrta:**	**Št. mape:**
1	Supply and Erection of SSSC	R4PO01---6E/01	R4PO01---6E/M01
2	Supply of high-voltage equipment	R4PO01---6E/02	R4PO01---6E/M02
3	Supply and installation of 220 kV cable system	R4PO01---6E/03	R4PO01---6E/M03
4	Supply of control and protection equipment	R4PO01---6E/04	R4PO01---6E/M04
5	Electrical assembly works	R4PO01---6E/05	R4PO01---6E/M05
6	Supply of clamps and suspension equipment	R4PO01---6E/06	R4PO01---6E/M06
7	Civil works - 220 kV switchyard	R4PO01---6G/01	R4PO01---6G/M01
8	Steel structures - 220 kV switchyard	R4PO01---6G/02	R4PO01---6G/M02

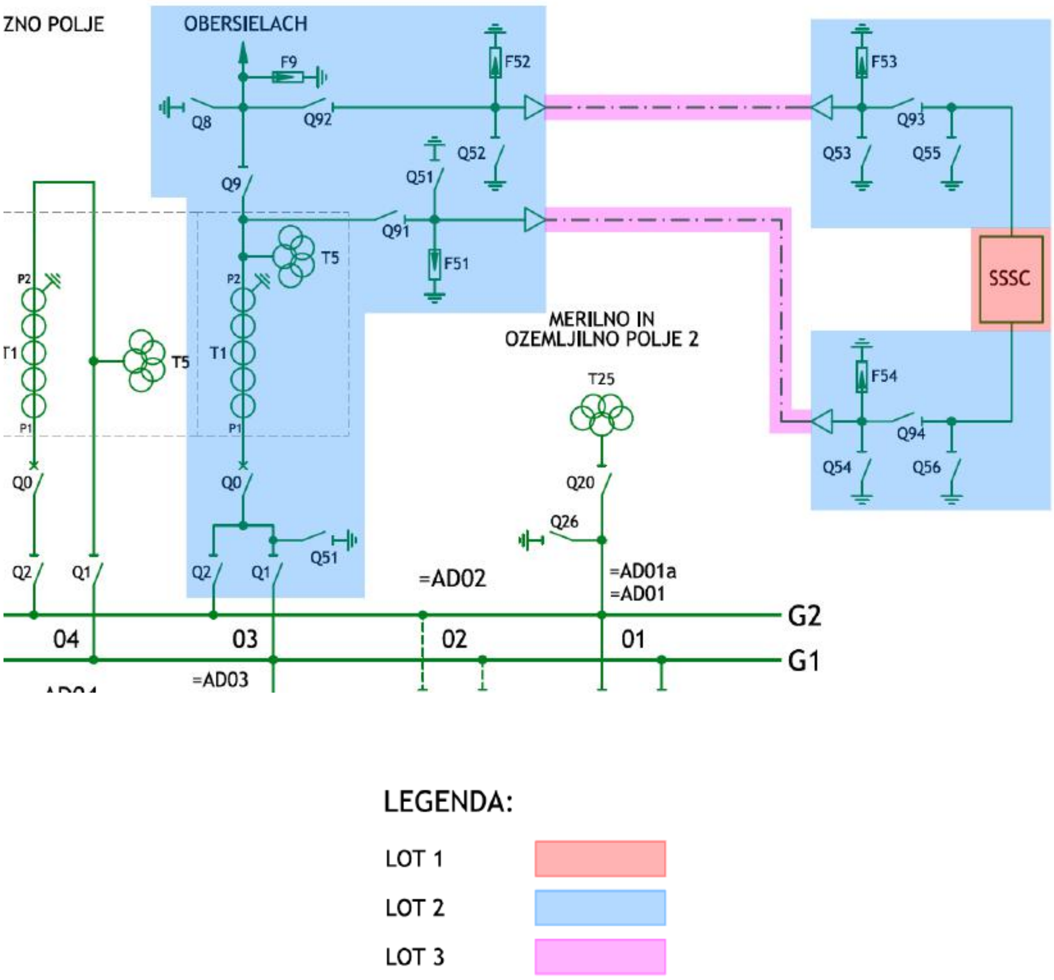

Figure 1.3.1: Block diagram of delivery boundaries

1.4 MATERIALS AND SERVICES FURNISHED WITHIN OTHER LOTS OF THIS TENDER DOCUMENT

The contractor will, in parallel with SSSC project, modify the existing AD03 bay to accommodate the connection of the SSSC. These works, along with the SSSC installation project, will be carried out concurrently to ensure efficient implementation. These works includes:

- All the civil works necessary to instal new 220 kV equipment in AD03 feeder, 220 kV equipment between AD03 feeder and SSSC, civil works necessary to install 220 kV cables and all necessary subsurface installations for cable connections,
- All steel structures for HV equipment,
- Supply of HV equipment to be installed in AD 03 feeder and between AD 03 feeder and SSSC,
- Supply of 220 kV cables and cable equipment (cable terminals, etc) including erection and testing,

- Supply of all the necessary secondary equipment (control, protection, metering, auxilliary supply) for AD 03 feeder and 220kV equipment between AD 03 feeder and SSSC,
- Erection works including supply of LV cables and optical cables for AD 03 feeder and 220kV equipment between AD 03 feeder and SSSC,
- All civil works required for SSSC installation (buildings, VN equipment supports including foundations, underground electrical and drainage systems, paved manipulation and access areas, etc).

1.5 MATERIALS AND SERVICES FURNISHED BY THE EMPLOYER

When performing works according to this Tender document, The Employer will cooperate with the following activities and materials:

- On the basis of the Contractor's data, he will prepare the documentation for obtaining a building permit, acquire all the necessary consents and a building permit,
- On the basis of the Contractor's data, he will elaborate all the documentation necessary for carrying out the technical inspection, and obtain an operating permit,
- At the time of construction, he shall provide the Contractor with electricity and water,
- He will enable the connection of the device to AC and DC sources for auxilliary supply,
- He will restore the control equipment in the AD03 field and install partial protection equipment (differential serial transformer protection).

1.6 LISTS OF ABBREVIATIONS AND DEFINITIONS

Abbreviation	Description
=AD 03	220 kV bay in Podlog SS toward Obersielach
AC	Alternating Current
BIL	Basic Insulation Level
BSI	British Standards Institution
CEN	European Committee for Standardization
CENELEC	European Committee for Electrotechnical Standardization
CISPR	International Special Committee on Radio Interference
Contractor	An organisation that contract with Employer (ELES) for the delivery and construction of SVC/STATCOM
CT	Current Transformer
DC	Direct Current
COLM	Central on-line monitoring system
DIN	Deutsches Institut für Normung
ELES	Slovenian TSO
EMC	Electromagnetic Compatibility
EMF	Electromagnetic Field
EMI	Electromagnetic Interference
Employer	ELES, Slovenian TSO, Employer of the SVC/STATCOM or his entitled representative

Abbreviation	Description
EMS	Energy Management System
EN	European Norms
ENTSO-E	European Network of Transmission System Operators for Electricity
ETSI	European Telecommunications Standards Institute
FAC	Final Acceptance Certificate
FACTS	Flexible AC Transmission System
FAT	Factory Acceptance Tests
GZ	Building Act
HMI	Human Machine Interface
HPP	Hydro Power Plant
HRC	High Rupture Current
HS&E	Health, Safety and Environment
HV	High Voltage
IEC	International Electrotechnical Commission
IGBT	Insulated Gate Bipolar Transistor
ISO	International Organization for Standardization
IT-K	Non-grounded installation system configuration with insulation monitoring
LED	Light Emitting Diode
LV	Low Voltage
MMC	Modular Multilevel Converter
MV	Medium Voltage (3 to 72 kV)
NCC	National Control Centre
NPP	Nuclear Power Plant
OHL	OverHead Line
PAC	Provisional Acceptance Certificate
PCC	Point of Common Coupling
pu	Per Unit
PVC	Poly Vinyl Chloride
RS	Republic of Slovenia
RTDS	Real Time Digital Simulator
SS	Substation
SAT	Site Acceptance Tests
SCADA	Supervisory Control and Data Acquisition
SIST	Slovenian Institute for Standardization
SSSC	Static Synchronous Series Compensator, including all the systems and subsystems necessary for successful operation as serial transformer (if necessary)fv, auxiliary supply, control, protection, etc.
Tender	The Contractor's signed bid for the works and all other documents which the Contractor submitted therewith (other than these Conditions and the Employer's Requirements, if so submitted), as included in the contract
Tenderer	The organisation bidding the Scope of Works against this specification

Abbreviation	Description
THD	Total Harmonic Distortion
TIF	Telephone Influence Factor
TN-C	Grounding/protection system according to IEC 60364
TN-C-S	Grounding/protection system according to IEC 60364
VDE	Verband Deutscher Elektrotechniker
VSC	Voltage Sourced Converter
VSR	Variable Shunt Reactor
VT	Voltage Transformer
XLPE	Cross-Linked PolyEthylene
ZMer-1-UPB1	Slovenian Metrology Act (Zakon o meroslovju)
ZSta-1	Slovenian Standardization Act (Zakon o standardizaciji)
ZVZD-1	Slovenian Health and Safety at Work Act (Zakon o varnosti in zdravju pri delu)

/	/	/	
Revision:	Revision note:	Revision date:	Signature:

Investor: ELES	Facility: RTP 400/220/220 kV Podlog Sistem za regulacijo moči (SSSC) v RTP Podlog
Design engineer: IBE, svetovanje, projektiranje in inženiring Ljubljana, Slovenija	Part of facility/system: Supply and Erection of Flexible Serial Compensation – SSSC in Podlog SS
/	Type of design: TECHNICAL SPECIFICATION

	First name/Name:	Id. No.:
Approved by:	mag. Marko Testen, univ. dipl. inž. el.	E-1293
Confirmed by:	mag. Marko Testen, univ. dipl. inž. el.	E-1293
Checked by:		
Designed by:	mag. M. Testen, univ. dip. in.e., D. Lenarčič, univ. dip. in. el.	E-1293, E-0076
07.2023		

Title of document:

2. SITE CONDITIONS AND SITE ARRANGEMENT

Design doc. No.:	R4PO01-A025/597	Type of documentation:	DZR
Classification No.:	C D	Page/ pages:	1/11
Identification No.:	R 4 P O 0 1 - 6 E 1 0 0 2	Spr.:	

VSEBINA:

2 Site conditions and Site arrangement

2.1 Site conditions

2.1.1 Location

The SSSC system will be located in 400/220/110 kV Podlog substation located approx. 170 km in NE direction and 65 km away from Ljubljana.

2.1.2 Ambient Conditions

The ambient conditions listed below shall be assumed in the design of all equipment unless specified otherwise elsewhere in this specification. The equipment shall be capable of operating continuously at any output, appropriate to the ambient conditions, regardless of how long these ambient conditions have prevailed.

Condition:	**Value:**
Altitude Above Sea Level	250 m
Annual Rainfall	1120 mm
Extreme Rainfall	117 mm/h
Max. Relative Humidity	100 %
Min. Relative Humidity	11,3 %
Max. Outdoor Temperature	+40 C (dry bulb)
Max Daily Average Outdoor Temperature	+30 C (dry bulb)
Min. Outdoor Temperature	-25 C (dry bulb)
Pollution	medium
Wind Load	25,3 m/s
Snow Load	1,5 kN/m^2
Max. Solar Constant	1,526 kW/m^2

2.1.3 Seismic Requirements

With respect to earthquake resistance, all the equipment, structures and foundations shall be designed, produced and erected in accordance with the Slovenian standards SIST EN 1998-1 and SIST EN 1998-5, including their National Annexes, considering the following general requirements:

- reference peak ground acceleration on type A ground: $a_{g,R}$ = 0,2g[1]
- importance factor: γ_I = 1,4;
- ground type: to be determined by geological and geotechnical investigations[2];

[1] Nova karta potresne nevarnosti | GOV.SI and National Annex to SIST EN 1998-1
[2] Ground type C has been determined in the last geological and geotechnical investigations performed on site (Geološko-Geomehansko poročilo o zgradbi tal in pogojih temeljenja na območju RTP Podlog, ECONO, maj 2016))

- Type I horizontal elastic response spectra, with Table 3.2 Parameters in SIST EN 1998-1 as defined by the National Annex to SIST EN 1998-1;

2.1.4 Geogological Requirements

Geological surveys, based on the results of which construction works will be carried out, are the contractor's obligation. The requirements for carrying out geological surveys are presented in Chapter 7 (R4PO01-6E1007).

2.1.5 Access to Site

The transportation of heavy goods can be carried out by roads or by railway, depending on the transport path, including sea.

The Contractor shall obtain all information regarding transportation to the Site and he shall select the most suitable way for delivery of the equipment to the Site by himself.

All transportation, unloading and on-site transportation to complete the construction and erection of the Works shall be included in the scope of the Works.

2.1.5.1 Transportation by Roads

SS Podlog is accessible from Koper port via highway A1/E61 to Ljubljana, then via A1/E57 to exit towards Šempeter and then via national road 447 and local road to location of substation.

For all transports it is obligatory to consider regulations, which deal with planning and building of roads and bridges, as well as regulations considering road safety.

Prior to each exceptional (oversized) transport, the Contractor shall obtain the adequate transport permission from the Road Administration Service and submit to the Employer. If total weight of the exceptional transport exceeds the regulated weight, or when permitted loadings of bridges or roads could be exceeded, a stability assessment for individual bridge and/or road section shall be carried out.

2.1.5.2 Transportation by Railway

The nearest railway station to the SS Podlog location is Žalec, approx. 7 km distant from the SS.

The railway connects Žalec to the port of Koper, to Austria (via Jesenice), to Croatia (via Zidani Most and Zagreb) and to Italy (via Trieste).

2.1.5.3 Ports

The nearest ports to the SS Podlog site are:

- Koper, Slovenia - approx. 170 km by the main roads,
- Trieste, Italy - approx. 165 km by the main roads (partly via Italy),
- Monfalcone, Italy - approx. 190 km by the main roads (partly via Italy).

2.1.5.4 Airports

The nearest airport is:

- Ljubljana/Joze Pucnik approx. 60 km away from the site

2.1.6 Conditions of Loading, Load Limitations

The Contractor shall make his own arrangements and inquiries with regard to the loading, unloading and transport of all equipment and material required for the Works. He shall make all necessary investigations as to the heaviest loads that can be handled at ports or transported to the Site by road or railway. In particular with regard to the loading capacities of all relevant bridges and culverts along the transportation way, he shall deal with all applicable regulations valid in the Republic of Slovenia.

2.2 Site arrangement

2.2.1 General on the Execution of the Works

The Contractor shall be responsible to provide skilled labour force, their accommodation and feeding, site offices as well as all sanitary, technical and safety measures in compliance with the regulations, including insurance.

The Contractor shall provide enough erection material and tools, open air and indoor storage facilities, workshops, compressed air preparation and distribution, measuring devices and instruments, office stationery, transport facilities and required spare parts and machines.

The Contractor shall be responsible for the communications between the Employer and his equipment suppliers.

The number and qualifications of engineers and workers shall be such as to enable undisturbed execution of the Works according to the proposed program and in the required quality.

The Contractor shall be aware that some of the Works will be performed in circumstances where other facilities are in operation.

2.2.2 Work Under Extraordinary Conditions

For the Works performed in the vicinity of the equipment under voltage, special provisions about performing the Works and safety at work, i.e. the same as for the operation and maintenance personnel of the Employer must be considered.

The Contractor shall together with the Employer carefully prepare and co-ordinate the scope and sequence of the Works where the construction interferes with the existing Switchyard. The Contractor shall furnish a program of work including a detailed description of technology, the time schedule of the Works, all temporary installations required for an uninterrupted operation of other electromechanical equipment as well as any required special precautions for safety at work.

2.2.3 Site Organization

In preparing the Site and performing the Works the Contractor shall observe all the provisions of the Construction Act in force in the Republic of Slovenia and all other regulations, codes, ordinances, such as:

- Regulations for safety at construction work,
- Regulations for the manner and procedure of awarding the contract for the Works,
- Regulations for the contents and manner of keeping the daily log on the progress of the Works and the documentation the Contractor shall keep on the Site, marking of the Site and of the building.

The Contractor shall use the existing access roads to the Site and the existing transport roads on the Site. The Contractor will have approach to the construction site and to the space provided for the site organization (Site offices, storage areas) through maintenance enterance in the substation fence and service road between 400 kV and 110 kV switchyards, The access road is asphalted/paved. The Contractor will have to arrange with The Employer about the conditions of entry into the enclosed part of the SS (the gatekeeper, etc.)

Upon completed Works the Contractor shall reinstate the original conditions on the Site.

2.2.4 Site Offices, Locker Rooms

The Contractor shall organize on the Site the site offices and locker rooms for his personnel.

Mutual agreement on this subject should be attained between the Employer and the Contractor within dates as stated in General Master Plan. The Contractor shall submit to the Employer his proposal for the arrangement of site offices, locker rooms, and any electrical and mechanical workshops required for the execution of the Works.

2.2.5 Access to erection area

Access to the construction site will be possible through the existing 6.0-meter-wide entrance. The entrance is intended for occasional use and is not secured. The contractor will be responsible for the technical and physical supervision of the entrance during the construction period. The schematic representation of the access route to the construction site within the SS is shown in the image below.

2.2.6 Storage Facilities

The Contractor shall (upon the agreement with the Employer) organize and maintain the required open air or indoor storage facilities of appropriate size and depending on the equipment.

The Contractor shall prepare a General Master Plan in the manner that equipment and materials will be delivered to the Site in due time.

The Contractor shall organize storage facilities inside substation as mentioned in other parts of this Lot and the power plant boundary and all the required services: storage keeper with appropriate system of evidence regarding the equipment in the storage, storage protection, etc.

Security of the Site and control over the access to the Site area shall be arranged by the Contractor.

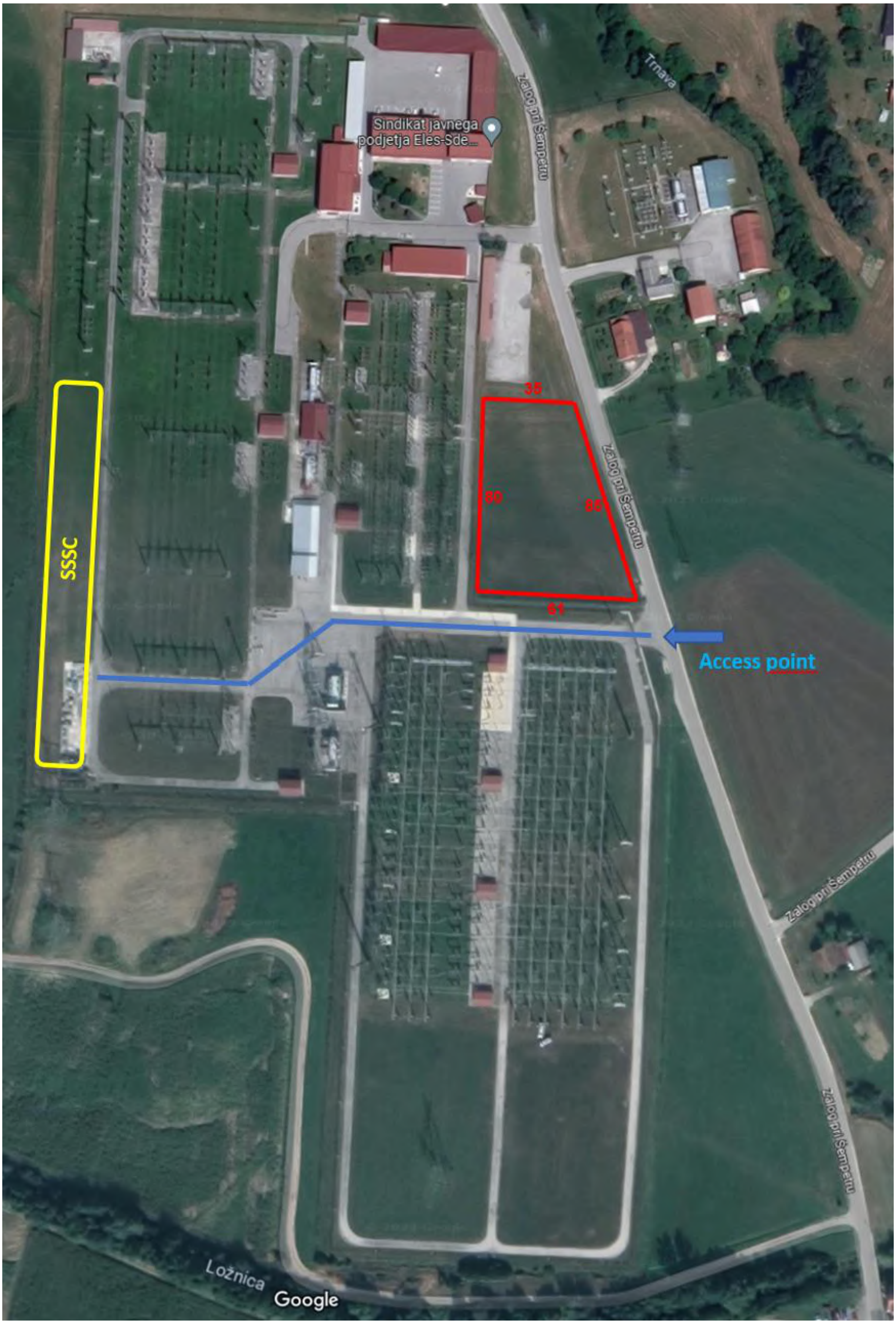

Figure 1.1-1: Area for storage facilities – red area

Figure 1.1-1: Area for storage facilities

Figure 1.1-1: Area for storage facilities

The Contractor shall promptly report about conditions (situation, stocks, etc.) at the storage facilities.

Outside the substation, on the east side of the 110 kV substation, there is a space available for the Site Office and storage area. The available space is 35 x 85 x 81 x 80 m (see the area in red). Seven (7) 110 kV overhead lines crossing the area and are connected to the substations. The hight of the overhead lines must be considering and Contractor must measure the hight of each line.

Should the Contractor require an additional access to the Site or close any of the existing access roads or any other road on the Site due to the erection works, a permission is to be obtained from The Employer.

The Employer expects that all scheduled Works will be carried out in accordance with the General Master Plan.

2.2.7 Accommodation for Contractor's Site Personnel

Accommodation for the Contractor's personnel on the Site is not possible. The Contractor shall at his own expense arrange for accommodation of his own personnel outside the Site. The Contractor shall also organize and take care of the necessary local transport of personnel between their lodging and the working site.

2.2.8 Transport and Handling of Equipment on the Site

The Contractor shall be responsible for all transport and handling of equipment on the Site.

2.2.9 Electricity

The Employer shall place at the disposal of the Contractor the required number of 400 V (3-phase) connection points, distribution to the individual points of consumption, taking into consideration that all relevant safety regulations shall be meet by the Contractor.

The Contractor shall be responsible for sufficient lighting of all the places where the erection will take place and shall bear all the costs. Upon completed erection works the Contractor shall remove all temporary installations.

2.2.10 Water

The Employer shall give free of charge to the Contractor at his disposal the required potable water on the Site.

The Contractor shall be responsible for the water distribution to the points of consumption.

2.2.11 Compressed Air

The Contractor shall take care of the compressed air on the Site required for the purposes of the Works.

2.2.12 Telecommunications

Telecommunications required during the erection and testing, which are not part of the existing telephone system in the Switchyard, shall be organized by the Contractor.

2.2.13 Sanitary Accommodation

Sanitary accommodations shall be provided by the Contractor. Optionally, and upon the agreement with the Employer, the sanitary accommodations can be given at disposal by the Employer.

The Contractor shall be responsible that the Site shall be kept in a clean and orderly condition throughout the execution of the Works.

2.2.14 First Aid Facilities

The Contractor is obliged to organize the first medical aid service at Site. It shall provide also for the personnel performing testing during commissioning.

2.2.15 Restitution of the Site to its Original Condition.

The contractors shall after finishing the Works restore the Site to its original condition at their own expense, i.e. each Contractor shall remove all the temporary provisional arrangements he had set up at the Site and to restore the condition equal to or similar to the one from before them being set up.

For all the activities of restitution to original condition, he shall acquire a consent by the Employer in advance.

2.2.16 Tools and Equipment

The Contractor shall supply and provide all erection and construction equipment and material for work, tools, tackles, materials, consumables, etc. required for the erection of new equipment.

If required, the Contractor shall organize on the Site a smaller mechanical and electrical workshop for his own needs.

/	/	/	
Sprememba:	Opis spremembe:	Datum spr.:	Podpis:

Investitor: ELES	Facility: RTP 400/220/220 kV Podlog Sistem za regulacijo moči (SSSC) v RTP Podlog
Izdelovalec: IBE, svetovanje, projektiranje in inženiring Ljubljana, Slovenija	Part of facility/system: Supply and Erection of Flexible Serial Compensation – SSSC in Podlog SS
/	Type of design: TECHNICAL SPECIFICATION

	Ime in priimek:	Ident. št.:	Title of document:
Approved by:	mag. Marko Testen, univ. dipl. inž. el.	E-1293	3. GENERAL REQUIREMENTS
Confirmed by:	mag. Marko Testen, univ. dipl. inž. el.	E-1293	
Checked by:			Desogn doc. No.: R4PO01-A025/597 — Vrsta projekta: DZR
Designed by:	/	/	Classification No.: C D — Stran/strani: 1/33
11.2023			Identification No.: R4PO01-6E1003 — Spr.:

VSEBINA:

3. GENERAL REQUIREMENTS

3.1 GENERAL

Unless specified otherwise in other parts of this document, the electrical equipment of any electrical installation to be provided under this Contract must fulfil the applicable requirements of this Section.

All components shall be of an approved and reliable design. The highest extent of uniformity and interchangeability shall be met. The design shall facilitate an easy maintenance and repair of the components.

The equipment shall be pre-assembled to the highest possible extent in the Contractor's or Subcontractor's workshop. Mounting of all the components and wiring up to terminal blocks is requested. The terminals of the individual apparatus shall be marked in accordance with the stipulations of this Section.

Unless agreed upon or accepted otherwise and whether originally specified or not, the current or power ratings of electrical equipment selected or proposed by the Contractor, shall generally include a safety margin of every component as included in standard producer's design to achieve requested availability and reliability.

All equipment shall be suitable for the climatic conditions prevailing at Site.

All open-air installed parts shall be protected against weather impact (sun radiation, snow, rain…) by means of adequate covers or shields.

The Contractor is particularly requested to supply all equipment and installations according to regulations currently in force in the Republic of Slovenia, including those listed here bellow:

- for LV installations and components: Tehnična smernica TSG-N-002: Pravilnik o zahtevah za nizkonapetostne električne inštalacije v stavbah (latest issue) and Pravilnik o zahtevah za nizkonapetostne električne inštalacije v stavbah (latest issue),
- for overvoltage protection: Tehnična smernica TSG-N-003 - Zaščita stavb pred delovanjem strele (latest issue) and Pravilnik o zaščiti pred delovanjem strele (latest issue),
- for EMC Pravilnik o elektromagnetni združljivosti (latest issue).

3.2 UNITS OF MEASUREMENT

The Contractor shall design and manufacture all equipment in accordance with metric standards. All documents, drawings, instruction manuals and test certificates shall use metric units.

3.3 LEGISLATION, REGULATIONS AND STANDARDS

Design, materials, manufacture, erection and testing of all equipment (the Works) under this Contract shall comply with the: legislation, regulations and standards, valid in the Republic of Slovenia.

All Works connected with the supply of the SSSC system shall be performed in accordance with the requirements of the appropriate IEC/ISO standards. Where no IEC/ISO standard exists, the SSSC system shall comply with recognized standards and design practices. If the requirements of this specification conflict with any of the above standards or practices, this specification shall apply.

Without limiting the Contractor's obligations, the Works shall comply with the latest editions or versions of the Slovenian Laws, codes and standards.

Standardized publications of the following organizations apply as work standards under this Contract:

- SIST – Industrial standards in force in the Republic of Slovenia (Slovenski inštitut za standardizacijo/ Slovenian Institute for Standardization),
- EN, CEN, CENELEC – European standards,
- ISO - International Standardization Organization,
- IEC – International Electrotechnical Commission,
- DIN – German Industrial Norms/Deutsche Industrienormen,
- VDE – German Electrotechnical Commission,
- BSI - British Standards Institution.

The priority of the standards shall be in accordance with the above listed sequence.

For major SSSC components the following standards in particular shall apply:

Description:	Standard:
Metric Standards	SIST EN ISO 80000
Quality Certification	SIST EN ISO 9001
Power installations exceeding 1kV AC	SIST EN 61936
Earthing of power installations exceeding 1 kV AC	SIST EN 50522
Short circuit currents – calculation of effects	SIST EN 60865
Shunt Capacitors	SIST EN 60871
Reactors	IEC 60076-6
Bushings	SIST EN 60137
AC HV Disconnectors and Earthing Switches	SIST EN 62271-102
AC HV Breakers	SIST EN 62271-100
Surge Arresters	SIST EN 60099
Transducers for Electrical Measurements	SIST EN 60688
Insulating Oil for Transformers and Switchgear	SIST EN 60296
Power Transformers	SIST EN 60076
Measuring relays and protection equipment	SIST EN 60255

Description:	Standard:
EMC – immunity for the equipment used in power station and substation environment	IEC 61000-6-5
High Voltage Test Techniques – Part 2 : Measuring Systems	SIST EN 60060-2
Insulation Coordination	SIST EN IEC 60071
Semiconductor Devices – Discrete Devices – Part 9 : IGBT	IEC 60747-9
Voltage sourced converter (VSC) valves for static synchronous compensator (STATCOM) - Electrical testing (As applicable)	SIST EN 62927
Power losses in voltage sourced converter (VSC) valves for high-voltage direct current (HVDC) systems	IEC 62751-2
Additional requirements for low power passive voltage transformers	IEC 61869-11
Protocol for reporting operational performance of FACTS	CIGRE TB 717
Guide to procedures for estimating the lightning performance of transmission lines	CIGRE TB 63
Selection and dimensioning of high-voltage insulators intended for use in polluted conditions	IEC 60815

If in any or some cases there is no SIST, EN, IEC or ISO standard available, the Contractor must submit a relevant national standard for the Employer's approval.

The Employer may also approve any other standard proposed by the Contractor, on the assumption that it is written or translated into the Contract language and listed as equivalent to one of the standards specified in this Chapter.

It is the duty of the Contractor to take into account the Slovenian industry acts based on the Slovenian SIST, European EN and international IEC standards and to meet all the requirements of the relevant European Union guidelines. In the event that the above mentioned standards for certain equipment do not exist, the Contractor may propose the application of relevant national standards.

At his work, the Contractor must consider at least the following:

- Gradbeni zakon GZ1 (Construction Act, Off. Gazette of the RS) with all corrections, amendments and modifications (Uradni list RS, št. 199/21, 105/22 – ZZNŠPP in 133/23),
- Zakon o meroslovju ZMer-1-UPB1 (Metrology Act, Off. Gazette of the RS, No. 26/2005),
- Zakon o standardizaciji (Standardization Act, Off. Gazette of the RS, No. 59/1999),
- Zakon o varnosti in zdravju pri delu (Health and Safety at Work Act, Off. Gazette of the RS, No. 43/2011),
- Zakon o varstvu pred požarom ZVPoz-UPB1 (Fire Protection Act, Off. Gazette of the RS) (Uradni list RS, št. 71/93, 87/01, NPB1, 110/02 – ZGO-1, 105/06, NPB2, 3/07 – UPB1, NPB3, 9/11, NPB4, 83/12, NPB5, 61/17 – GZ, NPB6, 189/20 – ZFRO, NPB7, 43/22 in NPB8) with amendments and modifications,
- Pravilnik o požarni varnosti v stavbah with amendments (Uradni list RS, št. 31/04, 10/05, 83/05, 14/07, 12/13, 61/17 – GZ in 199/21 – GZ-1),
- Naslov ang. Rules on fire safety in buildings),
- Tehnična smernica za graditev TSG-1-001:2019 Požarna varnost v stavbah s popravki,

- Zakon o varstvu okolja (ZVO-2), (Environmental Protection Act, Off. Gazette of the RS), Uradni list RS, št. 44/22, 18/23 – ZDU-1O, NPB1, 78/23 – ZUNPEOVE in NPB2

The equipment supplied shall meet the requirements and guidelines from EMC area.

For the equipment supplied the Contractor shall submit recommendations, regulations and standards according to which the equipment was manufactured and tested.

3.4 ENVIRONMENTAL IMPACT

3.4.1 Electromagnetic compatibility (EMC) and Electromagnetic interference (EMI)

All devices that are within the scope of supply shall comply with an appropriate degree of electromagnetic compatibility (EMC) and resistance to electromagnetic interference (EMI). Electrical devices shall be designed, constructed, installed and used so that:

1. Electromagnetic interferences caused by such devices will not exceed the level enabling radio, telecommunication and other electrical devices to operate in a way which they were intended for.
2. They have an adequate degree of their own immunity to electromagnetic interference.

This shall be proved by due statements, certificates, evidence on reliability, etc.
The Slovenian Regulations on Electromagnetic Compatibility (EMC) and appertaining by-laws shall be duly taken into account.

3.4.1.1 Radio Interference

3.4.1.1.1 General

Radio frequency interference signals generated by the semiconductor-switched MV switchgear shall in no way disturb the control, protection and telecommunications systems on the SSSC or the Substation control plant and material. In addition SSSC equipment shall not cause any broad band interference. The Contractor shall undertake all the actions necessary to mitigate such occurrences.

3.4.1.1.2 Radiated Noise

Measures shall be taken to eliminate all risk of interference to Substation plant and material due to radiated fields generated by the SSSC.
Susceptibility of SSSC electronics to withstand Radio-Frequency Interference:
The plant and material shall not mal-operate in any way when subjected to radiated field strength of 10V/m over the frequency range of 30 MHz to 1000 MHz.

3.4.1.1.3 Broad band interference

The electromagnetic interference generated by substations and transmission lines is propagated by radiation and conduction. The potential for higher frequency emissions should be limited to avoid interference with any properly licensed or authorized radio, television, microwave, or other equipment in service.

The broadband interference includes:

- Radio Interference (RI):
  - AM Band 150 – 1600 kHz;
  - Amateur radio and commercial radio bands as well as all other bands which are allocated to any voice, information, navigation or other service in the frequency range from 135 kHz to 50 MHz;
  - FM Band 87 - 108 MHz;
- Power Line Carrier (PLC) 14 - 500 kHz;
- Television Interference (TVI) 54 - 88 MHz.
- Microwave Interference 10 -108 GHz.

3.4.1.1.4 Radio / Television Broadcast Interference

The value of the electromagnetic field shall be as defined in IEC 61000-6-4. In the event of interference, control measurements will be performed and the measuring device will be consistent with CISPR.

3.4.2 Audible Noise

3.4.2.1 Maximum Permissible Noise of SSSC Devices

Maximum permitted sound level of SSSC Devices at reference points, which must not be exceeded at any time period of the day at maximum operating state.

Measuring location	Y	X	$L_{complete\ SSSC}$ [dBA]
MM1	125548	510571	38
MM2	125894	510477	38
MM3	126064	510347	38
MM4	126133	510190	38
MM5	126054	510197	38
MM6	126050	510174	38
MM7	126100	510308	38
MM8	125650	510550	38

Table 3-1: Maximum Permissible Noise of SSSC Devices

$L_{complete\ SSSC} = L_{AFeq\ SSSC} + K_t + K_i$

$L_{AFeq\ SSSC}$ is the equivalent noise level expressed in dBA and measured with a frequency weighted (A) and a time weighted (F)

K_t tonal sound (sound characterized by a single frequency component or narrow-band components that emerge audibly from the total sound (see point "Frequency analysis – tonal sound"))

K_i impulsive sound (sound characterized by brief burst of sound pressure)

Frequency analysis – tonal sound (K_t)

In order to determine the presence of tonal sound, a frequency analysis (without frequency weighting) of an equivalent noise level should be made in the range between 25 Hz and 10,000 Hz. A third octave frequency component that is higher than the Δ of the two adjacent is considered to be tonal, if the difference Δ is at least:

- 8 dB in the range between 25 Hz and 125 Hz,
- 4 dB in the range between 160 Hz and 400 Hz,
- 2 dB in the range between 500 Hz and 10.000 Hz.

Correction due to tonal sound is 4 dBA (K_t) in case of meeting the conditions for the tonal sound from the previous paragraph. In case of modelling calculation, data on the sound power spectrum of the considered noise sources should be obtained either on the basis of measurements or from the technical documentation of the noise source.

Impulsive sound (K_i)

Impulsive sound should be determined according to SIST ISO 1996-1. Correction due to impulsive sound is:

- for high-energy impulsive sound source: calculated according to SIST ISO 1996-1 Annex B,
- for highly impulsive sound source is 6 dB or 12 dB (SIST ISO 1996-1 Annex A),
- for regular impulsive sound source is 5 dB (SIST ISO 1996-1 Annex A).

Measurements after installing the equipment

After installing the equipment, it is necessary to perform warranty measurements of the total noise of the newly installed equipment. The operator of the noise measurements shall be determined by the investor. Measurements of noise must be carried out at the measuring locations in Table 3-1. On measurening locations should be performed short therm measurements. Measurements must be made at a time when the device is at maximum load. Measurements shall be carried out in accordance with the requirements of the SIST ISO 1996-1 and SIST ISO 1996-2 standards and the Decree on limit values for environment noise indicators and the Rules on initial measurements and operational monitoring of noise sources and on conditions for their implementation.

3.4.2.2 Noise from existing devices

In Podlog substation, multiple installed devices cause constant environmental noise. The main source of it are the following energy transformers: T421 (400/220 kV, 400 MVA), T411 (400/110 kV, 300 MVA, T211 (220/110 kV, 150 MVA), T212 (220/110 kV, 150 MVA) and T121 (110/20 kV, 4 MVA).

Due to the already high noise levels, the investor will build noise barriers at transformer T211 and/or in location of the east fence (direction from T211 and T212 to residential building at address Zalog pri Šempetru 23a).

3.4.3 Electromagnetic field (EMF)

Self-emission of low-frequency electromagnetic fields caused by SSSC must not be excessive. The basis for determining the exposure and evaluation of environmental impact by electromagnetic field of SSSC should be the limit values (Table 3-2 and Table 3-3), which are used for evaluation outside the Podlog substation fenced area.

Frequency range f [Hz]	*Electric field strength E [kV/m]*
> 0 =< 0,1	0,7
> 0,1 =< 60	0,2
> 60 =< 1.500	30/f
> 1.500 =< 10.000	0,04

Table 3-2: Limit values for the evaluation of SSSC self electric field strength

Frequency range f [Hz]	*Magnetic flux density B [μT]*
> 0 =< 0,1	4.000
> 0,1 =< 1,15	2.800
> 1,15 =< 1.500	250/f
> 1.500 =< 10.000	2

Table 3-3: Limit values for the evaluation of SSSC self magnetic flux density

In the assessment of the electromagnetic field exposure, which must be determined on the basis of the calculation process, such data must be taken into account on the normal operation of SSSC, which results in the worst case electromagnetic field. For the various operating states of SSSC, the maximum contribution in the spectrum of the magnetic flux density spectrum and the spectrum of electric field strengths should be estimated. The highest frequency in the spectrum of magnetic flux density and the electric field strength of SSSC must be given.

The electromagnetic field outside the fenced area of Podlog substation is excessive if at the place of valuation for its self electrical field strength and self magnetic flux density the following applies at any frequency :

$$\sum_{i} \frac{E_i}{E_{RL,i}} > 1 \qquad \sum_{k} \frac{B_k}{B_{RL,k}} > 1 \qquad 0 < f \leq 60 \text{ Hz},$$

$$\sum_{i} \frac{E_i}{E_{RL,i}} + \sum_{k} \frac{B_k}{B_{RL,k}} > 1 \qquad 60 < f \leq 10\ k\text{Hz},$$

Where:

- *E_i is a peak value of the electric field strength for the frequency range from 0 to 0,1 Hz or the effective value of the electric field strength for the remaining frequency ranges,*
- *B_k is peak value of the magnetic flux density for the frequency range from 0 to 0.1 Hz or the effective value of magnetic flux density for the remaining frequency ranges,*
- *$E_{RL,i}$, i-th frequency range corresponds to the limit value of the electrical field strength specified in the table 1,*
- $B_{RL,k}$ *k-th frequency range corresponds to the limit value of the* of the magnetic flux density *specified in the table 2.*

In the calculation referred in the preceding paragraph, only shares in the frequencies are taken into account for which:

- $E_i / E_{max} \geq 0,2$ and
- $B_k / B_{max} \geq 0,2$

where E_{max} and B_{max} are the largest of all E_i and B_k in EMF spectrum, which contribute to the electromagnetic field.

3.5 LOSSES

3.5.1 Calculation of Losses

The tenderer shell provide a document of a loss study, as part of the proposal. This document should provide details of losses across all major equipment components; e.g.: transformer if applicable, interphase magnetics (if applicable), power electronics, harmonic filters (if applicable), control and protection equipment, cooling, auxiliary supply, etc..).

3.5.2 Existing Insulation Levels

The following insulation level exists in the substation where the SSSC will be located:

1. Minimum Basic Lightning Impulse Insulation level 1050 kV

2. Minimum Switching Impulse Insulation Level 750 kV
3. Rated surge arrester voltage 198 kV
4. Line circuit breaker BIL 1050 kV

3.5.3 *Short-Circuit Levels*

Napetostni nivo	220 kV
Trifazne kratkostične razmere	
Maksimalni tok trifaznega kratkega stika	I_{k3}'' = 23,1 kA
Udarni tok[1]	i_{p3} = 58,5 kA
Maksimalna kratkostična moč	S_{k3}'' = 8,8 GVA
Minimalni trifazni kratkostični tok[2]	I_{k3}'' = 3,2 kA
Dvofazne kratkostične razmere	
Maksimalni tok dvofaznega kratkega stika	I_{k2}'' = 20,0 kA
Udarni tok[2]	i_{p2} = 50,7 kA
Maksimalna kratkostična moč	S_{k2}'' = 5,1 GVA
Minimalni dvofazni kratkostični tok[2]	I_{k2}'' = 2,7 kA
Kratkostične razmere dvofaznega kratkega stika z dotikom zemlje	
Maksimalni tok dvofaznega kratkega stika z dotikom zemlje	I_{k2EL2}'' = 23,4 kA
Del toka skozi zemljo	I_{kE2E}'' = 24,1 kA
Udarni tok[2]	i_{pk2E} = 55,2 kA
Maksimalna kratkostična moč	S_{k2E}'' = 6,0 GVA
Minimalni dvofazni kratkostični tok[2]	I_{kE2E}'' = 1,9 kA
Enofazne kratkostične razmere	
Ozemljitev 220 kV nevtralne točke	ozemljeno
Maksimalni tok enofaznega kratkega stika	I_{k1}'' = 23,6 kA
Minimalni tok enofaznega kratkega stika [2]	I_{k1}'' = 2,4 kA
Faktor zemeljskega stika na 220 kV zbiralkah[3]	k_0 = 1,02
Prevodni KB ekrani, kompenzacijski vodniki in zaščitne vrvi	
Ozemljevanje prevodnih ekranov 220 kV KB	*Enostransko*
Minimalni prerez prevodnega KB ekrana pri enostransko ozemljenih KB ekranih	Cu ≥ 165 mm²/žilo KB
Kompenzacijski vodniki ob 220 kV KB pri enostransko ozemljenih KB ekranih	Cu ≥ 125 mm²
Ozemljitveni vodniki	Cu ≥ 125 mm² ali FeZn ≥ 345 mm²

Table 3-4: Short-Circuit Levels

3.5.4 *Fault Clearing Time*

The following table provides the tripping times of individual distance stages on the 220 kV Podlog-Obersielach overhead transmission line. The first data represents the tripping time from the Podlog substation to the Obersielach substation, and in parentheses is the time for the distance zone from the Obersielach substation to the Podlog substation.

Stage 1:	150 ms	(150 ms)
Stage 2:	750 ms	(400 ms)
Stage 3:	2.0 s	(1.35 s)
Stage 4:	4.8 s	(3.0 s)

Typical break time of Eles CB's is estimated at 50 ms.

3.6 STANDARD VOLTAGE LEVELS FOR LV EQUIPMENT

The following standard voltage levels according to SIST EN 60038 shall be respected for all low-voltage equipment, power and control installations within cubicles, panels, desks, MCC, etc.

Low Voltage AC Equipment

- Nominal system voltage: 3 x 230/400 V
- Nominal system frequency: 50 Hz
- Maximum voltage variation: ± 10 %
- System configuration: 3-phase (4-wire and 5-wire system), solidly grounded (TN-C and TN-C-S)
- Test voltage (1 min): 2.5 kV
- Minimum insulation resistance:
  - Phase-to-phase: 400 kΩ
  - Phase-to-earth: 230 kΩ

Low Voltage DC Control, Protection and Trip Circuits:

- Nominal system voltage: 220 V DC
- Test voltage (1 min): 1.5 kV
- Minimum insulation resistance: 220 kΩ
- System configuration: non-grounded, with insulation monitoring (IT-K)

Voltage Transformer Secondary

- Secondary windings for a rated voltage of 100/√3 V are requested.

Current Transformer Secondary

- Secondary windings for a rated current of 1 A are requested.

3.7 COLOR CODING

Cables and conductors identification shall follow harmonized color or/and alphanumeric marking according to CENELEC HD 308 S2:2001 and SIST EN IEC 60445:2021.

Screen displays, control panels, etc., shall be color coded as follows:

- 400 kV red
- 220 kV green
- 110 kV light-blue
- 20 kV black
- 10 kV red
- 230/400 V AC violet
- 220 V-DC orange

3.8 CONTROL CUBICLES

3.8.1 Panels, Cubicles and Marshalling Racks

3.8.1.1 Design and Construction

Panels, cubicles, and marshalling racks shall be of free standing design and shall be constructed of folded sheet steel of minimum thickness of 1.5 mm to ensure rigid support for the equipment. They shall be supplied complete with their fixing and lifting lugs, with eye bolts and with all required base frames, anchors, etc.

They shall be equipped with bottom frames suitable for bolting onto the concrete or other supporting structure. Panels or cubicles mounted in rooms provided with false floor should have their own supporting structure, being fixed on the cable floor ground.

The cubicles, panels and marshalling racks shall be workshop completed with all locks, color coded busbar, internal wiring, terminal boards and accessories.

The overall height of cubicles, panels and racks shall not exceed 2500 mm. The finishing painting color shall be selected and agreed upon by the Employer. Earthing connections shall be clean of paint.

All cubicles must be suitable for continuous operation under the climatic conditions prevailing at Site. A dust and vermin-proof design with degree of mechanical protection not less than IP41 is requested for indoor installations and IP55 for outdoor installations.

A proper natural ventilation of cubicles with dust-protected vent openings shall ensure the temperature inside the cubicle to stay below 45°C in any case.

The panels/cubicles design shall enable mounting of additional panels/cubicles at both side ends. Means shall be provided to limit the opening angle of doors to approx. 100°.

Cable connections to panels and cubicles must be provided with suitable seals as to prevent the ingress of dust or vermin, or the propagation of possible flames. A provisional sealing of cable entrances is required during installation. For cubicles or marshalling racks the cables must enter from below.

Each panels/cubicles shall be provided with earthing devices for earthing the incoming cables as requested by EMC regulations. An earthing bar with a minimum cross-section of Cu 50 mm^2 shall run the full length of the cubicles, panels or boards. All metallic cable shields shall be earthed using EMC glands with fixed 360^0 contact surface (not a spring clip or any kind of flexible tongues).

All dial instruments, relays, control and selector switches, indicating lamps, push-buttons and trip levers shall be flush-mounted and located at convenient heights on the front of the cubicle in a logical and clear manner. The layout of these panels is subject of approval of the Employer.

An adequate vibration and shock-absorbers shall be installed wherever required for the correct operation of instrument and relays.

Clearances between live parts and to earth shall be in accordance with the latest relevant regulations.

All panels/cubicles shall still have minimum 10 % spare room for mounting of auxiliary relays, etc. when commissioning is finished.

The following auxiliary installations shall be provided within the cubicle:

- two single phase receptacles 230 V/10 A with protection contact,
- LED lamp(s) with door switch for interior lightning,
- earthing of cubicle door with flexible flat wire Cu 16 mm^2.

Motor control centers (MCC) assemblies shall be of verified type acc. to EN 61439.

3.8.2 Low Voltage Equipment

3.8.2.1 Miniature Circuit Breakers

Miniature circuit-breakers (MCB) shall be single, two or triple pole with adequate current ratings. The operating and the overload mechanism shall be sealed.

Special attention is required for DC miniature circuit-breakers dimensioning, selection and selectivity. Selectivity has to be proven by the Contractor during design period.

Two auxiliary switches with switchover contacts, shall be provided on each MCB and wired to the nearest terminal block and further into the control system.

3.8.2.2 Contactors

Low-voltage contactors shall be of the air break type with arc shields according to IEC Standards, adequate selected according to the burden requirements. When closed, the contactors shall withstand the system prospective fault current determined by the subsequent coordinated short-circuit tripping device. The related thermal overcurrent releases shall be adjustable in order to fit the motor requirements. A thermal release shall be temperature compensated up to 70°C ambient temperature.

The following control voltage variations shall be respected:

- 80 % to 110 % of the rated control voltage for closing of contactors
- The contactor shall still hold closed contacts at applied 70 % of the rated voltage.

If contactors are used for difficult loads, often operation, tough environment or DC application, heavy duty contactors or similar technical value solution has to be implemented. Contractor has to point the selection procedure and approve it with additional documentation from the manufacturer.

3.8.2.3 HRC Fuses

The high rupture current (HRC) fuses shall be suitably selected to comply with the local climatic conditions, and the feeding or connected load.

They shall be of the current limiting type with characteristic corresponding to the associated equipment. Pre-connected fuses up to 63 A shall be inserted into crowbar operated fuse isolators so that no special tool is required for their replacement. An indicator must be provided to indicate the fuse blowing into the control system.

3.8.2.4 Load Disconnecting Switches

The load disconnecting switches shall ensure local manual operation from the front panel but they shall be designed so as to allow mounting of a remote control device. They shall have a padlocking device and self-cleaning contacts with a high resisting anti-arc case and with quick-making and quick-breaking action, capable of switching the specified rated currents. If suitable, the load break switches may be combined with the HRC-fuses.

3.8.2.5 Overcurrent discrimination of LV AC circuits

The overcurrent devices must respond selectively in order to restrict any fault to the affected part of the system. The Contractor shall be responsible for proper overcurrent discrimination of protective devices within his scope of Works.

Full overcurrent discrimination means:

- routine current peaks must not cause the disconnection,
- when operating properly, only the protective device nearest to the fault in the supply direction must react,
- if this device fails, the next one to it in sequence must respond.

The overcurrent discrimination of protective devices shall be established by their time/current characteristics with particular attention to:

- 51 (long delay overcurrent),
- 51 (short delay overcurrent),
- 50 (instantaneous overcurrent),
- 51N (ground – fault).

3.8.2.6 Auxiliary Switches

Each item of the plant shall be equipped with all the necessary auxiliary switches, contactors and mechanism for indication, protection, metering, control, interlocking, supervisory and other services as applicable.

All auxiliary switches and mechanisms shall be mounted on easy accessible location clear off the operating mechanism and are to be protected in an approved manner.

3.8.2.7 Dial Instruments

All analog dial instruments provided for cubicles/panels shall be of the flush mounted, back connected, dust proof and switchboard type.

The dial instruments size shall be selected among frames of 96 x 96 mm and 72 x 72 mm with a circular scale angle not less than 240°.

Unless specified otherwise in Particular Technical Specifications, the requested class of instruments is 1.5.

Scale plates shall be white with black pointer and markings. The read-out window shall be non-reflecting, anti-static and with minimal parallax error.

The larger range of double-scale dial instruments shall be engraved on the outer side and the smaller range on the inner side of the scale curve. A clear indication shall tell the reader which scale is currently in service.

A zero adjustment device is requested for each dial instrument. The zero setting of the pointer shall be done by screw-driver and without removing the instrument cover.

3.8.2.8 Indicating Lamps and Push Buttons

Where indicating lamps and push buttons are used for control boards, a switchboard type and insulated for service voltage are to be provided. Only lighting indications based on the LED technology will be accepted.

The lamp and push button colors shall conform to standards set out under IEC 60073 and SIST EN 60204-1 as follows:

- Push button with back indication (general purpose) white
- Indicating lamps (general purpose) white
- Abnormal positions of selector and test switches yellow
- Disturbance lamps yellow
- Push button for emergency tripping red
- Push button and indicating lamp for ON position red
- Push button and indicating lamp for OFF position green

A switch to switch-off and a test switch for testing of lamps shall be provided.

3.8.2.9 Alarm Annunciation

All alarms shall be displayed on the Operator Station alarm screen and implemented with front-mounted alarm annunciation device locally.

The window of each illuminated alarm annunciation device shall be transparent, with engraved legend and shall be clearly readable only when the alarm is activated. Special care has to be paid to visibility and readability of screen announcements.

Requested alarm annunciation function will be implemented into the respective control equipment and will not be stand-alone equipment.

3.8.2.10 Selector Switches

Unless otherwise specified, selector switches and test switches for control boards shall be of the switchboard type, with the necessary positions and engraved plates. The normal position shall be vertical.

3.8.3 Small Wiring and Terminal Blocks

All panels, cubicles, and racks shall be factory wired. If they are shipped in more than one section, electrical connections between the sections via terminal strips shall be provided for this purpose.

Wiring within panels etc. shall be laid on trays and shall be segregated according to voltage level. Wiring carrying AC and DC voltage shall also be segregated.

All internal wiring of panels, racks, boards, etc. shall consist of stranded fine-wired and properly insulated copper wires. The insulation material shall be of fire-resistant polyvinyl chloride (PVC), or of other approved fire-resistant type. A squeezed sleeves or pins/AMP shall be provided at bare ends of stranded wires.

The minimum cross-section of each copper wire shall be as follows:

- 2.5 mm2 for all consumers (such as motors, heaters) and current transformer circuits,
- 1.5 mm2 for control wiring above 60 V service voltage,
- 0.75 mm2 for control wiring below 60 V,
- about 0.2 mm2 in case the applied connection technique of standard electronic equipment does not permit the use of larger cross-sections subject to the approval of the Employer.

All secondary wiring shall be arranged and protected to prevent damages caused by arching, or by mechanical effects. It shall be neatly run in PVC free rigid plastic raceways or trunks clear of any metal panels and filled not more than 70 %.

Compression type cable lugs shall be provided for the connections of cable cores with a cross-section of 1.5 mm2 or larger. The terminals shall be designed to ensure that no pinch-off of the cable cores may occur. Bimetallic clamps shall be provided if conductors of different material are connected.

The ends of every cable core and all the secondary panel wiring shall be fitted with identification plate of moisture and oil-resistant insulation material. An identification number of corresponding terminal and equipment shall be clearly engraved in black on each plate. Additional ferrules are to be used to identify phase circuits (L1, L2, etc.).

If different terminal boards are arranged close one to each other, the ferrules shall contain the terminal board denomination and the terminal number. The ferrules shall be fitted in such a way that they cannot become detached when the wire is removed from the terminal.

Wiring shall terminate in one or more terminal boards accommodated at the bottom of each panel or compartment. Internal wiring between instruments or other devices not using the terminal block shall be permitted within the same compartment only. All the internal wiring shall enter the terminal block at one side only.

Terminal blocks shall be snapped on rails according to DIN, and shall be numbered consecutively beginning from left to right (or top to bottom). Terminal block or group of blocks shall be labelled with clearly visible title.

All terminals shall have two (2) separate pressure clamping plates suitable for connection of incoming or outgoing, stranded or solid conductors respectively. Terminals with clamping screws in direct contact with the conductor are not acceptable.

Among others also the following categories of terminals shall be used:

- terminals for power circuits,
- terminals with short-circuit facilities for current transformer circuits and disconnecting facilities for voltage transformer circuits,
- terminals for measuring and control circuits with bridging facilities to the nearby terminal where applicable.

All terminal blocks shall contain 20 % spare terminals of category C. For communication connections respective connectors are to be supplied.

Insulation barriers shall be provided between each pair of power circuits and between the terminal categories. The height and the spacing shall give an adequate protection to the terminals and allow easy access to the same.

3.8.4 Identification and labelling

The names of all systems and components of the installation and its equipment shall be in the Slovenian language. The assignment of functional names shall be performed by the Contractor in consultation with the Employer's Representative.

All systems and components shall be provided with unique codes. Unique means that each system, accessory, instrument, mechanical or electrical component, etc. shall be provided with a distinctive code. The Contractor shall determine the assignment of codes in consultation with the Employer's Representative.

Registration of codes and the supply and fixation of nameplates and coding labels is included in the scope of Works.

Nameplates and coding labels shall remain legible from a distance during the entire lifetime of the Works and shall be attached permanently on a clearly visible spot on the apparatus. All nameplates shall contain the compulsory information mentioned by IEC. The nameplates shall be in the Slovenian language.

3.9 AUXILIARY POWER SUPPLY

3.9.1 AC Auxiliary Power system

It is foreseen that the SSSC will receive all the anticipated AC energy from an existing system of substation AC auxiliary supply. This means the following:
Up to 100 A MCB is available on the main 0,4 kV power distribution board in the substation auxiliary supply building.
Supply, installation and connection of cables from the SS auxiliary power supply distribution board to the SSSC facility distribution units is the subject of supply and installation of the Contractor.
The SSSC AC main and sub distribution boards shall be sized for ultimate configuration of the SSSC and shall have minimum 20 % spare feeders and capacity excluding the feeders reserved for future use.

3.9.2 DC Auxiliary Power system

It is foreseen that SSSC will also receive all the necessary DC energy from the existing power supply systems for auxiliary supply of the substation. DC distribution centre is powered by two lead-acid batteries 220 V DC.
For the SSSC needs, the two (one from battery A and one from battery B) circuit breakers 16 A are foreseen.
Erection of necessary cable conduits/ducts, installation and connection of cables from the SS auxiliary power supply distribution unit to the SSSC facility distribution is the subject of supply and installation of the Contractor.
The DC main and sub distribution boards shall be sized for ultimate configuration of the SSSC substation and shall have minimum 20 % spare feeders and capacity excluding the feeders reserved for future use.

All control and protection devices shall be supplied by 220 V DC. By use of appropriate converters, each device will adjust the voltage for its own needs. The 220 V DC system shall be supplied from a duplicated rectifier - battery system. Essential consumers shall be supplied from both sections of the 220 V DC distribution unit.

In case lower voltage levels are required, only industrial DC/DC converters are allowed for this purpose; they are foreseen for DIN standardized rail mounting, have screw terminal blocks and are declared by the manufacturer for use in such systems. The use of so-called wall adapters and similar solutions characteristic for “consumption” electronics are not allowed.

3.9.3 Power Supplies and Fusing

All monitoring and control equipment must be supplied from power system source 220 V DC
The Contractor must ensure that his installed equipment is not interfered by the long cable runs, particularly to the more distant components.

If the Contractor needs a different voltage level(s), he must design, supply and install all the needed equipment.

Miniature circuit breakers (MCB's) of adequate rated currents and tripping characteristics shall be supplied preferably. If the necessary selectivity cannot be realized, fuses with the supply voltage failure detector shall be applied.

The main power supply fuses shall be located in functional groups within separated power distribution cubicles.

Fuses or MCB's rating and time/current characteristics shall be carefully coordinated. A fault within an individual item or module shall cause only its fuse/MCB to rupture, and thus disconnect that item from the power supply, before the main fuse is affected.

Failure of a main fuse shall affect the protected zone only, having no effect to the entire functional group.

Failure of an individual module or component fuse/MCB. shall be indicated by an alarm, which shall state the cubicle type in which the fuse/MCB has failed. An individual signal in the respective control module shall be initiated.

All closed-loop circuits, including their drives and controllers, must be fused separately. If the control circuit fuse/MCB. fails, the manual control functions of the drive must be retained.

Particular design measures shall be taken to restrict the effect of faults in modules or other devices, which may block logic interlocks, or other control systems. Such fault shall be restricted to the system in which the fault has occurred.

All electronic devices and other auxiliary electrical elements and systems shall be protected against excessive voltage transients and other over voltages from the system or from outside sources, by adequate selected surge arresters.

Status and alarm indications shall be fused in groups independently of the logic equipment.
Binary signal conditioning and analog limit value modules should be fused separately, but may also be fused with the related drive control.

3.10 CABLES

3.10.1 General

Power supply, control and measuring cables for external connections of the Contractor's equipment to the equipment supplied by Others are included in the scope of supply unless otherwise specified in other parts of Tender.

The Contractor's obligation is:

- To specify in detail all the cables needed for proper connection of power supply and control connections of his equipment to equipment supplied by Others.
- To give any other information and instruction for cable connections that must be provided by Others.
- For his scope of supply the Contractor shall perform all relevant design and engineering of the cable system and prepare the cable plans, connection diagrams, list of cables and the cable routing plans.
- The Contractor shall select the most suitable and effective cable passage and raceways ensuring they do not interfere with other installations. All these passages must be clearly indicated on his equipment drawings.
- However, in any respect the scope of supply, laying and connecting of the cables must include, but not be limited to:
  - all necessary cables and wires for power, AC and DC instrument transformers, control, measuring, signals etc., as applicable
  - all necessary number plates for the cable-identification (numbering code will be fixed later),
  - all necessary fixing materials,
  - all necessary fire protection material for sealing cable openings through walls and ceilings as well as between switchgear and control, measuring, recording and switchgear cubicles, operating panels and desks, etc.,
  - all necessary cable connections including compression cable lugs, fixing and clamping materials, etc.,
  - all necessary cable sealing ends and cable connecting sleeves including fixing materials,
  - all necessary compression connectors,
  - all necessary cable glands.

The maximum continuous current carrying capacity of each individual cable type and cross-section used shall be determined by the Contractor taking into account site environmental conditions. The resulting load reduction factors are subject to the approval of the Employer. The conductor cross-section of each cable, moreover, shall be adequate for carrying the prospective fault current determined by the next relevant short-circuit protection device when operating under the specified load conditions without deterioration of the dielectric. All the above data and their calculation shall, accompanied by the short-circuit calculations appear in the documents to be supplied by the Contractor according to these Specifications.

Cables having a cross section greater than 16 mm2 are to be of XLPE copper cable type; LV cables of smaller size may be of PVC insulated type. All cables are to be suitable dimensioned for ambient temperature of 40 °C or higher acc. to highest temperature environment condition on site where they will be implemented.

Teflon- or silicone- based insulation must be provided for cables exposed to ambient temperature above 60 °C.

The cables must be suitable for lying indoor, outdoor (direct or indirect sunlight), in ducts, on trays, underground and in water. The cable-sheaths must be resistant to solar radiation, the effect of oil, bacterial action, insects, rodents and seawater.

All cables must be fitted with a name plate at each end for identification in accordance with the identification system. The individual cores must be identified by numbers or by a color code.

The cables must be laid in such a way that they can be replaced in a simple manner. Cables must be carefully arranged and ordered. In locations where proper positioning of the cables is not possible without securing them, quick-fastening UV – resistant PVC cable ties must be used.

The identity of the manufacturer shall be provided throughout the length of the cable by embossing the outer sheath with "name of Manufacturer - year of manufacture". The letters and numerals shall be raised and shall consist of upright block character. The gap between the identification marks shall not be greater than 200 mm.

3.10.2 LV Power Cables

All LV power cables shall be screened. The low voltage power cables shall be standard single and multi-core cables with copper conductor and XLPE or PVC insulation. The common core covering shall consist of non-hygroscopic filler.

To ensure the elimination of excessive contact potentials on any object, effective earthing must be carried out as a safety measure. A suitable type of 3-core, 4-core and 5-core low-voltage power cables must be provided.

The minimum conductor cross-section of the low-voltage power cables is 1.5 mm2.

If 3 1/2-core cables are used, the reduced conductor for protective neutral must have a cross-section of at least 16 mm2.

DC cables must be 2-core or 3-core as requested by the application. Single-core power cables of larger cross-sections may be used between batteries or rectifiers and the DC switchgear.
Cables feeding the automatic measuring and control systems below 60 V must have one core for the isolated screen earthing bars.

The LV power cables must be designed for the dynamic and thermal characteristics of the electrical system.

Conductor
The cables' conductors shall be made of stranded copper.

Conductor design:

- from 2.5 mm2 to 4 mm2 – circular stranded conductor
- from 6 mm2 to 25 mm2 – circular stranded conductor
- from 35 mm2 to 500 mm2 – sector shaped stranded conductor

The conductor of heat-resistant and flexible cables shall consist of fine-stranded copper.

Over sheath
The PVC over sheath shall be oil-resistant, treated in order to prevent the insulation from spreading fire and shall be colored black for all LV power cables. The sheath shall contain the manufacturer's name, the voltage levels Uo/U in kV and the cable type.

Screen
Screen shall be of braided copper or braided tinned copper.

3.10.3 LV cables on the transformer

All cables on step-up transformer for voltage level 231/400 V AC and 220 V DC shall be made for temperature range of -25 °C to 90 °C and shall be suitable for outdoor installation. Copper cord shall be flexible, finely wired (SIST EN 60228, cl 5), insulation shall be flame retardant and non-combustible (FRNC), numbered, with screen of tinned copper shield (at least 80% of area over the circumference), sheath shall be FRNC. All material shall be halogen free.

3.10.4 Measuring and Control Cables above 60 V

The control cables shall be of the multi-core, PVC-insulated type withstanding without deterioration the conditions prevailing at the individual place of installation. Cables for analogue signals shall have a common screen of braided tinned copper wires (coverage minimum 85%), and twisted-pair cores.

The minimum cross-section of each copper wire of the instrumentation and control cables shall be as given below:

- 1.5 mm2 for all cables above 60 V service voltage
- 1.5 mm2 for all cables leading from the terminal boxes to individual local instruments
- 1.5 mm2 for all thermocouple compensation leads
- 0.5 mm2 for all I&C multi-core cables leading from the local terminal boxes to the control cubicles.

Within control and electronic circuits, the minimum cross-section depends on design of the electronics. In all cases, the maximum voltage drop on the cable shall not exceed 5 % at the worst load and temperature conditions.

Cables with a common core screen and protection against electrical interference must be generally used for all leads going outside the building. This cable shielding shall exclude extraneous effects and prevent faulty signals generated by adjacent power cables. For use inside cubicles the shield can be omitted.

The multi-core cable with more than 7 cores shall have approx. 20 % spare cores for future use. Cables with six and more cores shall be number and/or color-coded or otherwise properly identified with permanent prints at intervals not greater than 300 mm throughout the core. The color-coding or other identification marks shall be shown on the circuit/connection diagrams.

3.10.5 Fieldbus Cables

Special fieldbus cables are to be used in measurement and control systems for connecting the field devices with the center in the field, where necessary. They should be dimensioned for adequate energy and data rates. Control functions and the energy supply of the terminal devices as well as additional services such as active wear monitoring for the terminal devices have to be transmitted via these connections. They have to correspond and have to be calculated and selected with their differing demands acc. to standard IEC 61588-2 and EN 50288-7.

3.10.6 Instrument Transformer Cables

The design of these cables must comply with Clause "Measuring and control cables above 60 V". The minimum conductor cross-section for instrument transformer cables is 2.5 mm2.

3.10.7 Measuring and Control Cables below 60 V

Measuring and control cables for voltages up to 60 V shall have stranded copper conductors of minimum 0.8 mm in diameter. Multi-pair control cables with paired lay-up of the leads and lay-up of the pairs themselves shall be used. The spare free capacity shall be 15 % at least.

The control cables shall have a common screen of braided tinned copper wires (coverage minimum 85%) to exclude any extraneous effects and to prevent faulty signals.

The individual cores of multi-pair control cables as well as the cable itself shall be identified by code numbers at both ends.

3.10.8 Cable Connections and Cable Joints

For the connections of cable cores with a cross-section of 1.5 mm2 or larger, compression type cable lugs shall be provided. The terminals shall be designed to ensure that no pinch-off of the cable cores occurs. If cables with a flexible cable core are used, the stripped ends of the cores shall be tinned or fitted with a core sleeve before connection. Bimetallic clamps shall be provided in case conductors of different material are connected. The same applies also for all connections to electrical consumers.

Stripped cable ends shall be attached to the rails with corrosion-resistant clips. Any cable joints required shall be of synthetic non-flammable material. T-joints will not be accepted.

Cable jacket

The cable jacket shall be oil-resistant, rodent-resistant and flame-retardant. It shall be coloured black for all conventional control and instrument cables. It shall contain the manufacturer's name, cable type and the voltage rating phase to earth/phase to phase in kV.

Cable joints and terminations

Joint boxes should be avoided wherever possible. Any boxes needed are to be made of flame-retardant material. Cable branch boxes will not be accepted.

Terminal Boxes and Terminal Cabinets

Terminal boxes or, wherever suitable, terminal cabinets shall be fitted on all the necessary points in order to simplify local grouping of cables and distribution of signals.

If the terminal boxes are not adequate, suitable intermediate terminal cabinets are to be used.

Terminal boxes and cabinets must be equipped with the necessary terminal strips, cable glands, cable screw couplings and attachment components for the connection of the cables.

Terminals used for connection of current transformers are to be fitted with short-circuit links. The necessary earthing terminals are to be provided for the earthing of the boxes and cabinets.

3.10.9 Cable Laying and Routing

Cables arranged on vertical runs, walls and ceilings must be secured with corrosion-resistant cable clips. In this case two cable clips must be used per meter of cable run where anchoring bars are used, while on vertical runs one clip per meter is sufficient. More than one cable may be exceptionally secured by one clip only where space restrictions do not allow side-by-side fixations.

Cable risers near gangways or in electrical rooms which are exposed to possible mechanical damage are to be protected up to 2 meters from ground by suitable metal cover.

Cables must not touch sharp edges or hot surfaces of the equipment which could damage the insulation and cause hazard. Holes in metalwork for cable routing or the termination of conduits shall be drilled with a twist drill of the correct size.

Holes in trunking shall be drilled, punched or cut by ring saw. After cutting, burrs and sharp edges on the metalwork or trunking shall be removed to prevent abrasion of cables. Wherever applicable, cable glands or proper bushes shall be applied to prevent any risk of cables damage.

After laying the cables, the openings in framework, in the ceiling, floors and walls must be fire-proof sealed. This request applies also to switchgear panels and cubicles, to passages between cable ducts which can be walked through and those which cannot, to vertical runs etc. As there is an increased risk of fire during the construction period, all breaks shall be sealed fire-proof at that early stage.

If not supported on cable trays or vertical runs, the power, DC and instrument transformer cables must be generally laid singly in PVC pipes. Where ambient temperatures above 60 °C are expected, galvanized steel conduits must be used. Similar lighting cables, measuring and control cables and telephone cables, can be run in one conduit. Surface-mounted conduits must be secured every 1.5 m.

Cables for double feeders of switchgear, distribution boards, cubicles and cabinets must be laid separately so that a short circuit in one feeder does not affect the other one.

Power supply cables and control/instrumentation cables must be strictly segregated and laid in separate runs. The cables must be laid in such a manner that they can be easily replaced or added to.

The following minimum separations are to be respected:

- 300 mm between low-voltage power cables and control, measurement and signaling cables for voltages above 60 V,
- 600 mm between medium/high voltage cables and control, measurement and signaling cables for voltages above 60 V.
- The Contractor is to ensure that adjacent cables do not interfere electrically by using the above mentioned spacing.

When laying cables on trays, vertical runs, in cable ducts, etc. and when choosing the size of cables, care must be taken to ensure that adequate ventilation is guaranteed and that there is no risk of thermal overloading, undue pressure or distortion of the cables. Not less than 300 mm is allowed between two cable trays, cables could be laid on trays or ladders only in one layer. Adequately reduction factors acc. to method of installation has to be used for cable dimensioning.

Cables which move with connected apparatus due to thermal expansion must be of a flexible type or must have sufficient slack at the location.

Contractor should prepare all necessary mounting supports and perform all necessary preparation works for mounting cable trays on equipment under his supply.

3.10.10 Cable Terminations

At all terminations of wires and cables, the insulation shall be neatly stripped without nicking the strands of the conductors. Cable lugs for power cables shall be of adequate size. Cable glands or clamps shall be fitted in all cases to prevent any stress being borne by the conductors or the terminals. It is important that the sealing compound and sleeves used in terminations should be selected to suit the service conditions under which the cable is to operate.

Where cable terminations are likely to be disturbed for maintenance purposes, some slack cable in a loop or other suitable form is to be allowed at a convenient place in the run.

3.10.11 Optical Cables

Contractor must also deliver, lay, splice, label and connect all respective optical cables. Contractor must perform also all related control measurements. Contractor must perform all related works and supply all related installation material as needed for successful cablings. At least the following is requested:

- all related optical connections,
- splicing and connecting of optical cables,
- all related labels/identification plates (for cables as well as for individual fibers),
- all others following the general requirements for cabling and
- corresponding measurements of optical connections after successful cable laying and connector installation.

Optical cable routes

On all cable routes, where optical cables must be installed, always PVC tube (TEWEBE) with diameters 21/28 or 29/36 mm must be used for optical cables installation.
For simple and obstacle free installation of optical cables into respective tubes, the latters must be smoothly and tightly connected using standard smooth coupling clamps on both sides.
Wherever the tubes are disconnected, the cable must be adequately mechanically protected. Entry of a cable into tube must be made with standard PG cable gland.
It is very important to mention that temperature factor of PVC tube is approximately 0.2 mm/m°C what can cause also rupture of PVC tube form respective metallic clamps.
Laid cables must be labeled with following labels (after each 3 m of cable length):

- saying "INFORMACIJSKI KABEL",
- displaying optical cable sign "Caution laser beam" and
- cable identification.

Cable laying

Adequate number of Contractor's specialists must be trained with respect to optical cables. They must have adequate tools for testing and cable pulling within allowed tension range. Pulling force must be permanently controlled by tensionmeters or breakaway swivel. Cables must be laid only under ambient conditions as defined by the cable manufacturer. Cable route must be selected in such a way that mechanical damage cannot occur.

Optical cable splicing

Only trained personnel with adequate splicing and measuring equipment must perform splicing of optical cables. When respective splicing works are completed, then geometry, mechanical, optical and transmission characteristic are verified. Measuring results must be transparently displayed in corresponding tables as appendix to measuring protocol.

3.10.12 Tests

Cables shall be workshop tested in accordance with applicable standards. The minimum scope of tests shall include:

- dielectric loss factor (tgδ) test for 2.25 times rated voltage and constant ambient temperature (MV and HV cables only),
- dielectric loss factor with increasing temperature (HV cables only),
- measurement of insulation resistance at 20 °C room temperature. If the actual temperature is higher, the measured value shall be adjusted accordingly,
- measurement of sheathing and protecting layers thicknesses,
- high voltage impulse test (HV cables only),
- high voltage DC test (HV cables only).
- Site test on power cables shall include:
    - measurement of insulation resistance (Megger test)
    - high voltage test on HV cables only

Site test on control cables shall include the voltage drop measurements on critical lengths.

3.11 HIGH-VOLTAGE INSTALLATION

3.11.1 Voltage and Short circuit Capability of HV equipment

All high-voltage equipment to be designed and delivered as part of the Works shall be designed for the following ratings and design parameters:

	Requested Voltage and short circuit levels of HV equipment
HV system voltage level	220 kV
Nominal voltage	220 kV
Highest voltage for equipment Um acc. IEC 60071	245 kV
Additional requirements for HV equipment: Highest voltage for equipment must withstand 1,15 p.u. for 60 minutes.	253 kV (60 min)
Earthing of system	Solid
Peak short-circuit current, peak value	100 kA
Rated symmetrical short circuit current 1s	40 kA

Table 3-5: Design voltage and short Circuit parameters

The short circuit withstand capability of all MV apparatus shall be designed assuming an available three phase or single phase fault level corresponding to the maximum future short circuit level as specified in other parts of this Lot.

3.11.2 General technical requirements

The degree of protection for the entire installation shall be such that there is no danger to people. The Contractor shall prove that safety measures comply with the applicable standards.

The installation shall be designed in such a way that there is a minimum risk of faults and the reliability of the components and attachments will remain guaranteed under all weather conditions that can occur.

The installations shall be designed to have a lifespan of at least 30 years. Design of the equipment shall be such that minimum ~~of~~ maintenance shall be required during this time.

Maintenance or repair work on one of the bays or busbars shall not have any impact on the operation of the other bays or busbars

3.11.3 Layout and design

Fire-wall shall be provided between serial transformer (if any) and adjacent equipment. Access roads and rails shall be provided for easy movement of SSSC transformer (if any) and any other heavy movable power components.

It shall be possible to walk within the SSSC area without danger (from bumping into or tripping over objects etc.) while the SSSC is de-energized. Therefore cables, pipework, etc. shall be buried or laid in trenches only (not laid on the surface of the ground or placed with their supporting structures). Equipment such as reactors, switchgear, transformers and supporting structures shall not be mounted over the cable ducts or in such close proximity to them that adverse effects may occur to the functionality of the cable circuits in the cable ducts.

3.11.4 Maintainability

The SSSC shall be designed such that all branches (VSC, Filters, and cooling systems) can safely be maintained and repaired with adjacent plant and material in operation. All applicable redundant systems shall allow maintenance and repair on one system with the other system in service. The layout shall be arranged in such a manner that access to and removability of any plant and material is possible without disconnecting other plant and material.

3.11.5 Ferro-resonance

There is a possibility of ferro-resonance with some combinations of capacitive and iron cored inductive elements. If SSSC ferro-resonance could occur, then a practical method of quenching shall be provided by the Contractor.

3.11.6 Accessibility and ergonomics

All Plant and Materials shall be easily accessible for maintenance, repair and replacement. Particularly, a suitable set-up location for a hydraulic lift or a crane shall be taken into consideration. It shall be possible to operate or read operating elements and gauges from a safe place.

The height of the supports of high voltage components, measured from the top of the foundations to the underside of the insulator's flange shall be at least 2.5 m.

Energized parts below 2.5 m height shall be adequately fenced with adequate warning signs.

3.11.7 Temperature calculations for maximum load and short-circuit

The design shall be such that under the worst-case climatic conditions, neither maximum loading nor short-circuits cause any component of the busbar system to exceed the following temperatures:
85° C at a rated current, assuming 1250 W/m2 solar radiation and, for 5 m/s wind speed.

For short-circuits, the following temperatures shall not be exceeded:

- copper: 250 °C.
- aluminum: 200 °C.
- thermally galvanized steel: 400 °C

for other materials, the Contractor shall select appropriate values.

The Contractor shall prove by thermal calculations, that these requirements are fully met.

3.11.8 Mechanical calculations for maximum load and short-circuit

The Contractor shall show by mechanical calculations, that the entire high-voltage installation can withstand forces originating from:

- static and dynamic loads resulting from the installation weight, wind pressure and all other climatic conditions
- static and dynamic loads resulting from electrical currents in the installation
- dynamic forces as a result of a short circuit at the specified short-circuit current level.

The Contractor shall prove by mechanical calculations made in accordance with IEC 60865 that these requirements are fully met.

3.11.9 Earthing and lightning protection system

An earthing system shall be in accordance with "Pravilnik o elektroenergetskih postrojih izmenične napetosti nad 1 kV", SIST EN 61936-1, SIST EN 50522 and generally in accordance with the requirements of the IEEE 80 standard and shall be provided under this Contract. Installation and supply of Plant and Materials shall also be included. The earthing system shall be connected to the existing main substation earthing grid to provide the connection to the general body of the earth and all conductors and connections to all electrical equipment and metallic structures on the Site. The earthing system shall include earth electrodes if necessary. The earth electrode shall limit the potential rise under fault conditions and buried conductors shall be provided to limit potential differences on the Site and adjacent to the Site to ensure safety to people and animals.

The Plant shall be provided with an earthing system that satisfies the following functional requirements:

- step, touch and mesh voltages shall remain below safe levels as per "Pravilnik o elektroenergetskih postrojih izmenične napetosti nad 1 kV", SIST EN 61936-1 and SIST EN 50522.
- all primary components shall be connected to earth by means of a redundant connection.
- the earthing system shall be capable to withstand the specified fault currents without damage due to thermal and/or mechanical effects.

The Contractor shall be required to earth the SSSC plant and material to ensure the safety of personnel and for the protection and proper operation of the SSSC plant and material in accordance with SIST EN 61936-1 and SIST EN 50522. Existing earthing in SS Podlog is realised with galvanized steel tape (FeZn 40x4 mm). Contractor shall be obliged to connect existing earthing system with grounding system of SSSC which is also his obligation.

SSSC earthing shall be realised with Cu stranded wires or FeZn 40x4mm. Connection of SSSC earthing and substation earthing shall be of exothermic type or with cross clamps protected by Corodal tape (See drawing Figure 3.1, Figure 3.2).

Figure 3.1: Example of an exothermic connection between a FeZn 40x4 mm and a copper earthing rod

Figure 3.2: An example of a cross clamp protected with a Corodal tape

Facilities for application of portable groundings shall be provided for all switchyard equipment live terminals. Facilities for application of portable grounding shall be provided in accordance with the Employer' principles of temporary grounding in switchyards specification.

The Plant shall be provided with a lightning protection system that satisfies the following functional requirements:

- protection of buildings complying to IEC 62305.
- lightning protection according to level LP3.
- the probability of a direct lightning strike to any part of the high-voltage installation substation area and the SSSC installation shall be sufficiently low according to level LP3. The maximum lightning current shall comply with the insulation co-ordination study results and with applied surge arresters.

The area designated for the installation of SSSC equipment (approximately 15 x 70 meters in size) will be protected by six lightning rod tips, each 23 meters in height, ensuring adequate lightning protection up to a height of 16 meters. The installation of the lightning rod tips will be carried out under the scope of other lots in this tender. In the event that the Supplier's equipment is positioned outside the specified area, the Supplier must coordinate the heights of the lightning rod tips with the construction contractor and steel structure works. Any potential modifications are included in the scope of this lot.

The Contractor shall submit a report, in which it is shown that the earthing and lightning protection system complies with these functional requirements, to the Employer's Representative approval.

3.12 OTHER REQUIREMENTS

3.12.1 Modification of existing equipment

The Contractor shall make clear which necessary modifications and supplies to secure proper functioning of the SSSC are included in his scope of Works.

/	/	/	
Revision:	Revision note:	Revision date:	Signature:

Investor: ELES	Facility: RTP 400/220/220 kV Podlog Sistem za regulacijo moči (SSSC) v RTP Podlog
Design engineer: IBE, svetovanje, projektiranje in inženiring Ljubljana, Slovenija	Part of facility/system: Supply and Erection of Flexible Serial Compensation – SSSC in Podlog SS
/	Type of design: TECHNICAL SPECIFICATION

	First name/Name:	Id. No.:	Title of document:
Approved by:	mag. Marko Testen, univ. dipl. inž. el.	E-1293	4. HV, MV EQUIPMENT AND TRANSFORMER
Confirmed by:	mag. Marko Testen, univ. dipl. inž. el.	E-1293	
Checked by:			Design doc. No.: R4PO01-A025/597 — Type of documentation: DZR
Designed by:	mag. M. Testen, univ. dip. in.e., D. Lenarčič, univ. dip.	E-1293, E-0076	Classification No.: C D — Page/pages: 1/39
11.2023			Identification No.: R4PO01-6E1004 Spr.:

VSEBINA:

4 HV, MV EQUIPMENT AND TRANSFORMER

4.1 220 KV EQUIPMENT

The Podlog SS was constructed more than sixty years ago as SS with 110 kV level as highest, fifty years ago it has been upgraded with 220 kV level and later with 400 kV level. In the meantime, the equipment was refurbished once or even several times while the basic single line diagram of all three voltage levels has been preserved.

On the 400 kV voltage level, the switchyard is constructed in the system of two main and one auxiliary busbar while the 220 kV and 110 kV switchyards are built in a system of two main busbars with one bus tie coupler and a measurement/bus-grounding bays.

All switchyards are of air-insulated type while their control and protection are provided by numerical terminals. The C&P equipment is installed in relay houses and partially in control building.

Auxiliary supply equipment is mostly situated in the separate structure.

The facility is controlled from four levels - normally remotely, but due control is provided also from the control building, from the relay kiosk or from the device itself.

SSSC plant will be connected to Podlog – Obersielach (Austria) transmission line which is connected to 220 kV switchyard.

The Podlog SS single line diagram in the existing state is given in other parts of this Lot.

The following 220 kV fields are currently in operation:

1. AD01 OHL Cirkovce with measuring of G2 system voltage
2. AD02 Spare
3. AD03 OHL Obersielach (Austria)
4. AD04 Bus tie bay
5. AD05 OHL Šoštanj (TPP)
6. AD06 OHL Beričevo
7. AD07 Spare
8. AD08 T 211 220/110 kV, 150 MVA
9. AD09 Spare
10. AD10 T 212 220/110 kV, 150 MVA
11. AD11 Spare
12. AD12 Spare
13. AD13 Spare
14. AD14 Spare

15. AD15 Spare

16. AD16 T 421 400/220 kV, 400 MVA

The main data of HV equipment already installed in 220 kV switchgear are:

Circuit breaker Q0 in AD01, AD03, AD04, AD05, AD06 feeders:

- Producer: ABB
- Type: HPL 245B1
- Rated voltage: 220 kV
- Rated current: 2500A
- Rated I SC breaking current (1 s): 40 kA
- Rated SC peak withstand current: 100 kA

Circuit breaker Q0 in AD08, AD10 and AD16 feeders:

- Producer: ABB
- Type: HPL 245B1
- Rated voltage: 220 kV
- Rated current: 4000A
- Rated I SC breaking current (1 s): 50 kA
- Rated SC peak withstand current: 125 kA

Disconnecting switches:

- Producer: Alstom
- Types: S2DA and S2DAT
- Rated voltage: 220 kV
- Rated current: 1600A (2500 A in AD 04)
- Rated SC current (1 s): 40 kA
- Rated SC peak withstand current: 100 kA

Combined Current/Voltage transformers in AD01, AD03, AD04, AD05, AD06, AC08, AD10 and AD16 feeders:

- Producer: Končar
- Type: VAU
- Rated voltage: 220 kV
- Rated SC current (1 s): 40 kA
- Rated SC peak withstand current: 100 kA
- for current measurements: five cores
- voltage measurements: four windings

Surge arresters:

- Producer: Ohio Brass
- Type: VN
- Feeder AC 06: MCOV=152 kV rms, Ur=192 kV

4.2 220 KV BAY AD03

A 220 kV bay for connection of OHL Obersielach is already in operation (AD03). In order to make the 220 kV equipment of the bay AD03 to which the SSSC is connected, as adapted to the new device as possible, the Employer has decided to replace and reorganise all the 220kV equipment. All the works to be executed in AD03 feeder are listed in separate Lots of this tender document.

Presently single-line diagram of the bay AD03 and single line after upgrade are shown on the following figures:

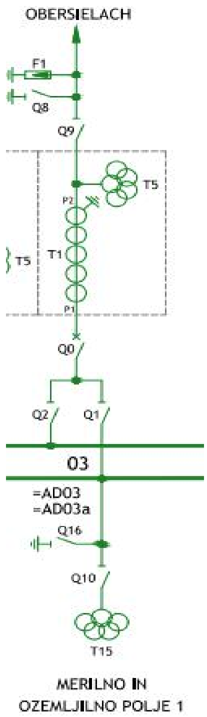

Figure 4.1: 220 kV bay for OHL Obersielach – present status

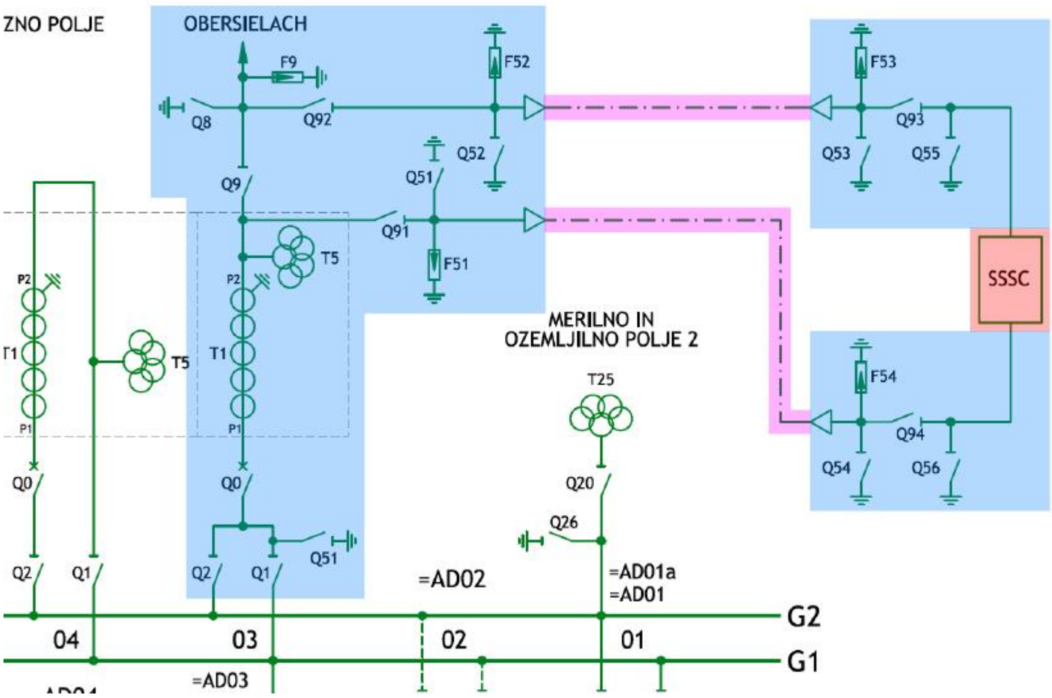

Figure 4.2: 220 kV bay for OHL Obersielach – after rehabilitation and upgrade

4.2.1 *Supply and erection works of 220 kV equipment provided within lots 2 and 3*

During rehabilitation works of AD03 feeder the following rehabilitation and upgrade works on the part of HV equipment will be realised (markt with blue color):

1. Substitution of the following existing with new equipment in AD03 feeder:
    a. Circuit breaker Q0,
    b. Disconnection switch Q1 will be substituted with Q1/Q51,
    c. Disconnection switch Q2,
    d. Disconnection switch Q9/Q8,
    e. Combined metering transformer T1/T5,
    f. Lightning arresters F9.
2. Additionally erected equipment in AD03 feeder:
    a. Disconnection switch Q91/Q51,
    b. Disconnection switch Q92/Q52,
    c. Two sets of 220 kV cable terminals,
    d. Lightning arresters F51, F52.
3. Additionally erected equipment outside AD03:

a. Disconnection switch Q93/Q53/Q55,

b. Lightning arresters F53,

c. Disconnection switch Q94/Q54/Q56,

d. Lightning arresters F54,

e. Two sets of 220 kV cable connections between AD03 and SSSC.

4.2.2 *Supply and erection works of 220 kV equipment provided by contractor*

Contractor is obliged to supply and erect the following 220 kV equipment:

1. Serial transformer (if any necessary),
2. All the additional 220 kV equipment (if any necessary),
3. Connections between SSSC, 220 kV equipment supplied by contractor and disconnection switch Q93/Q53/Q55,
4. Connections between SSSC, 220 kV equipment supplied by contractor and disconnection switch Q94/Q54/Q56.

Note: All the 220 kV equipment supplied by the contractor must be in accordance with technical schedules located in Chapter 09. All the technical schedules must be fulfilled in the offer phase.

Supply and erection of additional HV equipment is contractors obligation in the case that HV equipment supplied and erected within other lots can not guarantee proper functioning of AD 03 feeder and associated SSSC plant.

The construction work required to install new equipment is described in Chapter 07 Civil works and will be provided by Contractor.

Contractor is obliged to provide all the necessary data and information necessary for the design for building permit as well as for design and execution of civil works requested in other lots of this tender document in due time to follow contractual time schedule.

In the case of installing a serial transformer, the supplier must prepare layout, cross-sections, equipment placement, Single Line Diagram (SLD), operation descriptions, protection, and provide everything else necessary to ensure the full functionality of the SSSC.

4.3 THE SUPPLY AND INSTALLATION OF THE 220 KV EQUIPMENT

The requirements for equipment in this chapter are applicable.
The provider must comply with these requirements if this equipment is essential for SSSC functionality. In this case, the equipment is entirely within the scope of supply.
All delivery documentation will be subject to the customer's approval.

4.3.1 Serial transformer

The serial transformer (if any necessary) must meet the requirements of ELES as requested in other parts of this document (technical parameters, etc.) and must meet all the requirements and needs for connecting SSSC to AD03 feeder.

4.3.2 220 kV Circuit breaker

The circuit breaker (if any necessary) must meet the requirements of ELES as requested in other parts of this document (technical parameters, drive type, number of auxiliary contacts, etc.) and must meet all the requirements and needs for connecting SSSC to AD03 feeder.

4.3.3 220 kV disconnecting/earthing switch

The disconnecting or earthing switch (if any necessary) must meet the requirements of ELES as requested in other parts of this document (technical parameters, drive, number of auxiliary contacts, etc.) and must meet all the requirements and needs for connecting SSSC to AD03 feeder.

4.4 SERIAL TRANSFORMER

4.4.1 Basic requirements

4.4.1.1 Basic data

Scope of this chapter is delivery of serial transformer (if any necessary) within the scope of SSSC delivery and erection of it in Substation (SS) Podlog.

Technical data for the supply of serial transformer shall be in accordance with the requirements and calculations of the provider, fulfilling the requirement for an optimal operation of the entire supplied set of equipment.

All conditions, requirements and information specified in Site Conditions and General Requirements of this tender document are applied for the supply and installation of the serial transformer, as well. In case of discrepancies in the requirements in individual documents, this documentation also applies for the transformer.

4.4.1.2 Requirements for transport

Equipment construction shall be suitable for the railway or road transportation (the decision shall be taken by Contractor). For each type of the equipment, the greatest weight and dimension of the package shall be listed.

All heavier equipment items shall be equipped with lifting hooks or jacks for transportation and erection purposes.

Contractor shall organize transportation, loading and unloading in complete by himself. He must examine all possibilities for transportation of heavy and big equipment to the site and in site to the final position. The Contractor shall inform Employer in details about the most important transport data, at least eight months after Contract signing. The Contractor shall offer separate prices for transportation and for transport insurance.

At the transformer transport to the final site, the transformer shall be equipped with two (2) mechanical stress measuring devices (Shock recorder, capable to record accelerations in all directions (axis x, y and z)) which shall be placed diagonally each other on the transformer tank. After transportation the devices shall be opened and records analysed in the commission, in presence of the Contractor and Employer. The Contractor shall submit report about the transformer transport stresses to the Employer.

4.4.1.3 Scope of supply

The Contractor is to supply all other parts of equipment and render all those services free of charge that from whatsoever reasons or faults have not been specifically stated in the Tender, if they are of essential importance for continuous, reliable and safe operation of the Works.

The scope of the supply and the Works to be carried out include but is not limited to:

1. serial transformer acc. to General technical specifications, Design specifications, other Special technical specifications, and Contractor’s own requirements and specifications all together with required documentation,
2. packaging and transportation, placing transformer to the transformer civil base with transportation insurance,
3. transformer erection (bushing insulators, cooling systems, conservator, oil charging ...),
4. erection supervision, tests and acceptance tests, commissioning acc. to General technical specifications and Special technical specifications,
5. parameterization of the system for on-line monitoring and inclusion of the system in the
6. existing central system for real-time control in ELES
7. training of Employer's personal,
8. used packaging material removal from the site and clearing away parts of the equipment.

Civil works are in the scope of supply. Contractor shall assure that he will deliver on time all necessary documentation for continuation of all works on the project.

Time limit for equipment supply is defined in Contract signed by Contractor and Employer.

4.4.1.4 Spare parts

The Contractor shall provide service activities and functionally identical spare parts of the transformer for the overall lifetime of the equipment (minimal period of 25 years).

4.4.1.5 Erection tools

All tools, necessary for the transformer erection works in accordance with detailed description and instructions, shall be assured by the Contractor.

4.4.2 Construction, materials and workmanship

4.4.2.1 Standards

As stated in General Technical Specifications, the latest edition of standards shall be binding for the manufacture erection and testing of the transformers.

Below are the additional necessary standards that must be respected when supplying the transformer.

The list of applicable standards and clauses shall be prepared by the Contractor and agreed with the Employer before signing the Contract.

Here below, only some of important IEC Standards are listed for reference:

- SIST EN 60076 — Power transformers General
- IEC 60076-2 — Temperature rise for liquid-immersed transformers
- IEC 60076-3 — Insulation level & dielectric tests external clearances in air
- IEC 60076-4 — Guide to the lightning impulse and switching impulse testing - Power transformers and reactors
- IEC 60076-5 — Ability to withstand short circuit
- IEC 60076-7 — Loading guide for oil-immersed power transformers
- SIST EN 60076-10 — Determination of sound levels
- SIST EN 60296 — Fluids for electro-technical applications - Unused mineral insulating oils for transformers and switchgear Tap-changers
- SIST EN 60450 — Measurement of the average viscometric degree of polymerization of new and aged cellulosic electrically insulating materials
- SIST EN 60567 — Sampling of gases and analysis of free and dissolved gases Guidance
- SIST EN 60599 — Mineral oil-impregnated electrical equipment in service - Guide to the interpretation of dissolved and free gases analysis
- SIST EN 60616 — Terminal and tapping markings for power transformers
- SIST EN 60567-6 — Graphical symbols for diagrams SIST EN 60567-6 Production and conversion of electrical
- SIST EN 61125 — Unused hydrocarbon based insulating liquids - Test methods for evaluating the oxidation stability
- SIST EN 61181 — Mineral oil-filled electrical equipment - Application of dissolved gas analysis (DGA) to factory tests on electrical equipment

- SIST EN 61198 Mineral insulating oils – Methods for the determination of 2-furfural and related compounds
- SIST EN 61869-1 Instrument transformers -- Part 1: General requirements
- SIST EN 61869-2 Instrument transformers - Part 2: Additional requirements for current transformers
- SIST EN 60422 Mineral insulating oils in electrical equipment -– Supervision and maintenance guidance
- SIST EN 50629 Energy performance of large power transformers (Um > 36 kV or Sr ≥ 40 MVA)« or Commission Regulation (EU) No. 548/2014 of 21 May 2014 on implementing Directive 2009/125/ES

4.4.2.2 General requirements

The transformer shall meet the latest stage of development reached in the design and construction of HV transformers. Equipment and materials shall be designed to conform to the climatic and operating conditions. The mechanical and electrical design of the transformer shall be based on the following conditions and requirements:

1. The main dimensions must take into account all requirements and limitations from the site and from the attached drawings.
2. The mounting arrangement of higher voltage terminal bushings shall be based on the conditions from the attached drawings.
3. The maximum permissible temperature rise of the serial transformer oil (top oil) shall not exceed 55 K and the average temperature rise of the winding is to be limited to 60 K (hot spot 73 K). The transformer, completely assembled with bushings and connections, shall be designed and constructed to withstand without damage the effects of external short-circuits as per IEC 60076. It shall be taken into account the different forms of system faults that can arise in service, such as line-to-line, double line-to-ground and three-phase faults associated with the relevant system and transformer grounding conditions.
4. The transformer shall be constructed as core-type transformer, for outdoor installation.

4.4.2.3 Magnetic circuit

4.4.2.3.1 Core

The design of the magnetic circuit shall be such as to avoid static discharges, a development of short circuit paths internally or to the grounded clamping structure.

The core shall be built up of high-grade, non-ageing, low-loss, high-permeability, cold-rolled, grain-oriented silicon sheet steel. Quality of the steel shall be constant across all surface. The steel shall be of thin laminations, annealed after cutting and rolled, to ensure smooth, surfaces at the edges. Both sides of each sheet shall be insulated with an oil and heat-resistant material.

The core shall be clamped and braced with sticks and other elements to withstand, without damage or deformation, the forces caused by short-circuit stresses, earthquake, transportation, or handling, and to prevent the shifting of the core laminations. The column clamping structure shall be of a nonmagnetic type.

Suitable vertical cooling ducts shall be provided to ensure free circulation of oil and efficient cooling of the core.

Adequate metallic bridges shall be provided between the core lamination packets in order to keep all portions of the core assembly at the same potential.

In order to prevent closed magnetic circuit via the tank, the top main core clamping structure shall not be connected to the tank cover. The magnetic circuit shall be insulated from all structural parts, and shall be capable of withstanding a test voltage to core bolts and to the frame of 2 kV RMS for one minute. The main grounding connection shall have a cross-sectional area of not less than 80 mm2 but connections inserted between laminations may have cross-sectional area reduced to at least 20 mm2.

Magnetic core shall be grounded at one point, through insulated conductor and terminals in the grounding box, which has to be mounted on the outer side of the transformer tank.

4.4.2.3.2 Flux density

The magnetic flux density in the magnetic core shall not exceed 1.7 Tesla at rated voltage 220kV and frequency 50Hz.

The core design shall be such that there will be no adverse effects due to core or stray flux heating with the quality of steel employed in any cases acc. to IEC 60076-7.

4.4.2.4 Winding

Electrolytic copper of high conductivity and insulation material of class A (IEC) shall be used for the windings and other energized parts. For HV winding insulation thermo-stabilized or thermo-stabile paper shall be used. For MV and tertiary (if any) winding insulation thermo-stabilized or thermo-stabile paper shall be used. At the design and production of the windings, all mechanical and electrical stresses which can occur during operation shall be considered. Windings shall be produced according to latest technology and praxis.

All windings shall have full insulation strength on their entire length. The insulation of windings and connections shall be free from compositions likely to soften, shrink or to collapse during service. None of the materials used shall shrink, disintegrate, carbonize or become brittle under the action of hot oil at any load condition.

The windings shall also be thoroughly dried and shrunk by the application of axial pressure in time duration long enough to ensure that further shrinkage will not occur in service. With drying moisture shall be removed from the windings according to table of technical data.

Permanent current-carrying joints or splices shall be welded or braced, properly formed, finished and insulated to avoid concentration of dielectric stresses. The eddy currents influence shall be minimized.

Windings shall be so designed as to obtain an optimal value for series and shunt capacities in order to have a favourable distribution of overvoltages with different shapes.

The coils shall withstand network short circuits, overloads, and high-voltage stresses without local overheating. Contractor shall approve all these requirements with the type test. If the Contractor do not possess a type test for the offered transformer, he has to attach a type test of a similar transformer.

As a similar transformer it is to be understood: Serial transformer for SSSC of the same or similar characteristics as offered within this scope.

If the Contractor for the required transformer does not have a type test, he must attach approvals about transformer withstanding capability for short-circuit forces acc. to IEC 60076-5.

Leads from winding to bushings shall be adequately supported to prevent injury from vibration and short-circuit forces. The coils, windings, and leads shall be sufficiently braced and fastened to form rigid assemblies, preventing any relative movement due to transport, vibrations or other circumstances that may occur in service.

Adequate barriers shall be provided between windings and core; end coils shall have additional protection. The winding design shall permit an unobstructed flow of cooling oil through cooling ducts.

All windings shall have the insulation strength at site conditions according to IEC 60076-3 and acc. to Tender requirements.

4.4.2.5 Transformer tank and equipment

4.4.2.5.1 Transformer tank

The transformer tank shall be of all welded construction, fabricated from high tensile strength steel plate. When containing the core and coil assembly and fully oil filled, any packing, lifting, rolling, and handling shall not cause overstressing of any part of the tank.

All tank junction points, except those which have to be taken to parts, shall be welded to become oil tight. For points which have to be taken to parts O ring washers shall be used. Oil tank shall have three valves for oil sampling – on the bottom, in the middle and on the top. Oil sampling valves quality shall be at least equal as for other transformer valves (see Chapter 4.3.2.5.3). Oil sampling valves selection shall be approved by the Employer, for this reason the Contractor shall submit valves documentation to the offer, where proposed quality is clearly visible. Each tank shall be equipped with oil level or gas pressure indicator, with marking of the minimum value.

The tank shall be absolutely watertight and hot-oil tight. All seams and joints other than those, which may have to be broken, shall be welded both inside and outside.

The tank shall be vacuumed to 10 kPa during testing. No gas leakage or permanent distortion of the tank shall be accepted. The completely assembled transformer shall be capable of withstanding without damage, under service conditions, the forces arising under pressure conditions exceeding 35 kPa over the maximum operating protection pressure setting.

The tank and cover shall be designed in such a manner as to leave no external pockets in which water can lodge, no internal pockets in which oil can remain when draining the tank. Where pockets cannot be avoided, pipes shall be provided to vent the pocket. The same requirement is valid also for inner air and gas pockets in case of filling or draining oil. The vent pipes shall have a minimum inside diameter of 25 mm.

Easy access shall be provided to all external surfaces for painting. To access conservator and Buchholz relay a fixed going up system shall be provided.

The ladder shall be equipped with a protection system to secure workers from falling.

The tank cover shall be equipped with

Inspection openings shall be provided to give access to the internal connections of bushings. Each opening shall be correctly located and must be of ample size for the purpose for which it is intended. All inspection bolted type covers shall be provided with lifting handles.

At least five pockets shall be provided for a resistance or capillary type temperature sensors. Wired pockets shall be located in the position of maximum oil temperature (on the transformer tank cover close to phase V) and it must be possible to remove any sensor without lowering the oil level in the tank. Spare pockets can be located also close to phases U and W. Captive screwed caps shall be provided to prevent the ingress of water to the thermometer pockets when they are not in use.

4.4.2.5.2 Conservator, breathers, air dehumidifiers

The transformer shall be provided with an overhead conservator tank formed of substantial steel plates and arranged above the highest point of the oil circulating system.

The conservator tank shall be 10 kPa pressure vacuum proof and it shall have sufficient capacity to allow oil expansion from 0 °C to 120 °C.

The conservator shall be connected to the main tank through a straight slope pipe of at least 50 mm internal diameter, along which the Buchholz relay shall be mounted. The pipe shall be on a tank installed on a highest point of oil. Adequate isolating valves shall permit the removal of the relay with the conservator being still connected to the tank by a pipe by-passing the relay.

Openings of ample size shall be provided at the ends for inspection, cleaning, and repainting. The cover plates of the inspection openings shall be bolted to the conservator and shall be fitted with handles to facilitate removal.

For the transformer a synthetic diaphragm airtight and oil resistant seal (bag) shall be provided to prevent direct oil to air contact. The interior of this bag shall be in contact with the ambient air through a dehydrating breather; the outside of this bag shall be in direct contact with the oil. The conservator with an air-bag shall be designed for vacuum-filling of the oil. Conservator shall be fitted with an oil level indicator.

Vessel shall be equipped with a dehydrating breather and an oil trap. Dehydrating breather shall be of such design, that no maintenance or replacement of silicagel is needed. Breather shall be equipped with silicagel heater, when it is filled with the moisture. It shall be suitable for the site environment temperature levels, as stated in Chapter 02 – site conditions. Supply voltage 230 V

AC, signal contacts for 220 V DC. Power supply circuit shall be protected with an undercurrent protection (<<I). For maintenance and supervision of the air drier a three way valve shall be used, which ensure continuous operation of at least one drier. Breather must be, as all other devices for maintenance and control, mounted approximately 80 to 180 cm from the floor.

4.4.2.5.3 Piping, valves, joints, gaskets

All necessary drain and filling valves, shut-off valves, check valves, air release plugs, sampling taps etc. shall be supplied in such a quantity as to correspond with the size of transformer. They shall in complete correspond to DIN 3230-3 (leakage rate 1). Their quantity is subject to the approval of the Employer.

The material of fittings, pipes and seals shall be of the best quality to perfectly suit the purpose and shall not suffer from deterioration due to the weather conditions. All valves up to and including DN 50 mm shall be of brass or gunmetal. Larger valves may have cast iron bodies with gunmetal fittings.

Every valve shall be provided with an indicator to show clearly the position of the valve: open/closed.

All oil-tight joints shall be made with machined flanges and approved type of gaskets. Materials shall be approved by the Employer too. Means shall be provided to prevent over compression of the gaskets. All joint faces shall be arranged to prevent the ingress of water or leakage of oil with a minimum of gasket surface exposed to the action of oil or air. All gaskets between metal parts shall be designed in a way that after tightening, metal to metal contact is achieved.

All valves, pipes ends and similar, which are not in use, must be closed or tightened with suitable flanges, screwing caps or plates.

All elements shall be provided with correct identification and described in transformer drawings.

The transformer shall be fitted with the following valves, as a minimum requirement:

Transformer tank

1. one DN 50 mm bore filter valve located near to the top of the tank,
2. one DN 50 mm bore filter valve located near to the bottom of the tank and diagonally opposite to the filter valve required under a). Valves a) and b) shall be prepared for oil treatment device connection according to Employer's requirement acc. to IEC 60567,
3. one DN 50 mm drain valve which has to ensure that the tank can be completely drained of oil,
4. three valves prepared for oil sampling – one on the top, second in the middle and third on the bottom of the transformer tank.

Conservator

1. One valve for the oil pipe by-passing Buchholz relay,
2. two valves for isolating and removing Buchholz relay,
3. oil filling plug,

4. one drain valve so arranged that the conservator tank can be completely drained of all oil.

Radiators

1. Valves at each point of connection to the tank and in accordance with Paragraph Transformer cooling.

4.4.2.5.4 Pressure relief valves

An approved pressure relief valve of a spring-controlled type and of sufficient size shall be provided for the rapid release of over pressure that may be generated in the tank. It should operate at a static pressure lower than the hydraulic test pressure. It shall be provided with at least one normally open signalling contact. The pressure relief device shall be mounted on the tank cover and shall be provided with a skirt extended at least 25 mm into the tank to prevent gas accumulation.

Discharge of oil shall be directed away from the transformer top cover and clear of any operating position. A suitable pipe extension shall be provided to lead the oil discharge down to the oil collector bellow the transformer.

4.4.2.5.5 Grounding terminals

Four stainless steel flag type grounding terminals or copper faced pads of adequate size to carry the lower voltage short-circuit for 3 s shall be provided and mounted diagonally near the bottom of transformer tank. The grounding terminals shall have two holes and shall be welded onto the transformer tank. All grounding connections shall be yellow green colour.

4.4.2.5.6 Support structures and handling facilities

To form a rigid base structure, heavy steel cross beams shall be welded to the bottom cover of the tank.

The base of tank shall be so designed that it is possible to move the complete transformer unit in any direction without injury. The movement of the transformer shall be achieved with sliding transformer on the foundation with embedded steel I beams. The change of the direction shall be made after lifting the transformer with hydraulic jacks. The metal I beams shall corresponds to the drawings. The transformer, when erected, will be left standing directly (without any wheels or similar) on transformer foundation. The Contractor shall submit a proposal to prepare the foundation of the transformer. Distances between base-line of transformer foundation shall comply with the associated drawings.

Jacking pads shall be provided high enough above ground level and at convenient locations on the transformer tank to allow the jacking of the completely filled transformer. Load carrying capacity of each jacking pad and each jack shall not be less than 50 % of the total weight of the transformer unit. Pads shall be clearly marked with black colour.

4.4.2.5.7 Identification plates

The following plates made of approved material capable of withstanding continuous outdoor service shall be supplied:

1. a rating plate according to IEC 60076 with the impedances at the maximum, minimum and main taps added and voltage and current at all taps if applicable,
2. a diagram plate showing in an approved manner the internal connections and the voltage vector relationship of the several windings in accordance with IEC 60076, and in addition, a plan view of the transformer giving the correct physical relationship of the terminals,
3. a plate showing the location and function of all valves and air release cocks or plugs. This plate shall also warn the operator to refer to maintenance instructions before applying the vacuum treatment, mineral oil type according to SIST EN 60296,
4. numbered plates for all oil valves, cocks, oil pumps, fans, water valves, breathers, etc.,
5. the inscriptions on plates mounted on valves shall correspond with inscriptions on valve plate,
6. a plate showing all electrical circuits and terminal blocks. This plate shall be located at the inner side of the hinged door of the marshalling kiosk,
7. a plate showing the points for jacking, lifting and pulling as well as the load carrying capacities and the necessary dimensions of permitted angles of lifting ropes,
8. all plates with connections designation shall be clearly visible for the floor standing,
9. a plate for the main control cubicle, whereon exact locations of optic temperature sensors in the windings are given.

4.4.2.6 Transformer cooling

4.4.2.6.1 Cooling general requirements

All equipment (for example radiator components, valves, control devices, etc.) used for the transformer, shall be standardized and interchangeable without adjustment.

4.4.2.6.2 Cooling principle

The serial transformer shall be designed in such a way to meet the noise requirements of the entire device and the technical requirements for supplying SSSC.

Cooling banks and oil pipelines shall withstand the same overpressure (35 kPa) and vacuum (10 kPa) as required for the transformer tanks.

If fans will be used for cooling, the following applies. The fans shall form an integral part with their individual motors and shall be arranged in groups mounted in fan housing. The fans shall be located below radiators (with vertical axes). The fan blades shall be dynamically balanced. Mechanical protection to prevent accidental touch with rotating parts shall be provided by galvanized wire guard with mesh not exceeding 15 x 15 mm.

The fan motors of squirrel-cage, totally enclosed type, suitable for outdoor use, shall be designed for direct - on line - starting and continuous running from the three-phase power supply 400/230 V, 50 Hz. The fan units shall be mounted underside of the cooling bank (radiators), also fan units shall be suitable for horizontal mounting.

Mounting arrangement of fan units shall enable each unit to be individually removed without dismantling the cooler structure framework.

The following standard equipment and accessories shall be provided as minimum for each transformer cooling system:

1. one (1) valve each for inlet and outlet oil pipe for each radiator,
2. one (1) oil drain valve at the lowest point each for oil pipes and for each radiator,
3. one (1) air vent plug at the highest point each for oil pipes and for each radiator,
4. one (1) thermometer pocket fitted with captive screwed cap each for inlet and outlet oil pipe on the transformer tank with dial instrument for local reading (acc. to producer opinion),
5. all necessary flanged pipes between cooler banks and transformer tank, coupling, expansion, and sealing devices, hot-dip galvanized frameworks and support structures for coolers and pipelines, including foundation pieces to be embedded.

4.4.2.7 Cooling Control and Measuring Cabinet

The cooling control equipment and measuring, monitoring and protection equipment shall be accommodated in a suitable cabinet mounted onto the transformer tank and cabinet shall be bonded to tank with conductor H07V-K 70 mm2 minimum.

4.4.2.7.1 Cooling control

The electrical supply for the control of the cooling units shall be provided by means of a LV circuit breaker as an incoming feeder in the cooling control cabinet. Each auxiliary motor shall have its own motor starter of adequate size, fitted with thermal and magnetic overload release as well as miniature of moulded case circuit breakers. For supply circuit monitoring voltage relays shall be used.

For automatic control through the temperature controlling devices and autonomic protection relays on the transformer or local electrical or remote control, AC operated contactors shall be provided for control and signalization voltage.

Temperature monitoring equipment shall activate the proper number of fans, if applicable. The fans shall be switched on or off by relay combination taking into consideration both the winding and the oil temperature. The criteria for automatic ON shall be the winding temperature and the automatic OFF shall follow the oil temperature setting.

Each motor could be insulated from the system in any time or exchange it without interrupting others operation.

Change-over from automatic to manual control shall be possible (selection switch). Manual mode for local control shall permit operation of the cooling system regardless the oil and the winding temperatures. In automatic mode the cooling control system shall perform automatic activation of each fan for at least 20 minutes monthly.

The following lamp initiating devices having auxiliary normally opened contacts shall be included as applicable for the cooling system:

1. cooling fans failure for each radiator group,
2. cooling fans start for each group,
3. cooling system switched on manual,
4. cooling system switched on automatic control.

4.4.2.7.2 Measuring, monitoring and protection equipment

The transformer shall be fitted with a control cabinet mounted on the transformer tank, in a position easily accessible from the ground level. Fluorescent type lighting fixtures (in line with EMC requirements) of standard commercial size together with door contacts as well as a manual control switch shall be provided for internal illumination. The cabinet shall be adequately ventilated and equipped with an anticondensation heater. The cabinet shall contain all control and protective equipment for the cooling system, as well as the termination of all secondary circuits. All metallic cable shields shall be grounded using EMC glands with fixed 360° contact surface (not a spring clip or any kind of flexible tongues). The cabinet shall be bonded to transformer tank with conductor H07V-K 70 mm2 minimum.

The internal arrangement of the cabinet shall keep the various circuits clearly separate from each other (e.g. input circuits separated from output circuits), permitting easy and safe independent maintenance and repair of each item without disturbing the others.

Electrical connections between sensors, current transformer, and all other accessories with the local control cabinet shall be enclosed in perforated stainless metal raceways or conduits of ample size securely fastened to the transformer tank to prevent mechanical damage or vibrations.

The main technical data as well as size and location of every component are to be described in the Tender and shown on one of the relevant transformer drawings they are subject to the approval of the Employer.

The following measurement equipment shall be supplied as minimum for step up transformer:

1. one (1) double float Buchholz relay with test cock and sufficient sets of contacts,
2. one (1) dial capillary type thermometer for measuring the oil temperature with a maximum demand indicator and with a sufficient number of independent and adjustable contacts for cooling control and for alarm and tripping purposes. The range of temperature indication shall be 0 °C - 160 °C,
3. one (1) resistance (Pt-100, three leads) for oil temperature measurement - above,
4. one (1) resistance (Pt-100, three leads) for oil temperature measurement - below,
5. one (1) resistance (Pt-100, three leads) for oil temperature measurement collector of cooling system - above,
6. one (1) resistance (Pt-100, three leads) for oil temperature measurement collector of cooling system - below,

7. one (1) magnetic type oil level indicator with two independent adjustable contacts (low and high level),
8. one (1) instrument for monitoring of the winding temperature, with a sufficient number of adjustable contacts for cooling control and for the remote signal alarm and tripping purposes. The range of temperature indication shall be 0 °C – 160 °C (Contractor has to attach a measuring value - temperature curve),
9. one (1) current transformer in phase V HV winding for coil image shall be incorporated in the serial transformer and shall not be class P. Means shall be provided for external calibration by current injection into the current transformer secondary circuit,
10. one (1) current transformer in each phase HV winding class 1 Fs 5 for (connected to On-line monitoring system),
11. one (1) spring operated protection valve with alarm contact on the tank.
12. OTI and WTI should be installed in a casing in order to be protected against atmospheric impacts.

In the phases A (one piece), B (two pieces) and C (one piece) of HV (220 kV) and MV winding, transformer winding temperatures (hot spot) direct measurement optical sensors shall be mounted. Number (at least 12, 6 of them for measuring and other 6 for redundancy) of sensors and proposed location shall be approved by the Employer. Optical system shall contain:

1. optical sensors (at least 6 – 5 on windings and 1 in cooling channel of transformer core),
2. location of the optical sensors shall be agreed with the Employer,
3. connection part on the tank wall,
4. winding temperature indicator on the transformer tank,
5. remote winding temperature monitoring via on-line monitoring system.

4.4.2.8 On-line monitoring system

Serial transformer shall be equipped with an on-line monitoring system with all appertain elements. On-line monitoring system supply shall contain (located in the control box on transformer):

1. measuring equipment (sensors) in the transformer,
2. control box (controller) on the transformer including connections with measuring equipment,
3. monitoring server located in Podlog SS control room including communication with control box and communication port (for the connection with diagnostic center in Ljubljana),
4. optical cable supply and erection for connection between control cubicle and system server in the SSSC building,
5. application software for the system server including visualization of the temporary measuring values and calculations, and for archive documentation of measurements,

6. sensors and measuring values parameterization and calibration on transformer and system server and alarm levels calibration,
7. optical winding temperature sensors connection and calibration to the on-line monitoring system,
8. operation start,
9. contractor must coordinate communication port (on monitoring server located) to ensure communication with the diagnostic center in Ljubljana.

4.4.2.8.1 Communication to diagnostic center in Ljubljana

Central on-line monitoring system (COLM) is intended for direct monitoring and diagnostics of transformers. The structure of the COLM system is designed on the basis of the SinaproWPort product, Kolektor Sistech and enables a robust and fast multi-user access as well as a permanent data storage, easy processing, data analysis and display using modern web technologies and tools. Local system data is transmitted to a COLM temporary transaction basis using service application to capture raw format data (process values, events and alarms), wherefrom data preparation and copying into an illustrative data base is performed; this one enable faster multi-user access and permanent data storage at ELES central SQL database. Parameter vales are captured from local systems as current or archival values from the fieldbus or database, depending on the type of captured PV.

The Contractor shall ensure complete inter-operability of his equipment with the above-described center. On-line monitoring shall support next communication protocols:

1. Modbus TCP,
2. IEC 61850,
3. web services.

The Contractor shall ensure complete inter-operability of his equipment with the above-described center. On-line monitoring shall enable communication with COLM by protocols Modbus, IEC 61850 and web services. COLM shall capture raw format data (process values, events, alarms) from on-line monitoring system. Operation data and alarm (event) states shall be simultaneously visible. Contractor shall include transformer in common display mask of COLM web visualization. The Contractor should enable data storage at ELES central database of all parameter values and alarm (event) states of on-line monitoring.

The Contractor shall offer serial communication sensors (Modbus TPC, DNP3 or IEC 61850).

Capture and monitoring:

1. upper and lower oil temperature,
2. environment temperature,
3. temperature of the oil inlet and outlet on separate coolers,
4. sensors (hydrogen and CO, and moistures – Morgan Schaffer Calisto 2),
5. operating current on the internal current transformer,

6. cooling system monitoring – separate coolers monitoring (fans, pumps), efficiency and cooler operation time,
7. Buchholz relay and oil level indicator monitoring,
8. power factor measurement,
9. operating voltages of all phases in PCC,
10. for transient over-voltages, capacitance and dissipation/power factor of HV bushings Omnicron Montrano shall be used,
11. on load tap changer temperature measurement.

4.4.2.8.2 On-line monitoring system software

Software shall comprise suitable modules for parameter calculation and evaluation functions for:

1. winding hot spot temperature acc. to IEC 70076-7,
2. paper insulation relative humidity,
3. insulation aging level acc. to IEC 70076-7,
4. already used operating age acc. to IEC 70076-7,
5. actual losses,
6. insulation system withstand voltage,
7. bubbling oil temperature,
8. standard 1,2/50 μs overvoltage impulse amplitude indication and registration,
9. overcurrent indication and registration, with a sampling time 20 ms or less in all three phases,
10. cooling system efficiency and fans operating time,
11. cooling efficiency (heat resistivity),
12. on load tap changer contacts usage (with actually current and on load tap changer steps),
13. cumulative transformer aging,
14. transformer bushing capacity variation, on the basis of all three phases voltage measurement values,
15. software for in transformer oil dissolved gases analysis and diagnostics acc. to MSS, Doernenburg, Rogers, Duval and IEC methods,
16. simulation software for automatic parameter calculation and for diagnostic results presentation.

Software shall enable:

1. archived data and report examination,
2. main trends review,

3. statistic data analyses,
4. data and analyses results archiving,
5. sensors – server connections monitoring,
6. sensors operation supervision,
7. connected equipment status examination,
8. data archiving (storage) in standardized data base (MS SQL),
9. automatic stored data duplication for security reasons (back up),
10. display and print of any selected data combination for one or more transformers connected on the monitor,
11. from the common monitor screen (mask) access shall be provided to the screens/displays for transformer data bases, which will be connected to the on-line monitoring system,
12. on the common monitor screen/mask at the same time status and alarm data of transformer which will be connected to the on-line monitoring system,
13. monitor screen for each transformer/unit must be equipped with actual transformer picture,
14. possibility to retrieve limit values for measured process values (low active, low inactive, etc.) by Employer central monitoring server.

All offered software shall be inspected, user friendly and shall allow personal computer connections via adequate server through internet/intranet. Connected users shall nave possibility to use all server display and control functions.

Software shall allow parameterization (alarm levels, historical data base processing and other specific interventions) to the user.

Software shall allow alarm state visualization and shall include possibility for responsible personal annunciation (internet/intranet, mobile phone, etc.).

Data shall be stored in the server RAM unit with a high time resolution, after certain time average values of each measured magnitude shall be automatically stored in the long duration data base. All asynchrony appeared phenomena, as alarms or regulation switch status changes, shall be stored separately, with definite date, time and measured value.

Software updates shall be supplied to the Employer free of charge at least for three years after the first installation.

On-line monitoring system shall be:

1. made and manufactured by a renowned equipment manufacturer in the field of power engineering,
2. made in a manner that ensures servicing and elimination of potential failures by using standard components without the need for interventions/servicing of the equipment at the manufacturer,
3. designed that in case of a short COLM downtime no data is lost from sensors or OLM.

4. The software upgrades and all included monitor screens (masks) shall be in Slovene language.

4.4.2.9 Anticorrosion protection

The transformer tank with the pertaining equipment is made from quality construction steel. After it has been leakage tested, it is protected against corrosion.
The two-pack system: Zinc-Rich Epoxy Primer - EP Intermediate coat - PUR consists of a primary, intermediate and finish coating. It is applicable for the regions with the following climate characteristics (EN ISO 12944-2:2017):

- Industrial areas and coastal areas with moderate salinity.

The two - pack corrosive coating Zinc-Rich Epoxy Primer is made on the basis of epoxy bounding material and polyamide hardener. The high content of zinc dust (80%) enables galvanic protection. The coating is resistant humidity, all kinds of atmospheric influences, different organic and inorganic chemicals, oil derivatives, aggressive gases etc. Due to the contents of zinc, the resistibility is limited within the range pH 5-9. It also distinguishes itself by good physical properties such as adhesion, elasticity and strength. The two - pack PUR finish coating allows good resistance to atmospheric influences and chemicals.

The bellow table provide some of the essential data of the selected system:

COATING	INNER 80 µm	OUTER ≥260 µm		
	PRIMARY	PRIMARY	INTERMEDIATE COAT	TOP COAT
Type of the coating agent - colour	EP - Primer EMC 182 white K-DB	Zinc-Rich Epoxy Primer EMD 156 HS grey	Epoxy intermediate coat EMD 30 RAL 8012	PUR - top coat RAL (1), -ADD 47
Surface state prior to coating application	Sand blasted Sa 2½ ISO 8501-1:2007	Sand blasted Sa 2½ ISO 8501-1:2007	- degreased - dedusted - dry	- degreased - dedusted - dry
Number and thickness of layers	1 x 80 µm (2)	1 x 80 µm (2)	1 x 100 µm (2)	1 x 80 µm (2)
Application	- airless - conventional spray - brush - roller	- airless - conventional spray - brush - roller	- airless - conventional spray - brush - roller	- airless - conventional spray - brush - roller
Pull-off test EN ISO 4624:2016	/	≥ 5 MPa		

(1) Top coat shade, as defined in transformer Technical specification, will be provided however, if not defined; factory standard top coat shade RAL 7038 will be provided.

(2) Dry film thickness acceptance criteria acc. to EN ISO 12944-5:2019, chapter 7.3.

4.4.2.10 Bushings and terminals

4.4.2.10.1 Transformer bushings

Bushings for 220 kV voltage level shall be of the resin-impregnated condenser type with silicone insulators and shall contain no oil. HV and MV bushings shall be produced in the European Union by a company, which is approved by the Employer and defined in Technical schedules.

The insulation strength shall at least comply with the values of the basic insulation level (BIL) and the power frequency test voltage of the corresponding windings.

The shed material shall be a polymeric material formed from silicone. The final polymer compound after the addition of functional fillers shall contain at least one-third pure silicone rubber but shall not contain any ethyl vinyl acetate (EVA), ethyl propylene rubber (EPR), ethylene propylene diene monomer (EPDM) or other UV-sensitive material. Only high temperature vulcanized silicone rubber (HTV) or liquid silicone rubber (LSR) shall be used. Room temperature vulcanized silicone rubber (RTV) shall not be used in high voltage applications. Tracking resistance 4.5 kV in class 1A per IEC 60587. Recovery of hydrophobicity: HC 1-3 48 hours after complete loss of hydrophobicity (IEC TS 62073)

All hollow silicone composite insulators shall comply with the requirements of the IEC publication IEC 61462 and the relevant parts of IEC 62217. The design of the composite insulators shall be tested and verified according to IEC 61462 (design test and type test). Each composite insulator shall undergo routine tests according to IEC 61462.

Bushings shall be equipped with loss factor (tg□) measuring connections with no need to disconnect primary connections. Replacement shall be possible with a minimum lowering of transformer oil level.

Each complete bushing shall be marked with the manufacturer's name or identification mark, year of manufacture, serial number, electrical and mechanical characteristics in accordance with IEC 60137 and declination (for bushings with declination over 30º).

The location of all bushings on the transformer tank as well as sequence of line and neutral terminals shall comply with layout given in the drawings.

4.4.2.10.2 Transformer terminals

Lower voltage and higher voltage terminals with neutral point terminals shall be suitable for connection with aluminium alloy conductors. 220 kV terminals shall be of bold type.

4.4.2.11 Transformer oil and insulation paper

The transformer oil shall be new, at the first filling with properties complying with all requirements in the Schedule of technical data and acc. to IEC 60296 - Transformer oil I.

The transformer oil shall be mineral, inhibited, naphthenic oil. It shall not contain PCB.

The transformer oil properties shall be tested according to standard IEC methods and shall correspond to requirements from the Schedules of technical data, items 23, 25 and 26 - Transformer oil and paper.

Before transformer production the paper polymerization level test shall be performed (acc. to IEC 60450). Before first oil filling in the factory an investigation shall be executed for defining new transformer oil quality (acc. to SIST EN 60296 and SIST EN 61125), method C.

The transformer shall be filled for the factory testing with its original oil (producer and oil type).

The Contractor shall submit his paper insulation and oil testing reports to the Employer.

The transformer shall be supplied and shipped without initial oil filling, filled with dry air kept under pressure above ambient pressure (the procedure shall be a subject of approval by Employer).

Drained oil removed for shipment shall be delivered in cistern, under the nutrition pressure, in sufficient quantity to refill the transformer oil volume and to replenish losses during subsequent processing at site.

Thermo stabile insulation paper shall be produced by Weidmann. Other renowned insulation paper producers shall be confirmed by Employer.

Paper tests shall perform after drying in every stage of production. Testing samples of the used insulation paper shall after driing process correspond to the following requirements:

1. average degree of polymerization of taken samples must not be lower than 1050, value for particular sample must be greater than 1000,
2. humidity must be lower than 0.5 %.

Sample taking shall be performed before winding production (more than three samples). Samples shall have the same path of drying as transformer and will be a subject of inspections and tests after transformer drying in every stage of transformer production. Oil sample collecting shall be performed before first filling and after testing. Sample taking and testing shall be executed in the name of Employer by an authorized and accredited independent institution.

4.4.3 Inspections and tests

Tests shall be used to verify whether the material and devices comply with the specification. All tests must be executed in the way to consider operation conditions. All test results shall be submitted to the Employer for supervision and approval. Employer is reserving a right to get another independent opinion (checking correctness of the measuring results, tests, type tests …).

All tests shall be executed according to SIST or IEC standard requirements, if not differently agreed between Contractor and Employer.

All necessary testing devices and instruments shall be provided by the Contractor.

Contractor shall announce the Employer about date, time and scope of testing at least four (4) weeks before tests, test date shall be approved at least 14 days before execution. Contractor must allow Employer or his representative to be present at any test procedure. Certified test report must be submitted to the Employer immediately after each test.

If after factory or on-site testing, for any reason repair of the equipment or replacement of any parts are necessary, the Contractor shall finish all works as soon as possible. The Contractor shall submit to the Employer all results of repeated tests.

4.4.3.1 Factory tests

On the QA/QC plan basis the Employer will define control points, where he wants to be present. During the manufacture of the various transformer parts the Employer may require any part to be inspected and tested in his presence or in the presence of his representative and therefore, the Contractor shall systematically advise the Employer in writing of the dates on which each part of the said equipment becomes ready for a particular test. The Contractor shall prepare all required test samples for the Employer. Tests will be provided in the independent institution.

The transformer shall be subject to acceptance tests to be performed at the Contractor's workshop in presence of the Employer in order to verify their conformity with the guaranteed and other design data. The methods of testing shall be submitted for approval.

Employer reserves the right to carry out 48-hour no-load losses at higher voltage (107 % of rated voltage) with HPLC and gas chromatography to check possible local overheating of the core.

4.4.3.1.1 Routine tests

At least the following routine tests shall be performed:

1. visual inspection (anticorrosion protection check),
2. dimensional check of the transformer main dimensions,
3. measurement of voltage ratio and vector group check,
4. measurement of winding resistance,
5. measurement of no-load losses and current after core heat run test and dielectric tests at 90 %, 100 %, 110 % and 115 %.
6. measurement of short-circuit losses and voltage after core heat run test,
7. measurement of zero-sequence impedance (all combinations),
8. dielectrical test with separate source voltage 50 Hz, 60 sec,
9. dielectrical test with induced voltage – ACLD,
10. lightning impulse test,
11. switching overvoltage test,
12. partial discharge measurement,
13. insulation resistance measurement,
14. HPLC and gas chromatography before and after testing. HPLC and gas chromatography shall be executed before and after dielectric tests and after transformer heating test,
15. determination of polymerization degree of paper insulation (DPv) before and after drying transformer windings.

4.4.3.1.2 Type tests

At least the following measurements and tests shall be carried out:

1. temperature rise test + thermographic inspection,
2. core heat run test at 107 % of rated voltage 48 h,
3. chopped lightning impulse test.

4.4.3.1.3 Special tests and measurements

At least the following special tests and measurements shall be carried out:

1. capacitance and loss factor (tg δ) measurement,

2. FRA measurement,
3. measurements of the noise level acc. to sound pressure method by IEC,
4. measurements of the harmonic content of no-load current,
5. measurements of the magnetizing currents at voltage 400 V 50 Hz,
6. measurements of fans motor drives power consumption,
7. current transformer measurements,
8. measurements of oil break down voltage,
9. oil examination acc. to IEC 60422,
10. complete transformer vacuum test,
11. over pressure 35 kPa completed transformer test,
12. functional cooling test, protective and monitoring equipment,
13. determination of efficiencies.

4.4.3.1.4 QA tests and documents

All measurements and tests, which are provided on any part by the producer must be executed and documented according to Contractor QA procedure.

Results must be sent to the Employer in form of certificate, not later than FAT date.

1. QA certificates
    a. insulated copper conductors,
    b. steel sheet core,
    c. hard insulation materials,
    d. insulation oil,
    e. construction steel,
    f. wiring cables,
    g. paint and oil resistance.
2. Test reports
    a. bushings,
    b. current transformers,
    c. radiators,
    d. auxiliary cubicles.
    e. on-line monitoring system.
3. Functional test and QA certificates
    a. Buchholz relay,

   b. over-pressure valve,
   c. thermal image,
   d. Pt 100 temperature measuring sensors,
   e. on-line monitoring system,
   f. gas sensors,
   g. humidity sensors,
   h. optical temperature sensors,
   i. system for measuring of winding temperature,
   j. magnetic oil level indicators,
   k. capillary contact thermometer,
   l. fans,
   m. conservator air pads and dehydrating breathers,
   n. fire annunciation.
4. Transformer tank test documents.
5. Overpressure and vacuum test report for complete transformer
6. Anticorrosive protection inspection report
7. Interphase inspection report
   a. magnetic cores,
   b. windings,
   c. active part,
   d. active part drying.
8. Factory measuring and test acc. to item 5.1
9. Manufacturer's declaration that the transformer is made of materials and according to procedures that are consistent with EU environmental directives (the so-called eco-transformer) acc. to EZ-1 Articles 327 and 328.

4.4.3.2 On site tests

The transformer shall be subject to acceptance tests to be performed at the site in presence of the Employer in order to verify their conformity with the correct and safe operation requirements, functionality and guaranties, which are required according to Special technical specifications and Tables of technical data.

Measuring methods details, conditions and their execution must be agreed between Contractor and Employer according to the test program. Agreement shall be made also for special test operation requirement (grid requirement for example).

All needed standard and special equipment, insulation testers, measuring bridges, HV measuring sources and all other equipment, necessary for testing, must be provided by the Contractor.

At least the following measurements and tests shall be carried out on the transformer on site:

1. tank and cooling system pressure test,
2. capacitance and loss factor tg δ measurement,
3. measurement of winding resistance,
4. measurement of insulation resistance,
5. capacitance and tg δ measurement of condensation bushings,
6. frequency domain spectrum (FDS),
7. magnetizing current at 400 V,
8. FRA measurement,
9. dielectric strength and humidity level measurement for insulation winding,
10. recalibration and current injection on temperature indicators,
11. 2 kV voltage test on control and monitoring equipment wiring,
12. control and monitoring equipment functional test,
13. cooling system functional test, including temperature measurement,
14. on line monitoring system functional test,
15. winding temperature direct measurement optical sensors functional test,
16. visual inspection,
17. final anticorrosion protection check,
18. physical -chemical oil inspection from the new transformer,
19. gas chromatographic transformer analysis.
20. stray inductance measurement

After successfully finished and with documentation approved tests, the device is ready for trial run.

4.4.4 Contractor documentation

Before transformer production start the Contractor shall submit list of all documents (drawings, calculations, manuals, test reports, etc.) to be prepared for the project in conformity with Employer's requirements and praxis. Document list shall include submitting dates (time schedule) for approval and approved and original document formats.

The Contractor shall submit his documents list for documents, all of them will be checked and approved by the Employer (Design Review).

Required documents:

1. documentation classification plan, for all documentation which will be prepared for this project, with list of documents and dates of issue,
2. transformer temporary dimension drawing,
3. transformer dimension drawing,
4. transformer equipment and device list (in Slovenian),
5. transport drawing,
6. transport plate,
7. identification plate and connection drawing (in Slovenian),
8. bushing dimension drawing,
9. transformer boxes dimension drawing (cooling control box, protection and signalization, on-line monitoring device box …),
10. cooling system operation diagrams and drawings, measuring system, and transformer primary protection,
11. diagram of permissible short-time and long-time overload,
12. cooling system and other motor drives electrical power consumption data,
13. report/protocol of drying process,
14. core grounding principle,
15. valve plates and position identifications,
16. cable laying drawing for control, signalization, measuring and aux. supply cables,
17. anticorrosion protection system,
18. equipment list with producers,
19. seismic resistance calculation,
20. proposal of transformer foundation (according to the corresponding drawing),
21. transformer short circuit forces resistivity calculation,
22. QA/QC plan,
23. factory testing detail description and plan,
24. on site erection works description,
25. on site testing detail description and plan,
26. test equipment,
27. test reports and documentation,
28. on-line monitoring system,
29. optical sensor temperature measurement system technical documentation,
30. position of winding temperature sensors,

31. transport elaborate (in Slovenian),
32. operation and maintenance manuals for transformer and equipment (in Slovenian).

Contractor and Employer will define submitting dates for all documents, which are important for the project time schedule, during the contract signature.

All documents shall be submitted in paper and electronic version taking into the account that individual documents shall be submitted separately in one of the usual electronic formats. The electronic formats shall be duly labelled for import purposes and easier search in the document system.

4.4.5 Documentation for serial transformer to be included in the Tender

The Tenderer shall submit information as listed in other parts of this tender document and the following data:

1. documents required in General tender specification,
2. tables of technical specification,
3. equipment and works specification with filled Tables of technical data,
4. list of routine and type tests for similar transformer,
5. transformer description and auxiliary equipment operation description with catalogues and leaflets,
6. preliminary drawings for transformer,
7. preliminary diagram of permissible short-time and long-time overload,
8. information about materials, used for cores, windings and winding insulation,
9. drawings, catalogues and pamphlets for standard elements, mounted in the transformer,
10. magnetic core and winding production description,
11. preliminary list of alarms and signalization, with preliminary alarm list, with actuators description,
12. proposed timetable plan for transformer production and supply (MS Project - last version) in digital version and paper printed,
13. proposed time schedule for documents submitting with dates of approval,
14. training program.
15. design review for winding design, active part of the transformer and calculation of effectiveness of the cooling system.

Documents, prepared by contractor for design review:

1. no load and short circuit characteristics (calculation data),
2. detail information about monitoring system,

3. transport data,
4. QA/AC program, test program during production and erection.

Documentation for the designing of civil works (transformer foundation) shall be submitted to the Employer at least three (3) months after signing the contract.

4.5 OTHER HV EQUIPMENT

All additional HV equipment required by design different as mentioned in SLD, Customer must meet the requirements of the HV equipment provided within LOT 2.

4.6 MV VOLTAGE EQUIPMENT

4.6.1 General

As MV equipment (medium voltage equipment) it is to be understand the HV equipment in the range of insulation level between 3,6 and 72,5 kV. If any necessary, MV equipment must be delivered in the form of gas-insulated medium voltage switchgear.

All medium voltage cells and their equipment must be designed and type-tested according to the requirements of the applicable standards:

1. SIST EN 62271-1 for general requirements,
2. SIST EN 62271-200 for switchgear cells,
3. SIST EN 62271-102 for grounding switches,
4. SIST EN 62271-100 for circuit-breakers,
5. SIST EN 62271-203 for high voltage switchgear and controlgear,
6. SIST EN 60071-2 for insulation coordination,
7. SIST EN 60265-1 for switch disconnectors,
8. SIST EN 60529 for mechanical protection degree.
9. SIST EN 61869 for instrumental transformers.

MV cells in the switchgear shall be metal enclosed, with a minimum LSC-2A class according to SIST IEC 62271-200, which ensures the possibility of maintenance even in the event of voltage on the main busbars, of partition class PM - with metal partitions. The cell's structural elements must be made of at least steel sheet, which is coated with a layer of alu-zinc or hot-dip galvanized for corrosion protection. Cells must be equipped with all necessary mechanical and electrical interlocks between circuit-breakers, grounding switches, and withdrawable parts.

Electrical passages through sheet metal walls between cells must be made with busbar barriers, conductive insulators, or otherwise sealed against the passage of electrical arcs between cells. All necessary equipment, supports, clamps, other fixing equipment, and similar for making connections must also be included in the supply. If the supplier requires steel base frames for installing cell assemblies on prepared concrete floors, they must be included in their supply under this tender. The supplier must define all necessary building openings under cells, their dimensions, and location in their documentation.

Relief covers that open in the event of an internal fault with an open electrical arc and direct any resulting gases away from the operator who could be standing in front of or behind the cell must be installed on top of each cell.

Each cell must be equipped with voltage presence indicators (inductive or capacitive) in all three phases. MV cable-connected cells must be designed for cable entry from the bottom.

The doors of individual MV cell cabinets will have installed:

1. local/remote switch with buttons for circuit-breaker on/off. Control buttons must be mechanically protected against any accidental triggering.
2. position signaling of the circuit-breaker, disconnector, and grounding switch,
3. circuit-breaker operation counters,
4. spring charging indication,
5. voltage presence indication on the supply side and
6. a single-line diagram (SLD) of the connections with element labels. The SLD on all MV cells must illustrate the single-line diagram of the entire MV switchgear.

Each cell will have a control cabinet, the MV cell cabinet, with a mounting plate for equipment installation. The cabinet must be of uniform size for all cells in the system. The control cabinet above the cell serves to sort the measuring circuits that will be connected to the current and voltage instrument transformers of the corresponding cell, and to mount control-protective and measuring equipment. Voltage measuring and protective circuits must be protected with appropriate circuit breakers with outage signaling, with at least two auxiliary contacts, as well as circuit breakers that must be installed for the needs of protective or power circuits. All equipment, including terminals, must be of standardized design and mounted on mounting rails. Separate terminal blocks with at least 30% spatial reserve must be provided for each device in the cabinet.

Each cell will have a separate 230 V AC power supply for heating, which will be controlled via a thermostat.

The power supply circuit, as well as two disconnecting circuits, will be powered separately. The supply voltage of control and signal circuits is 220 V DC, which will be supplied separately from two battery systems. The power supply for individual devices must be provided from the subdivision within each cell.

The power supply voltage of MV switch and circuit breaker motor drives and control-protective terminals is 220 V DC, and each distribution in the cell must be equipped with its own circuit breaker.

Signaling, control and measurement circuits must be connected to the designated terminal blocks in each cell - protective disconnecting circuits must be wired in a four-wire system. Standard terminal blocks for measuring circuits must be used for distribution of measuring circuits.

All cells must be equipped with medium-voltage switching devices, electromotive and/or manual drive mechanisms, control levers and rod mechanisms, instrument transformers, surge arresters, insulators, support, connecting and supporting elements, control-protective terminals, measuring instruments, elements for manual local control, position indicators, voltage indicators, control switches, and all other auxiliary equipment necessary for their operation.

4.6.2 Routine tests

In addition to the tests mentioned in other parts of this tender document, the following component tests and on-site installation tests are required for the supplied equipment. The supplier must specify the tests and provide precise references to the standards according to which they are performed.

4.6.2.1 Metal-enclosed MV switchgear

MV switchgear must undergo type testing. Component tests of the cells must be carried out in accordance with the latest editions of the relevant and valid standards of the SIST EN 62271 series. The limit values identified during type testing serve as a basis for evaluating the results of acceptance tests at the manufacturer's premises. The limit values should be specifically highlighted in routine test reports and tests conducted in the presence of the customer.

The following is an overview of standard and component tests. Other tests according to current or future editions of reference standards, which may not be listed in this document, are also acceptable.

1. The following standard tests must be conducted on each cell type:
    a. Dielectric tests
    b. Heating tests
    c. Current tests with short-duration and impulse short-circuit currents
    d. Verification of IP protection level
    e. Electromagnetic compatibility (EMC) tests
    f. Current withstands tests for switchgear during switching on and off
    g. Current withstands tests for grounding switches during switching on
    h. Mechanical operation tests
    i. Endurance tests against internal arcing
2. Component routine tests conducted on each cell must include at least the following:
    a. Visual inspection and examination
    b. Mechanical operation testing
    c. Verification of internal wiring and testing of auxiliary electrical control, protection, and measuring devices

d. Partial discharge testing of critical cell parts (as per the supplier's detailed proposal)
e. Dielectric tests of main circuits with grid frequency voltage,
f. Resistance measurements of main circuits

Acceptance tests in the presence of the Client or their representative at the manufacturer's premises must include all the above-mentioned component tests for each selected equipment.

The suitability of individual cell components must be confirmed by results or certificates of type and routine tests that correspond to the offered device configuration. Certificates of performed type tests must be attached to the offer.

3. The following activities will be carried out at the installation site:
   a. Verification of correct installation.
   b. Functional testing of all elements and systems.
   c. Measurement of insulation resistance.
   d. Measurement of main circuit resistances in all assemblies that could not be tested at the factory (e.g., complete switchgear assembly, etc.).
   e. Repetition of the short duration withstand voltage test at power frequency under dry conditions.

4.6.2.2 Individual medium voltage devices

4.6.2.2.1 Circuit Breaker

Circuit breakers must be type-tested in accordance with the requirements of IEC 62271-100. The following routine tests must be conducted at a minimum:

1. Short-duration power frequency withstand voltage test in dry conditions for main contacts and partial discharge measurement,
2. Voltage test of auxiliary circuits,
3. Measurement of main circuit resistance,
4. Mechanical operational tests of control and drive mechanisms, as well as contact poles,
5. Inspection of execution and visual inspections,
6. Time recording of main and auxiliary contacts,
7. Minimum control voltage test at which the switch still operate,

8. Determination of the minimum amount of stored energy at which the switch can still properly disconnect and connect.

The supplier must attach a detailed list of tests that will be performed on-site in accordance with the standards to the offer.

4.6.2.2.2 Current Instrument Transformer

Current transformers must be tested at least according to the requirements of SIST EN 61869-1:2009 and SIST EN 61869-2:2013, as well as other applicable standards and regulations. The following routine tests must be conducted:

1. Inspection of terminal markings.
2. Power-frequency voltage test on primary windings and measurement of partial discharges.
3. Power-frequency voltage test on secondary windings.
4. Power-frequency voltage test between cores.
5. Interturn voltage withstand test.
6. Determination of measurement Accuracy test.
7. Composite error test.
8. Measurement of the Phase displacement (tg δ).

In the event that the supplier intends to use current sensors instead of current transformers, they must accurately define the methods and procedures for testing them in the offer.

4.6.2.2.3 Voltage instrument transformer

Voltage transformers must be tested at least according to the requirements of SIST EN 61869-1:2009 and SIST EN 61869-3:2012, as well as other applicable standards and regulations. The following routine tests must be performed:

1. Measurement of capacitance before voltage tests
2. AC voltage test between low-voltage terminals and grounding
3. Verification of terminal markings
4. Power-frequency voltage test and measurement of partial discharges
5. Power-frequency voltage test on secondary windings
6. Power-frequency voltage test on primary windings
7. Determination of measurement Accuracy test.
8. Measurement of Phase displacement (tg δ)

In case the supplier intends to use non-voltage sensors instead of voltage transformers, they must precisely define the methods and execution of their testing in the offer.

4.6.2.2.4 Surge arrester

Surge arresters must be tested at least according to the requirements of SIST EN 60099-1 and SIST EN 60099-4, as well as other applicable standards and regulations.

The following routine test must be performed:

1. Power-frequency voltage test on dry arrester.

/	/	/	
Revision:	Revision note:	Revision date:	Signature:

Investor: ELES	Facility: RTP 400/220/220 kV Podlog Sistem za regulacijo moči (SSSC) v RTP Podlog
Design engineer: IBE, svetovanje, projektiranje in inženiring Ljubljana, Slovenija	Part of facility/system: Supply and Erection of Flexible Serial Compensation – SSSC in Podlog SS
/	Type of design: TECHNICAL SPECIFICATION

	First name/Name:	Id. No.:
Approved by:	mag. Marko Testen, univ. dipl. inž. el.	E-1293
Confirmed by:	mag. Marko Testen, univ. dipl. inž. el.	E-1293
Checked by:		
Designed by:	mag. M. Testen, univ. dip. in.e., D. Lenarčič, univ. dip. in. el.	E-1293, E-0076
11.2023		

Title of document:

5. Static Synchronous Series Compensator (SSSC)

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CONTENTS:

5 STATIC SYNCHRONOUS SERIES COMPENSATOR (SSSC)

5.1 FUNCTIONAL CHARACTERISTICS OF THE SSSC

5.1.1 Technology Types

SSCCs are part of the family of series controllers within FACTS devices. Two variants are possible:

- The conventional SSSC, connected to the transmission line through a transformer
- The transformerless SSSC, connected to the transmission line through multilevel inverters (such as modular transformerless SSSCs).

5.1.2 Voltage and Reactive Output Rating

5.1.2.1 Continuous Rating

SSSC must ensure following continuous Ratings at point of common coupling:

1. The SSSC shall be capable of continuous operation from 0,8 pu to 1,15 pu primary phase voltage.
2. The Contractor shall select the nominal operating voltage for the low voltage side of the step-down transformer in order to optimize the design of the SSSC (in case if the SSSC is connected to the transmission line through a transformer).
3. The nominal continuous operating capability shall be no less than 45,2 kV at the nominal current 920 A in inductive direction. In capacitive direction continuous operating capability shall be no less than 18 kV at current 920 A. The continuous capability is graphically presented in Figure 5.1.
4. The minimum voltage of the converter, measured between the terminals of the unit, shall be 120 V or less in both directions (inductive/capacitive).
5. The SSSC device must be capable of withstanding continuous current of 1800 A RMS.
6. The SSSC device must be capable of injecting voltage at currents at 120 A RMS or higher.
7. The SSSC shall be capable of continuous unrestricted operation for system frequencies as specified in other parts of documentation.
8. Current values of short circuit level at Substation Podlog are: Ik = 23,1 kA, Sk = 8.800 MVA. In abnormal condition 3.000 MVA.
9. SSSC shall be capable to withstand short circuit level capability Ik = 40 kA.
10. The SSSC shall be capable to withstand minimal short circuit level as defined in other parts of this documentation.
11. Ramp rate change of injected voltage of the SSSC within normal operating ranges following any initialization delay should be between 2 kV/s and 45 kV/s. At fast current limiting the SSSC shall achieve no less than 40,5 kV in up to 500 ms..

12. The operation of SSSC during start-up / initial switching on should not create any energizing transients causing voltage drop, voltage distortion and oscillaitons in voltage at the power line by more than +/-1,0%.
13. The SSSC shall be capable of unrestricted repetitive response throughout the entire dynamic operating range in accordance with the above ratings.
14. The SSSC shall be designed to be able to operate at the temporary frequency deviations specified in other parts of documentation.

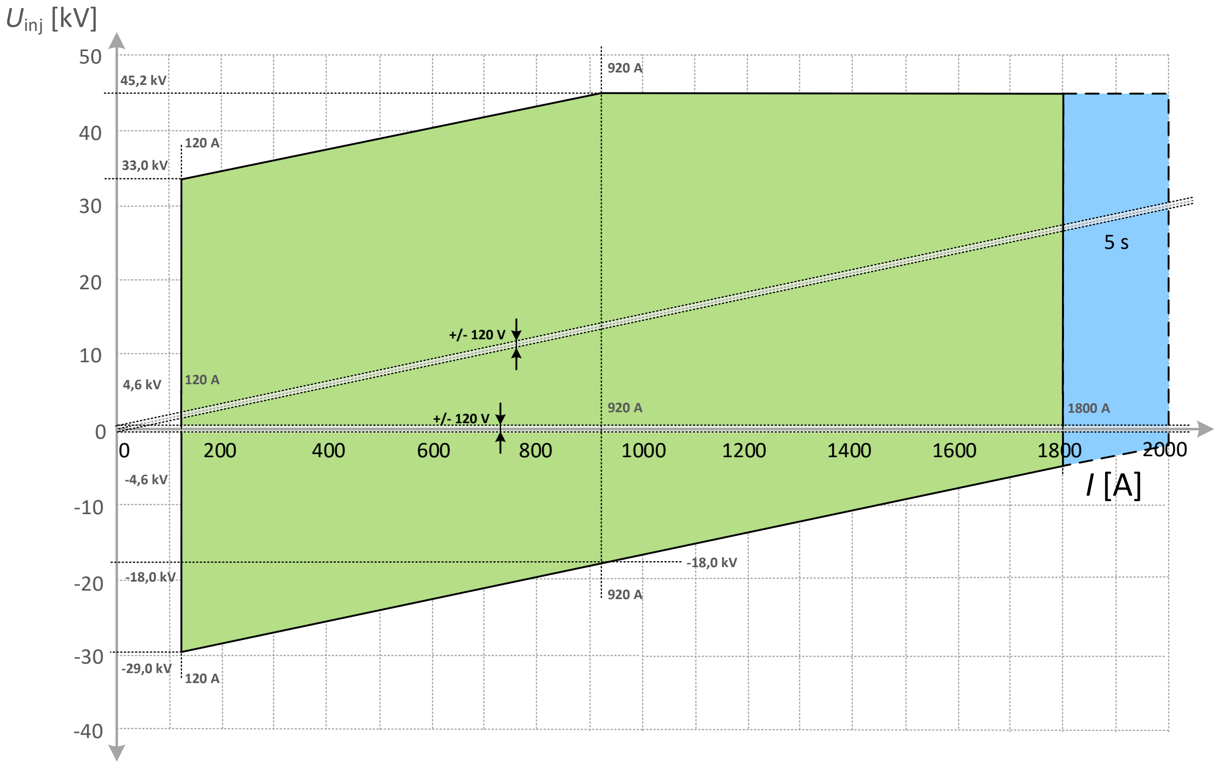

Figure 5.1: SSSC Continuous Voltage Operating Range Characteristic

5.1.2.1.1 Transmission System Overcurrent

SSSC shall be in normal operation at currents up to 2000 A for 5 seconds.

5.1.3 Overall Control Concept

The static synchronous series compensator (SSSC) shall employ a Voltage Sourced Converter (VSC) connected in series to a transmission line through a transformer or multilevel inverters. Its output is a series injected voltage, which leads or lags the line current by 90°, thus emulating a controllable inductive or capacitive reactance.

The SSSC will be used to reduce or increase the equivalent line impedance and enhance the active power transfer capability of the line. Moreover, additional functionalities and services to the energy system is also expected since SSSC is highly controllable device e.g., SSSC can increase or decrease steady-state power flow or change it dynamically to counteract dynamic disturbances to increase transient stability.

The quadrature relationship between the output voltage of the SSSC and the line current shall ensure approximately zero real power exchange between the SSSC and the AC system, except for the small amount (maximum 1% at full output) required to replenish the internal losses of the converter. This power shall be drawn from line by the converter, by a small (less than one degree) deviation from the ideal 90°, to keep the DC capacitor charged without an external DC power supply.

The control system shall coordinate the operation of the SSSC to regulate the injected voltage. Operation logics such as by-pass control, supervision control of all components, etc. in the SSSC shall also be incorporated in the control system. The control shall be programmable and have sufficient scope and flexibility (software programming margin of at least 20 %) to permit re-programming according to future changes in the power system.

5.1.3.1 Major Control Functions

The SSSC shall respond rapidly to changes in the system, making it an effective tool for maintaining system stability and control. The SSSC shall adjust its output, providing quick and accurate regulation of current and power flow. The control system shall coordinate the operation of the SSSC to achieve the following goals:

1. The SSSC shall control the current and flow of power on the transmission line by injecting series voltage.
2. The SSSC shall maintain its harmonics emissions below the allocated harmonic distortion limits (see chapter 5.1.4).
3. Operation logics for the by-pass shall also be incorporated in the control system.
4. The transition between operating modes should be smooth and seamless..
5. The control shall be programmable and have sufficient scope and flexibility (software programming margin of at least 20 %) to permit re-programming according to future changes in the power system.

Control functions can be divided into three types of control that can run simultaneously. Those types are:

1. user control,
2. slow auto current limiting,
3. fast auto current limiting.

5.1.3.1.1 General control modes

5.1.3.1.1.1 Stand-by mode

In stand-by mode the following is true:

1. Auxiliary load is in operation.
2. The device is in by-pass (if applicable).
3. Control modes are disabled.
4. Must enable smooth and seamless transition to any control mode.
5. Must enable transition to any control mode within 2 second after the command has been received in SSSC. Control mode can be changed only on demand and not automatically.
6. SSSC protection is active and in operation.
7. Monitoring of network quantities is active and in operation and available in device HMI (Human Machine Interface).
8. Total harmonic distortion is limited to 0.
9. Minimum losses.

5.1.3.1.1.2 Monitoring mode

In monitoring mode the following is true:

1. Auxiliary load is in operation.
2. The device is in operation.
3. SSSC carries line current.
4. SSSC energized and capacitors are pre-charged.
5. Control modes are disabled.
6. SSSC is not reacting to grid conditions.
7. Must enable smooth and seamless transition to Current limiting mode.
8. Must enable transition to current limiting mode within 2 second after the command has been released. Control mode can be changed only on demand and not automatically.
9. SSSC protection is active and in operation.
10. Monitoring of network quantities is active and in operation and available in device GUI.
11. Total harmonic distortion is limited according to paragraph 5.1.4.
12. Minimum losses.

5.1.3.1.1.3 Energy-saving mode (stand-by) with auto current limiting

In energy-saving mode (stand-by) with auto current limiting the following is true:

1. Auxiliary load is in operation.
2. The device is in by-pass.
3. User control modes are disabled (e.g. injected voltage is zero, setting of setpoint not possible).

4. Must enable bumpless transition to any control mode.
5. Must enable transition to any control mode within 2 second after the command has been released.
6. SSSC protection is active and in operation.
7. Monitoring of network quantities is active and in operation and available in device GUI.
8. Total harmonic distortion is limited to 0.
9. Minimum losses.
10. Fast auto current limiting optional with normal enabled.
11. Slow auto current limiting optional with normal enabled.

Fast auto current limiting is described in section 5.1.3.1.4, slow auto current limiting is described in section 5.1.3.1.3.

5.1.3.1.1.4 Full control mode

In full control mode the following is true:

1. Auxiliary load is in operation,
2. The device carries line current and in operation.
3. User control modes are enabled.
4. User control modes available: current control mode(I), constant injected voltage mode (U), constant reactance mode (X).
5. Must enable smooth and seamless transition to any control mode.
6. Must enable transition to any control mode within 2 second after the command has been released.
7. SSSC protection is active and in operation.
8. Monitoring of network quantities is active and in operation and available in device GUI.
9. Total harmonic distortion is limited according to paragraph 5.1.4.
10. Minimum losses.
11. Fast auto current limiting optional with normal enabled
12. Slow current limiting optional with normal enabled for constant injected voltage mode and constant reactance mode.

Fast auto current limiting is described in section 5.1.3.1.4, slow auto current limiting is described in section 5.1.3.1.3.

5.1.3.1.2 User control modes

5.1.3.1.2.1 Current control mode

In this control mode the injected voltage is controlled to manage a line current above or below specified levels. While line current is between the specified levels, the converter injects no voltage. If line current exceeds a specified upper level I_{up_start} for a specified time, the converter injects an inductive voltage using a droop characteristic to limit the current. When the current drops below I_{up_end} for a specified time, unit stops to inject inductive voltage. If line current drops below a specified lower level I_{low_start} for a specified time, the converter injects a capacitive voltage using a droop characteristic to boost the current. When the current exceeds I_{low_end} for a specified time, unit stops to inject capacitive voltage. SSSC shall enable setting of upper and lower level of current I_{up_start}, I_{up_end} and I_{low_start} and I_{low_end}, together with the droop and the delay. Parameters that can be set are in Table 5-1 **Napaka! Vira sklicevanja ni bilo mogoče najti.**.

Type of control	Parameter	min - max	Step
Current control mode	I_{up_start}	Imin - 1800 A	1 A
	I_{up_end}	Imin - 1800 A	1 A
	I_{low_start}	Imin - 1800 A	1 A
	I_{low_end}	Imin - 1800 A	1 A
	Delay	1 - 300 s	0,1 s
	Droop	5 - 5000 V/A	1 V/A

Table 5-1: Parameters that can be set in current control mode

5.1.3.1.2.2 Constant injected voltage mode

In this mode the VSC converter injects a constant voltage. SSSC shall enable setting of injected voltage U_{inj}. Positive value means inductive injection, negative value means capacitive injection. Parameter that can be set is in Table 5-2

Type of control	Parameter	min - max	Step
Constant injected voltage mode	U_{inj}	1 % – 100 %	1 % of Umax

Table 5-2: Parameter that can be set in constant injected voltage control

5.1.3.1.2.3 Constant reactance mode

In this control mode the injected voltage is continuously adjusted to the current through the SSSC to simulate a constant reactance of the SSSC. SSSC shall enable setting of the reactance X_{SSSC}. Positive value means inductive injection, negative value means capacitive injection. Parameter that can be set is in Table 5-3.

Type of control	Parameter	min to max	Step
Constant reactance mode	X_{sssc}	–240 to +275 Ω	0,1 Ω

Table 5-3: Parameter that can be set in constant reactance control

5.1.3.1.3 Slow auto current limiting

Slow current limiting shall be available in parallel to constant reactance mode and constant injected voltage mode. SSSC shall enable to switch this control on and off. SSSC shall enable setting of the current I_{online_limit}, at which the SSSC reaches its maximum injected voltage. Setting of I_{online_limit} shall be enabled to enter manually from the transmission system operator and automatically from the operator's system for monitoring of conductor temperature. SSSC shall enable setting of the difference (I_{online_lim} – I_{lim})for slow current limiting. In slow current limiting, only inductive direction of injected voltage shall be possible. The slope *k* of U/I characteristics and the value I_{lim} shall be calculated internally by SSSC according to I_{online_limit} and the difference (I_{online_lim} – I_{lim}). SSSC shall enable setting of the difference (I_{lim} - I_{end}). Principles of U/I characteristics for slow current limiting are presented in Figure 5.2.

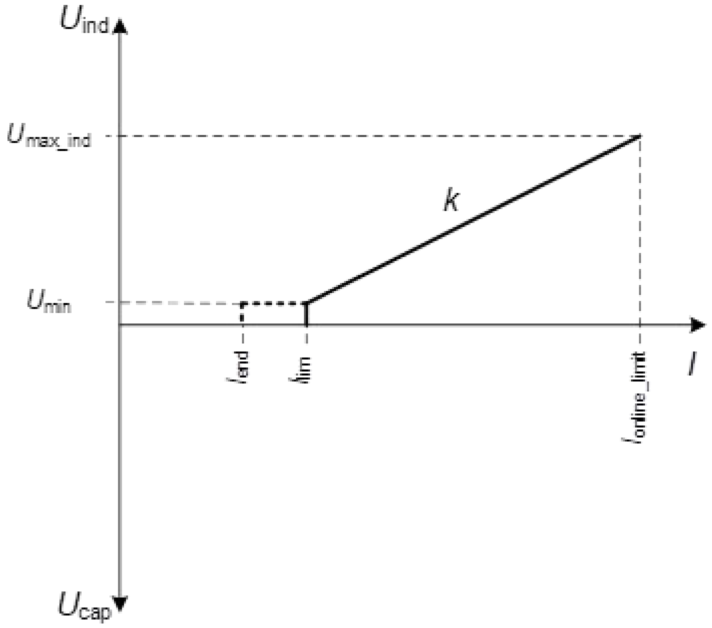

Figure 5.2: Slow current limiting in combination with standby control

Parameters that can be set are in Table 5-4.

Type of control	Parameter	min - max	Step
Slow auto current limiting	I_{online_limit} - I_{lim}	10 - 1680 A	1 A
	I_{online_limit}	120 - 1800 A	1 A
	Delay I_{lim}	1 - 300 s	0,1 s
	I_{lim} - I_{end}	10 -1000	1 A
	Delay I_{end}	1 - 300 s	0,1 s

Table 5-4: Parameters that can be set in slow auto current limiting

5.1.3.1.4 Fast auto current limiting

In this control the injected voltage increases to at least of 90 % of maximum injected voltage within 500 ms or faster. SSSC shall enable to switch this control on and off. The control shall be available in parallel to energy-saving mode (stand-by) with auto current limiting, to any of the user control modes and to slow auto current limiting. Transition to fast auto current limiting from other control modes must be automatic when current exceeds the value I_{lim}. Maximum delay for transition to fast auto current limiting is 1 s. 90 % of maximum injected voltage of SSSC shall be reached at least in 1,5 s after current exceeds the value I_{lim}. Fast auto current limiting shall be available for currents above 800 A RMS. SSSC shall enable setting of the current I_{online_limit}, at which the SSSC reaches its maximum injected voltage. Setting of I_{online_limit} shall be enabled to enter manually from the transmission system operator and automatically from the operator's system for monitoring of conductor temperature. SSSC shall enable setting of the difference (I_{online_lim} – I_{lim}) for fast current limiting. In fast current limiting, only inductive direction of injected voltage shall be possible. The slope *k* of U/I characteristics and the value I_{lim} shall be calculated internally by SSSC according to I_{online_limit} and the difference (I_{online_lim} – I_{lim}). SSSC shall enable setting of the difference (I_{lim} - I_{end}). Principles of U/I characteristics for fast current limiting are the same as for slow current limiting presented in Figure 5.2. The overshoot of injected voltage shall not exceed the range of +/- 10% of maximum voltage and the settling time for the injected voltage to stay within +/- 1 % of the maximum voltage shall be less than 3 s.

If the SSSC is in bypass due to the fault in the power system and the current through SSSC is not interrupted, fast current limiting shall be available within 1 s after the current decreases below the treshold for bypass.

Parameters that can be set are in Table 5-5.

Type of control	Parameter	min - max	Step
Fast auto current limiting	I_{online_limit}	800 - 1800 A	1 A
	I_{online_limit} - I_{lim}	10 - 1680 A	1 A
	I_{lim} - I_{end}	10 -1000	1 A

Table 5-5: Parameters that can be set in fast auto current limiting

5.1.3.1.5 Operation in case of communication failure

In case of communication failure with TSO control center the SSSC continuously delivers a pre-programmed default level of reactance or voltage.

5.1.3.2 Protection system

The SSSC protection system must be designed to ensure the safe and reliable operation of the SSSC system. The protection system should be able to detect and isolate any fault conditions, such as:

1. overvoltage,
2. overcurrent, and short circuits,
3. earth fault,

4. overtemperature,
5. equipment failure,
6. trigger pulse supervision,
7. etc..

and protect the SSSC from damage. Following design requirements must be achieved:

1. Fast and accurate detection of fault conditions: The protection system should be able to detect fault conditions quickly and accurately to ensure that appropriate corrective actions can be taken in a timely manner.
2. Selectivity - protection system must be able to isolate the faulted part of the system while maintaining the healthy parts of the system in operation.
3. Sensitivity - protection system should be able to detect faults of small magnitudes to ensure that corrective actions can be taken before they become critical.
4. Reliability - protection system must be reliable and should not cause false tripping, which can result in unnecessary interruptions to the power supply.
5. Redundancy - protection system should have redundancy in case of failure of one component, to ensure that the system continues to operate safely and reliably.
6. Compatibility - protection system must be compatible with the overall SSSC system, including the control and monitoring systems, to ensure seamless integration and effective operation.

5.1.4 Harmonic Performance

5.1.4.1 Planning levels

The harmonic emission limits considered for the device follow the indicative harmonic planning levels from IEC/TR 61000-3-6 and are shown for individual harmonics in the Table 5-6.

Odd harmonics (non-multiple of 3)		Odd harmonics (multiple of 3)		Even harmonics	
Harmonic order h	Harmonic voltage $L_{h,max}$ [%]	Harmonic order h	Harmonic voltage $L_{h,max}$ [%]	Harmonic order h	Harmonic voltage $L_{h,max}$ [%]
5	2	3	2	2	1.4
7	2	9	1	4	0.8
11	1.5	15	0.3	6	0.4
13	1.5	21	0.2	8	0.4

17 … 49	$1.2 \cdot \frac{17}{h}$	21 … 45	0.2	10 … 50	$0.19 \cdot \frac{10}{h} + 0.16$

Table 5-6: Indicative values of harmonic planning levels (as a percentage of the fundamental component) for EHV and HV transmission systems (IEC 61000-3-6)

When determining maximum SSSC harmonic emissions, Method 1 from IEC/TR 61000-3-6 is considered, which gives slightly lower harmonic distortion limits. Considered is also the recommendation in standard 61000-3-6, stating if the calculated maximum values of the allowed global device contribution are lower than 0.1 %, these values can be raised to 0.1 %. This approach avoids low values that are difficult to achieve and measure in practice.

The SSSC shall maintain its harmonics emissions bellow the allocated harmonic distortion limits shown in Table 5-7.

Harmonic component	*G* (%) Max. global contribution for Podlog	*Max. global contribution for SSSC E_{SSSC} (%)*	*Max. global contribution for SSSC E_{SSSC} (%)*
	Metod 1	Metod 1	Metod 1 (U_h > 0.1 %)
2	0.3266	0.1954	0.1954
3	0.4665	0.2791	0.2791
4	0.1866	0.1116	0.1116
5	0.7071	0.4899	0.4899
6	0.1414	0.0979	0.1000
7	0.7071	0.4899	0.4899
8	0.1414	0.0978	0.0978
9	0.3535	0.2449	0.2449
10	0.1237	0.0857	0.1000
11	0.5303	0.3674	0.3674
12	0.1125	0.0779	0.1000
13	0.5303	0.3674	0.3674
14	0.1045	0.0724	0.1000
15	0.1060	0.0734	0.1000
16	0.0985	0.0682	0.1000
17	0.4242	0.2939	0.2939
18	0.0939	0.0650	0.1000
19	0.3796	0.2630	0.2630
20	0.0901	0.0624	0.1000
21	0.0707	0.0489	0.1000
22	0.0871	0.0603	0.1000
23	0.3136	0.2172	0.2172
24	0.0845	0.0585	0.1000
25	0.2885	0.1998	0.1998

Harmonic component	G (%) Max. global contribution for Podlog Metod 1	*Max. global contribution for SSSC* E_{SSSC} *(%)* Metod 1	*Max. global contribution for SSSC* E_{SSSC} *(%)* Metod 1 (U_h > 0.1 %)
26	0.0824	0.0571	0.1000
27	0.0707	0.0489	0.1000
28	0.0805	0.0558	0.1000
29	0.2487	0.1723	0.1723
30	0.0789	0.0546	0.1000
31	0.2326	0.1612	0.1612
32	0.0775	0.0537	0.1000
33	0.0707	0.0489	0.1000
34	0.0763	0.0528	0.1000
35	0.2061	0.1427	0.1427
36	0.0752	0.0521	0.1000
37	0.1949	0.1350	0.1350
38	0.0742	0.0514	0.1000
39	0.0707	0.0489	0.1000
40	0.0733	0.0508	0.1000

Table 5-7: Allocated harmonic distortion limits

The contribution of SSSC to the total voltage harmonic distortion should also be limited. The recommendation is that the device contribution to the **THD value should be limited to 0.7 %.** The device should not inject DC current.

5.1.4.2 Compatibility level

Planning levels calculated above are based on the recommendations of the standard IEC/TR 61000-3-6. However, the Compatibility levels described in it are just for the LV in MV and therefore, are not defined for HV and EHV.

Compatibility levels for public supply system harmonics are specified in IEC Basic Standards 61000-2-2 and 61000-2-12. A comprehensive explanation of the application of compatibility levels and planning levels and their relationship with emission and immunity limits and levels is to be found in IEC Standard 61000-2-12. Figure bellow illustrates the relationships between the EMC levels and limits and is taken from IEC 61000-2-12.

Compatibility levels of the SSSC should be based on the calculations using the Table 5-8. It needs to be considered that the THD level used is 3.5 %.

Odd harmonics (non-multiple of 3)		Odd harmonics (multiple of 3)		Even harmonics	
Harmonic order	Harmonic voltage	Harmonic order	Harmonic voltage	Harmonic order	Harmonic voltage

h	[%]	h	[%]	h	[%]
5	3.0	3	1.7	2	1.0
7	1.5	9	0.5	4	0.8
11	1.0	15	0.3	6	0.5
13	1.0	21	0.2	8	0.4
17	0.5	>21	0.2	10	0.4
19	0.5			12	0.2
23	0.5			>12	0.2
25	0.5				
>25	$0.2 + 0.3 \cdot \frac{25}{h}$				

Table 5-8: Harmonic Voltage Compatibility Levels for 275 and 400kV Systems (IEC 61000-2-2)

5.1.5 Design Criteria

The events to be used for insulation coordination shall include abnormal occurrences not only in the SSSC itself, but also in the surrounding network including but not limited to:

1. Over-voltages on the transmission system including dynamic over-voltages, switching surges and lightning.
2. 220 kV bus faults or single and multiple line faults or system transformer faults, including auto re-closures, up to maximum design fault clearing times.
3. SSSC associated power line or other low side equipment faults.
4. SSSC valve or control mal-operation or malfunction.
5. Outdoor insulators have to be dimensioned according to IEC 60815. Site pollution severity classes has to be at least Medium. The respective voltage shall be taken, either phase-phase or phase-earth, depending on whether the respective insulator is phase-phase or phase-earth. Unified specific creepage distance shall equal or more than 34,7 mm/kV.

5.2 READINESS, AVAILABILITY AND MAINTAINABILITY

The SSSC system is being installed to provide steady state and transient power flow support, in order to improve the security of the transmission system and enhance the reliability and quality of power delivery.

5.2.1 General

The SSSC is located at a normally unmanned substation remote from technical maintenance staff although operational staff would provide the first line of maintenance. The main function of the SSSC is to control the flow of power on OHL and damping the oscillations on OHL that occur due to changes of load.

The integrity of this plant and material is therefore of vital importance to the 220kV transmission network and the Employer's customers. The condition of the SSSC shall not be affected by any external failure of plant and material or network disturbances. Internal failure of plant and material or components shall have a minimal effect on operation and the network.

Every care shall be taken to select high quality, conservatively rated components, while workmanship shall be of the highest class. Due attention shall be given to the reliability of auxiliary plant to ensure that the availability of the SSSC is not compromised by frequent failures of pumps, fans, or other minor components.

The proper operation of the SSSC in the time following a major disturbance is crucial to the security of the Employer’s system; therefore, operational readiness is extremely important. The design must ensure that the SSSC will not trip or fail to operate under such conditions.

Availability is also important and must be high. However, when a design decision requires a choice between availability and operational readiness, operational readiness shall govern. Redundancy shall be employed to the extent necessary and to the minimum extent specified in this specification to achieve the required operation readiness level.

Operation readiness means, when available, that the SSSC will perform as planned for any power-system disturbance. Below must be followed to achieve high operation readiness:

1. All key components are robust with high reliability inherent in the design.
2. Fail-safe security which is monitored and correctly indicates the operational status of the SSSC.
3. Correctly identify and isolate failed SSSC components or subsystems to minimize the tripping of the complete SSSC.

In the Tender documentation, the Tenderer shall include a specific description on principle and detailed measures taken in the design of the SSSC to obtain highest possible degree of readiness.

5.2.1.1 Definitions

The following definitions apply:

1. Forced outages are outages caused by faults in the SSSC equipment that result in loss of part or all the essential functions of the SSSC system.
2. Scheduled outages are outages necessary for preventive maintenance to assure continued and reliable operation of the SSSC system. They may result in the temporary loss of part or all the essential functions of the SSSC system.
3. Outage duration is the elapsed time in hours from the instant the SSSC is out of service to the instant it is ready to be returned to service. The following may be included in the outage duration:
    a. The downtime required to determine the cause of an outage or to determine which equipment or units of equipment to repair or replace.

b. The time required by system operators to disconnect and ground equipment in preparation for repair work and to remove grounds and reconnect equipment after repairs are complete. Delays caused by unavailability of qualified user personnel are not accumulated in the outage duration.

c. Partial outage. If partial SSSC output is available, the duration of equivalent outage should be calculated as the product of the derated condition duration and the proportion of the nominal output range that cannot be achieved during this period.

4. Annual availability is the annual equivalent availability for forced outages, both total and partial, in percent and is defined with duration in hours.

$$\text{Annual availability } [\%] = \left[1 - \frac{\sum Duration\ of\ equivalent\ event\ [h]}{8760}\right] * 100$$

5.2.1.2 Required Availability and Reliability

Reliability performance required is as follows:

1. The annual availability for forced outages for the SSSC system should be at least 99%,
2. There should be no more than two forced outages of the SSSC system per year,
3. The Tenderer should state the expected or guaranteed average number and duration of scheduled outages per year,
4. The Tenderer should guarantee the quoted availability performance for 2 years from commercial operation. The Contractor will be notified of major outages. During the guarantee period, the user will maintain records of the number and duration of forced and scheduled outages, hours of operation, and any other relevant data and should make those records available to the Contractor upon request,
5. If the actual performance is different from the values stated in this LOT the Contractor should provide corrections and modifications to meet the availability guarantees at no extra cost to the user,
6. Maintenance intervals should occur regularly for inspection and, where necessary, repair. The Tenderer should suggest the maintenance interval suitable for its equipment and should describe any condition monitoring offered.

The Tenderer/Contractor is responsible (with Employer support) to gather all necessary data and do the RAM evaluation in the operation period.

5.2.1.3 Maintainability

The scheduled maintenance shall take place according to the Contractor's recommendations.

In case of equipment replacement, this must be accomplished within twelve hours, for all pieces of equipment, stored as spares in the station.

In the Tender documentation, the Tenderer shall include a preliminary plan for needed spare parts and scheduled maintenance, including intervals and time durations for specific activities.

5.3 MAIN COMPONENTS – REQUIRED FUNCTIONS AND FEATURES

5.3.1 Voltage Source Converter (VSC)

5.3.1.1 Overall Performance

The Voltage Source Converter should be designed to ensure operation according to the overall performance requirements of the SSSC system.

5.3.1.2 Access to Power Switching Device Modules

The design of the modules support structure should permit easy access by the user for visual inspection, routine maintenance, troubleshooting and component replacement.

5.3.1.3 Design Robustness

The switching modules should be designed with individual devices and other components applied in a conservative manner regarding their basic design parameters, as follows:

1. The switching modules should withstand maximum overvoltage and overcurrent stresses due to system faults and switching.
2. The switching module design should include an appropriate allowance for unequal voltage distribution across individual devices in the modules due to stray capacitor and component tolerances.
3. The SSSC system should be designed to prevent, or alternatively, to withstand, false firing events, i.e., the firing of any valve at an incorrect time in the cycle or when not ordered. The Tenderer should describe the details of prevention or withstand inherent in its design.
4. Each switching module should be able to operate within component ratings, generally with at least two failed modules and min. 10 % of the modules. The number of possible failed modules should be selected by the Contractor, demonstrated to the user, and be consistent with the availability requirements of the SSSC system.
5. The VSC should be designed to manage the heat generated by the power electronic switches.

5.3.1.4 Monitoring and maintenance

Switching module monitoring and maintenance requirements are as follows:

1. A monitoring means to identify any modules that have failed should be provided.

2. The switching modules should be designed to allow easy replacement of failed modules. Other system components should be capable of continued service while a module is being changed or during similar maintenance.

5.3.2 Power Electronic Valves

5.3.2.1 General Design Requirements

The valve shall be designed to meet the performance requirements described in this specification and as described below:

1. The valves shall be designed to ensure satisfactory operation according to the overall performance requirements and include all necessary auxiliary equipment.
2. The valves shall be indoor air-insulated and of a liquid-cooled type.
3. The valves shall be of modular or sectional design and have removable components for ease of maintenance. The valves shall be mounted to allow easy access for visual inspection, routine maintenance, and replacement, or facilities shall be provided to enable easy access.
4. Semiconductor Switches - The valve shall be designed with individual semiconductor switches applied in a conservative manner regarding their basic design parameters. The semiconductor switch shall meet the requirements of IEC 60747 except where otherwise specified herein. The proposed semiconductor switch shall be of a type which is in, or ready for, commercial operation with characteristics fully proven by recorded years of operation in other installations. The Contractor shall provide a standard data sheet of ratings for the semiconductor switches offered.
5. The semiconductor switches shall be designed to withstand all stresses expected under steady state, transient and temporary over-voltage conditions as specified in this specification including, but not limited to the following:
    a. Transient over-voltages due to AC system fault application and fault clearing.
    b. Temporary over-voltages originating in the AC system (e.g., such as load rejection), or caused by AC system faults (such faults normally result in combined overcurrent and overvoltage stresses).
    c. Resonant voltage oscillations on the medium voltage side of the SSSC transformer excited by system disturbances such as fault application, fault clearing, line switching and transformer energization.
    d. Fast surges transferred from the AC system.
    e. Steep-front surges generated by insulation failure on the medium voltage side of the SSSC transformer.
    f. Over-voltages due to control malfunction such as false firing of the valve, loss of firing signal, mal operation of the voltage control loop and loss of synchronization.

g. Transient over-voltages due to partial blocking caused by, for example, improper firing, forward recovery protection or VBO/EOP (electronic overvoltage protective) firing.

6. Redundant Levels - Redundant levels are levels which may become short-circuited during service without impairing the ability of the VSC phase unit to meet its performance requirements. A minimum of 2 redundant levels are required in each single-phase valve. The actual number will be determined based on the stated requirements for availability and reliability for the SSSC. Measures shall be implemented where necessary to ensure that the voltage across the healthy semiconductor switch is within the capability of the semiconductor switch in the event of failure of a level. The voltage rating of the semiconductor shall be such that no cascading failure shall result in the event of failure of all redundant levels + 1.
7. Valve Reactors - Valve reactors may be provided within the semiconductor switch levels or in series with the valves to limit semiconductor switches di/dt and du/dt stresses and limit radio interference.
8. Replacement of failed valve levels - The valves shall be designed to allow easy replacement of failed power modules or submodules in the valve. If they are liquid cooled, it shall be possible to replace faulty power modules/submodules with minimum loss of the cooling medium only and with minimum disturbance to other plant and material. Any special tools required for replacement of these parts shall be provided under the Contract.
9. Firing System - The firing control signals from circuits at ground potential shall be transmitted either by optical coupling via light guides, or by magnetic coupling via pulse transformers. The firing system shall be designed to tolerate electromagnetic interference present in the valve. The firing pulses shall be sufficiently coherent not to impose excessive overvoltage stresses on the last levels to tum on.
10. Monitoring System - Monitoring of submodule status while the SSSC is in operation shall be provided and the number of failed submodules and their location shall be indicated. Monitoring of repetitive firing by a voltage break over (VBO) action (if present) shall also be provided. The monitoring system shall be designed to prevent false indication due to electromagnetic interference present in the valve. Light guides or magnetic transformers may be used to transmit the signals.
11. The valve shall be designed for the maximum over-voltage and over-current stresses due to system faults and switching. The semiconductor valve components which are the main heat-generating components (e.g., semiconductor switch, damping and grading components, valve reactors, gating circuits and current carrying connections within the valve) shall be designed to withstand the thermal stresses which affect their operating characteristics. The semiconductor switch valves shall be capable of withstanding the highest over-currents expected in service and be capable of blocking corresponding voltages at the highest semiconductor switch junction temperature reached. The Contractor shall provide details of the complete valve, including control and protection circuitry, valve cooling facilities, including their means of control, temperature and flow

monitoring and alarms, mechanical design, container design, auxiliary wiring and earthing, EMC, etc. This shall be included in the valve design report.

12. Conductivity of cooling medium (if applicable). The cooling medium shall have adequate dielectric withstand capability and an alarm for high conductivity of the cooling liquid.
13. Each valve level shall be provided with a corrosion-resistant identification showing the identification number.
14. Heat-sinks. The heat-sinks for the semiconductor switch shall be treated to ensure good electrical contact, if necessary, without risk of corrosion.
15. Semiconductor Firing Pulse Synchronization and Generation. The semiconductor firing pulse synchronization and generation systems must be able to operate under the following conditions:
    a. maximum steady-state voltage unbalance
    b. variation in three-phase short-circuit levels (existing, future and abnormal) at the SSSC HV bus
    c. presence of harmonic distortions during transient, dynamic, and steady state conditions
    d. single- or multi-phase faults on the AC network
    e. transformer, reactor or capacitor switching on the AC network
    f. possible transient and temporary over-voltages on the AC network.
16. The semiconductor firing pulse synchronization and generation systems shall be designed to minimize the generation of non-characteristic harmonics and prevent any harmonic instability.
17. Firing pulse strategy shall be implemented to protect them from direct blocking voltage throughout the anticipated conduction period.

5.3.2.2 Valve Overvoltage Protection

Where surge arresters are connected directly across the terminals of the semiconductor valve, the valve shall be designed to commutate the maximum current flowing in the associated arrester at the instant the valve is fired during a transient overvoltage across the valve (If the valve is permitted to be fired during the over-voltage).

Where the individual semiconductor levels are protected by VBO/EOP firing or by metal oxide varistors (MOV) against partial blocking or failure of some semiconductor levels, such protection shall be capable of repetitive operation, and such operation shall not overstress the semiconductor level components. If a surge arrester connected in parallel with the valve is also provided, the VBO/EOP or MOV level shall be properly coordinated with the protection level of the surge arrester.

1. Surge Arresters (if applicable) - The arresters shall be of the gapless metal oxide type and shall be connected directly in parallel with the valve. The associated valve shall be

designed to be capable of withstanding additional current transferred from the parallel arrester in the event the valve is fired when the arrester is conducting maximum current. The protective level of these arresters shall be properly coordinated with arresters in other locations of the SSSC, where provided.

2. Metal Oxide Varistors (if applicable) - The metal oxide varistors (MOVs) may be connected across each semiconductor switch level to limit the semiconductor switch voltage in the event of semiconductor switch level failure, partial blocking (when only some of the semiconductor switches remain blocked while other series-connected semiconductor switches are turned on), or uneven voltage distribution within the valve.
3. Protective Firing - Protective firing initiated at a predetermined voltage across the DC capacitor of VSC valve, shall be provided as follows:
    a. There shall be over-voltage mitigation method in each VSC valve. The over-voltage mitigation block can smoothly decrease the DC capacitor voltage. In this condition, the VSC valve shall continuously be in operation below the over-voltage protection level.
    b. VSC valve over-voltage protection is fired in the event of VSC valve over-voltage. The protection level shall be set to a predetermined threshold based on the prospective recovery voltage of the VSC valve. The threshold of this protection shall be coordinated to lie between the maximum commutation overshoot voltage and the minimum voltage break over devices (VBO) protection threshold. Furthermore, this threshold of this protection shall be coordinated to the maximum safe operation voltage of the DC capacitor.

5.3.2.3 Valve Over-current Protection

Over-current protection shall be provided for the semiconductors to ensure that the highest semiconductor junction temperature reached under the worst case over-current conditions is such that: the semiconductor when blocked will be capable of withstanding the worst-case blocking voltage at the elevated junction temperature, the resulting highest semiconductor junction temperature is below the value above which the semiconductor can be damaged by thermal filamentation.

5.3.2.4 Valve Fire and Electrical Arc Protection

The semiconductor valves and other valve hall plant and material shall be designed to minimize the risk of fire, or an electrical arc being initiated within the valve hall and to limit the consequences of such a fire if it occurs. The use of flammable materials in the valves shall be minimized as far as practicable. Where such materials cannot be avoided, they must be demonstrated to exhibit self-extinguishing capability equal to or better than the Underwriters Laboratory UL-94-V0 classification for vertical material, and UL-94 HB for horizontal material.

The electronic components in the valve shall be designed to minimize the risk of fire or electrical arc by using components of low flammability, high reliability, and adequate ratings margins. Measures shall be taken to prevent lateral or vertical propagation of fire or electrical arc through adjoining plastic materials or fiber-optic channels, such as use of fire barriers of high fire and arc resistance capability.

5.3.2.5 Valve Tests for Chain-linked topology type SSSC

5.3.2.5.1 General

The Contractor shall carry out tests on VSC phase units and valves in accordance with the requirements stated below and with applicable portions of IEC 62927. The tests shall include but not be limited to tests listed below.

Dielectric tests, operational tests and the EMC test shall be performed on completely assembled valves or VSC phase units, as applicable.

The VSC valve or VSC phase unit used for type tests shall first pass all production tests. On completion of the type test program, the VSC valve or VSC phase unit shall be checked again for compliance with the production test criteria. A valve or VSC phase unit shall be deemed to have failed a test if the production test criteria are not met, short-circuit or flashover have occurred and/or functionality is partly or wholly lost.

The same VSC phase unit or VSC valve shall be used for all type tests. Material for the type tests shall be selected at random.

Type tests acceptance criteria:

1. Breakdown or external flashover across common electrical equipment associated with more than one valve, or disruptive discharge in dielectric material forming part of the valve structure, cooling ducts, light guides, or other insulating parts of the phase unit shall not be permitted.
2. The permitted number of valve failures during type testing is:
    1. not more than one valve failure during any one type test item;
    2. not more than two cumulative valve failures during and after complete type test program including all type test items.
3. The valve and each valve of the phase unit shall be checked after each type test item to determine whether any valve failed. If the valve failed during any type test item, the failure cause should be analyzed. If the failure cause is not a nature of inadequate design, it may be replaced, and the failed type test item shall be repeated. Otherwise, the complete type test program shall be repeated.

All operational tests shall be carried out under conditions, which would result in the highest component temperature and the highest semiconductor junction temperature that may occur in real operation.

All dielectric tests on a complete VSC phase unit shall be carried out with redundant valve levels short-circuited. The location of the valves to be short-circuited shall be agreed upon between the Employer and the Contractor.

A list of all tests to be performed on all auxiliary plant and material associated with the valve shall be submitted to the Employer for review and comment. The Contractor shall provide test reports of all type tests on the valves.

5.3.2.5.2 Test Program

The Contractor shall submit a detailed test program for the VSC phase unit and valve which shall include type and production (routine and sample) tests to be carried out in the factory. The test program shall include details such as test levels (and their derivation) test duration, test circuits, test procedures and the pass/fail criteria to be used. All components of the VSC phase unit or valve shall be subjected to rigorous testing, inspection, and quality assessment.

5.3.2.5.3 Minimum test schedule

The following minimum type test schedule is required for the 'chain-link' topology SSSC. The terms and definitions, provided in Section 5.3.2 apply to the test procedures as provided in the referenced standards.

Test	Standard	Section	Test object
Operational type tests			
Maximum continuous operating duty test	SIST EN 62927	6.4	Valve or valve section
Maximum temporary over-load operating duty test	SIST EN 62927	6.5	Valve or valve section
Minimum start voltage test	SIST EN 62927	6.6	Valve or valve section
Over-current turn-off test	SIST EN 62927	10	Valve or valve section
Short-circuit current test (optional)	SIST EN 62927	11	Valve or valve section
SIST EN 62927SIST EN 62927SIST EN 62927SIST EN 62927SIST EN 62927SIST EN 62927Valve support DC voltage test	SIST EN 62927	7.3.1	Valve support
Valve support AC voltage test	SIST EN 62927	7.3.2	Valve support
Valve support switching impulse test	SIST EN 62927	7.3.3	
Valve support lightning impulse test	SIST EN 62927	7.3.4	Valve support
MVU DC voltage test	SIST EN 62927		MVU
MVU AC voltage test	SIST EN 62927		MVU
Test for valve insensitivity to electromagnetic disturbance	SIST EN 62927		Valve or valve section

5.3.3 Converter Cooling System

5.3.3.1 Cooling principle

The requested converter cooling system requirements include liquid cooling, with consideration of the following aspects:

1. A closed-loop recirculating system should provide full heat rejection capacity with redundancy for pumps, heat exchangers, and fans, appropriate to the SSSC availability requirements. The cooling system should be able to maintain full capacity at maximum ambient temperature and maximum SSSC reactive power output. The cooling system should be able to operate at the lowest ambient temperature and zero output specified, and the Tenderer should describe how this operation is done.
2. If applicable replacement of certain cooling equipment (e.g., pumps, fans, cooler unit), if defective, should be possible while the cooling system still operates.
3. A purifying loop to maintain liquid resistivity should be provided. The Tenderer should state the design value of liquid resistivity and describe methods of detecting and responding to abnormal conditions.
4. The quantity of ionizing material should be sufficient for a period longer than the specified maintenance interval operation without replacement. Deionizing materials should be replaceable without cooling system shut down. Instructions for frequency of inspection and change should be given.
5. The Tenderer should describe the necessary maintenance actions and their frequency.
6. Maintenance of closed loop systems and make up for loss of liquid should not be required more than once a year.
7. For SSSC systems where the loss of mains AC power or any undervoltage or overvoltage conditions to the supply of the cooling system can leave the convertors in service, the cooling system should be designed to remain in service at least 30 seconds .

5.3.3.2 Cooling System Protection

The cooling system should monitor its own operation and the condition of the cooling medium.

1. For liquid-cooled systems, the protection system should include, as a minimum, the following warning alarms:
    a. Low coolant level
    b. Primary pump stopped.
    c. Primary fan stopped.
    d. High coolant temperature
    e. Failure of pump cycling scheme
    f. Depleted demineralizer (deionizing) cell (if applicable)

   g. Low water resistivity (if applicable)

2. For liquid-cooled systems, the protection system should include, as a minimum, the following shutdown alarms:
   a. High temperature
   b. Low coolant level
   c. Both pumps stopped or blocked flow

3. For air-cooled systems (if applicable), the protection system should include, as a minimum, the following warning alarms:
   a. Blower transfer
   b. High exhaust air temperature
   c. High differential pressure across the filter
   d. Low air flow

4. For air-cooled systems (if applicable), the protection system should include, as a minimum, the following shutdown alarms:
   a. Excessive exhaust air temperature
   b. Loss of air flow

5.3.4 By-Pass Switch

The by-pass switch shell provides protection and control of the power electronic converters. The bypass switch for SSSC should be designed and specified to meet the following requirements:

1. The by-pass switch should be rated to handle the full power capacity of the SSSC and should be capable of carrying the maximum current and voltage levels of the power system (Continuous Rating and Short-time Ratings).
2. The by-pass switch should provide a low-impedance path for current flow around the SSSC to minimize voltage and power losses during bypass operation.
3. The by-pass switch provides a means to bypass the SSSC in the event of a fault or failure, allowing the transmission line to continue operating without interruption. This is critical to ensure the uninterrupted operation of the transmission line and minimize the risk of power outages or other disruptions.
4. The bypass switch must be equipped with a protection system that can detect faults or failures in the SSSC or power line and automatically initiate the bypass mode. The protection system can include current and voltage sensors, and fault detection algorithms to monitor the performance of the SSSC.
5. The bypass switch must be designed with adequate cooling to ensure that the components do not overheat during operation.

6. The bypass switch must be integrated with the SSSC control and monitoring system. This shall allow the system operator to monitor the status of the by-pass switch and switch between the SSSC and bypass modes as needed.

5.3.5 Control, Monitoring and Protection

Minimal requirements for control and protection equipment and operator interface are listed in the Chapter Control and Protection systems.

5.3.6 Serial Transformer

This chapter apply if SSSC is connected to the transmission line through a serial transformer.

1. Serial transformer should be rated to handle the full power capacity of the SSSC and should be capable of carrying the maximum current and voltage levels of the power system (Continuous Rating and Short-time Ratings).
2. Serial transformer should be designed for high efficiency to minimize power losses and enhance the overall efficiency of the power grid.
3. Serial transformer should be designed to operate reliably over a long period of time.
4. Serial transformer should be designed to be compatible with the SSSC control system to ensure that the voltage regulation and compensation functions are operating as intended.

Minimal requirements for serial transformer are listed in the other parts of this Lot.

5.3.7 MV Surge arresters

All MV surge arresters shall be of ZnO type and in accordance with results of Insulation coordination study and insulation design (as requested in other parts of this Lot).

5.3.8 Auxiliary Power Supplies

The SSSC system equipment should include all the power supplies necessary for its operation, (AC and DC distribution boards etc). Available AC and DC sources are listed in other parts of this Lot.

5.4 SPARES

The basic supply of the SSSC should include a full complement of essential spare parts, which are to be furnished at the same time and as part of the SSSC supply. It is the Contractor’s responsibility, based on the design for the SSSC, to provide adequate spare parts to meet the reliability and availability requirements specified.

5.4.1 Spares Strategy

A strategy for spare parts should be developed to demonstrate that the complement of spare parts will be adequate to meet the reliability requirements specified.

1. The spares strategy should be based on a tabulation of all of the components in the SSSC, down to the level of the lowest "replaceable module" (In other words, all components suitable for unit replacement at the first level of maintenance should be included in the tabulation, but individual devices that would not be replaced except as part of a shop or bench repair of a replaceable component should not be in this tabulation).
2. Each component in the tabulation should be identified for its importance to the operation of the SSSC, according to the following classification:
    a. Category A: SSSC operation is not possible until this component has been repaired or replaced (e.g., main serial transformer).
    b. Category B: SSSC operation can continue (or resume) at reduced rating, but further failures may lead to an SSSC outage.
    c. Category C: SSSC operation can continue an emergency basis, but a critical function has been lost or bypassed. Some risk of further complications or equipment damage exists until the function is restored (e.g., one of two pumps out of service, protective relaying, UPS, or cooling alarm sensors not in service).
    d. Category D: Operation can continue without serious impairment (e.g., building services such as lighting or heating).
3. The tabulation should include the failure rate or the expected replacement rate of the component over a 10-year period.
4. The tabulation should include the manufacturer's name and model number, suggested source, and estimated delivery cycle.

Each device should either be:

1. Included on an inventory list of all site spares. The inventory list should show the description, quantity, and storage location of each spare, assuming that any time that a spare is used, the item is reordered.
2. Provided with a contingency plan to obtain a replacement on short notice if a spare is not being kept on hand.

5.4.2 Spare Parts Storage

The spare parts for the SSSC should be stored on site, and the SSSC project should be designed to include suitable storage facilities. Where appropriate, storage arrangements for indoor and outdoor equipment should be seismically qualified.

5.4.3 Spare Parts Accounting

An inventory of the spare parts should be prepared at the time when the SSSC is turned over to the user and again at the end of the warranty period. Any shortages should be replenished by the Contractor so that the spare parts inventory is at its 100% level at the end of the warranty period.

5.5 STUDIES

5.5.1 Tender studies

For the purpose of the technical offer, a preliminary facility design should be carried out. The preliminary design will be validated with regard to proposed voltage injection ratings, short circuit levels (as in 5.1.2), currents, voltages, insulation levels etc by means of dedicated studies. The studies shall argue proper selection and design of the primary facility components. No detailed studies are required; however the Tenderer shall at least present the criteria and methods for primary equipment selection and assumptions used during the preliminary design process. The results of the studies are not binding and do not necessarily represent the final design. A level of freedom exists to further improve and optimize the design during the Engineering stage of the project as long as requirements of this technical specification are met. In case that detailed studies carried out during the Engineering stage show lower rated equipment values compared to those offered with a difference of more than 5%, Employer's approval of the adjusted ratings is required. All of these studies are RMS and the data of simplified network model is provided in the chapter 5.6.5.1 and/or in the appendix in PowerFactory format. The same general simulation parameters should be applied in PowerFactory as in the model in the appendix.

Tender studies must include:

1. **Preliminary equipment rating and design study**
   This study shall define the range and operating conditions of the SSSC as well as ratings of crucial device components such as valves, reactors, transformers, surge arresters, breakers etc. Preferably a separate dedicated draft report should be provided for valves and the main valve connection circuit. The steady-state design parameters shall be determined with respect to the operating range of the device and assumed normal operating conditions. Also determined, considered and properly documented shall be currents and voltages in the system components during abnormal conditions (e.g. short circuits) required for robust dimensioning and design of the device.

2. **Preliminary harmonic study**
   The harmonics study shall determine, if AC filters are required to fulfill the requrements of this specification on harmonic limits on the high-voltage AC side of the installation. The Tenderer shall identify assumptions and methodology used for calculation of the fundamental frequency and harmonic stresses and performance. The study should include preliminary verification of the effects of resonance between the SSSC and the 220kV AC system, and verification that AC filters, should they be required, limit the harmonic distortion and current distortion at the point of connection to less than the limits identified in this specification. The harmonics' frequency range considered in the study shall be from

0 Hz to 2,5kHz. Harmonics emissions shall be calculated for various operating points of the SSSC, at a minimum for operating points as given in other parts of this tender document.

3. **Preliminary study on the SSSC losses**
   This study shall determine efficiency of the SSSC facility for the Podlog project. It includes calculating total active power losses of the complete facility as given in other parts of this tender document. For each operating point the losses shall be broken down to a major-component level, but not less than suggested. The data provided shall allow for evaluation of losses.

4. **Preliminary study on the audible noise**
   The purpose of the preliminary audible noise study is to evaluate the ability of the SSSC Contractor to meet the performance and function requirements as specified in the tender specification. The auditable noise study main objectives are:

   - To give the maximum sound pressure levels of the noise generated by the SSSC (with accentuated tones and without) for specified points.
   - To show eventual audible noise sources with accentuated tones.
   - To show eventual audible noise sources with impulsive sound.
   - To give a sound pressure levels contour of 38 dBA under SSSC operating conditions, resulting in the highest sound pressure noise level. From the contour the spread of noise in the environment (with accentuated tones and without) should be visible.

5. **Preliminary steady state performance study**
   The study shall show the capability of the SSSC to generate the specified amount voltage injection considering the voltage, current, and frequency ranges given in other parts of this tender document.

6. **Report on startup/shutdown sequence and voltage/current deviation**
   Report demonstrating that design meets the performance requirements on Voltage/current deviation during energization as requested in other parts of this document.

7. **Preliminary dynamic performance study**
   The study of dynamic performance shall demonstrate that control algorithms and parameters developed and proposed by the Tenderer meet the requirements of this specification. The study shall provide proof and description of dynamic performance of the device during slow network events and faults in the 220kV AC system. The models in DIgSILENT PowerFactory for three sets of dynamic simulations are already prepared and are part of tender documentation.

   The proposed set of dynamic event simulations includes:

   1. Energizing of SSSC:

- SSSC offline and disconnected;
- Line current approximately 1400 A;
- Switching of SSSC onto grid and initialization of the converter starting sequence;
- SSSC shall regulate the line current below 1000 A at a maximum rate;
- SSSC shall continue current regulation, remain stable and in operation.

2. Short circuit and loss of nearby line:
    - Line current approximately 1000 A;
    - SSSC grid connected and in operation with minimum output;
    - Sudden increase of the line current to approximately 2000 A, due to loss of line 400 kV Podlog – Maribor and one system of 400 kV Maribor – Kainachtal line following a short circuit;
    - SSSC shall regulate the momentary value of line current below 1440 A in 2 seconds after the loss of line 400 kV Podlog – Maribor and one system of 400 kV Maribor – Kainachtal, and permanently below 1150 A in 5 seconds with reference to Figure 5.3;
    - SSSC shall continue current regulation, remain stable and in operation.

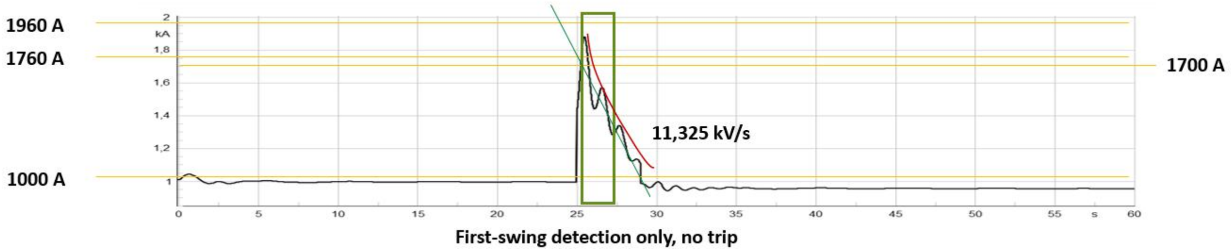

Figure 5.3: SSSC current during fast current limiting

3. Short circuit on connecting line:
    - Line current approximately 1000 A;
    - SSSC grid connected and in operation with 20% inductive output;
    - Occurrence of a three-phase fault 150 ms in duration at 35 % line length without line trip (transient fault);
    - SSSC shall remain stable and in operation.

Note that scenarios above shall also be part of FAT with RTDS unless otherwise stated.

8. Scope of digital simulator studies and tests

The Contractor shall include/propose sufficient number of scenarios in the scope of hardware-in-the-loop (HIL) simulations with RTDS for testing of SSSC and verification of the simulation model to be provided to the Employer. In addition, the proposed scope of hardware-in-the-loop (HIL) tests should also include similar scenarios as in preliminary dynamic performance study or additional tests as deemed adequate by the employer.

9. **Preliminary reliability availability and maintainability study**
   The results from the Reliability, Avaliability and Mantainability (RAM) study should identify possible causes of malfunction, decreased performance and unplaned outages. The basis for the calculations of the RAM should include all crucial device components.

   The results of the study should summarize:

   - requirements for components redundancy,
   - requirements for spares,
   - calculated performance of the SSSC:
     - number and duration of forced outages,
     - number and duration of scheduled outages,
     - forced unavailability,
     - scheduled unavailability.

   The Tenderer should clearly state the expected and guaranteed average number and duration of scheduled outages per year.

   In the Tender documentation, the Tenderer shall include a preliminary plan for needed spare parts and scheduled maintenance, including intervals and time durations for specific activities.

5.5.2 Engineering Studies

Pre-manufacturing engineering design and verification studies should be performed by the Contractor within the scope of supply after the contract start.

These studies are in addition to the actual SSSC design simulator and field performance tests.

The studies shall verify and demonstrate to the Employer’s satisfaction that the SSSC meets the specified performance requirements.

The Contractor shall perform studies to determine the design ratings and requirements of all plant and material to be supplied under this Contract.

The studies shall demonstrate and confirm that the SSSC meets all system and equipment specified performance criteria.

The Contractor shall perform simulation studies within agreed time frames for review, comment and participation by the Employer. The Employer reserves the right to perform parallel verification studies on its own, or by a third party.

In the studies EMT and RMS models corresponding to the Employer’s SSSC shall be used. They will be made in sufficient detail to suit the purpose of the investigations.

The Contractor shall develop and provide a suitable models for:

1. RMS in PowerFactory,
2. EMT and harmonics in Dig SILENT PowerFactory and in PSCAD,

for independent design verification and system modelling.

The software version for which the models shall be delivered will be specified by the Employer after the project start.

The models shall not be encrypted, functional and fully accessible as required in 5.5.3. The Contractor shall also provide suitable documentation, single lines and block diagrams to the satisfaction of the Employer. Also help in using these models shall be provided.

The Contractor shall supply the Employer with a preliminary PSCAD model within 4 weeks and with a preliminary PowerFactory model within 12 weeks after Contract award date. Updated models shall be supplied after system studies, SSSC controller design and HIL testing. The detailed (final) models shall be supplied before the start of the performance verification testing.

If the Employer's or third party's studies indicate disagreement with the Contractor's results, the Contractor shall be prepared to work with the Employer or his representative to reach an agreement on the controversial issues and/or to make the required design corrections, in accordance with this specification.

Engineering studies shall include, but not be limited to, all requested studies described in this tender document and shall include updated studies supplied in tendering phase.

The Contractor shall identify, and the Employer shall provide, all existing equipment and network data reasonably needed by the Contractor in performing their studies. The simulation studies will be based upon the Employer's equivalent network, considering the list of contingencies described. The maximum and minimum generation as well the maximum and minimum load networks shall be considered. The data not provided by the Employer shall be clearly indicated by the Contractor if the information provided in this specification is inadequate. The Contractor shall also clearly state the reasons for requiring such data and the purposes for which it will be used.

Acceptance by the Employer does not absolve the Contractor's overall responsibility for the proper functioning of the SSSC as specified.

The Tenderer should list all engineering studies.

The Contractor shall submit all design data, design study and simulation study reports to the Employer in accordance with the documentation requirements. These reports shall contain assumptions, controller design specification, study methods, results, significant findings and conclusions. The Contractor shall submit all design study reports within the timescale stipulated in this specification. The reports shall be submitted in *.doc or *.pdf file types or as otherwise agreed with the Employer.

The Contractor shall provide full details (title and detailed scope) of all the studies planned and indicate this on the Program.

As a minimum Engineering Studies must include

1. Steady state performance study
2. System dynamic performance studies

3. Harmonic performance and component rating studies
4. Electromagnetic transients control performance and overvoltage studies
5. Insulation coordination study
6. Protection coordination study

5.5.2.1 Steady state performance study

The study shall define the capability of the SSSC to generate the specified amount of reactive power considering limitations given in other parts of this document. It shall be a revision of the Bid study.

5.5.2.2 System Dynamic Performance Studies

Dynamic performance studies shall verify that the SSSC controls the system's dynamic performance during system disturbances, such as major faults and load rejection, and evaluate all functions specified under various system conditions (i.e., heavy and light load conditions and weak and strong system conditions). The following is a list of types of dynamic performance studies:

1. Studies to verify that the SSSC provides adequate dynamic control to meet the system and SSSC performance criteria for selected local and wide area disturbances
2. Study of response time and of the SSSCs behavior and contribution to the system's recovery from faults
3. Studies to evaluate the interaction of the SSSC controls with the other nearby control systems, including generator controls and other transmission system devices.
4. Studies to verify that the SSSC is able to support the power system restoration process and does not cause any instability or unwanted controller interactions (hunting).

The total number of simulation cases shall be such that secure and stable operation of the SSSC in the electrical network of Employer is ensured and will be agreed upon between the Employer and Contractor. However, should technical arguments exist, but no agreement is possible, the Contractor shall comply with Employer's requirements at no extra costs.

The dynamic study shall be performed on dynamic simulation model of the Slovenian power system, including interconnections, with typical normal-operation topology and for system restoration conditions as provided by the Employer.

5.5.2.3 Harmonic Performance and Component Ratings Studies

The studies should evaluate resultant maximum harmonic levels at the SSSC point of common coupling and determine maximum stresses on all SSSC components. The study report shall include the following:

1. Evaluation of specified system operating conditions, including maximum and minimum system current levels, and maximum and minimum voltage injection of the SSSC with maximum harmonic generation at any operating point in the SSSC range.
2. Evaluation within maximum ranges of SSSC system component tolerances (worst performance values may not occur at detuning extremes), including filters, if applicable,
3. Evaluation with maximum system voltage unbalance and firing angle unbalance for a non characteristic harmonic generation,
4. Evaluation of worst-case resonance condition between SSSC and system,
5. Evaluation of possible resonant overvoltage,
6. Evaluation of the SSSC system component thermal ratings based on specified operating conditions, including filters, if applicable,
7. Transformer saturation induced harmonics for component rating calculation only,

Determination of maximum system harmonic levels shall be based on calculation of the network harmonic impedance using the data supplied in the specification considering the worst case for both maximum current and voltage distortion and amplification.

5.5.2.4 Electromagnetic Transients, Control Performance and Overvoltage Studies

Transient overvoltage studies should be performed with the actual controls modeled to verify that the SSSC system equipment is adequately protected against overvoltage and overcurrents (including excessive valve recovery voltages) from power system transients resulting from switching, fault clearing events and credible SSSC system mis-operations. Concerns that should be evaluated include the following:

1. Study of SSSC start-up, including transformer energization (if applicable), shutdown, switching coordination and other local area network switching events,
2. Study of SSSC system protection and protection coordination,
3. Faults on the high-voltage and low-voltage bus (single line-to-ground, phase-to-phase, and three-phase),
4. Faults across the VSC converter and other equipment,
5. The potential for false-firing of any valve under the most severe system conditions.

5.5.2.5 Insulation Coordination

The Contractor shall be responsible for the insulation coordination of the SSSC, including SSSC serial transformer (as applicable). The responsibility includes the high voltage equipment installed on the 220 kV side specified in other parts of this document.

The Contractor shall carry out a thorough insulation co-ordination study to determine plant insulation design, insulation levels, surge arrester ratings, creepage distances and clearances.

The Contractor shall establish and submit to the Employer, with detailed explanation, the magnitudes of the worst voltage and current stresses associated with the overload, overvoltage and under-voltage events described in this specification. It shall also establish and explain, to the satisfaction of the Employer, the operation of the protection devices (arresters, circuits associated with the valves, semiconductors e.g., snubber and VBO/EOP, BOD, etc.) in order to ensure proper insulation co-ordination for the valves, semiconductors and main components (capacitors and reactors), while allowing them to perform as required in these specifications.

The insulation co-ordination study shall comply with the standards and technical broshures stated in other parts of this document.

The insulation co-ordination study shall consider and quantify the following effects:

1. over-voltages resulting from the operating characteristics of the SSSC for all modes of operation (e.g., normal, overload or transient),
2. power-frequency voltage variations,
3. power-frequency overvoltages,
4. switching over-voltages,
5. HV and MV faults (line-to-ground or line-to-line),
6. semiconductor valve blocking and misfiring,
7. malfunction of SSSC control,
8. temporary overvotlages,
9. transient state operation of the SSSC,
10. short circuits on the HV and MV side,
11. lightning over-voltages, including transferred surges from strokes to the EHV/HV/MV kV system,
12. surge arrester characteristics,
13. site conditions (pollution, weather).

A minimum of 20 % margin is required between the arrester protective level and the selected insulation level for lightning impulse and 15 % margin for switching surges. Surge arresters shall be coordinated to limit full wave voltage surges to 80 % of the basic insulation level. Safety factor shall be according to IEC 60071-2.

The insulation co-ordination study shall establish values for:

1. insulation levels of equipment (power frequency, switching, lightning, combinations, both phase-to-earth, phase-to-phase and across open breaker contacts),
2. test voltages for equipment,
3. minimum clearances,
4. creepage distances across insulation,

5. surge arrester ratings and location,
6. expected lightning performance of the installations.

The report of the insulation co-ordination study shall be submitted by the Contractor for approval of the Employer.

The discharge currents and corresponding residual voltages for all arresters included in the design of the valve branches shall be evaluated and submitted to the Employer. These discharge currents shall take account of the worst transient state contingencies.

5.5.3 Protection Co-ordination Study

The protection concept must comply with all the requirements of this tender and be designed in such a way that its protection is triggered only in case of a fault in the SSSC.

A fault in a SSSC shall only lead to tripping of the faulty unit, the other components remaining in service.

Separate protection relays shall be provided as a backup protection.

The Contractor shall ensure that the operation of the SSSC is fully isolated from and properly protected against any undesirable dynamic stability interactions, unstable operating modes, and resonances with the AC system, internal and external faults to the SSSC system.

The Protection Co-ordination Study must also encompass the purchaser's protections for the transmission line and busbars.

The Contractor shall present the calculation of relay protection setting levels together with the principles of protection design and co-ordination.

A detailed protection co-ordination study shall be submitted to the Purchaser’s Representative for approval prior to commissioning of the plant.

A summarized list of the protection settings shall be given. The Protection Co-ordination is inclusive of the changes required for the busbar protection, line protections settings and the complete SSSC system.

5.5.4 Other Studies

Other studies include the following: grounding study, electric and magnetic field strength, Loss Study, Reliability Study and other studies as applicable.

A similar report on plant efficiency and losses as submitted with the Tender shall be revised to include the as built losses. Total SSSC loss characteristics for entire SSSC operating range dependent on main parameters shall be provided.

A similar audible noise report as submitted with the Tender shall be revised to include the as built noises.

Post-commissioning Studies.

1. **Report on type and route tests**
   Upon the equipment takeover at the factory, it is necessary to prepare, complete, and systematically deliver the following documentation to the customer:
   1. Copies of standard tests for individual equipment elements (in both paper and electronic format - PDF),
   2. Copies of routine tests for individual equipment elements (in both paper and electronic format - PDF).

5.5.5 SSSC computer models

As specified in Network Code on Requirements for Grid Connection of Generators by Article 15.6.c (NC RfG 15.6.c), the Contractor must provide models suitable for balanced load-flow calculations, time-domain studies (used for dynamic stability analysis) and three-phase, electromagnetic transient simulations. The models are to be provided in software formats as defined by the Employer. Details of the required software formats, current software versions, computer platform, compiler version etc, are specified by the Employer in this document. The Employer may from time to time update these specifications and request that the models be updated to be compatible with changes in the Employers' computing environment. The Contractor shall ensure that such updated models are provided without undue delay or in any event, within 28 Business Days of the date of the request. Specifications for models provided in each of the software environments required by the Employer are described in the following sections.

The models will be considered approved after successful validation of the Employer.

5.5.5.1 Load-flow, dynamic and harmonic models

The models shall be provided for DIgSILENT PowerFactory and PSCAD Software.

5.5.5.1.1 Dig SILENT PowerFactory

The RMS and harmonic models should be provided for Dig SILENT PowerFactory.

The model must have all the protective functions that the actual device has.

The model must enable all control modes that the actual device enables.

The user must have the possibility to access and modify all parameters that can be changed on the actual device.

The model must be suitable for calculation of:

1. power flows.

2. symmetric and asymmetric short circuits (three-phase, two-phase with and without ground contact, single-phase ground fault).
3. contingency analysis.
4. RMS dynamic simulations.
5. Modal/Eigenvalue analysis.
6. Power Quality and Harmonic analysis.
7. PTDF calculations.

The model must have the same dynamic response to disturbances as the actual device during and after the disturbance. The response is observed for the following disturbances:

1. Symmetrical and asymmetrical short circuits (three-phase, two-phase with and without ground contact, single-phase ground fault).
2. Voltage dips in the network.
3. Load, line, and transformer switching operations.
4. Frequency variations within the device's operating range.
5. Step change in the reference value of injected voltage.
6. Change in control mode.
7. Change in control parameters.

The model must exhibit the same spectrum of harmonics as the actual device, at least within the range of up to 3000 Hz.

The model must operate stably and without errors in both stationary and dynamic simulations.

The model should allow compilation (translation) using standard library models of Dig SILENT PowerFactory or, where necessary, user-defined models written in DSL code, including all blocks, frameworks, types, and elements. Already compiled (pre-translated) models or 'black-box' SSSC device models must be accompanied by appropriate documentation, which may include the source code of the model.

The model is developed for the software version provided by the Employer after the project begins.

5.5.5.1.2 PSCAD

The EMT model should be provided also for PSCAD.

The model must have all the protective functions that the actual device has.

The model must enable all control modes that the actual device enables.

The user must have the possibility to access and modify all parameters that can be changed on the actual device.

The model must be suitable for the calculation of:

1. power flows,
2. short circuits (symmetrical and asymmetrical short circuits - three-phase, two-phase with and without ground contact, single-phase ground fault),
3. transient stability,
4. transient phenomena during switchings,
5. transient phenomena during transformer energization,
6. Power Quality and harmonic analyses.

The model must have the same dynamic response to disturbances as the actual device during and after the disturbance. The response is observed for the following disturbances:

1. Symmetrical and asymmetrical short circuits (three-phase, two-phase with and without ground contact, single-phase ground fault).
2. Voltage dips in the network.
3. Switching operations of loads, lines, and transformers.
4. Step change in the reference value of injected voltage.
5. Change in control mode.
6. Change in control parameters.
7. Start-up and shut-down of the SSSC device.

The model must exhibit the same spectrum of harmonics as the actual device, at least within the range up to 3000 Hz.

The model must operate stably and without errors in both stationary and dynamic simulations.

The model should allow compilation (translation) using standard models from the PSCAD library or, where necessary, user-defined models, including all blocks, frameworks, types, and elements. Precompiled (pre-translated) models or 'black-box' SSSC device models must be accompanied by appropriate documentation, which may include the source code of the model.

The model is developed for the software version provided by the Employer after the project begins.

5.5.5.1.3 Model verification

The performance of the digital models shall be verified by comparison with the fundamental frequency component of corresponding simulator and/or field tests for:

1. Steady-state dominant modes of operation.
2. Dynamic operation.

5.5.5.1.4 Model documentation

The models shall be described in enough detail and shall be in such a form as to allow the Employer to code it directly in the PowerFactory and PSCAD dynamic simulation software and obtain the same results. The model documentation shall include:

1. A description of the overall structure of the model and an overview of all module and user-defined parameters.
2. A description of the mathematical background and the basic characteristics and limitations of the model.
3. A description and diagram of each module, and a detailed diagram showing all parameters and their dimensions.
4. A diagram showing all module-interface variable and control signals.
5. An explanation of all approximations lumped or equivalent components.
6. A description of each simulation verification case.

5.5.5.2 General Model Usability Guidelines

All models provided to the Employer must be usable. Models shall be intuitive, practical and not cause simulation problems. Models shall be suitable for inclusion in automated software. The practical usability considerations include but are not limited to the following:

1. Model technical parameters shall be consistent with the real physical values and the actual performance of the SSSC. This information shall be provided either on the appropriate per unit base or in physical units.
2. The model shall be consistent and understandable.
3. The parameter ranges of the model (e.g., current limits and range of possible injected voltages) shall be consistent between load-flow and dynamic models and shall be representative of the actual SSSC.
4. The Contractor shall specify the allowable application ranges for the model of the SSSC. This shall include current limits and possible injected voltage ranges. These limits shall be consistent with the limits for the actual SSSC.
5. Both the load-flow and dynamic models shall function error-free and in a stable manner provided that the SSSC is operated within these ranges, including operation at the limit of the parameter range (e.g., operating at max injected voltage).
6. The load-flow and dynamic model shall initialize without the need for manual intervention. It is unacceptable for models to require manual adjustment before the simulation initialization or initialize without warnings.
7. The model shall be autonomous and independent from other external algorithms. The combined load-flow and dynamic model shall initialize and run without the need to execute external software routines that adjust parameters in either the load-flow case or the dynamic case or both.
    a. The model shall not fill the progress monitoring files with content that is not relevant to monitoring the technical behaviour of the dynamic simulation. It is not acceptable to include legal disclaimers in the progress monitoring files. Models shall not spuriously report to the monitoring file during normal operation. Models that experience instability during simulation should report to the progress monitoring file.

b. Models shall interface with the host software in a manner that is consistent with the behaviour of standard library models.

8. Models shall allow for accessing and visualizing (plotting) all variables and parameters representative of device performance for the duration of the simulation.

9. In the case where the SSSC trips during simulation, the relevant models shall set the flag that indicates that the SSSC has tripped.

It is not acceptable for the model to crash catastrophically and provide no documentary evidence as to why the simulation failed.

5.6 TESTS

5.6.1 Factory Tests of Converter

Switching devices should undergo type and production tests in accordance with the most recent relevant IEC standard applicable to SSSC Voltage Sourced Converters. Type tests evidence in lieu may be offered.

The Tenderer shall provide full details of type and production (routine) tests offered in respect of the project. If previous type tests have been conducted, the Tenderers can submit a type test assessment report, providing sufficient details to validate the relevancy of the previous tests for the project design offered. The type and routine tests offered, must cover the complete design of the SSSC Voltage Source Converter with specific reference to the following key design characteristics:

1. Maximum and minimum voltage capability, during both steady state as well as transient, short-term conditions such as voltage surges, switching surges and low voltage conditions.

2. Maximum and minimum current values, with specific reference to the thermal strengths of the power electronic components, during both steady state as well as transient, short-term conditions such as voltage surges, switching surges and low voltage conditions.

3. Short circuit capability. With specific reference to the ability of the complete VSC and its associated components to withstand without damage internal equipment failures and short circuits based on the range of short circuit levels provided.

4. Insulation coordination tests and capabilities, based on standard practices for similar devices,

5. Any other network condition that could impact the basic design of the VSC such as changes in frequency or phase shift.

5.6.2 Factory Tests of Controls

SSSC control function type tests on a simulator should include the following:

1. Verification of each control function,

2. Verification of control linearity,
3. Verification of control redundancy,
4. Verification of the monitoring system,
5. Verification of the protection system with reference to integrated protective functions included in the controllers, and firing controllers,
6. Verification of overall system performance for minor and major system disturbances,
7. Verification of processor loading of all digital controllers,
8. Verification of SSSC parallel operation with other controls in the system and control stability,
9. Verification of control equipment performance for auxiliary power supply voltage (ac and dc) and frequency variations (ac) - not necessary if type tests are already passed,
10. Climatic test, i.e., verification of control equipment performance for a specified range of ambient temperatures and humidity. If climatic test certificates are available for the conditions specified, no further tests are needed - not necessary if type tests are already passed,
11. Interference tests, i.e., the controls should be tested to operate in the environment of ac substations and suitable surge withstand capability (SWC). Tests should be carried out, or proof of previous testing provided, in accordance with IEEE Std C37.90.1-1989 (covering fast transient burst and a damping oscillatory wave) and ANSI Std C63.16-1993 (electrostatic discharge tests). - Not necessary if type tests are already passed.

Routine production tests of all control functions, and separately of all protection functions, should be made to demonstrate manufacturing quality.

5.6.3 Tests of Other Components

All other SSSC components should be tested according to the relevant equipment standards.

5.6.4 Field Tests

Field tests should be carried out in accordance with CIGRE TB No. 663 Guidelines for the procurement and testing of SSSCS (WG B 4.53, August 2016)

5.6.5 Hardware-in-the-loop (HIL) tests

The Contractor shall perform all necessary functional hardware-in-the-loop (HIL) tests to confirm proper functioning of the SSSC as per requirements of this specification.

As part of the HIL tests the Contractor shall also verify SSSC performance for a set of 10 (ten) contingencies as specified by the Employer after the project start.

All necessary arrangements for performing the HIL tests of the contingencies, including dynamic network reduction study and implementation in HIL test configuration, shall be performed by the Contractor. Employer will provide the data of the reduced network for HIL tests.

For HIL tests two networks shall be considered. The first one is a reduced Slovenian network presented in Figure 5.4 and the second one is a single-machine infinite-bus test system presented in Figure 5.13.

5.6.5.1 Data of the reduced network

The structure of the reduced system that shall be used in HIL tests is presented in the Figure 5.4.

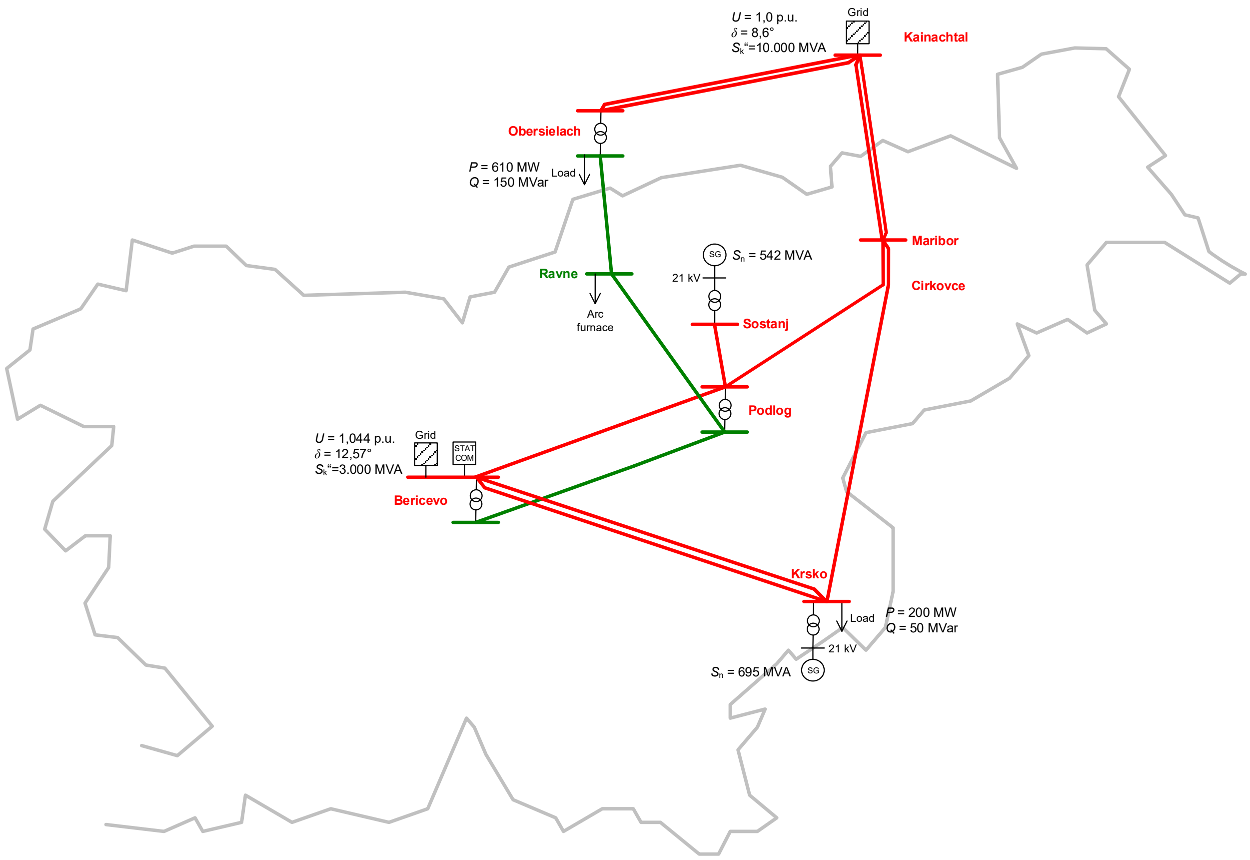

Figure 5.4: Reduced test system for HIL tests

Basic data for the reduced system are given in Table 5-9.

Overhead lines 400 kV	Parallel lines	l [km]	x [Ω/km]	r [Ω/km]	c [μF/km]
Obersielach - Kainachtal	2	70	0,32	0,03	0,012
Maribor - Kainachtal 1	1	58	0,32	0,03	0,012
Maribor - Kainachtal 2	1	58	0,32	0,03	0,012
Maribor - Krsko	1	76	0,32	0,03	0,012
Beričevo - Krsko	2	71	0,32	0,03	0,012
Bericevo - Podlog	1	50	0,32	0,03	0,012
Maribor - Podlog	1	71	0,32	0,03	0,012
Podlog - Sostanj	1	13	0,32	0,03	0,012

Overhead lines 220 kV	l [km]	x [Ω/km]	r [Ω/km]	c [μF/km]
Bericevo - Podlog	63	0,41	0,06	0,009
Podlog - Ravne	44	0,41	0,06	0,009
Ravne - Obersielach	29	0,41	0,06	0,009

Transformers	Sn [MVA]	uk [%]	ur [%]
Obersielach 400/220 kV	1200	12	0,2
Podlog 400/231 kV	400	12	0,2
Bericevo 400/231 kV	600	12	0,2
Krsko 400/21 kV	800	15	0,2
Sostanj 400/21 kV	710	15	0,2

Load - constant Z	Pn	Qn
Krsko	500	200
Obersielach	200	50

Generators	Pn [MW]	Qn [Mvar]	Ta [s]	AVR type	Governer type
Krsko	695	120	8,4	IEEEX1	IEEEG1
Sostanj	500	20	10	ST7B	IEEEG1

Grid	Sk" [MVA]	U [p.u.]	δ [°]
Kainachtal	10000	1,05	31,5
Bericevo	3000	0,98	0

STATCOM Bericevo	Sn [MVA]	Control mode	Transformer [Up/Us; Sn; uk; ur]
	+/-150	Vdc - Q	400/10 kV; 180 MVA; 4%, 0,1%

Arc furnace Ravne	Pn [MW]	Qn [Mvar]	Oscilations [Pmin, Qmin, Pmax, Qmax, fmin, fmax]
	100	100	[0 MW; 0 Mvar; 100 MW; 100 Mvar; 0,1 Hz; 10 Hz]

Table 5-9: Basic data of the reduced system

Oscillations of the active and the reactive power of arc furnace shall follow the square function between 0 MW / 0 Mvar and 100 MW / 100 Mvar with the frequencies form 0,1 Hz to 10 Hz . An example of such oscillations is presented in Figure 5.5.

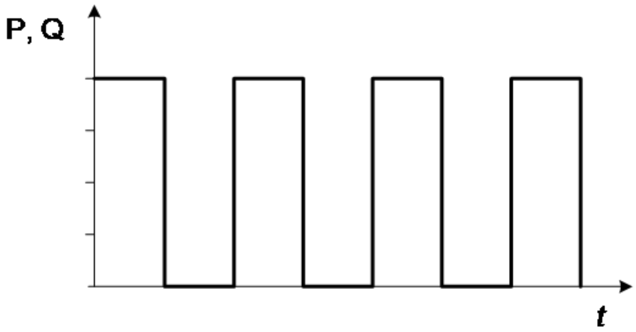

Figure 5.5: An example of the oscillations of the active and the reactive power of arc furnace

In following tables and figures are the data for exciter and governor of generator in Sostanj and Krsko.

Name	Value	Unit	Type	Description
UEL_flag	1	[1/3]	d	UEL router selector
OEL_flag	1	[1/3]	d	OEL router selector
Kl	1	[pu]	d	Feedback gain
Kh	0	[pu]	d	Feedback gain
Kpa	40	[pu]	d	Voltage regulator gain
Tr	0	[s]	d	Input filter time constant
Tb	1	[s]	d	Voltage regulator lag time constant
Tc	1	[s]	d	Voltage regulator lead time constant
Tf	1	[s]	d	Voltage input lag time constant
Tg	1	[s]	d	Voltage input lead time constant
Kia	1	[pu]	d	First order feedback gain
Tia	4	[s]	d	First order feedback time constant
Vmin	0,95	[pu]	d	Voltage reference minimum limit
VRmin	-4,655	[pu]	d	Voltage regulator minimum limit
Vmax	1,05	[pu]	d	Voltage reference maximum limit
VRmax	4,655	[pu]	d	Voltage regulator maximum limit

Table 5-10: Data for the exciter ST7B in Sostanj

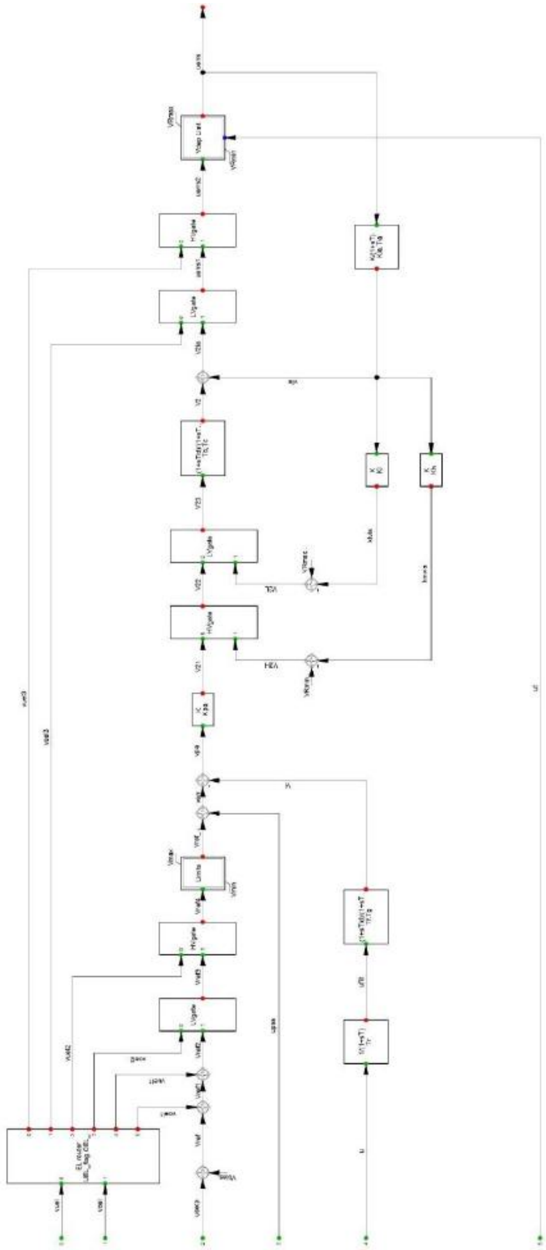

Figure 5.6: Structure of the exciter ST7B in Sostanj

Name	Value	Unit	Type	Description
K	20	[p.u.]	d	Controller Gain
T1	0	[s]	d	Governor Time Constant
T2	0	[s]	d	Governor Derivative Time Constant
T3	0,004	[s]	d	Servo Time Constant
K1	0,275	[p.u.]	d	High Pressure Turbine Factor
K2	0	[p.u.]	d	High Pressure Turbine Factor
T5	15	[s]	d	Intermediate Pressure Turbine Time Constant
K3	0	[p.u.]	d	Intermediate Pressure Turbine Factor
K4	0	[p.u.]	d	Intermediate Pressure Turbine Factor
T6	0,2	[s]	d	Medium Pressure Turbine Time Constant
K5	0,389	[p.u.]	d	Medium Pressure Turbine Factor
K6	0	[p.u.]	d	Medium Pressure Turbine Factor
T4	0,1	[s]	d	High Pressure Turbine Time Constant
T7	0,3	[s]	d	Low Pressure Turbine Time Constant
K7	0,336	[p.u.]	d	Low Pressure Turbine Factor
K8	0	[p.u.]	d	Low Pressure Turbine Factor
PNhp	0	[MW]	d	HP Turbine Rated Power(=0->PNhp=PgnnHp)
PNlp	0	[MW]	d	LP Turbine Rated Power(=0->PNlp=Pgnnlp)
Uc	-5	[p.u./s]	d	Valve Closing Time
Pmin	0	[p.u.]	d	Minimum Gate Limit
Uo	0,125	[p.u./s]	d	Valve Opening Time
Pmax	1,05	[p.u.]	d	Maximum Gate Limit

Table 5-11: Data of the governor IEEEG1 in Sostanj

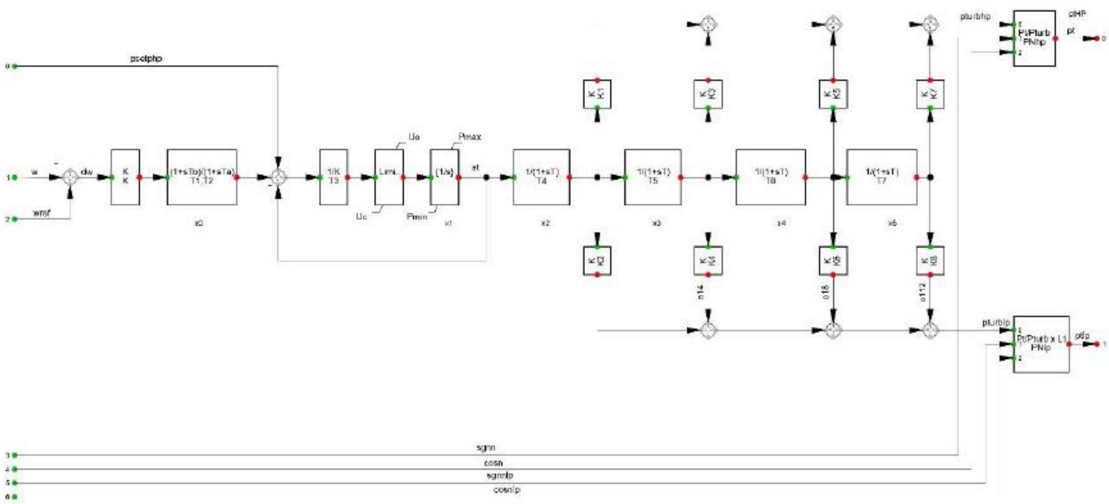

Figure 5.7: Structure of the governor IEEEG1 in Sostanj

Name	Value	Unit	Description
Tr	0,02	[s]	Measurement Delay
Ka	200	[pu]	Controller Gain
Ta	0,05	[s]	Controller Time Constant
Tb	1	[s]	Filter Delay Time
Tc	1	[s]	Filter Derivative Time Constant
Te	0,5	[s]	Exciter Time Constant
Kf	0,04	[pu]	Stabilization Path Gain
Tf1	1	[s]	Stabilization Path 1th Delay Time
Tf2	0,5	[s]	Stabilization Path 2th Delay Time
E1	3,9	[pu]	Saturation Factor 1
Se1	0,1	[pu]	Saturation Factor 2
E2	5,2	[pu]	Saturation Factor 3
Se2	0,5	[pu]	Saturation Factor 4
Ke	1	[pu]	Exciter Constant
Vrmin	-5	[pu]	Controller Minimum Output
Vrmax	5	[pu]	Controller Maximum Output

Table 5-12: Data for the exciter IEEEX1 in Krsko

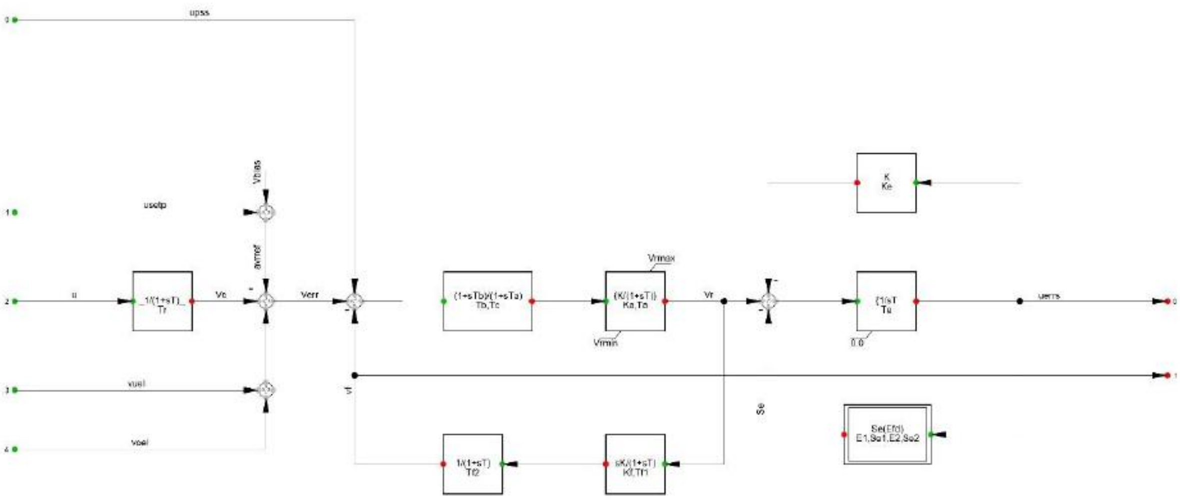

Figure 5.8: Structure of the exciter IEEEX1 in Krsko

Name	Value	Unit	Description
db	0,0002	[p.u.]	Dead band range
K	20	[p.u.]	Controller Gain
T1	0	[s]	Governor Time Constant
T2	0	[s]	Governor Derivative Time Constant
T3	0,1	[s]	Servo Time Constant
K1	0,3	[p.u.]	High Pressure Turbine Factor
K2	0	[p.u.]	High Pressure Turbine Factor
T5	10	[s]	Intermediate Pressure Turbine Time Constant
K3	0,4	[p.u.]	Intermediate Pressure Turbine Factor
K4	0	[p.u.]	Intermediate Pressure Turbine Factor
T6	0,2	[s]	Medium Pressure Turbine Time Constant
K5	0,3	[p.u.]	Medium Pressure Turbine Factor
K6	0	[p.u.]	Medium Pressure Turbine Factor
T4	0,3	[s]	High Pressure Turbine Time Constant
T7	0,3	[s]	Low Pressure Turbine Time Constant
K7	0	[p.u.]	Low Pressure Turbine Factor
K8	0	[p.u.]	Low Pressure Turbine Factor
PNhp	0	[MW]	HP Turbine Rated Power(=0->PNhp=PgnnHp)
PNlp	0	[MW]	LP Turbine Rated Power(=0->PNlp=Pgnnlp)
Uc	-0,2	[p.u./s]	Valve Closing Time
Pmin	0	[p.u.]	Minimum Gate Limit
Uo	0,1	[p.u./s]	Valve Opening Time
Pmax	1,05	[p.u.]	Maximum Gate Limit

Table 5-13: Data of the governor IEEEG1 in Krsko

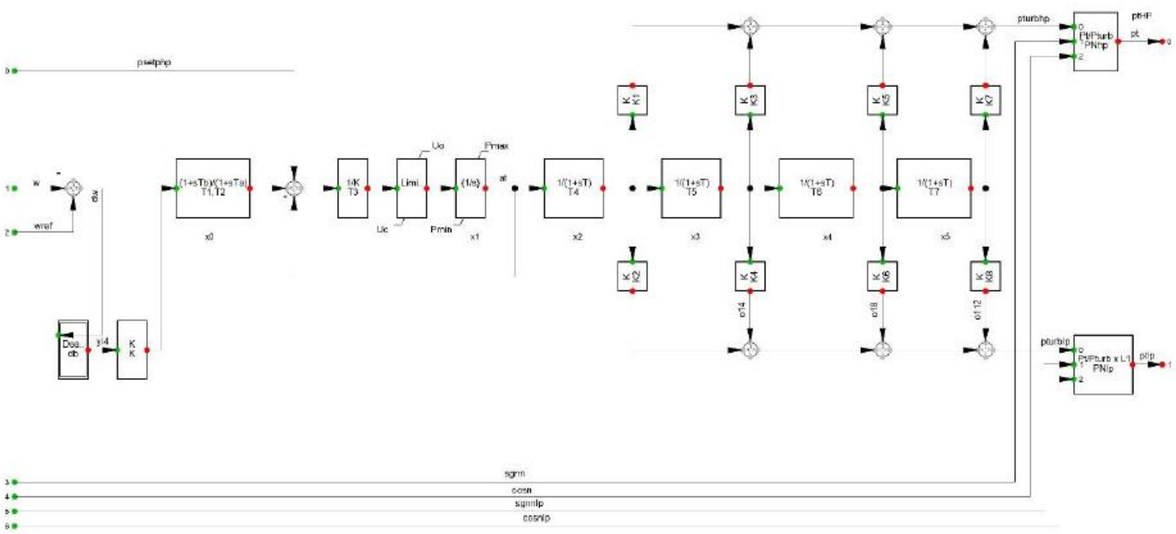

Figure 5.9: Structure of the governor IEEEG1 in Krško

For STATCOM in Bericevo the data of the PQ controller are given in Table 5-14 and structure of the PQ controller in Figure 5.10.

Name	Value	Unit	Description
Kp	10	[p.u.]	Active Power Control Gain
Tp	0,002	[s]	Active Power Control Time Constant
Kv	4	[p.u.]	Voltage Control Gain
Tv	0,002	[s]	Voltage Power Control Time Constant
droop	10,05		
Trdc	0,001		
Trac	0,01		
i_min	-2,67		
i_max	2,67		

Table 5-14: Data of the STATCOM PQ controller

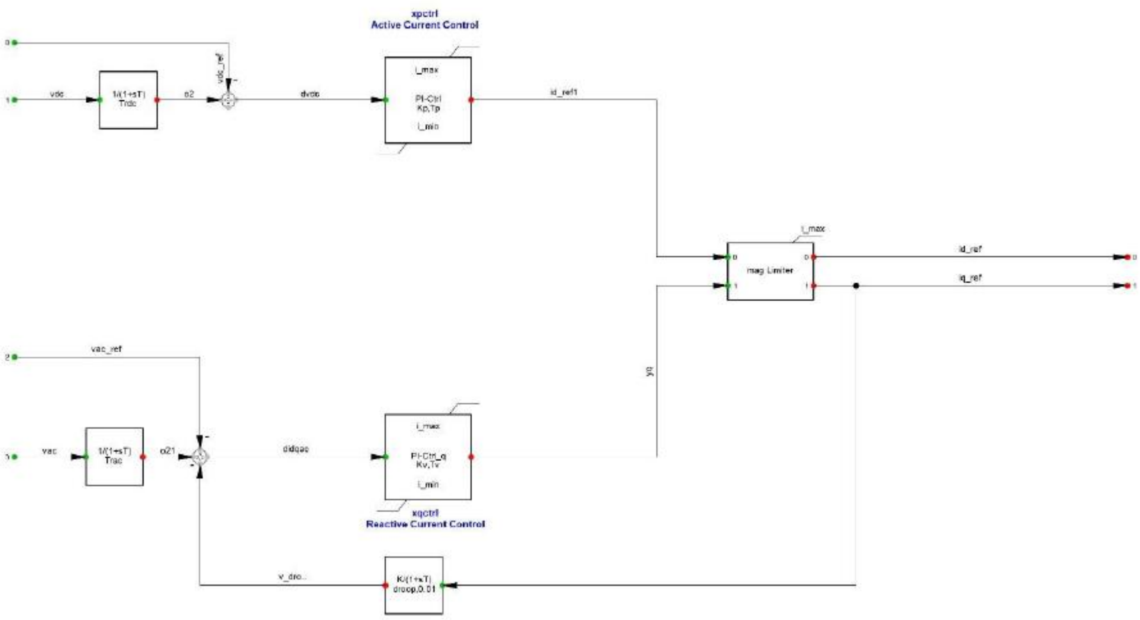

Figure 5.10: Structure of the STATCOM PQ controller

5.6.5.2 Results of simulation in the reduced network

In normal operation the power-flow calculation without SSSC shall give the results as presented in Figure 5.11.

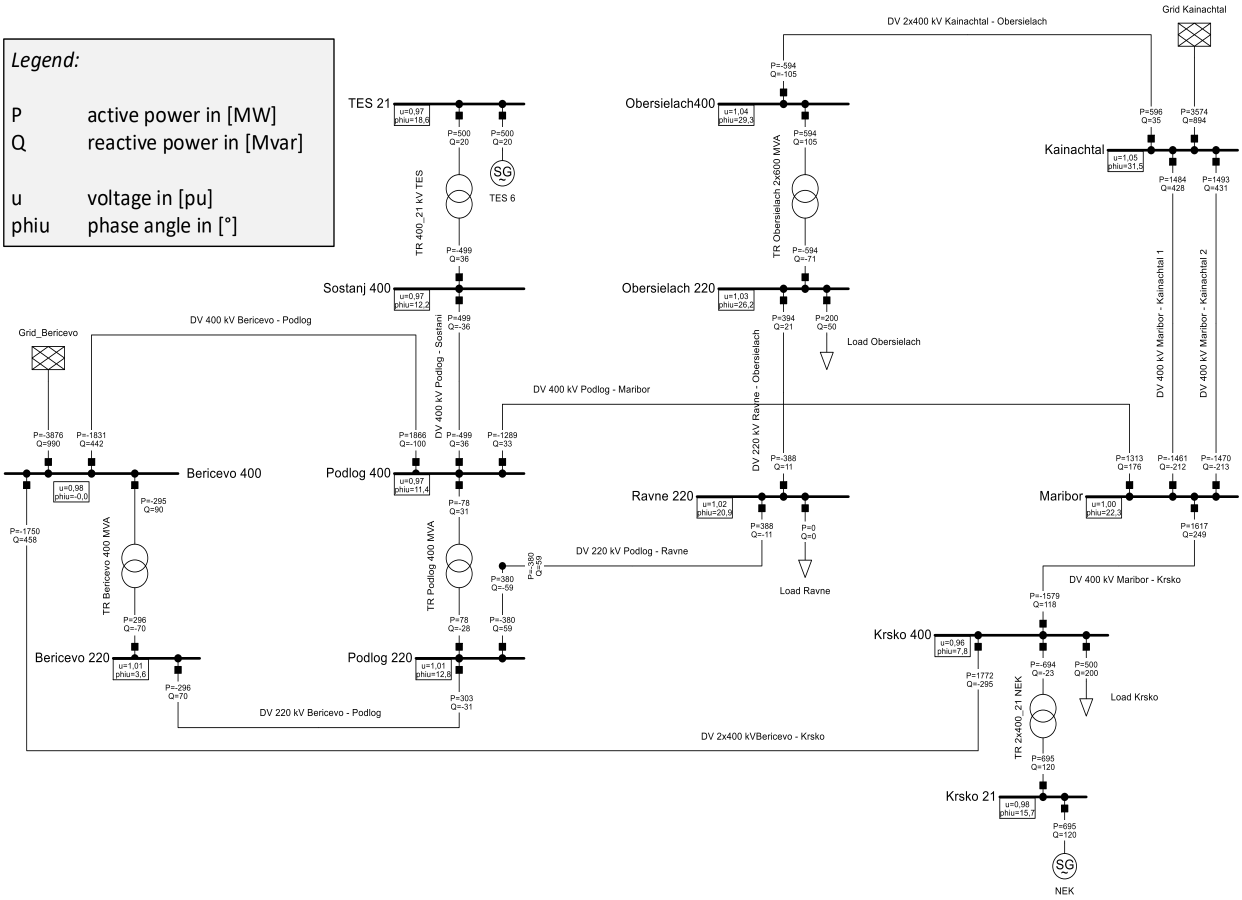

Figure 5.11: Load-flow calculation results in normal operation

In the case of simultaneous disconnection of 400 kV lines Maribor – Kainachtal and Maribor – Podlog at time 25 s, the current presented in Figure 5.12 shall be obtained, considering that SSSC is not activated.

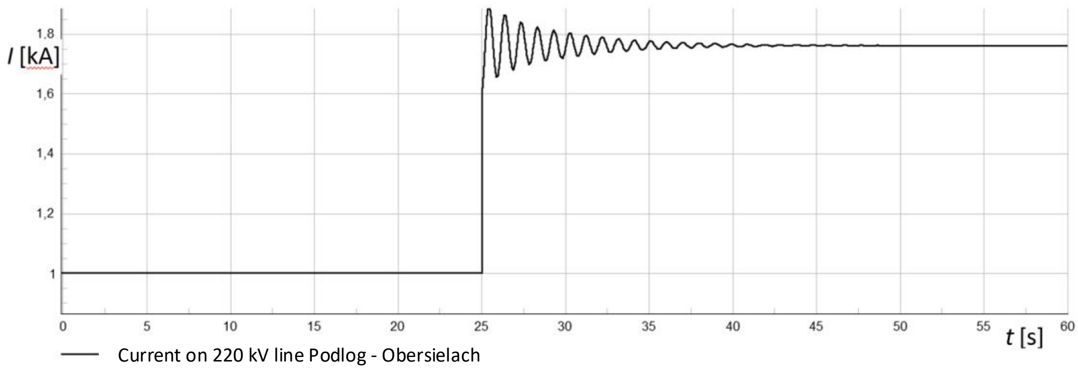

Figure 5.12: Current in 220 kV line Podlog – Obersielach

5.6.5.3 Single-machine infinite-bus test system

The structure of the single-machine infinite-bus test system is given in Figure 5.13 together with the load-flow calculation results. The generator is modelled as a classical model, i.e., a constant voltage behind transient reactance, without excitation and turbine controller.
The simulation model is operated based on the settings provided by the customer.

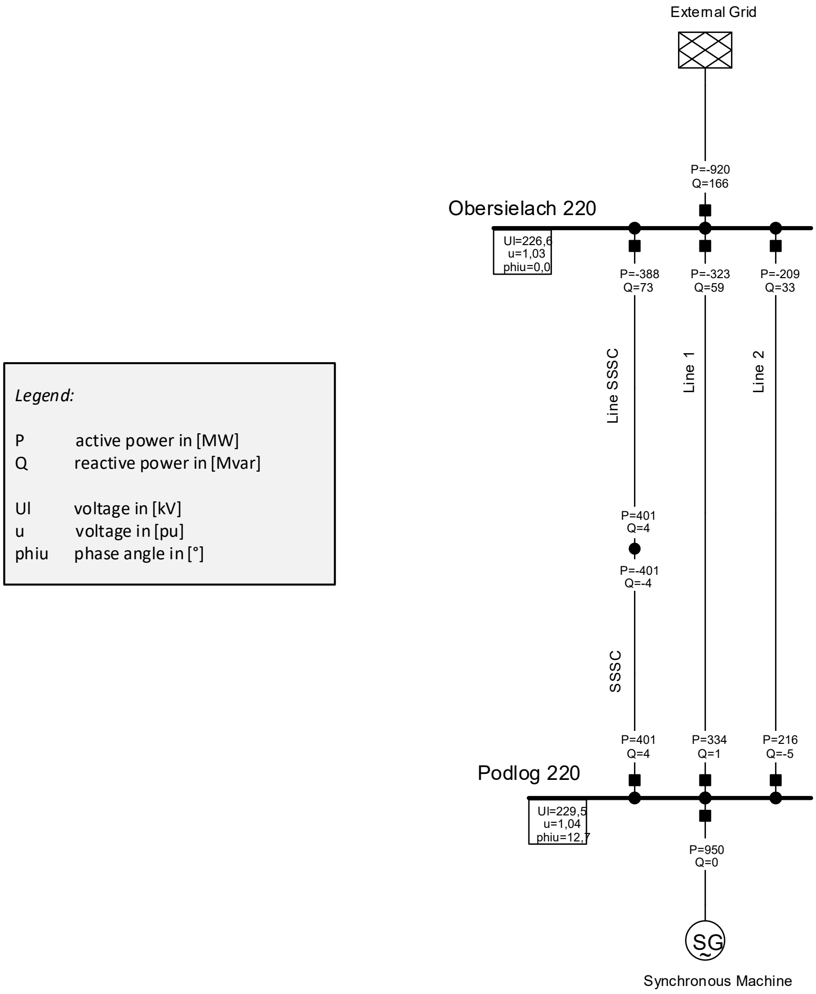

Figure 5.13: The structure and load-flow results of single-machine infinite-bus test system

The data for the single-machine infinite-bus test system are given in Table 5-15.

Overhead lines 220 kV	l [km]	x [Ω/km]	r [Ω/km]	c [µF/km]
Line SSSC	70	0,41	0,06	0,009
Line 1	84	0,41	0,06	0,009
Line 2	130	0,41	0,06	0,009

Generators	Pn [MW]	Qn [Mvar]	Ta [s]	AVR type	Governer type
Synchronous Machine	950	0	10	-	-

Grid	Sk" [MVA]	U [p.u.]	δ [°]
External Grid	10000	1,03	0

Table 5-15: Data of the single-machine infinite-bus test system

In the case of the three-phase short circuit in "Line 1" at time 25 s and disconnection of this line at time 25,15 s, the current presented in Figure 5.14 shall be obtained in "Line SSSC", considering that SSSC is not activated.

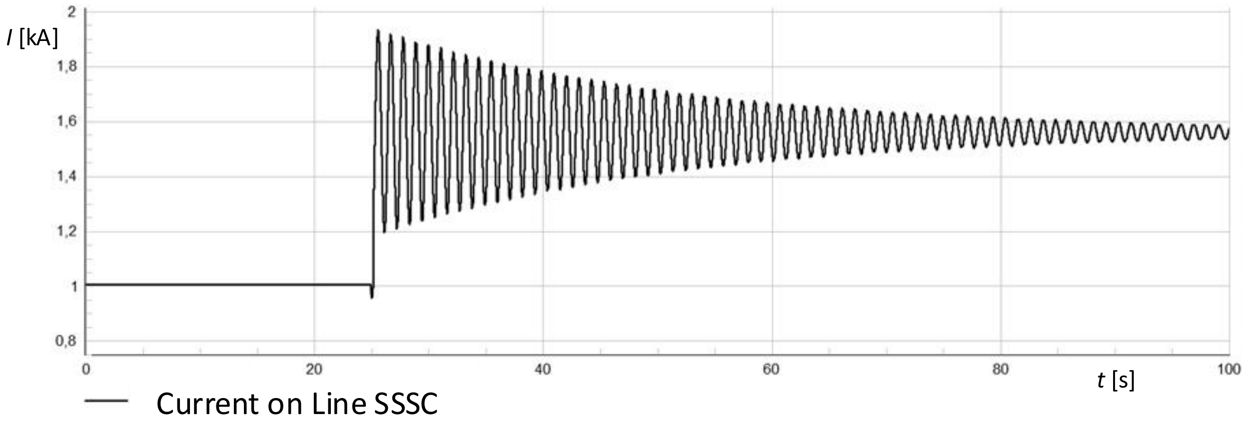

Figure 5.14: Current in »Line SSSC«

/	/	/	
Revision:	Revision note:	Revision date:	Signature:

Investor: ELES	Facility: RTP 400/220/220 kV Podlog Sistem za regulacijo moči (SSSC) v RTP Podlog
Design engineer: IBE, svetovanje, projektiranje in inženiring Ljubljana, Slovenija	Part of facility/system: Supply and Erection of Flexible Serial Compensation – SSSC in Podlog SS
/	Type of design: TECHNICAL SPECIFICATION

	First name/Name:	Id. No.:
Approved by:	mag. Marko Testen, univ. dipl. inž. el.	E-1293
Confirmed by:	mag. Marko Testen, univ. dipl. inž. el.	E-1293
Checked by:		
Designed by:	mag. M. Testen, univ. dip. in.e., D. Lenarčič, univ. dip. in. el.	E-1293, E-0076
11.2023		

Title of document:

6. Control And Protection Systems

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Identification No.:	R 4 P O 0 1 - 6 E 1 0 0 6	Spr.:	

CONTENTS:

6 CONTROL AND PROTECTION SYSTEMS

6.1 DELIVERY BOUNDARIES AND INTEGRATION WITH CLIENT SYSTEMS

The boundaries between the customer's systems and the equipment delivered thrue other lots, , are shown in the block diagram (Figure 6.1). Delivery of control equipment for other parts of equipment is requested in other lots.

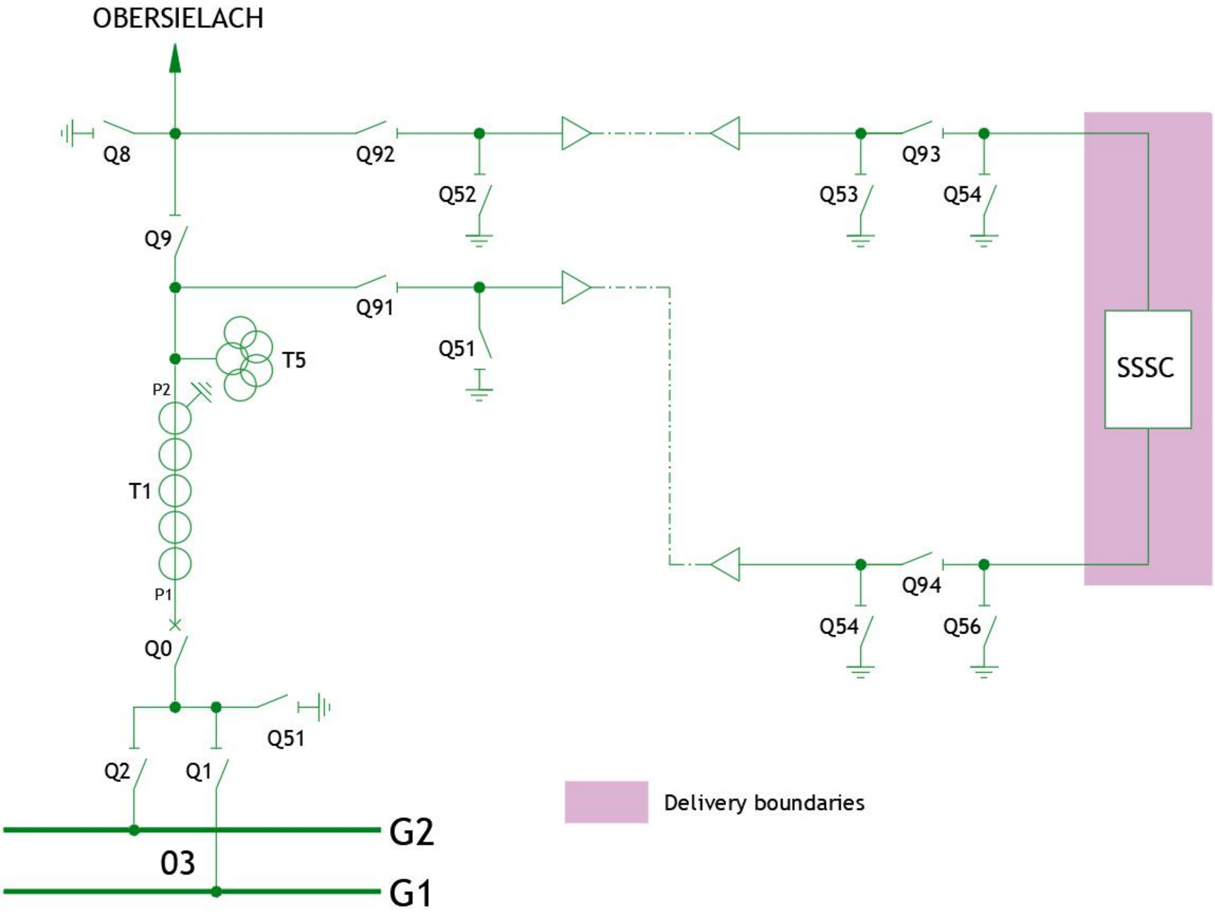


Figure 6.1: Block diagram of delivery boundaries

The control and protection systems of the Obersielach 220 kV HV line bay, which includes the control and supervision of additional HV disconnectors and earthing switches required for connection to SSSC, are not part of the delivery.

The control and protection of the SSSC equipment is fully included in the scope of delivery, and the contractor is entirely responsible for it.

The contractor's responsibility is also to coordinate and to ensure that functional compatibility between their equipment and ELES equipment is as required in these tender documents.

6.1.1 Connections toward existing substation protection equipment

The scope of this tender requires a protection system that will provide safe operation of the SSSC. With the coordination with the customer's protection systems, it must ensure the safe operation of the entire system.

The current protection configuration for the HV line bay Obersielach is shown in Figure 6.2. The following protection terminals are in use in the bay at present:

1. Distance protection (-A301): Siemens 7SA6111,
2. Line differential with distance protection (-A351): Siemens 7SD5211 (only distance function is active),
3. Busbar protection – bay unit (-A371): Siemens 7SS523.

As shown in Figure 6.1 (new situation) and Figure 6.2 (current situation), the configuration of the Obersielach bay will be changing to enable the connection of SSSC, but the client intends to keep the same concept of HV line protection.

The contractor is responsible for assessing the potential impact of their equipment on the proper functioning of ELES protection system. Any identified hazard must be clearly outlined in the offer, along with appropriate technical solutions to prevent negative effects on ELES protection system.

If it is necessary for the SSSC protection to trip the Q0 circuit breaker of the HV line, this must be done via two galvanically separated tripping relays installed in the 220 kV HV line protection cabinet. When executing these trips, the contractor must adhere to the following requirements (see Figure 6.3):

1. This trip can only be used as an additional protection to the protection that must be implemented in SSSC e.g.: in case of a failure of the tripping device inside SSSC.
2. The tripping circuits of the circuit breaker must be organized on the 1st and 2nd trip relays.
3. The tripping circuits must be powered separately using two 220 V DC sources.
4. The tripping circuits must be made in the form of quads, allowing for simple integration and control of the tripping protection contacts.
5. Each tripping circuit must be controlled by a tripping circuit supervision device to enable monitoring of the galvanic connection and the presence of voltage on the tripping circuits.
6. The contractor should consider that the switching off of the HV line on the opposite side is not under the ownership or responsibility of ELES, and there shall be delays in this process.

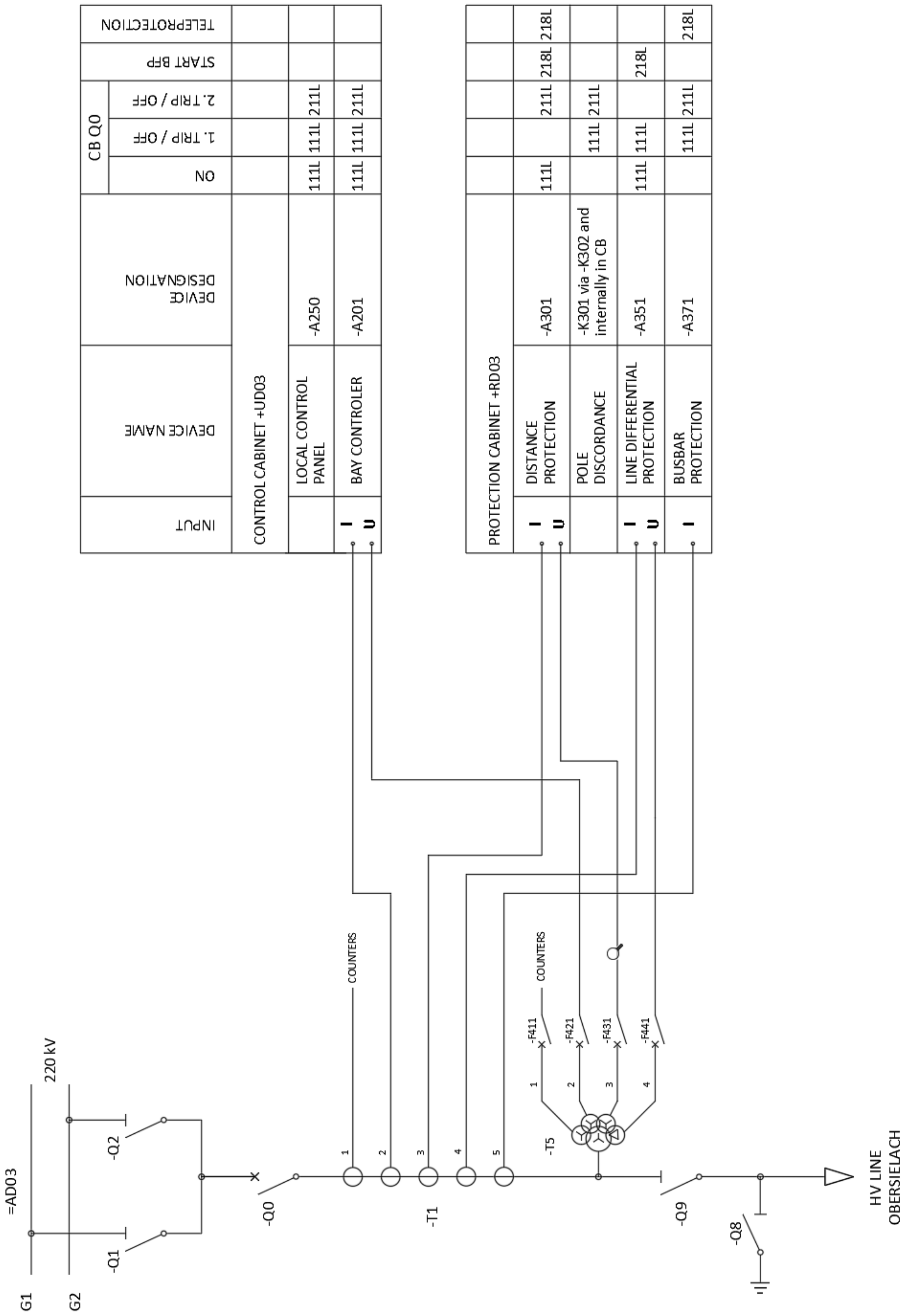
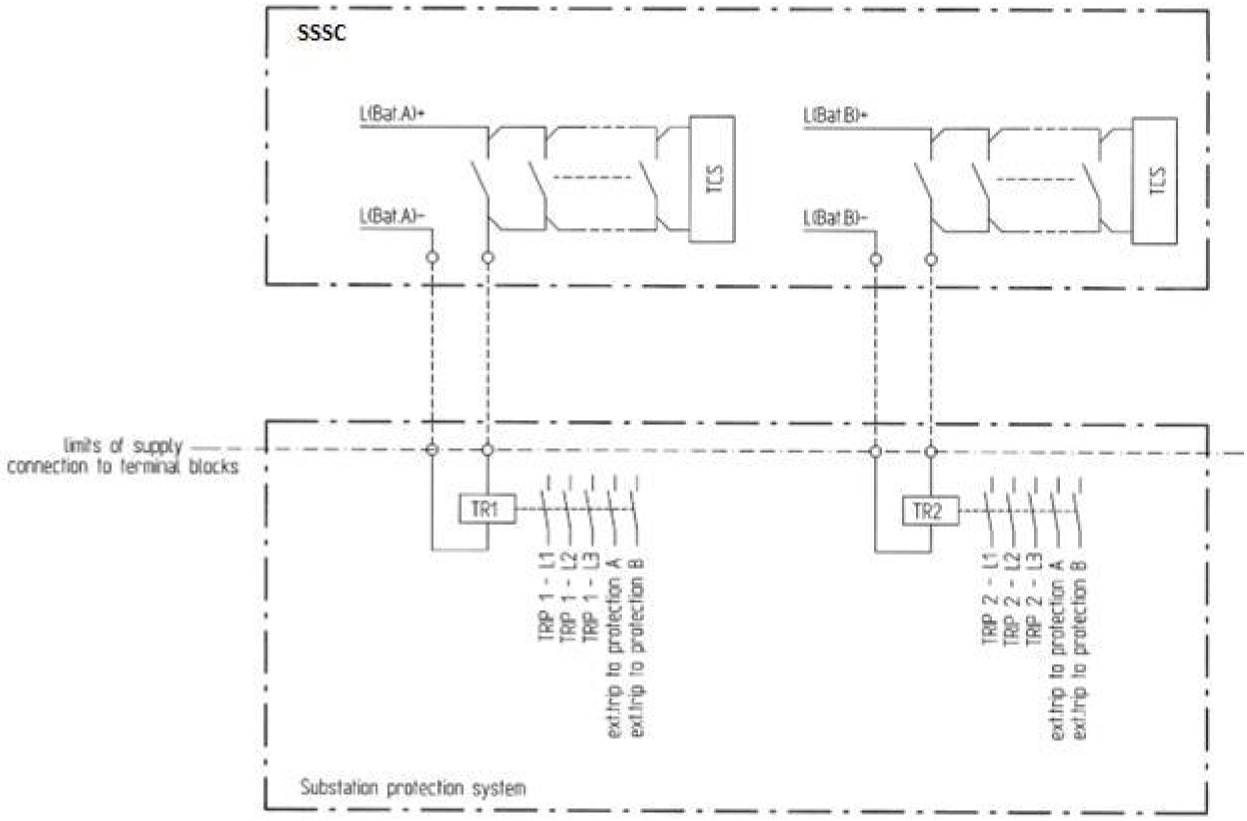


Figure 6.2 : Block diagram of the existing protection system



Remarks: TR1, TR2 - trip relays
TCS - trip circuit supervision relay

Figure 6.3: Stylized display of tripping circuits on a 220 kV HV line circuit breaker

In case the contractor finds, within the scope of the Protection Co-ordination Study, that he cannot ensure comprehensive protection, including all HV equipment in the AD03 bay, including SSSC equipment, cables and OHL line, or cannot guarantee proper functioning of all protective terminals (including client's protection terminals protecting the busbars and OHL line), then the provider is obliged to find an appropriate alternative solution from the one proposed in this tender.

If the implementation of this solution requires additional equipment (e.g., additional instrument transformers or protective terminals), then this additional equipment shall be fully included in their supply. The solutions must be previously coordinated with and approved by the customer.

6.1.2 Connections toward existing substation control equipment

No direct link is foreseen between the control system of the SSSC and the control system of the S/S Podlog substation. The control system of the SSSC operates independently of other systems, and the provider must follow these restrictions or guidelines:

1. For SSSC supervision at the substation level, the contractor will supply an additional SCADA workstation that will be installed in the switchyard control room,
2. Between the SSSC building and the substation control building there is, as part of supply, the multi-mode 50/125 µm fiber optic cable; included are cable lines and other equipment necessary to ensure a full functionality of communication links (e.g.: IEC 60870-5-104 and

SCADA workstation in the control room, etc.). The optical cable ends on both sides at the multi-mode optical splitter via LC connectors.

3. If there is a need for information exchange between both systems (e.g.: for position indication, interlockings etc.), it can be carried out via potential-free contacts.

6.1.3 HV Interlocking

All interlocks for high-voltage side switchyard (if needed) will be implemented in the bay computer, which is not part of the delivery.

All required interlocks between SSSC and bay computer (mainly effecting HV circuit breaker and SSSC disconnectors) shall be hard wired. The precise interlocking requirements are to be defined more in detail by the Contractor during the Contract stage and are subject to the approval of the Purchaser.

6.1.4 Communication with NCC

Communication with the NCC (National Control Centre of TSO) must be implemented according to IEC 60870-5-104. The SSSC control system communicates directly with the National Control Centre via the IEC 60870-5-104 protocol.

The functionality of the communication system according to IEC 60870-5-104 must enable two groups of redundant connections in accordance with the IEC 60870-5-104 standard, as follows:

1. the first group of four redundant connections for the main NCC control system and
2. the second group of two redundant connections for the test NCC control system.

Each redundant group (on SSSC control system) must have its own data transfer settings and its separate communication buffer on a communications computer.

The SSSC remote control system must have at least two independent Ethernet interfaces with separate IP addresses. The required communication configuration between the remote control system and the ELES control center is shown in Figure 6.4.

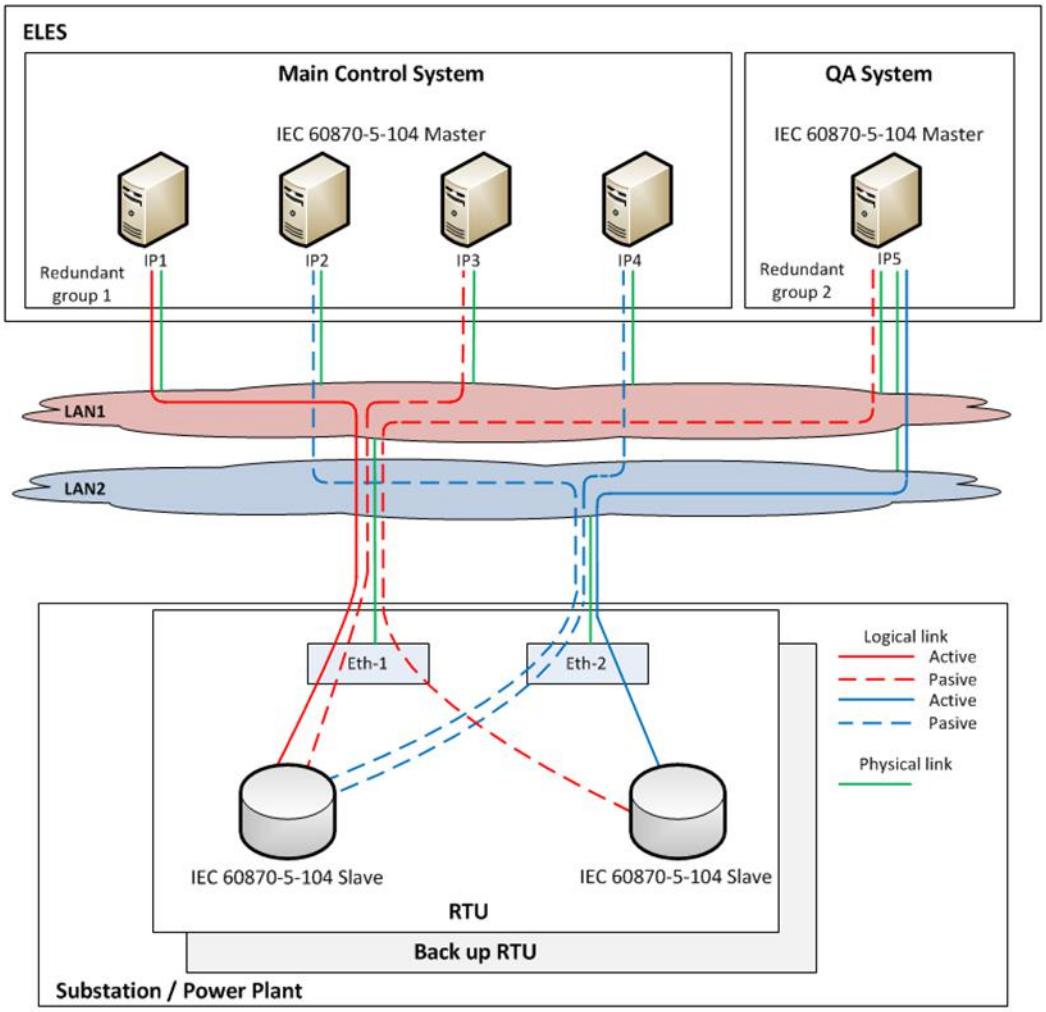


Figure 6.4: Block diagram of communications between SSSC and NCC

6.2 CONTROL

The SSSC system shall be controlled locally and remotely. Individual levels of control shall be provided on the following directions:

Service/emergency level:

Directly on the primary equipment, i.e. on the HV apparatuses themselves.
In general, on the primary equipment level, the devices can be controlled via a local control cubicle, attached directly onto the device (e.g.: control cubicle on HV Circuit Breaker, etc..).

1st level: on control cabinets of individual devices

These cabinets represent a local control level and can enclose programmable logic controllers with local (touch screen) panels and local operation possibility. The control on this level shall be enabled over a local/remote selector switch. The control on this level can also be performed via classic selector switches and keys, and an appropriate optic signalization (e.g.: Bay Controller, Cooling System Controller, etc …).

2nd level: substation level

The control system of the SSSC and the control system of the existing S/S Podlog are two separate systems. The SSSC must have its own SCADA system with at least two HMI's interfaces:

- one in SSSC building and
- one in the control room of S/S Podlog.

On this level we can choose between:

- control from the HMI's or
- switch over to ELES National Control Center (in this case SSSC control system must accept commands via IEC 60870-5-104).

3rd level: National Control Center (NCC)

- The highest control level is provided from the National Control Center ELES (the SSSC equipment shall be connected to this level via communication according to IEC 60870-5-104).

Changeover switches shall control selection between levels to prevent simultaneous control signals resulting in conflicting control requirements for a particular function. Control requirements shall be accepted only from the selected level. An operator on a lower control level can always take over control from the upper control level.

In order to provide its regular operation all communications within the system shall enable the system characteristics as required (e.g., speed, redundancy, insensitivity to EMC, etc.).

6.2.1 Open and Closed Loop Control

General requirements for Open and Closed Loop Control systems are:

1. The control system must have enough processing power to execute all the required functionalities efficiently.
2. The control system must be able to monitor and maintain accurate control over the process variables.
3. The control system must be able to perform reliably under various operating conditions and be resistant to disturbances or system failures.
4. The control system should be able to adapt to changes in the process variables and adjust the control parameters accordingly.
5. The control system should be able to communicate with other systems, devices, or controllers that are involved in the process.
6. The control system should be designed with safety features to ensure that the process operates within safe limits and can handle emergency situations.
7. The control system should be easy to maintain, with minimal downtime required for maintenance or repair.

8. The control system should be user-friendly, with an intuitive interface that allows operators to monitor and control the process easily.

6.2.2 Control and Monitoring System

The entire control and monitoring system, including all its components on all control and monitoring levels, must be designed with redundancy to ensure continued operation, reliability, and safety in the event of a failure or malfunction.

For devices that are redundant as an assembly where the smooth operation of the system is ensured by numerous identical devices, where the failure of one device does not jeopardize the operation of the whole system (e.g., valve-based electronics or comparable devices) non-redundant components within individual assembly is acceptable.

To reduce outage times and facilitate fault-finding, the construction of the system must incorporate diagnostic and self-checking capabilities for the controller, valves, gate firing and drive circuits, interface hardware, and software.

The controller must be designed to allow for reprogramming, to ensure flexibility in adapting to changing requirements and to facilitate maintenance and upgrades.

The system shall allow remote operation of all assemblies, as well as the setting and changing of reference and limit values for open or closed loop controllers. This refers to the functionality that must allow all control parameters to be set within the selectable limits.

All control signals available for remote control shall also be available locally to ensure that the local operator can operate the SSSC if the communication link to the remote control center is lost.

6.2.3 Human Machine Interface

The SSSC shall have a Human-Machine Interface (HMI), which must allow an operator to interact with the SSSC through the graphical user interface of the HMI.

The provider must supply two HMI systems, one of which will be installed at the SSSC location (where the contractor also plans the installation site), and the other will be installed in the existing control room of RTP Podlog (where the contractor will arrange all necessary power supply, while the delivery of needed communications is part of the delivery).

The HMI shall be designed in a way that is intuitive and easy to navigate for the user.

The SSSC HMI shall provide operators with centralized control over all required control functions, fault detection, abnormal condition detection and correction and system diagnostics.

The SSSC HMI shall include the following diagrams as different screens in the display system (as applicable regarding to the offered system):

1. Complete SSSC single line diagram including HV and MV busses,
2. AC and DC auxiliary supply diagrams,
3. Converters overview with module status,

4. Start/stop sequences,
5. Change of references, settings, etc. …
6. Alarm acceptance and, where appropriate, reset,
7. Semiconductor cooling systems,
8. Protection systems,
9. Interlocking system.

Diagrams displayed on the HMI shall indicate the following:

1. status of the components,
2. alarm and trip indications, including the type of alarm and the time it occurred,
3. voltages and currents for each component (as applicable).

The HMI shall provide complete diagnostics for alarm and trip indications as required, including the following:

1. detailed information on the cause of the alarm or trip,
2. recommended actions to resolve the issue,
3. the ability to acknowledge alarms and trips from the HMI,
4. a log of all past alarms and trips, including the time they occurred and their resolution status,
5. the ability to filter and sort the alarm and trip log based on various criteria, such as time or type of alarm.

A facility shall be provided whereby the local HMI features and functions shall be accessible from remote. Access security by password shall be provided to prevent unauthorized access to the remote HMI features and functions.

6.2.4 Fault Recording

An integrated Transient Fault Recording (TFR) System shall be supplied by the Contractor. The Contractor shall install and commission the TFR. This shall include trigger level settings, etc. and shall be subject to review and comment by the Purchaser's Representative.

Disturbance and event recording facilities are required to locally monitor the SSSC following a disturbance on the power system or the SSSC. The following inputs are required:

1. All analogue signals (output signals).
2. All digital signals (control outputs, status indications, alarms and trip indications).
3. Internal SSSC control signals/variables to be selectable.
4. The TFR's accuracy for event inputs shall be at least 100 μs for analogue signals (sampled at 10 kHz) and 1 ms for digital signals (sampled at 1 kHz).

5. The TFR shall have provisions for remote access and retrieval of recorded information, and a communication link to the Substation LAN shall be implemented for this purpose.
6. If applicable, the Contractor shall include the remote software application for data retrieval.

6.2.5 Supervision and Control Functions for SSSC System Integrity

The Contractor shall provide a supervision and control functions for SSSC system integrity. This function shall provide two signals:

1. one indicating readiness and the
2. other indicating the need for maintenance.

Both signals shall be annunciated on the SSSC HMI and shall be available remotely. This function can be integrated as a part of the standard control philosophy.

The monitoring signals must have at least two states. The maintenance signal must indicate "all-okay" or that at least one local alarm exists at the SSSC. The readiness signal must indicate "fully-ready" or "not-ready".

The fundamental concept of the function is to monitor and supervise the total SSSC system.

The readiness signal shall clearly distinguish between a dangerous condition and a fault condition which will result in the SSSC not being able to fulfill the functions. It shall prevent the SSSC from being switched on or switch the SSSC off, if required. However, if a fault condition exists that does not interfere with the SSSC's ability to respond to a system condition, the SSSC shall not be prevented from being switched on and/ or it shall remain in operation.

In addition, the monitoring system shall indicate the readiness of each valve.

The system shall be designed to have two key aspects:

1. Fail-Safe:
   the fail-safe aspect means that a failure of either the device or the monitoring system itself must result in a failure indication.
2. Full-Coverage:
   the full coverage aspect means that any component problem which might prevent proper response to a major system disturbance or full performance must be monitored.

A typical example is the SSSC cooling system failure as a result of an auxiliary problem. This could result in the SSSC being switched off.

However, upon clearance of the problem, the SSSC shall be able (ready) to be switched on. Alternatively, a faulty indication of a disconnector or earth switch position (discrepancy) is considered dangerous and the SSSC shall remain in the off state or be switched off (not necessarily tripped) until the condition is removed or changed.

The maintenance signal is a "summary" of all possible states, equipment, etc. that are either faulty or redundancy has been lost but does not affect the SSSC performance. Both these signals have to be carefully integrated with the total system control, protection and any other interlocking system.

Since these requirements are in opposition to the high availability objective, the reliability and security of the monitors must be extremely high.

6.2.6 Monitoring of Status Control

To ensure reliable and safe operation of the SSSC, the system must continuously monitor various critical components and parameters. The following minimum requirements must be met for status control monitoring:

1. The system must monitor the proper operation of all system components and enable fault detection.
2. Any internal power supply failure or detectable component failure in the automatic control system must be monitored and detected.
3. If any malfunction of the automatic control system is detected, the SSSC must immediately shut down to prevent further damage or hazardous operation.
4. Moreover, all redundancy elements and systems must be monitored, and their status indicated to ensure proper operation and timely maintenance.

6.2.7 Discrepancy functionality

If a switchable device, a bus coupler or bus section is not OK due to discrepancy or communication failure, the specific device becomes not available and an alarm is set on the local HMI.

If a device does not react to a switching instruction, the device must become unavailable and set to a disturbed condition. An alarm is set on the local HMI.

Every command shall be monitored. In case of a too long transition time, an alarm shall be given on the local HMI. The object shall be blocked until the alarm is acknowledged.

In case an object is not in its end position, only a command to a save position shall be possible. Automatic repetition of commands is not permitted.

In all cases the alarm is also sent to the local SCADA and to the NCC (National Control Centre).

6.2.8 I/O processing

The I/O processing equipment must:

1. have sufficient capacity to handle all of the inputs and outputs required for operation of SSSC,
2. be highly reliable, with a proven track record of similar operation in industrial applications.

The SSSC control unit shall be able to record all events of all equipment of the corresponding area. This data shall be processed for local presentation and shall also be sent to the NCC.

6.2.9 Signals to be exchanged between SSSC and NCC

The Contractor shall propose a signal list indicating the signal points that must be exchanged between the SSSC and the NCC, and this proposed list must be submitted for approval.

The Contractor shall be responsible for implementing and parameterization of these signal points at the SCADA connection level in the Substation.

Hardware and software provision shall be made for at least 20 % of each kind of input or output signals, indications, and controls to be spare for future use.

6.2.10 Time Synchronization

Supply of Time synchronization equipment shall include NTP server with an integrated GPS receiver, antenna & its mounting kit, surge protector/ lightning arrestor, all cables and processing equipment, connectors, accessories to make functional.

Time Synchronization device shall allow all components of the SSSC control and protection system to be time synchronized with local time including daylight savings time functionality.

6.2.11 Valve Cooling Control

A digital valve cooling control system shall be supplied for the valve branches. Valve Cooling control system must be:

1. designed to maintain a stable temperature for the valve branches, preventing overheating or cooling beyond the specified range,
2. able to detect and respond to any malfunctions or abnormal operating conditions, such as a failure of the cooling system or an increase in temperature beyond the specified range,
3. designed with redundancy and fail-safe features to ensure continuous operation in the event of a failure of one or more components.

6.2.12 Switchyard Control

These requirements apply only to the equipment included in the scope of supply, if applicable.

The SSSC switchyard control system should be fully integrated with the SSSC control system to efficiently and reliably manage the HV/MV circuit breakers, disconnectors, earth switches, transformers, and auxiliaries. The interlocking functionality must be fault-tolerant and prevent all possible operating malfunctions.

6.2.13 Ambient Temperature Monitors

The Contractor shall provide temperature alarms in the SSSC Valve Rooms and inside the SSSC control buildings with inputs to the SSSC Control System, as required for indication and annunciation, if applicable.

6.2.14 Control System Testing

Requirements for testing of a control system:

1. A comprehensive test plan should be created that covers all aspects of the control system, including hardware, software, and communication interfaces.
2. Test scenarios should be developed that simulate real-world operating conditions and cover a wide range of possible scenarios.
3. The test environment should be set up to replicate the actual operating environment as closely as possible.
4. The appropriate test equipment should be used to test the system, including testing tools, simulators, and testing instruments.
5. Clear and concise test procedures should be developed and documented, including step-by-step instructions for executing the tests.
6. Test data should be recorded and analyzed to verify the correct operation of the control system and to identify any areas that require improvement.
7. Performance criteria should be established to evaluate the system's performance against the required specifications, including accuracy, speed, and reliability.
8. The control system must be tested for safety and reliability to ensure that it operates safely and reliably under all expected conditions.
9. Physical inspection of all components.
10. Functional testing should be performed to verify that the control system meets all functional requirements.
11. Integration testing should be performed to ensure that all system components and interfaces work together seamlessly.
12. Verifying the system redundancy.
13. Verifying of communication with NCC.
14. Verifying that the control system meets all customer requirements and specifications.
15. Comprehensive documentation should be produced that outlines the testing procedures, test results, and any issues or defects that were identified during testing.

6.3 PROTECTION

To ensure that faults are cleared within the critical clearing time, minimize damage to the system, avoid load loss, and prevent violations of limitations, a redundant, high-speed protection scheme should be implemented.

This requires the use of two separate protection schemes that function independently to provide working protection even in the event if one protection scheme failing or being switched out for maintenance.

Each scheme shall generally meet the functional requirements as described in this section.

6.3.1 Protection System Design

The SSSC shall be completely self-protecting (unit protection). All SSSC plant and material shall be protected from damage for all conditions of overcurrent, overvoltage, excessive reactive power loading, unbalance due to loss of capacitor elements, phase-to-phase and phase-to-ground faults, three phase faults, loss of cooling, semiconductor valve or control malfunction, faults (SSSC MV) in individual primary connected components of the SSSC, HV system faults, etc. The SSSC shall withstand the maximum fault current as specified for a period of the maximum fault clearing time as specified, considering second contingency cases due to the previously mentioned conditions.

All protection equipment and systems should be properly coordinated to prevent incorrect operations of the protection equipment or systems during normal SSSC operation, including anticipated abnormal conditions on the distribution and transmission system, as specified. Fail-safe principles should be applied throughout.

The Contractor shall develop a protection concept which is subject of Purchaser/Engineer approval. The Contractor shall be responsible for a detailed design of the protection systems.

6.3.2 Protection General Requirements

The basic principle and order of precedence for control and protection shall be as follows:

1. Minimize to the maximum extent the tripping of the SSSC system or reducing the ability of the SSSC to respond to a condition in the system that requires it to be operationally available.
2. Correctly identify a fault, problem, or error condition.
3. Isolate the minimum number of components or subsystems, whenever possible.
4. Utilize degraded modes (if applicable, e.g., more than one branch) to the maximum extent possible, either directly (with no interruption of the SSSC operation) or indirectly (by tripping the SSSC momentarily in order to isolate the branch and automatically re-energize the SSSC).
5. Trip the SSSC and lock it out, if necessary.

A protection trip of the SSSC, causing the SSSC breaker to trip, shall only be initiated if the automatic control protection (control system) is unable to remove the problem or has failed itself.

The protection of the electrical system shall be designed and installed in such a way that the failed equipment is disconnected selectively and automatically. Complete equipment is to remain inoperative during transient phenomena, which may arise during switching or other disturbances to the system.

The failure of the SSSC Substation Interface (SCADA interface) shall not result in a protection trip of the SSSC. A fail-safe philosophy shall be implemented to allow the SSSC to operate safely and independently from the SSSC Substation Interface (SCADA interface).

The term "trip" is used in the context of protective devices to refer to a function that causes a circuit breaker (e.g.: Vacuum Switch, Silicon Controlled Rectifier, Solid State Switch, etc.) to rapidly open or close in response to a fault or other abnormal condition in the SSSC system. Depending on the specific technology used, a "trip" can refer to either the opening or the closing of the breaker. This must be reasonably taken into account in the requirements of this Tender Document.

6.3.2.1 Protection relays

Protection equipment shall be designed and applied to provide maximum discrimination between faulty and healthy circuits.

The Protection shall be sufficiently sensitive to cater for the full range from maximum to minimum fault level condition. The Protection shall also be suitable for a system fault level equal to the switchgear rating. All current transformer design shall be based on these fault levels.

All required protective, control devices, etc. including auxiliary instrument transformers and panels, relays, cabling, wiring, indication, and all other associated plant and material necessary for the effective operation of the protection systems shall be supplied and mounted under this Contract.

The protective relays shall be microprocessor based.

Relays shall be of approved type; they shall have approved characteristics and be flush mounted in dust and moisture proof cases.

The protective relays shall be provided with optical indication for starting, tripping and malfunctioning of the protective function. The LEDs shall be reset without opening the covers.

The protection relays shall also be equipped with MMI facilities suitable for manual parameter settings and viewing of the settings.

Relays with provision for manual operation from outside the case, other than for resetting, will not be accepted. Relay settings shall be visible and readable without having to remove the relay cover.

Relays shall be of approved construction and shall be arranged so that adjustments, testing and replacement can be affected with the minimum of time and labor. Auxiliary Relays of the hand reset type if provided shall be capable of being reset without opening the case.

Electrically reset tripping relays shall be provided as required by the system of control, such as for those circuits which are subject to remote supervisory control.

Relay contacts shall be suitable for making and breaking the maximum currents which they may be required to control in normal service but where contacts of the protective relays are unable to deal directly with the tripping currents, approved Auxiliary tripping relays shall be provided. In such cases, the number of auxiliary tripping relays operating in tandem shall be kept to a minimum in order to achieve fast fault clearance times. Separate contacts shall be provided for alarm and tripping functions. Relay contacts shall make firmly without bounce and the whole of the relay mechanisms shall be as far as possible unaffected by vibration or external magnetic fields.

Steps shall be taken to protect the circuitry from externally impressed transient voltages which could reach the circuitry via connections to instrument transformers or the station battery. The routing of cables should be such as to limit interference to a minimum. Any auxiliary supplies necessary to power solid state circuits shall be derived from the main station battery and not from batteries internal to the protection.

Protection relays shall fulfil the following basic technical characteristics:

1. Protection shall operate autonomously and independently of the control system.
2. In case of power supply failure, all protection settings shall be maintained.
3. Protection relays must be synchronized with accurate time; e.g. events in protection relays shall be equipped with accurate time with resolution ≤ 1 ms.
4. Protection devices shall ensure the highest availability level. For this purpose, appropriate monitoring and control mechanisms shall be built in for self-diagnosis of their proper operation.
5. Settings, parameterization, settings back-up, diagnostics, display of measurements and data on the protection device operation shall be enabled:
    a. Directly, on the protection relay via a built-in man-machine unit. Protection relays shall be equipped with appropriate man/machine interfaces, which shall provide the user with fast and efficient diagnostics of the protection relay operation.
    b. Locally, via a temporarily connected laptop with appropriate software. On the protection devices, a separate communication input shall be available for this purpose on the front of the protection relay, and
    c. Remotely, via Ethernet connection.
6. Rated voltage of protection relays supply is 220 V DC.
7. All analog and digital inputs and outputs shall be harmonized with the primary equipment within the scope of supply.
8. The equipment shall comply with at least the following standards:
    a. Immunity to electromagnetic interferences (EMC) according to IEC 61000-6-5, class 4, performance criterion A, i.e. :
        i. Electrostatic discharge: 60255-22-2 / IEC 61000-4-2
        ii. Fast transient bursts: IEC 60255-22-4 / IEC 61000-4-4;
        iii. Conducted disturbances: IEC 61000-4-6
        iv. Damped oscillatory wave: IEC 61000-4-18
    b. HV dielectric test minimum 2 kV (except for communication interfaces),
    c. Resistance to vibrations: IEC IEC60255-21-1; class 1.
9. Casing mechanical protection degree ≥ IP 51 except behind ≥ IP 20.
10. Temperature range of operation at least: from -5°C to 55°C.

11. The Contractor shall deliver all the necessary software for parameterization and testing of protection devices.

6.3.2.2 Tripping schemes

Trips HV, MV kV circuit breakers shall be done by means of two-separated trip signals, each with its own independent DC supply.

The trip circuits should be equipped with a "lockout" function that can be reset manually and remotely by the operator (where necessary for safety reasons).

The input circuits of the digital protections should be monitored using a plausibility check. If any incorrect information is found, the protection function should be blocked by the protection relay. All protection relays should have facilities for monitoring trip circuits. Detection of an interruption in case of a switched-on circuit breaker should be signaled.

Tripping of Q0 on the 220 kV HV line side shall be organized on the 1st and 2nd tripping relay coil (located in a 220 kV protection cabinet that is not part of the delivery). See chapter "Connections toward existing substation protection equipment" for more detailed explanation.

6.3.2.3 Test facilities

It shall be possible to test the protective device during operation without causing trips. Links shall be provided for isolation of individual protection trip circuits and the common protection trip circuit to each circuit breaker trip coil.

In addition to each protection relay the Contractor shall supply also an appropriate test socket-outlet (Type: ABB RTXP18 and/or RTXP24). The protection relays shall enable easy and safe testing of individual protection functions. This shall be so performed that testing is possible during operation, without any interventions to the protection relay connection terminals. Injection of test current and voltage shall be enabled whereby an automatic short-circuiting of current circuits and blocking of protection or tripping circuits shall be provided.

The test socket-outlet supplied shall be to the approval of the Purchaser.

6.3.2.4 Electromagnetic Compatibility

Electronic Relays and other electronic devices and ancillary circuits connected to them, such as power supplies, current and voltage transformer secondaries, status or tripping or alarm circuits shall be designed to ensure that they are compatible for use in the hostile electrical environment found in an MV or HV substation.

Adequate steps by means of a suitable design shall be taken to prevent Electromagnetic Interference (EMI) (generated by sources such as circuit breakers, disconnectors, lightning, radio or radar emissions, switching contactors in DC circuits etc.) or Electrostatic Discharges (ESD) from affecting relay performance or causing damage to components.

All relays offered shall therefore have been type tested to meet the current requirements of IEC 60255 with respect to high frequency disturbance, fast transients, electrostatic discharge, radio frequency interference testing etc.

6.3.3 Protection Philosophy

6.3.3.1 Protection Systems Characteristics and Performance

The protection systems connected to the SSSC shall be reliable, safe and selective and shall not hinder proper operation of the SSSC.

The protection systems shall be designed:

1. to allow full use of the overload capability of installation and materials,
2. to allow full use of the absorptive and generative reactive power range of the SSSC,
3. to allow full use of the SSSC degraded modes,
4. to utilize redundancy of components,
5. to withstand disturbances from the harmonic (voltage and current) distortion present in the dynamic, transient and steady states,
6. to withstand disturbances due to over-voltages and under-voltages and high frequency oscillations,
7. to withstand disturbances from SSSC switch on during dynamic and transient conditions.
8. All necessary measures shall be taken to prevent the following:
    a. disturbances to the control, protection and communication systems at the Substation due to the electromagnetic interference generated by the SSSC,
    b. disturbances to the SSSC protection systems due to the following:
        i. resonance and inrush currents likely to occur in the network,
        ii. phenomena that may occur on the network during the switching of circuit breakers, disconnectors, transformers, reactors and transmission lines,
        iii. erroneous measurements by the protection measuring apparatus in the presence of direct current, surges or faults,
        iv. presence of any system faults outside the SSSC system,
        v. any harmonic or DC currents emanating from the SSSC or the network.

The protection systems shall be capable of achieving the required performance in the range from abnormal to maximum fault level as specified.

6.3.3.2 Protection Functions

In all bays, two independent redundant protection sets shall be provided. These sets shall act as backup to each other to prevent the loss of a complete protection system in case of a single device malfunction. The measuring and protection principles used in the two sets shall differ, where possible. Each of the two sets of protection shall be supplied by two independent DC supplies and two independent current transformer cores.

The protection system shall isolate the respective zone as quickly as possible. It should be possible to take any single protection system out of service without leaving any section of the SSSC unprotected or putting the SSSC plant and material at risk.

All protection associated with semiconductors and achieved through control systems shall be backed by back-up protection (overcurrent and earth fault). Due selectivity shall be achieved through the type of protection and grading of the trip times.

Each Valve Branch (semiconductor-controlled) shall have adequate overvoltage and overcurrent protection. Optionally branch directional earth fault protection could be provided.

The Contractor shall provide also control system protection (Open and Closed Loop), which shall include all protective functions not specified above but required.

6.3.3.3 Protection signaling

The signaling system shall provide information on the cause of relay triggering or tripping, as well as the time elapsed between the event and the corresponding relay action.

The Root Mean Square and peak values, power factor, disturbance records etc. of currents and voltages before and after the occurrence of trigger event shall be stored.

6.3.4 Protection System Relay Particular Requirements

The relays shall be insensitive to any DC-component in the CT output and should not mal-operate for conditions where one or more current transformers saturate due to through fault conditions.

6.3.4.1 Over Current/Earth Fault Protection Relay

Inverse definite minimum time overcurrent and/or earth fault relays shall be provided where appropriate. They shall be of numeric type and shall have standard inverse, very inverse, extremely inverse and long inverse time - current characteristics according to IEC 60255.

Relays should have adjustable settings for both operating current and time, the design of the relay being such that the setting adjustments can be carried out on load without taking the relay out of service. The protection function shall include high current settings for fast tripping via separate trip contacts.

The range of current settings for inverse characteristic shall be at least 50-200 percent of rated current with steps at no longer than 5 per cent of rated current and the time multiplier setting adjustment shall be 0 to 1 second or more at ten times the setting current. Time Multiplier settings shall be in steps not exceeding 0.025. The high current setting shall be at least 2 to 20 times rated current.

Inverse time earth fault relays, where specified, should also comply with the foregoing, but shall have a range of settings from 20 % to 80 % with steps at no longer than 2.5 % of the rated current. Time setting range shall be similar to that of the overcurrent relay.

The relays shall be thermally rated so that the operating time of the relay at the highest practical current levels on any combination of current and time multiplier settings shall not exceed the thermal withstand time of the relay. The continuous withstand current should be no less than twice rated current.

6.3.4.2 Requirements for Valve and Semiconductor Protection for VSC Branches

The requirements for protection of valve and semiconductor components for VSC branches are as follows:

1. Over-voltage Protection:
   The valves of the VSC semiconductor branches shall be protected against over-voltages of all wave shapes. Such protection shall not, however, prevent phase control of the VSC semiconductor branches up to the specified level. An alarm shall be produced in the event of persistent misfiring.
2. Over-current Protection
   The semiconductors of the VSC valves shall be protected against currents of excessive amplitude and duration. Time-delayed over-current protection shall be provided to match the short-time withstand characteristics of the VSC components. The over-current protection shall be properly coordinated with the over-current capability of the semiconductors, taking into account the time, magnitude and wave shape of the worst over-currents expected in service.
3. Semiconductor Fault protection
   The semiconductors must be monitored so that defective semiconductors are readily identified and located. If failure of a semiconductor is detected, an alarm shall be annunciated. The semiconductor monitoring system shall have the capability of tripping the SSSC and/or causing isolation of any branch in which semiconductors have failed to the point where the remaining healthy semiconductors are subjected to damaging stresses (loss of redundancy). The semiconductor fault detection system shall be reliable and spurious tripping of the SSSC branches shall not occur.

6.3.5 Trip Circuit and Power Supply Supervision

Trip circuit supervision shall be provided to monitor the status of a trip circuit. Relays used for supervision of trip circuits shall have sufficient contacts for alarm and indication purposes.

The trip circuit supervision scheme shall provide continuous supervision of the trip circuits of the circuit breaker in either the open or closed position and independent of local or remote selection at the local operating position. It shall also provide an alarm if the trip supply fails.

Relay elements shall be delayed on drop-off to prevent false alarms during faults on DC wiring on adjacent circuits, or due to operation of a trip relay contact. If protection with thyristor output is provided, due account shall be taken of the effect of the continuous supervision current which shall not prevent the thyristor “turn-off”.

Trip circuit supervision must be carried out in a way that mal-tripping of a circuit breaker is prevented.

Power supply supervision relays shall be provided to monitor DC power supplies for tripping, closing, CB fail, busbar protection, etc. An alarm shall be given if either supply voltage falls below 70 % of nominal voltage for a period in excess of 3 seconds. The relay shall be equipped with a self-resetting flag indicator and shall be suitable for continuous operation at 125 % of nominal DC voltage.

6.3.6 Protection Settings

The SSSC protection system shall be coordinated with the network protection system. The Contractor shall provide a detailed design report on the protection functions to be implemented in the SSSC and the co-ordination with the network protection.

Settings shall also be provided for those relays and other equipment provided under this Section of the Contract which do not require an intimate knowledge of the existing relay settings, e.g. circuit breaker fail relays. Detailed calculations shall be provided supporting the recommended settings.

The Contractor shall carry out the calculations necessary for evaluation and coordination of the relay settings. The Contractor shall request the required basic data.

6.3.7 Fault Recording

Each protection device shall be equipped with an event and failures recording (registration) function. Information on events and failures shall remain stored even if the power supply fails for a long time. Export of individual trouble/failure in Comtrade format shall be enabled.

Relays shall be able to detect abnormal conditions and to record detailed voltage current, frequency, operation status of protection relays and selected control devices (CB Tripping), and other related information during normal and abnormal situations.

In case of loss of supply, whatever has been recorded shall not be lost.

The data acquisition unit shall be triggered as follows:

1. Sensor (Analogue) Triggering -Change of voltage/current/frequency level under or over set point limits.
2. Event (Digital) triggering -Change of state (edge of level sensitive) of a contact on circuit protection relays, inter-trip receive, etc.
3. External (cross) triggering – initiation received from other recorders in the substation.

It shall be possible to set up the fault recording configuration, set up, retrieve and view the records (i.e. the substation name, feeder name and precise time of the occurrence of the fault to the nearest millisecond, pre-fault signal level, post fault signal level, fault current duration, designation of all channels, cause of triggering, length of record, etc.).

Fault analysis software shall be compatible (as far as possible) with all versions of the same brand installed in the Purchaser's system as well as any foreseen future development by the same manufacturer. It shall be possible to send fault data from the substation to SAS based on criteria such as combination relay operation and CB status, sensor trigger etc. user defined combination, as well as to provide automatic sending of fault data to different destination.

All necessary software with full options and hardware shall be supplied for fault analysis. The supplied software shall be capable of converting records to Comtrade files. The Contractor shall submit a list of facilities available in the analysis software for approval.

6.3.8 Protection System Testing

6.3.8.1 Protection Scheme Component Tests

Tests shall be carried out on individual elements in the protection system to:

1. Prove the calibration of each variable device by measurement of the minimum operating level at each calibration point.
2. Prove the plant and material characteristic, or boundaries of operation are as guaranteed. These tests should be done with the protection on the setting that will be used in service.
3. Demonstrate the operating and reset times of the protection performed on the settings that will be used in service, and at a sufficient number of fault levels to demonstrate compliance with guaranteed timing characteristics.
4. Determine the minimum operating current and voltage of all DC auxiliary relays.
5. Physically inspect all auxiliary and measuring relay components with particular emphasis on output contacts to demonstrate physical condition and correct adjustment.

6.3.8.2 Protection System Tests

Tests shall be carried out on the protection system to:

1. Demonstrate that the logic, functions, and indications of the protection system are in accordance with the design for all fault types, by injection of current and voltages at the input terminals to simulate faults "inside" and "outside" the protected zone.
2. Demonstrate the correct operation of all isolating switches, changeover switches and current transformer short-circuiting devices.

6.3.8.3 Tests at site

Tests at site shall include tests that are necessary to demonstrate to the Purchaser that the plant and material assembled in each cubicle performs correctly and in accordance with the specification. Without limiting the generality of the foregoing, the tests shall include:

1. Measurement of insulation resistance for the whole plant and material from the rail mounted terminals to earth.
2. Demonstration of satisfactory performance of all the relays used in the protection scheme, i.e. pick-up and drop-out values of "all-or-nothing" relays and five points on the operating characteristic of all measuring relays.
3. Demonstration of satisfactory performance of all auxiliary relays used in the protection scheme at the minimum DC auxiliary supply voltage.
4. Demonstration of proper operation of the complete protection scheme.

6.3.9 Documents and data

Technical specifications shall include as a minimum the following information:

1. protection co-ordination design document including settings and curves,
2. range of individual measurements,
3. detailed description of the complete system,
4. circuit and connection diagrams,
5. parts list (including part type, manufacturer, etc.),
6. drawings and weights,
7. data sheets.

*

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A	Revision based on the comments from the Client	9.4.2024	
Revision:	Revision note:	Revision date:	Signature:

Investor: ELES	Facility: RTP 400/220/220 kV Podlog Sistem za regulacijo moči (SSSC) v RTP Podlog
Design engineer: IBE, svetovanje, projektiranje in inženiring Ljubljana, Slovenija	Part of facility/system: Supply and Erection of Flexible Serial Compensation - SSSC in Podlog SS SUBSTATION
/	Type of design: TECHNICAL SPECIFICATION

	First name/Name:	Id. No.:
Approved by:	mag. Marko Testen, univ. dipl. inž. el.	E-1293
Confirmed by:	mag. Marko Testen, univ. dipl. inž. el.	E-1293
Checked by:		
Designed by:	*	*
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7 TECHNICAL REQUIREMENTS FOR DESIGN, DOCUMENTATION PRODUCTION, AND CONSTRUCTION

7.1 SCOPE

This Tender specification provides requirements for architectural, civil, structural, and electrical design and general requirements for construction of buildings, equipment supports, equipment foundations, building and yard utilities including connections to the existing Podlog Substation utilities, access, service, and manipulation surfaces required for installation and operation of the SSSC facility in the Podlog Substation.

The Client will provide design documentation for all high voltage equipment, supports, foundations and high voltage underground cable connections of the SSSC site to the Podlog Substation existing 220 kV air-insulated switchyard.
The Contractor shall review this design documentation in all design phases and propose modifications if required by his design.
All modifications are subject to the Client's approval prior to implementation.

Building and yard utilities under the Contractor's scope of works must include at least the following:

- low voltage electrical and telecommunication cable ducts, manholes or channels including connections to the existing systems in the Podlog Substation ,
- middle and high voltage cable ducts including connections to the existing systems in the Podlog Substation,
- grounding,
- lightning protection,
- lighting (interior and exterior),
- ventilation, heating, air-conditioning, and cooling,
- fire detection and fire protection system,
- technical security and monitoring,
- potable water supply if necessary for equipment operation,
- collection and retention of potentially polluted or hazardous substances,
- stormwater collection, cleaning and drainage of rainwater,
- access, service, and manipulation surfaces during construction and for operational and maintenance needs, including connections to the existing system of access, service, and manipulation areas in the Podlog Substation.

Furthermore, design and construction of all required modifications to the existing systems and/or structures in the Podlog Substation, necessary for installation and/or operation of the SSSC facility are also within the Contractor's scope of work.

7.2 LAWS, RULES, AND REGULATIONS

Design process, design documentation, and construction shall be in compliance with applicable laws, rules, and regulations of the Republic of Slovenia, available at https://www.gov.si/teme/graditev/:

- Gradbeni zakon GZ-1 (Uradni list RS, št. 199/21, 105/22 – ZZNŠPP in 133/23 – GZ-1A); *Construction Act (Official Gazette of the Republic of Slovenia, No. 199/21, 105/22 – ZZNŠPP and 133/23 – GZ-1A);*
- Zakon o arhitekturni in inženirski dejavnosti (Uradni list RS, št. 61/17 in 133/22 – odl. US); *Architectural and Engineering Services Act (Official Gazette of the Republic of Slovenia, No. 61/17 and 133/22 – Constitutional Court decision);*
- Zakon o urejanju prostora (Uradni list RS, št. 199/21, 18/23 – ZDU-1O, 78/23 – ZUNPEOVE in 95/23 – ZIUOPZP)
  Spatial Planning Act (Official Gazette of the Republic of Slovenia, No. 199/21, 18/23 – ZDU-1O, 78/23 – ZUNPEOVE, and 95/23 – ZIUOPZP)
- Zakon o gradbenih proizvodih (Uradni list RS, št. 82/13)
  Construction Products Act (Official Gazette of the Republic of Slovenia, No. 82/13)
- Zakon o tehničnih zahtevah za proizvode in o ugotavljanju skladnosti (Uradni list RS, št. 17/11 in 29/23)
  Technical Requirements for Products and Conformity Assessment Act (Official Gazette of the Republic of Slovenia, No. 17/11 and 29/23)
- Zakon o varstvu okolja (Uradni list RS, št. 44/22, 18/23 – ZDU-1O in 78/23 – ZUNPEOVE);
  Environmental Protection Act (Official Gazette of the Republic of Slovenia, No. 44/22, 18/23 – ZDU-1O, and 78/23 – ZUNPEOVE);
- Zakon o varstvu pred požarom (Uradni list RS, št. 3/07 – uradno prečiščeno besedilo, 9/11, 83/12, 61/17 – GZ, 189/20 – ZFRO in 43/22)
  Fire Protection Act (Official Gazette of the Republic of Slovenia, No. 3/07 – officially consolidated text, 9/11, 83/12, 61/17 – GZ, 189/20 – ZFRO, and 43/22)
- Zakon o varnosti in zdravju pri delu (Uradni list RS, št. 43/11)
  Occupational Health and Safety Act (Official Gazette of the Republic of Slovenia, No. 43/11)
- Zakon o zasebnem varovanju (Ur. l. RS, št. 17/11)
  Private Security Act (Official Gazette of the Republic of Slovenia, No. 17/11)
- Pravilnik o projektni in drugi dokumentaciji ter obrazcih pri graditvi objektov (Uradni list RS, št. 30/23)
  Regulation on Project and Other Documentation and Forms in Building Construction (Official Gazette of the Republic of Slovenia, No. 30/23)
- Uredba o razvrščanju objektov (Uradni list RS, št. 96/22)
  Regulation on Classification of Buildings (Official Gazette of the Republic of Slovenia, No. 96/22)
- Uredba o posegih v okolje, za katere je treba izvesti presojo vplivov na okolje (Uradni list RS, št. 51/14, 57/15, 26/17, 105/20 in 44/22 – ZVO-2)

Regulation on Environmental Impact Assessment for Certain Activities (Official Gazette of the Republic of Slovenia, No. 51/14, 57/15, 26/17, 105/20, and 44/22 – ZVO-2)

- Uredba o kriterijih za izračunavanje višine nadomestila za degradacijo in uzurpacijo prostora in o načinu njegovega plačila (Uradni list RS, št. 33/03, 79/09, 6/14, 61/17 – GZ in 199/21 – GZ-1)
  Regulation on Criteria for Calculating Compensation for Land Degradation and Usurpation and Its Payment Method (Official Gazette of the Republic of Slovenia, No. 33/03, 79/09, 6/14, 61/17 – GZ, and 199/21 – GZ-1)
- Uredba o preprečevanju in zmanjševanju emisije delcev iz gradbišč (Uradni list RS, št. 21/11, 197/21 in 44/22 – ZVO-2)
  Regulation on Prevention and Reduction of Particle Emissions from Construction Sites (Official Gazette of the Republic of Slovenia, No. 21/11, 197/21, and 44/22 – ZVO-2)
- Uredba o zagotavljanju varnosti in zdravja pri delu na začasnih in premičnih gradbiščih (Uradni list RS, št. 83/05 in 43/11 – ZVZD-1)
  Regulation on Ensuring Safety and Health at Work on Temporary and Mobile Construction Sites (Official Gazette of the Republic of Slovenia, No. 83/05 and 43/11 – ZVZD-1)
- Uredba o pogojih in omejitvah za izvajanje dejavnosti in posegov v prostor na območjih, ogroženih zaradi poplav in z njimi povezane erozije celinskih voda in morja (Uradni list RS, št. 89/08 in 49/20);
  Regulation on the conditions and limitations for the implementation of activities and interventions in areas threatened by floods and related erosion of continental waters and the sea (Official Gazette of the Republic of Slovenia, No. 89/08 and 49/20)
- Pravilnik o začasnih objektih (Uradni list RS, št. 79/22)
  Rule on Temporary Structures (Official Gazette of the Republic of Slovenia, No. 79/22)
- Pravilnik o projektni in drugi dokumentaciji ter obrazcih pri graditvi objektov (Uradni list RS, št. 30/23)
  Rules on documentation and forms related to construction (Official Gazette of the Republic of Slovenia, No. 30/23)
- Pravilnik o mehanski odpornosti in stabilnosti objektov (Uradni list RS, št. 101/05, 61/17 – GZ in 199/21 – GZ-1)
  Rule on Mechanical Resistance and Stability of Structures (Official Gazette of the Republic of Slovenia, No. 101/05, 61/17 – GZ, and 199/21 – GZ-1)
- Pravilnik o požarni varnosti v stavbah (Uradni list RS, št. 31/04, 10/05, 83/05, 14/07, 12/13, 61/17 – GZ in 199/21 – GZ-1)
  Rule on Fire Safety in Buildings (Official Gazette of the Republic of Slovenia, No. 31/04, 10/05, 83/05, 14/07, 12/13, 61/17 – GZ, and 199/21 – GZ-1)
- Pravilnik o prezračevanju in klimatizaciji stavb (Uradni list RS, št. 42/02, 105/02, 110/02 – ZGO-1, 61/17 – GZ in 199/21 – GZ-1)
  Rule on Ventilation and Air Conditioning of Buildings (Official Gazette of the Republic of Slovenia, No. 42/02, 105/02, 110/02 – ZGO-1, 61/17 – GZ, and 199/21 – GZ-1)
- Pravilnik o zahtevah za vgradnjo kurilnih naprav (Uradni list RS, št. 100/13, 61/17 – GZ in 199/21 – GZ-1)
  Rule on Requirements for Installation of Heating Appliances (Official Gazette of the Republic of Slovenia, No. 100/13, 61/17 – GZ, and 199/21 – GZ-1)

- Pravilnik o učinkoviti rabi energije v stavbah (Uradni list RS, št. 70/22, 161/22 in 129/23)
  Rule on Energy Efficiency in Buildings (Official Gazette of the Republic of Slovenia, No. 70/22, 161/22 in 129/23)
- Pravilnik o zahtevah za nizkonapetostne električne inštalacije v stavbah (Uradni list RS, št. 140/21 in 199/21 – GZ-1)
  Regulation on Requirements for Low-Voltage Electrical Installations in Buildings (Official Gazette of the Republic of Slovenia, No. 140/21 and 199/21 – GZ-1)
- Pravilnik o zaščiti stavb pred delovanjem strele (Uradni list RS, št. 140/21 in 199/21 – GZ-1)
  Rule on Protection of Buildings against Lightning (Official Gazette of the Republic of Slovenia, No. 140/21 and 199/21 – GZ-1)
- Pravilnik o zaščiti stavb pred vlago (Uradni list RS, št. 29/04, 61/17 – GZ in 199/21 – GZ-1)
  Rule on Protection of Buildings against Moisture (Official Gazette of the Republic of Slovenia, No. 29/04, 61/17 – GZ, and 199/21 – GZ-1)
- Pravilnik o gradbiščih (Uradni list RS, št. 55/08, 54/09 – popr., 61/17 – GZ in 199/21 – GZ-1)
  Rule on Construction Sites (Official Gazette of the Republic of Slovenia, No. 55/08, 54/09 – corr., 61/17 – GZ, and 199/21 – GZ-1)
- Pravilnik o geodetskem načrtu (Uradni list RS, št. 40/04)
  Rule on Land Survey Plan (Official Gazette of the Republic of Slovenia, No. 40/04)
- Pravilnik o varnosti in zdravju pri uporabi delovne opreme (Ur. l. RS, št. 101/04 in 43/11 – ZVZD-1)
  Rule on Safety and Health in the Use of Work Equipment (Official Gazette of the Republic of Slovenia, No. 101/04 and 43/11 – ZVZD-1)
- Tehnična smernica za graditev TSG-1-001:2019 Požarna varnost v stavbah s popravki
  Technical Guideline for Construction TSG-1-001:2019 Fire Safety in Buildings with Amendments
- Tehnična smernica za graditev TSG-N-002:2021 Nizkonapetostne električne inštalacije
  Technical Guideline for Construction TSG-N-002:2021 Low-Voltage Electrical Installations
- Tehnična smernica za graditev TSG-N-003:2021 Zaščita pred delovanjem strele
  Technical Guideline for Construction TSG-N-003:2021 Lightning Protection
- Tehnična smernica za graditev TSG-1-004: 2022 Energijska učinkovitost stavb
  Technical Guideline for Construction TSG-1-004: 2022 Energy Efficiency of Buildings
- Tehnična smernica za graditev TSG-1-005: 2012 Zaščita pred hrupom v stavbah
  Technical Guideline for Construction TSG-1-005: 2012 Noise Protection in Buildings
- Tehnična smernica za graditev TSG-V-006-2022 Razvrščanje objektov
  Technical Guideline for Construction TSG-V-006-2022 Classification of Buildings

The list of the current editions of Slovenian standards (SIST) is available at: https://www.sist.si/.

For construction products subject to harmonized European standards, provisions of the European Union Regulation on the Establishment of Harmonized Conditions for the Marketing of

Construction Products (EU Regulation No. 305/2011 of the European Parliament and of the Council of 9 March 2011 on the establishment of harmonized conditions for the marketing of construction products and repealing Council Directive 89/106/EEC) apply.

The list of the latest current editions of harmonized European standards for construction products is available at: https://ec.europa.eu/docsroom/documents/56834.

For all other construction product Zakon o gradbenih proizvodih (Uradni list RS, št. 82/13) /*Construction Products Act (Official Gazette of the Republic of Slovenia, No. 82/13)* applies.

Wherever an Act, Regulation, Rule, Technical Guideline or Standard is referenced within this specification, the latest current edition shall apply.

7.3 SITE DATA AND INVESTIGATION REQUIREMENTS

7.3.1 SSSC facility location

SSSC facility shall be located in the southwestern part of the Podlog Substation, in the extension of the 220 kV switchyard (Figure 1).

Figure 1: SSSC facility location in Podlog Substation

An existing storage platform and the Podlog Substation external lighting system is currently located at the proposed SSSC facility location.

The SSSC facility location is accessible via the southern entrance to the Podlog Substation and the existing internal service roads system.

A detailed description of the Podlog Substation facility, including the construction area, accessibility, and conditions for site arrangement is provided in Chapter 2 (R4PO01-6E1002) of the Tender specification.

7.3.2 Geology, Hydrology, and Seismicity

Site investigations at the SSSC facility location required for design and construction shall be carried out by the Contractor.
Investigation program and execution, the factual and interpretative report preparation shall comply with the requirements of SIST EN 1997-1 and SIST EN 1997-2 standards, including their corresponding National annexes, at least to the extent specified for geotechnical category 2 according to SIST EN 1997-1 and SIST EN 1997-2.
Investigations shall also be carried out to determine the ground type according to SIST EN 1998-1 and its corresponding National Annex.
The interpretative report shall also define the ground water table, measures required for excavation protection during earthworks and measures for adjacent existing structures and/or facilities protection.

Basic geology, hydrology, and seismicity data provided below are summarized from reports on investigations carried out during the Podlog Substation facility construction and recent reconstructions:

- Geološko-geomehansko poročilo o zgradbi tal in pogojih temeljenja na območju RTP Podlog, ECONO, poročilo št. 16599, maj 2016
  Geological-geomechanical report on the structure of the soil and foundation conditions in the RTP Podlog area, ECONO, report no. 16599, May 2016.
- Geotehnično poročilo za izdelavo projektne dokumentacije objekta "Kolokacija Podlog", Geoekspert Podjetje za uporabno geotehniko Igor Resanovič s.p., št. poročila 11/08, januar 2008
  Geotechnical report for the preparation of project documentation for the "Colocation Podlog" facility, Geoekspert Company for Applied Geotechnics Igor Resanovič, sole proprietorship, report no. 11/08, January 2008.
- Geotehnično poročilo o pogojih temeljenja RTP 400/220 kV Podlog II. Faza, Geološki zavod Ljubljana, št. poročila 223/1-1983, junij 1983
  Geotechnical report on the foundation conditions of RTP 400/220 kV Podlog II. Phase, Geological Institute Ljubljana, report no. 223/1-1983, June 1983.

The Podlog Substation site is composed of alluvial deposits of Quaternary age, overlaid by artificially deposited material (gravel and crushed rock) with a thickness ranging from 0.8 m to 1.5 m. The alluvial deposits consist mainly of clays and laminated clays with a thickness of 1 m to 3 m, below which carbonate gravels and sands with a thickness of 2 m to 3 m are present. The total thickness of Quaternary deposits in the Podlog Substation area ranges from 3.5 m to 5.0 m.

The pre-Quaternary substrate in the area consists of grey Miocene shale, with geomechanical properties improving with depth. In the northern part of RTP, Miocene tuffaceous sandstones to breccia of Miocene age are found in the substrate.

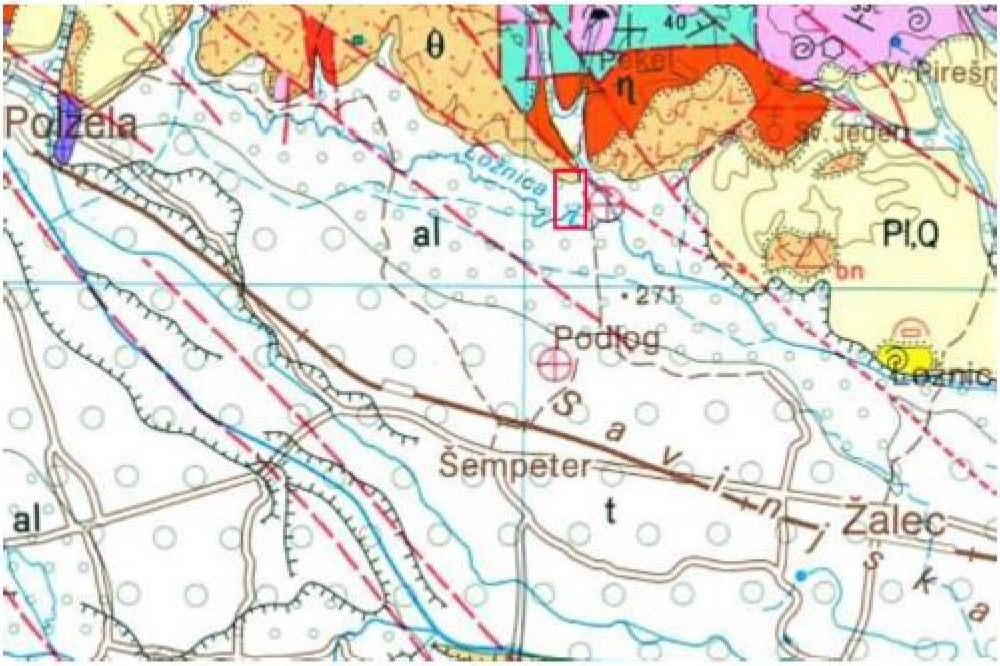


Figure 2: Extract from the Geological-Geotechnical Map, Celje Sheet (source: Geological-Geotechnical Report on Soil Structure and Foundation Conditions in the RTP Podlog Area, ECONO, Report No. 16599, May 2016)

Oznaka	Starost	Opis litologije
al	Kvartar	Aluvialni nanosi – gline in peščene gline.
t	Kvartar	Rečne terase – karbonatni peski in prodi.
θ	Miocen	Andezitni tuf, vulkanska breča in peščenjak
M_1	Miocen	Laporovec

Figure 3: Geological and Geotechnical Map, sheet Celje Legend (source: Geological-Geomechanical Report on the Soil Structure and Foundation Conditions in the RTP Podlog Area, ECONO, Report No. 16599, May 2016).

KEY
Oznaka – Tag
Starost – Age
Opis litologije – Description of lithology
Kvartar – Quaternary
Miocen – Miocene
Aluvialni nanosi – gline in peščene gline - Alluvial deposits - clays and sandy clays
Rečne terase – karbonatni peski in prodi - River terraces - carbonate sands and gravels
Andezitni tuf, vulkanska breča in peščenjak - Andesitic tuff, volcanic breccia and sandstone
Laporovec - Marlstone

Soil structure and groundwater table data from the Geological-Geotechnical Report on the structure of the soil and foundation conditions in the Podlog Substation , ECONO area, report No. 16599, May 2016, are presented below (Figure 4 and Figure 5).

Vrsta zemljine	AC klasifikacija	w [%]	γ [kN/m³]	Tlačna trdnost [kPa]	φ [°]
Glinaste in meljne zemljine	CH, CL, MI, ML	24,9 – 27,9	18,6 – 19,1	60 – 1.500	23 – 26
Peščene zemljine	SF_c	/	18,5		34
Prodno peščene zemljine	GP, GW, GF_s, GF_c	/	19,5 – 21,0		38
Glinovec		13,8 – 18,9	21,6	4.500 – 15.000	
Nasip grajen iz prodno peščenih zemljin	GP – GF_s		20		34

Figure 4: Characteristic Soil Parameters (Source: Geological-Geomechanical Report on Soil Structure and Foundation Conditions in the RTP Podlog Area, ECONO, Report No. 16599, May 2016)

Oznaka vrtine	Globina [m]	Št. SPT preiskav	Nivo podzemne vode [m]	Koordinata Y	Koordinata X	Koordinata Z
V – 1	5,0	3	- 0,8	510375,70	125999,90	274,73
V – 2	8,0	4	- 0,8	510417,00	125865,80	274,75
V – 3	8,0	4	- 1,3	510367,00	125772,00	274,83
V – 4	7,0	4	- 0,7	510377,64	125691,39	273,50
V – 5	7,0	4	- 1,0	510379,60	125644,40	273,50

Figure 5: Borehole and groundwater table data (source: Geological-Geomechanical Report on Soil Structure and Foundation Conditions in the RTP Podlog Area, ECONO, Report No. 16599, May 2016)

KEY
Vrsta zemljine – Soil type
AC Klasifikacija - AC Classification
Tlačna trdnost - Compressive strength
Glinaste in meljaste zemljine - Clayey and silty soils
Peščene zemljine - Sandy soils
Prodno peščene zemljine - Gravelly sandy soils
Glinovec - Claystone
Nasip grajen iz prodno peščenih zemljin – Embankment constructed of gravelly sandy soils
Oznaka vrtine - Borehole mark
Globina - Depth
Št. SPT preiskav - No. of SPT tests
Nivo podzemne vode - Groundwater level
Koordinata - Coordinate

Ground type C according to SIST EN 1998-1 applies according to Geological-Geomechanical Report on Soil Structure and Foundation Conditions in the Podlog Substation Area, ECONO, Report No. 16599, May 2016.

7.3.3 Flood Hazard

According to the Integrated Map of Flood Hazard Classes (Atlas okolja (gov.si) the area designated for the construction of SSSC facility lies in the so-called residual flood hazard zone (Figure 6).

Figure 6: Excerpt from the Integrated Map of Flood Hazard Classes (source: Atlas okolja (gov.si))

According to the 500-year Flood Hazard Map the SSSC facility location can be impacted by a 500-year flood water (Figure 7).

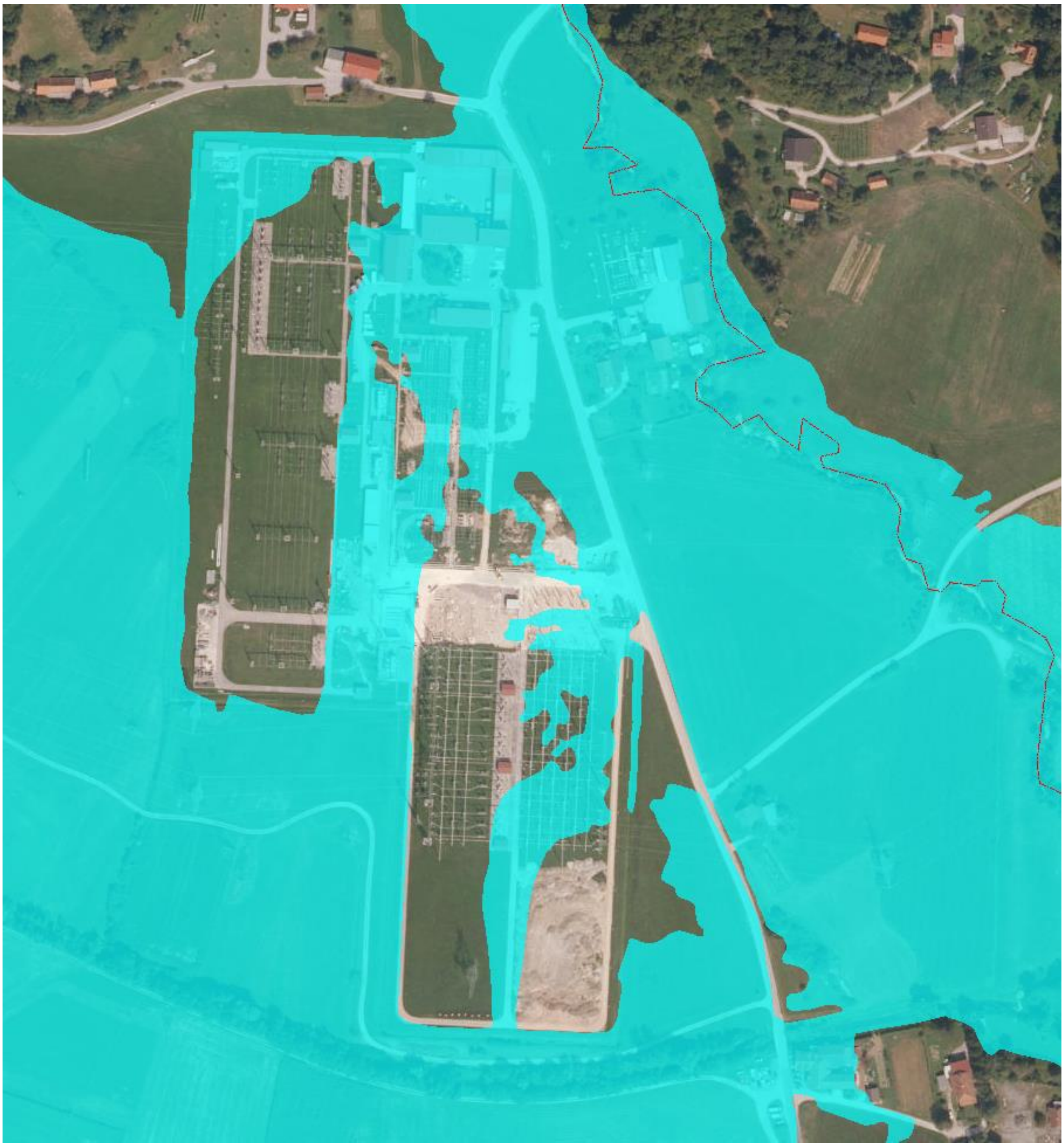


Figure 7: Excerpt from the 500-year Flood Hazard Map (source: Atlas okolja (gov.si))

During the design phase, the Contractor shall prepare a Hydrological-Hydraulic Report addressing the flood vulnerability of the SSSC location. The report shall identify the required protective measures, analyse the impact of construction on the existing floodwater regime and propose necessary mitigating measures.

The Hydrological-Hydraulic Report preparation shall comply to the provisions of applicable regulations (Uredba o pogojih in omejitvah za izvajanje dejavnosti in posegov v prostor na območjih, ogroženih zaradi poplav in z njimi povezane erozije celinskih voda in morja (Uradni list RS, št. 89/08 in 49/20)/ *Decree on conditions and limitations for constructions and activities on flood risk areas (Official Gazette of the Republic of Slovenia, No. 89/08 and 49/20).*

Data from previously conducted studies and reports, which shall be made available by the Eployer, may also be used if applicable:

- Hidrološko hidravlični elaborat za potrebe projekta RTP 400/220/110 kV Podlog - Izgradnja transformacije 400/110 kV, DHD d.o.o., št. elaborata 194, november 2016. *Hydrological-hydraulic report for the RTP 400/220/110 kV Podlog Project - Construction of the 400/110 kV transformation, DHD d.o.o., Report No. 194, November 2016*.
- Izdelava kart poplavne nevarnosti in kart razredov poplavne nevarnosti na urbaniziranih območjih na porečju Ložnice, IZVO-R, d.o.o., št. D08-FR/11, oktober 2011, dopolnitve april 2012. *Preparation of flood hazard maps and flood hazard class maps in urbanized areas in the Ložnica watershed, IZVO-R, d.o.o., Report No. D08-FR/11, October 2011, with amendments in April 2012.*

7.3.4 Site Meteorological Data

Complete meteorological data for the Podlog Substation site are provided in Chapter 3 of the Tender (R4PO01-6E1003).

7.4 DESIGN AND DESIGN DOCUMENTATION REQUIREMENTS

7.4.1 Design Documentation Content and Scope

The Contractor shall prepare the Design Documentation as specified below for all buildings, supporting structures and foundations for all equipment, all related utility lines, external access and service roads, manipulation and maintenance areas required for SSSC facility installation and operation, as well as any potential reconstruction of existing buildings, existing utility lines, existing access and service roads and manipulation areas.

Design Documentation shall be prepared for all design phases as defined in Gradbeni zakon (Uradni list RS, št. 199/21, 105/22 – ZZNŠPP in 133/23)/ *Building Act (Official Gazette of the Republic of Slovenia, No. 199/21, 105/22 – ZZNŠPP and 133/23)* and Pravilnik o projektni in drugi dokumentaciji ter obrazcih pri graditvi objektov (Uradni list RS, št. 30/23)/*Rules on documentation and forms related to construction (Official Gazette of the Republic of Slovenia, No. 30/23)*:

- Projektna dokumentacija za pridobitev projektnih in drugih pogojev (DPP)/*Design Documentation for obtaining design and other conditions*,
- Projektna dokumentacija za pridobitev mnenj in gradbenega dovoljenja (DGD)/*Design Documentation for obtaining opinions and building permits*,

- Projektna dokumentacija za izvedbo gradnje (PZI)/Desing Documentation for Construction,
- Projektna dokumentacija izvedenih del (PID)/As Built Documentation.

The content and scope of the design documentation for each phase shall be as specified in Gradbeni zakon (Uradni list RS, št. 199/21, 105/22 – ZZNŠPP in 133/23)/ *Building Act (Official Gazette of the Republic of Slovenia, No. 199/21, 105/22 – ZZNŠPP and 133/23)* and Pravilnik o projektni in drugi dokumentaciji ter obrazcih pri graditvi objektov (Uradni list RS, št. 30/23)/*Rules on documentation and forms related to construction (Official Gazette of the Republic of Slovenia, No. 30/23)*.

Design documentation shall be prepared in the metric system, in the standardized measurement system SI.

7.4.2 Architectural Design Requirements

7.4.2.1 Building Design

New buildings shall comply with spatial and functional requirements of the Contractor's technology as well as with architectural design of the existing buildings in the Podlog Substation. Typical existing building designs in the Podlog Substation are shown in the following figures.

Figure 8: Existing Warehouse Shed

Figure 9: Existing Relay Houses

Both typical buildings are single-story buildings with a rectangular footprint, the aspect ratio of the larger Warehouse Shed is 1:2.
The ceiling height in both typical buildings is determined by the technological equipment requirements.
Primary bearing structure of the Warehouse Shed is a steel spatial frame structure with reinforced concrete parapet wall, column foundations and ground floor slab. Profiled trapezoidal metal sheeting is used for facades and roof.
Primary bearing structure of the Relay House is a reinforced structural wall system with reinforced concrete strip foundations and reinforced concrete ceiling and ground floor slab. A double floor of 60 cm in height is constructed in the Relay Houses.

The above-see-level of the final floor in the buildings (double floor in Relay Houses, ground floor slab in the Warehouse Shed) is raised approximately 50 cm above the ground level for protection against potential flood (above-see level minimum 275.29).
Access to the buildings is provided through reinforced concrete ramps.

The heights of the buildings are technologically determined.
The roof of the smaller relay house is a gable roof with a wooden roof structure and a slope of 12°. The roof of the larger warehouse shed is an asymmetrical gable roof.

Requirements for basic architectural elements that shall be used for SSSC building design are provided in the following chapters.

7.4.2.1.1 Facades

Buildings shall be designed to visually connect with the existing buildings in the Podlog Substation.

Buildings shall also be illuminated with natural light, at least through windows above the entrance doors.
If the Contractor's technological design allows, additional windows shall be considered. Additional windows shall be elongated and aligned in both width and height with the windows above the doors. The windows shall consist of two segments: an opening segment and a fixed segment. The dimension of the opening segment shall be the same as the window above the doors, and the fixed segment shall be at least as large as the opening segment. Windows for larger-sized buildings shall be located on the entrance facade in the area under the eaves. They shall have a vertical shape, aligned in height with the entrance doors, and shall be without a windowsill.

Buildings shall be thermally insulated with 20 cm of stone wool thermal insulation, suitable for the selected type of final cladding. To ensure design consistency with existing designs, two facade types are allowed, while the base of the building facades, at least 50 cm high, shall be uniform and made of factory-prepared polished concrete panels.
For smaller buildings (Relay House), the facade shall be made of facade plaster in a brick-orange tone. The facade shall be protected by eaves.
For buildings with larger floor plan dimensions, a larger part of the facade shall be covered with panels made of profiled trapezoidal sheet metal in a brick-red colour (matching the colour of existing roofs in the Podlog Substation), and an eave is required along the entire entrance facade. The entrance facade shall be made of facade plaster in a grey tone. The shorter, side facades shall be aligned with the eave roof cap.
The steel facade shall be properly grounded.

Facade claddings shall be made of weather-resistant and durable materials. Materials shall visually complement each other. All materials and installation details shall be presented to the Client before implementation.

Figure 10: Perspective views of the entrance facade enclosed with an eave and side facade walls

7.4.2.1.2 Roof

The roof of smaller buildings (Relay House) shall be gabled with a wooden roof structure and a slope of 12°, featuring an eave extending a minimum of 35 cm from the edge of the final facade cladding. The roofing shall consist of trapezoidal sheet metal with anti-condensation treatment in

brick-red colour (matching the existing roofs in the Podlog Substation). All edges and details must be coordinated with the existing Relay Houses in the Podlog Substation.
The roof of larger buildings shall be asymmetrically gabled. The roof overhang shall have a steeper slope at 45°, while over the enclosed technological part of the building, the roof slope shall be 10°. Except for the entrance facade, all other facades shall be without overhangs.

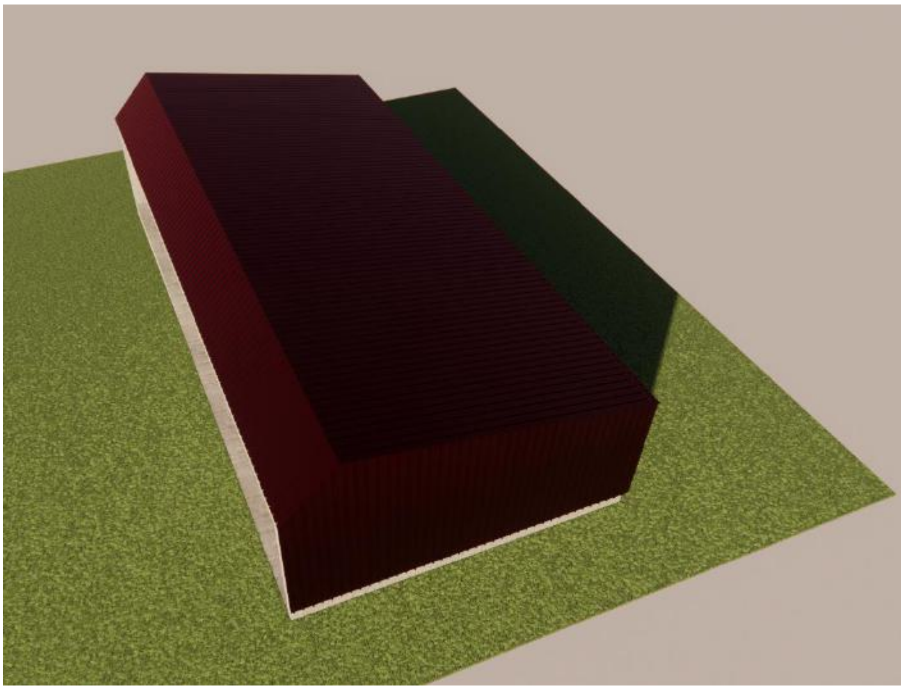


Figure 11: Perspective view of the asymmetric roof

7.4.2.1.3 Materials

External walls, roof, floors, and building fixtures shall comply with regulations regarding moisture protection[1]. The thermal insulation of the building shall be designed in accordance with the requirements of building physics[2].

Internal walls shall be treated and levelled with levelling compound and finished with appropriate paints and coatings of sufficient durability (e.g., latex paint).

Floor surface materials shall meet the technological requirements of individual rooms, including slip resistance, mechanical resistance, load-bearing capacity, and aesthetic considerations.

In rooms where technological requirements dictate, a raised double floor shall be installed. The double floor construction shall have the following characteristics:

- dustproof coating on the (lower) concrete surface,
- galvanized metal stands approximately 60 cm in height, with a floor load capacity of up to 7 kN,

[1] Pravilnik o zaščiti stavb pred vlago, Ur. l. RS, št. 29/04, 61/17 in 199/21
[2] Pravilnik o učinkoviti rabi energije v stavbah, Ur. l. RS, št. 52/10, 161/22 in 129/23

- load-bearing particleboard, entirely clad in galvanized steel sheet; a galvanic connection with the floor's supporting structure shall be ensured, with board dimensions of 600 x 600 x approximately 39 mm,
- electrostatic dissipative/antistatic rubber covering ($10^6 \leq \Omega \leq 10^8$).

The external sidewalk under the overhang shall be made of concrete, with a textured finish.

Facade windows shall be made of thermal-insulating aluminium profiles, powder-coated according to the RAL colour chart.
The glass for window glazing shall be insulating and of the following quality:

- thermal conductivity U_s = 0.50 W/m^{2}K
- total thermal conductivity $U_w \leq 0.9$ W/m^{2}K
- windows shall meet acoustic requirements R'_w=45 dB.

All windows shall be grounded without drilling through the window, using a standard grounding conductor.

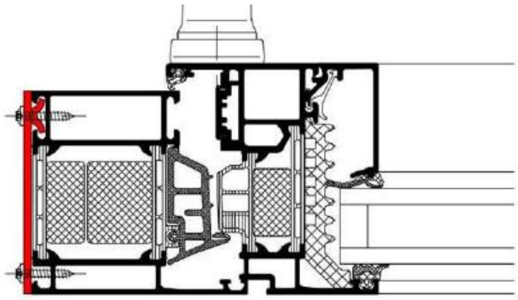


Figure 12: Window frame grounding detail

All assembly joints and finishes of windows and external doors shall be protected to prevent thermal bridging and ensure adequate protection against moisture (waterproof, vapor-permeable foils, thermal insulating PUR assembly foam (RAL installation), waterproofing tapes under windowsills, etc.).

External doors shall be of metal construction. The door leaf shall be filled with rigid mineral wool, with sheet metal adhered on both sides across the entire surface. Door frames shall be made of galvanized sheet metal, painted according to the RAL colour chart. The 6.8 cm thick door leaves shall be surrounded by galvanized sheet metal 1 mm thick and powder-coated according to the RAL colour chart, aligned with the door frame. All doors shall be equipped with identification plates and concealed self-locking mechanisms. Door and window characteristics shall also comply with the requirements of the Fire Safety Study, which is an integral part of the design documentation and shall be prepared by the Contractor.
All design and execution solutions shall be systematic, provided by the selected door supplier. All doors on evacuation routes shall be equipped with handles, in accordance with standard SIST EN 179.

All selected materials must comply with building product regulations[3] and sustainability requirements for buildings[4,5].
A Fire Safety Study must be conducted for the building. All selected materials must meet the fire safety study requirements for the used building products.

7.4.3 Structural and Civil design Requirements

7.4.3.1 Structural Systems and Construction Materials

The selection of structural systems and construction materials shall, to the greatest extent possible, be based on the existing structural systems and materials in the Podlog Substation.

For primary structural systems in the design of buildings, the following structural systems and materials shall be used:
• structural wall or structural wall-frame systems made of reinforced concrete,
• structural wall-frame systems made of reinforced concrete and steel (frames), or
• structural wall systems with vertical and horizontal ties or reinforced masonry in the case of multiple floors, or
• spatial frame systems made of reinforced concrete or steel.

Floors and ceilings shall be made of reinforced concrete, constructed on-site or prefabricated, or composite in case of steel frame systems.

Secondary structures (roof substructures, facade substructures, etc.) shall me made of steel or structural wood.

Typical structural systems for buildings in the Podlog Substation are shown in the following figures.

[3] According to the list of valid Slovenian standards, which are default harmonized standards for building products (the list is based on the publication in the Official Journal of the EU, the valid list is published on the official IZS website)
[4] Construction Products Act (ZGPro-1), Official Gazette RS, no. 82/13
[5] Technical Requirements for Products and Conformity Assessment Act (ZTZPUS-1), Official Gazette RS, no. 17/11 and 29/23

Figure 13: Steel Canopy for Vehicles during construction

Figure 14: Warehouse Shed during construction

Figure 15: Relay House during construction

Foundations for all buildings shall be made of reinforced concrete. The type of foundation system (shallow or deep) shall be determined based on the results of geological investigations (Chapter 7.3.2).

Anchoring of columns into foundations in concrete and steel frame structural systems shall be designed using cup foundations. For steel frame systems also, pre-installed anchors made of stainless steel may be used.
For single-story systems with smaller footprint dimensions, mechanical or chemical post-installed stainless-steel anchors may be used.

Equipment support structures shall be made of structural steel (carbon or stainless steel if technological requirements dictate). The design of support structures shall, to the greatest extent possible, be based on the existing structural systems for equipment supports in the Podlog Substation:

- cantilever structures made of round seamless or welded pipes, with flanges for equipment anchorage and anchorage to foundations,
- frame structures with columns made of round seamless or welded pipes, with flanges anchorage to foundations, combined with beams or planar frames for equipment support and anchorage.

For equipment support structures pre-installed stainless-steel anchors or post-installed stainless steel anchor bolts (mechanical or chemical) shall be used for anchorage to concrete foundations.

Figure 16: Pre-installed Anchors in Foundations for Equipment Supports

Foundations for equipment support structures shall be made of reinforced concrete. The type of foundation (shallow or deep) shall be determined based on the results of geological investigations (Chapter 7.3.2).

For cable connections of equipment to command, surveillance and other systems in the Podlog Substation solutions that resemble existing ones shall be used to the maximum extent possible (Figure 17).

Figure 17: Typical solution for routing equipment wiring into a cable trench alongside the foundation of the equipment support structure

Foundations for equipment not installed on steel supports (e.g., power transformers, outdoor electrical cabinets, etc.) shall be constructed from reinforced concrete. The type of foundation (shallow or deep) shall be determined based on the results of geological investigations (Chapter 7.3.2).

For equipment with smaller dimensions and weight, either pre-installed stainless steel anchor bolts or post-installed stainless-steel anchors (mechanical or chemical) shall be used.
For larger equipment, either pre-installed stainless-steel anchors or anchor elements with the possibility of subsequent installation of anchors shall be used.

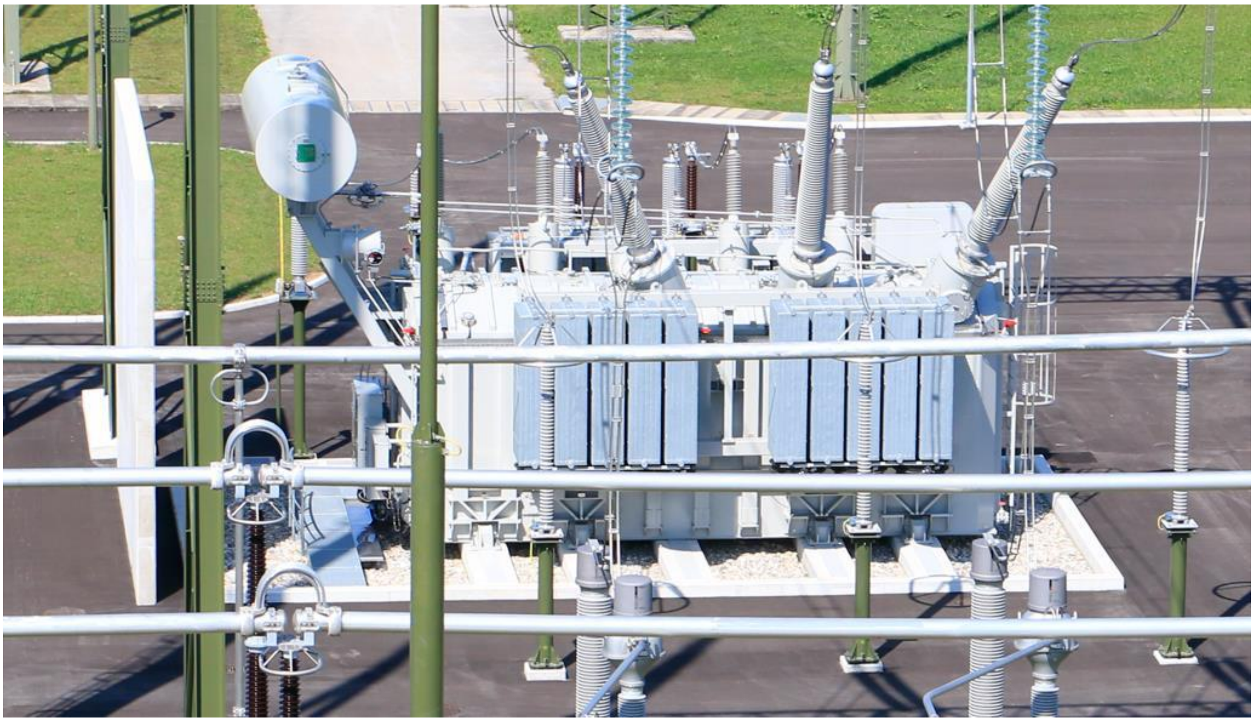


Figure 18: Existing power transformer 400/110 kV foundation

The design of foundations for power transformers (or other equipment with substantial quantities of potentially flammable cooling liquids), it is necessary to provide a fire barrier above the transformer pit. The barrier shall be both liquid-permeable and shall ensure effective extinguishing of burning liquids.
Systems with certified fire resistance and suitability for installation shall be used. These systems shall also be permeable to precipitation and with sufficient certified load capacity to allow safe (slip-resistant) pedestrian access to the equipment (for example: Meiser Stephuit FH grating system or equivalent).

Material specifications in the design documentation shall be defined in accordance with the applicable Eurocode standards, relevant harmonized SIST (EN) standards applicable to the selected material, or standards specified in technical approvals for products without harmonized standards.
For all primary concrete structures, the materials used shall conform to at least execution class 2 according to SIST EN 13670 and its National Annex and for steel structures at least requirements for execution class EXC-2 according to SIST EN 1090-2 shall be assured.

7.4.3.2 Special Requirements for Anticorrosive Protection of Steel Structures

Anticorrosion protection systems shall be equivalent to existing systems, including RAL colour.

Coating systems for steel structures shall comply with Class C3 atmospheric corrosivity according to standard SIST EN ISO 12944-2 and durability Class H according to standard SIST EN ISO

12944-1. The system's suitability and quality shall be demonstrated through test samples and certificates from the manufacturer.

For steel structures supporting equipment and not installed within buildings, zinc wire metallization with a minimum of three coats of paint shall be foreseen. The RAL colour finish coat shall match that of existing steel structures (RAL 6003).
The thickness of the metallized layer shall be at least 120 μm and shall be verified using non-destructive coating thickness measurement methods according to SIST EN ISO 2178. Coating quality shall be tested according to standard SIST EN ISO 2063.
The selected coating system shall adhere well to the metallized surface and shall be resistant to the local climate, defined by atmospheric corrosivity Class C3 and durability Class H.
The primer shall be environmentally friendly (lead-free), the intermediate coat shall have characteristics like the primer but with added micaceous iron oxide (MIOX), and the topcoat shall contain micaceous iron oxide (MIOX), if permitted by RAL colour, for additional enhancement of the anticorrosive properties of the system and resistance to UV radiation.

For building structures and secondary constructions, a hot-dip galvanizing protection system or a system combining hot-dip galvanizing and painting may be used.
The hot-dip galvanizing protection system shall meet the requirements of standards SIST EN ISO 1461 and SIST EN ISO 14713.
The coating thickness shall meet the requirements for atmospheric corrosivity Class C3 according to standard SIST EN ISO 12944-2 and durability Class H according to standard SIST EN ISO 12944-1.

In the hot-dip galvanizing and painting protection system, the primary protection shall be provided by hot-dip galvanizing according to the requirements of standards SIST EN ISO 1461 and SIST EN ISO 14713.
An additional layer of protection through painting is applied to the hot-dip galvanized surface. The selected coating system shall adhere well to the freshly galvanized surface and be resistant to the local climate, defined by atmospheric corrosivity Class C3 according to standard SIST EN ISO 12944-2 and durability Class H according to standard SIST EN ISO 12944-1.
Unless otherwise specified in requirements for architectural design, RAL 9006 is used for primary and secondary building structures.

7.4.3.3 Requirements for Analysis and Verification of Structures

All structures shall meet the essential requirements specified by the Construction Act (Official Gazette of the Republic of Slovenia, No. 199/21 and 105/22 – ZZNŠPP) and the corresponding Regulation on the Mechanical Resistance and Stability of Structures (Official Gazette of the Republic of Slovenia, No. 101/05, 61/17 – GZ, and 199/21 – GZ-1).

The fulfilment of essential requirements shall be demonstrated through computational analyses. Input data, analysis models and methods, loads and load combinations for all limit states, as well as results, shall be described in technical documents that are an integral part of the Design Documentation for Construction.

According to the Regulation on the Mechanical Resistance and Stability of Structures (Official Gazette of the Republic of Slovenia, No. 101/05, 61/17 – GZ, and 199/21 – GZ-1), the fulfilment of essential requirements for mechanical resistance and stability and fire resistance can be achieved by design in accordance with the principles and rules of Eurocodes (SIST EN 1990, SIST EN 1991 to SIST EN 1999).
The use of rules from other standards, technical guidelines, or other technical documents is also allowed if, in accordance with the principles of Eurocode standards, it is possible to ensure at least an equivalent level of compliance, with the loads not being less than those specified in accordance with SIST EN 1991 and SIST EN 1998, taking into account partial load factors in accordance with SIST EN 1990.

For supports and foundations of SN and VN equipment, in addition to the above requirements, the fulfilment of essential requirements shall also consider the provisions of standard SIST EN 50341-1, and the corresponding national provisions specified in SIST EN 50341-3-21.

All structures shall be designed to fulfil other essential requirements as well (safety in use, protection against noise, hygiene and health protection, and environmental protection) according to the Construction Act (Official Gazette of the Republic of Slovenia, No. 199/21 and 105/22 – ZZNŠPP).

7.4.3.4 Service and access roads, manipulation areas and Utilities

7.4.3.4.1 Rainwater Sewerage

For the design and planning of clean and waste rainwater sewerage systems, the requirements of the Regulation on the Technical Implementation and Use of Public Facilities and Devices for the Collection and Treatment of Municipal Waste and Stormwater (Official Gazette of the Republic of Slovenia, No. 45/20) shall be fulfilled. The system's capacities shall be designed for rainfall intensity data for the meteorological station in Celje (Figure 19).

Količina padavin (l/(sec*ha))

trajanje padavin	POVRATNA DOBA							
	2 leti	5 let	10 let	25 let	50 let	100 let	250 let	
5 min	254	340	398	470	523	576	646	l/(sec*ha)
10 min	189	255	298	354	394	435	489	l/(sec*ha)
15 min	160	223	265	318	358	397	448	l/(sec*ha)
20 min	139	195	233	280	316	351	397	l/(sec*ha)
30 min	110	160	192	234	264	295	335	l/(sec*ha)
45 min	85	125	152	186	211	236	269	l/(sec*ha)
60 min	69	102	124	152	172	192	219	l/(sec*ha)
90 min	52	75	91	110	124	138	157	l/(sec*ha)
120 min	43	61	73	88	100	111	126	l/(sec*ha)
180 min	32	44	52	62	69	76	85	l/(sec*ha)
240 min	27	35	41	48	54	59	66	l/(sec*ha)
300 min	23	30	35	41	45	49	55	l/(sec*ha)
360 min	20	26	30	35	39	43	48	l/(sec*ha)
540 min	15	20	23	26	29	32	35	l/(sec*ha)
720 min	13	16	19	22	24	26	29	l/(sec*ha)
900 min	11	14	16	19	21	23	25	l/(sec*ha)
1080 min	9	12	14	16	18	20	22	l/(sec*ha)
1440 min	8	10	11	13	15	16	18	l/(sec*ha)

Figure 19: Rainfall Intensity for the Celje Meteorological Station (source: https://meteo.arso.gov.si/uploads/probase/www/climate/table/sl/by_variable/return-periods/Celje.pdf)

KEY
Količina padavin – Precipitation amount
Trajanje padavin – Precipitation duration
Povratna doba – Return period
Leti/let - Years

Both rainwater drainage systems should be gravity-based. System elements should comply with general requirements in the standard SIST EN 476.

The minimum internal diameter of pipes shall be 150 mm, and the minimum cover height above the pipe invert shall be 80 cm.
The material used for pipes and manholes shall be selected based on purpose, load, hydraulic requirements, chemical resistance, abrasion, and an expected lifespan of at least 50 years.

Pipelines shall be made from polymer pipes according to SIST EN 12666-, 1SIST EN 1401-1, SIST EN 13476-2 or SIST EN 13476-3.

For pipelines from pits for equipment containing large quantities of light oil or other potentially pollutant liquids, systems enabling welding of joints on pipelines or tested certified sealing elements resistant to the effects of these liquids shall be implemented.

The minimum allowed pipeline slope shall be 1%. The media velocity in the pipeline shall not be less than 0.5 m/s and not more than 3 m/s.
The pipeline fill coefficient should not be less than 0.1 and not more than 0.7.

Considering the manufacturer's instructions, sewer pipes must be backfilled with non-cohesive material to a thickness that protects the pipeline from mechanical damage and freezing. If the pipes cannot withstand the foreseen load, they should be protected with a concrete lining determined by analysis.

Pipes shall be laid on a sand bed with a minimum thickness of 10 cm. For areas with high groundwater table, the pipes shall be laid on a concrete foundation with suitable covering made of concrete to prevent buoyancy.

The structural rigidity and resistance of the selected pipe type shall be sufficient for all anticipated influences; otherwise, an appropriately sized concrete covering must be provided, demonstrated through a computational analysis.

Inspection manholes shall be positioned at points where there is a change in direction, slope, or cross-sectional profile of the pipeline, and at locations where two or more primary pipelines merge.
A direct connection (without an inspection manhole) of the secondary pipeline to the primary pipeline may be made at a 45° angle in the direction of water flow in the primary pipeline and 45° vertically, above the level of the highest medium level in the primary pipeline.

Inspection manholes shall primarily be located in non-paved or less-loaded paved areas; if not feasible, they shall be located in the middle of the roadway or traffic lane or between tracks.

Maximum distances between inspection manholes are:
• For pipelines up to and including DN400 mm diameter: 50 m;
• For pipelines up to and including DN800 mm diameter: 100 m;
• For pipelines with a diameter greater than DN800 mm: 150 m.

When the height difference between the inlet and outlet pipelines in a manhole is greater than 0.50 m, a cascading inspection manhole shall be provided.

Standard prefabricated manholes made of polymeric materials or precast concrete sewer manholes shall be used in the sewer systems with manufacturer's certified and tested details for manhole structure execution, cover installation, and connections of pipelines to the manhole body.
In areas with high groundwater level, manholes shall be resistant to buoyancy effects (either through the manufacturer's standard solution or a designed measure proven by structural analysis, e.g., concreting, anchoring to an anti-buoyancy base plate, etc.).

Manholes shall be backfilled with non-cohesive material to a thickness that protects the manhole from mechanical damage and freezing. If the manholes cannot withstand the foreseen loads, they shall be protected with a concrete lining of a thickness determined based on structural analysis.

Manholes made of polymeric materials shall be manufactured and tested in accordance with standards SIST EN 13598-1 and SIST EN 13598-2. Nominal internal diameters of manholes shall be determined based on their design depth (minimum 600 mm, 800 mm, or 1000 mm). Concrete manholes shall be manufactured and tested in accordance with standard SIST EN 1917.

Manholes shall enable installation of additional connections in the bottom of the manhole or in the manhole body on-site, regardless of the selected pipe type.

All manhole elements shall have the same wall thickness and be made of the same material.

Manholes and pipelines shall be constructed to be watertight, including the inlets and outlets. Watertightness of the entire system shall be demonstrated by testing according to SIST EN 1610 before backfilling.

The covers on inspection manholes shall be made of cast iron or polymer, with dimensions of 60 cm × 60 cm or Φ 600 mm, and load-bearing capacity according to SIST EN 124-1 and SIST EN 124-2. All covers shall be labelled with "KANALIZACIJA".

The following additional requirements shall also be met for manholes and manhole covers:

- for Class B covers according to SIST EN 124-2, manholes allowing direct installation of Class B covers without additional work shall be provided;
- for Class D covers according to SIST EN 124-2, height-adjustable covers shall be installed on a concrete anchoring ring, transferring the load to the ground around the manhole. The use of levelling rings between concrete anchoring rings and manhole covers is mandatory;
- In flood-prone areas, the manhole cover must be watertight or raised by 0.50 m above the elevation of the 100-year flood level;
- manhole covers located in traffic areas must not pose obstacles (the upper edge of the roadway and the cover shall be level);
- in asphalt surfaces (Class D according to SIST EN 124-2), only covers allowing levelling (self-levelling, telescopic) with the road surface without a concrete collar and adjusting to changes in elevation along with the asphalt surface are allowed.

Sand traps shall be installed in the sewer system wherever it is necessary to prevent the entry of sand and other rapidly settling substances into the system.
They shall be dimensioned to separate rapidly settling substances at the highest possible flow rate. They shall be accessible for maintenance and have a designated method for removing sediments. The material selection for sand traps shall be the same as for inspection manholes in the systems.

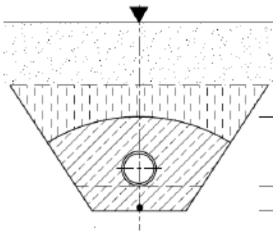
Oil separators (coalescent, gravitational) shall be installed wherever it is necessary to separate light liquids (with a specific gravity less than 0.95 kg/l), when draining rainwater from surfaces where there is a possibility of light liquid pollution.
Oil separators shall be manufactured and dimensioned in accordance with the applicable standards of the SIST EN 858 standard group. They shall be accessible for maintenance and have a designated method for removing separated light liquids.
Oil separators shall have a declaration of conformity with standards and a report of standard testing results.

On systems where there is a risk of large oil spills (e.g., sewer lines draining power transformer pits or similar), only bypass-free oil separators may be installed; on systems for other potentially contaminated surfaces, the installation of separators with bypass is permissible.
A manhole with a suitable type of valve shall be installed on the system before connecting to the oil separator, providing protection for the oil separator in case of a large oil spill. The selected valve type shall enable remote operation and control.
New rainwater systems may be connected to existing systems in the Podlog Substation, provided that the capacity of existing systems is sufficient, which shall be demonstrated by the Contractor in a hydraulic analysis, which shall be an integral part of the Design Documentation.
If connections to existing systems are not possible, the outlet of clean and treated wastewater from the system shall be directed to a drainage ditch running along the southern and partially along the southwestern edge of the Podlog Substation. The outlet head of the system in the ditch shall be equipped with a non-return cover.

7.4.3.4.2 Underground electrical systems

In the design of low-voltage cable ducting, in addition to the requirements specified in the electrical design documentation, the provisions of Regulation on Minimum Technical Requirements for the Construction, Operation, and Maintenance of Low-Voltage Power Lines (Official Gazette of the Republic of Slovenia, No. 21/20), along with the Client's guidelines and, where applicable, requirements from technical guidelines GIZ-TS-13, Electrical Cable Ducting, issued by the Economic Interest Grouping for the Distribution of Electric Energy (GIZ-TS-13-Electrical-Cable-Ducting.pdf (giz-dee.si)).

For low-voltage installations, ducts made of buried/concreted protective pipes shall primarily be used. If such solutions are not feasible, reinforced concrete channels (constructed on site or prefabricated) shall be used.



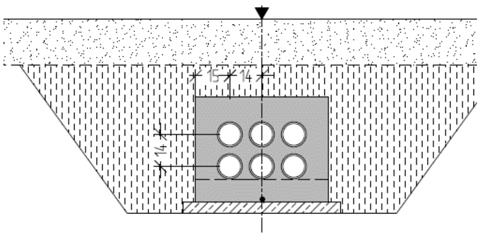


Figure 20: Typical Cross-Sections of Conduit Cable Ducts

Conduits shall be manufactured in accordance with SIST EN 61386-24. The selection of conduits in the design shall follow requirements for their nominal tensile strength based on the foreseen loads and temperature resistance as required by the electrical design documentation.

In areas with high groundwater level, cable conduits shall be appropriately protected against buoyancy effects. These measures (e.g., concrete encasement) shall be demonstrated/verified through analysis.

Manholes shall either be made of reinforced concrete (constructed on site or prefabricated), or prefabricated polymeric manholes shall be foreseen.
Suitability of reinforced concrete manholes constructed on-site shall be demonstrated by a computational analysis as outlined in Chapter 7.4.3.2 for buildings and structures.
Prefabricated manholes shall have their suitability for installation either proven with certificates or through the Supplier's design documentation.
In areas with high groundwater level, manholes shall be designed to resist buoyancy effects.

Manholes shall be placed at all changes of directions and at all connections. Distances between manholes shall not exceed 50 m. The designed distance between two consecutive manholes shall also be verified by the executability of electrical installation works.

All manholes shall be equipped with appropriately sized access openings and, if necessary, comply with the requirements for the execution of electrical installation works.
In paved areas, cast iron covers of the appropriate load class according to SIST EN 124-2 shall typically be provided, while in unpaved areas, access openings can also be equipped with covers made of polymeric materials, equipped with lifting handles.
The dimensions of polymeric covers on larger openings shall also allow individual opening. In flood-prone areas, covers must be watertight or raised at least 50 cm above the elevation of the 100-hundred-year flood water level.

Manholes of larger depths (more than 1.5 m) shall be equipped with fixed ladders for access. Ladders and inspection openings in such manholes shall be positioned to prevent damage to cables laid in the manholes.

For concrete channels constructed on site their suitability shall be demonstrated by a computational analysis as outlined in Chapter 7.4.3.2 for buildings and structures.
Prefabricated channels shall have their suitability for installation either proven with certificates or through the Supplier's design documentation.
In areas with high groundwater level, channels shall be designed to resist buoyancy effects.
In paved areas with heavy traffic loads the channel covers shall be designed to withstand all expected traffic loads. If constructed on site, their suitability shall be demonstrated by a computational analysis as outlined in Chapter 7.4.3.2 for buildings and structures. If prefabricated, their suitability for installation shall either be proven with certificates or through the Supplier's design documentation.

In other areas (paved or non-paved) covers made of polymeric materials, equipped with lifting handles may be used.

Typical cable channels and covers in the Podlog Substation are shown in figures below.

Figure 21: Reinforced concrete channels with heavy-duty concrete covers (designed for traffic loads equivalent to class D400 according to SIST EN 124-2)

Figure 22: Reinforced concrete channels with covers made of reinforced polyester (designed for pedestrian-accessible areas)

For medium- and high-voltage cable systems, in addition to the requirements specified in the electrical design documentation, the provisions of the Regulation on Technical Conditions for the Construction of Underground Power Lines with alternating nominal voltages above 1 kV up to 400 kV (Official Gazette of the Republic of Slovenia, No. 42/21 and 20/22) shall be taken account, as well as the Client's guidelines and, where applicable, requirements from the technical guideline GIZ-TS-19, Construction of Cable Ducts with Single-Core Power Cables 64/110/123 kV, Technical Guideline for Material and Construction, Economic Interest Group for the Distribution of Electrical Energy (GIZ-TS-19-Single-Core-Power-Cables-64-110-kV.pdf (giz-dee.si)).

For medium- and high-voltage cables, cables are primarily laid into an appropriately specified sand backfill or in conduits, either encased in concrete or laid in sand backfill.
The same requirements apply to conduits as for low-voltage cables.
In areas with a high groundwater level, cables or conduits with cables shall be adequately protected against buoyancy effects.

7.4.3.4.3 Requirements for paved surfaces

Service and access roads, as well as manipulation and maintenance platforms, shall be constructed using asphalt, reinforced concrete, or lean concrete.
For design, relevant valid technical specifications for public roads, accessible at the following link, should be considered: Information and guidelines for the professional public in the field of road infrastructure | GOV.SI.

The design of the subbase for paved surfaces shall comply with the specified guidelines and shall be based on the results of geological and hydrological investigations (Chapter 7.3.2).

For surfaces with pedestrian access only, prefabricated concrete slabs or pavers may be used. Asphalt or reinforced concrete may also be foreseen.

Typical existing solutions for paved surfaces in the Podlog Substation are shown in the following figures.

Figure 23: Asphalt service and access roads and platforms

Figure 24: Reinforced concrete equipment service and access platform

7.4.4 Fencing of outdoor equipment

SSSC equipment not installed in a building shall be fenced with a system of stainless-steel posts, connected with a steel chain, which also provides earthing connections for the fence (Figure 25).

Figure 25: Outdoor equipment fence

7.4.5 Survey Documentation for the Design phase

The Contractor will prepare all required survey documentation for the design phase (preparation of design documentation).
In this process the Contractor may use the survey plan already prepared by the Client, which is an integral part of the Tender documentation (attached in Chapter 9, R4PO01-6E1009) and shall be provided to the Contractor in digital format (dwg) on his request.

Surveying documentation for the design phase shall be prepared according to the requirements in Geodetic Plan Regulation (Official Gazette of the Republic of Slovenia, No. 40/04).

7.4.6 Requirements for Electrical Installation Systems

During the design phase, compliance with the technical guidelines for Low-Voltage Electrical Installations TSG-N-002:2021 is mandatory, as mandated by the "Regulation on Requirements for Low-Voltage Electrical Installations in Buildings" – Official Gazette of the Republic of Slovenia, No. 140/21, and the technical guideline for Protection against Lightning TSG-N-003:2021, as mandated by the "Regulation on the Protection of Buildings against Lightning" – Official Gazette of the Republic of Slovenia, No. 140/21.
Also, the technical guidelines for Fire Safety in Buildings TSG-1-001-2019 and Energy Efficiency in Buildings TSG-1-004-2022 shall be considered.

7.4.6.1 Lighting

General and emergency lighting shall be implemented in all buildings. When planning general lighting, adherence to applicable standards and recommendations, as well as criteria from the Slovenian Lighting Society regarding lighting design, is mandatory.
In technical and dedicated rooms, lighting activation should be provided through switches located at the doors. In auxiliary and transitional rooms (stairs, hallways, etc.), light activation should be via presence sensors with adjustable delay settings.

Emergency lighting must include safety and standby lighting, in accordance with Technical Guideline TSG-N-002:2021. In the event of a general lighting failure, it is intended for essential illumination of rooms and exit routes. Additionally, it should illuminate safety signs and fire safety or emergency equipment along the exit route, such as hydrants, fire extinguishers, manual fire alarms, the main electrical distribution panel, and first aid equipment.

Emergency lighting must comply with SIST EN 1838, SIST EN 50171, SIST EN 50172, and SIST EN 60598-2-22.

For access and service roads, external lighting is required, controlled according to the Client's external lighting control concept.

7.4.6.2 Electrical Installations Sockets and Electrical Connections

Power electrical installations must include single-phase sockets 16 A, 230 V, AC, single-phase sockets 16 A, 230 V, AC in parapet ducts for general power supply, three-phase sockets 16 A/32 A, 400 V, AC, and fixed electrical connections 230 V, AC, and 400 V, AC.

Technological spaces should have single-phase and three-phase sockets for technological needs, connecting all technological devices and equipment specified by the client and machinery equipment installations.

7.4.6.3 Universal Wiring

The universal wiring system must support both telephone and computer connections. Full compliance with standard SIST EN 50173:2000 is required, enabling the acquisition of a Class E certificate for adequate data transfer capacity to each workstation or data socket. In areas where installation distribution is planned in parapet ducts, dual compartment with metal separation must be used for electrical, telecommunication, and computer wiring.

7.4.6.4 Fire Alarm System

The fire alarm system must include combined multi-sensor detectors and manual fire alarm detectors according to the Fire Safety Study.

Fire signalling should include acoustic and visual indicators activated during an alarm. Fire detectors should be installed in double mounting floors or suspended ceilings, with additional parallel visual indicators. The entire fire alarm system must have the necessary certificates and undergo inspection by authorized technical inspectors, providing a certificate of flawless operation of the installed active fire protection system, following the Regulation on the Control of Installed Active Fire Protection Systems (Official Gazette of the Republic of Slovenia, No. 53/2019).

The automatic fire alarm system must be compatible with the existing system currently installed on the premises.

7.4.6.5 Intruder Alarm System

To control unauthorized entry during non-working hours, the installation of an intrusion detection control panel with its own backup power supply is required. Additionally, the central unit should operate as multiple independent alarm systems.

Internal space protection should use automatic motion detection with motion detectors employing combined PIR+MW technology. These detectors should allow for delayed operation, providing sufficient time for entry or exit and enabling or disabling security. A keypad should be provided at the entrance for employee or security personnel security activation or deactivation.

The intrusion detection system must be compatible with the existing system currently installed on the premises.

7.4.6.6 Access Control System

Access control is implemented to restrict personnel access to certain areas effectively and independently. Essential areas must be protected with access control. The access control information system must include contactless card reading. It should also include a central unit and other necessary equipment such as card readers, electric door openers, communication interfaces, etc.

Terminal connections should be established through a communication line connected to the local computer network via communication interfaces.

Identification or selection of individuals must be accomplished with a personal ID card at various control points (doors, passageways) on contactless card readers. The access control system must be compatible with the existing system currently installed on the premises.

7.4.6.7 Video Surveillance System

The video surveillance system provides additional monitoring of critical locations inside and outside the building and must comply with the Private Security Act /ZZasV-1/ (Official Gazette of the Republic of Slovenia, No. 17/2011) and the Personal Data Protection Act /ZVOP-2/ (Official Gazette of the Republic of Slovenia, No. 163/2022).

The complex must be equipped with a video surveillance system to monitor, record, review, and archive visual information. The concept should be based on closed-circuit television (CCTV) enhanced with IP technology.

For monitoring, static/dynamic IP cameras with a resolution of 2-4 Megapixels, with the option of Power over Ethernet (PoE), should be used. Cameras exposed to adverse weather and/or mechanical influences must be installed in weather/corrosion/UV-protected and thermally heated housings with the appropriate IP protection rating.

The integration of all IP-based video surveillance devices must connect to a dedicated local computer network, separated from all other networks.

The video surveillance system must be compatible with the existing system currently installed on the premises.

7.4.6.8 Main and Supplementary Equipotential Bonding

Main equipotential bonding must be achieved by connecting all foreign conductive parts together and with protective grounding. Conductors for bonding the potential of electrical distribution panels and other energy equipment installed in the building, as well as supporting and other metal structures, must be connected to potential rings inside the building.

7.4.6.9 Lightning Protection

The Lightning Protection System (LPS) must be implemented according to the Regulation on the Protection of Buildings against Lightning, with the corresponding technical guideline TSG-N-003:2021. As specified by the Regulation on the Protection of Buildings against Lightning, the Lightning Protection System (LPS) is an integral part of the building, compatible and logically connected with all other devices and installations in the building. The protective level of the building for lightning protection must be determined in accordance with standards SIST EN 62305-1 and 62305-2.

7.5 CONSTRUCTION

Construction planning and execution shall comply with the requirements of applicable laws, regulations, rules, and standards as stated in Chapter 7.2.

7.5.1 Units

The metric system in the standardized SI measurement system shall be used.

7.5.2 Technological Construction Plan and Safety Plan

Prior to construction start, the Contractor shall prepare the Technological Construction Plan, which shall be based on the Design Documentation for Construction prepared by the Contractor.
The Technological Construction Plan shall provide detailed method statements per each type of civil works, technology and materials used in execution, required manpower and timelines.

The Construction Plan shall be prepared in at least two phases:

- Preliminary document with content necessary for the preparation of the Safety Plan according to the provisions of the Regulation on Ensuring Safety and Health at Work on Temporary and Mobile Construction Sites (Official Gazette of the RS, No. 83/05 and 43/11 – ZVZD-1)/ (Uredba o zagotavljanju varnosti in zdravja pri delu na začasnih in premičnih gradbiščih (Uradni list RS, št. 83/05 in 43/11 – ZVZD-1), which shall be provided by the Client;
- Final document, which represents a revision and amendment of the preliminary document according to requirements defined in the Safety Plan.

The Technological Construction Plan for both phases shall be submitted to the Client for approval.

The Technological Construction Plan shall, in addition to the requirements of applicable legislation and standards as listed in Chapter 7.2, also consider the requirements and data provided in Chapter 2 (R4PO01-6E1002) of this tender documentation.
Technology selection, method statement preparation, civil works and construction site organization shall also consider additional requirements arising from spatial and safety limitations due to work within an existing and operational power facility as follows:

- The maximum dimensions of vehicles and machinery for work in the 110 kV switchyard must not exceed a height of 3.8 m to ensure the prescribed minimum safety distance to live parts.
- The maximum dimensions of vehicles and machinery for work in the 110 kV switchyard must not exceed a width of 2.5 m to ensure adequate clearances from device bases.
- Vehicles and machinery must be in the basic transport position during all movements in the switchyard.
- All machines, devices, equipment, and tools (working equipment) used on this site must have valid certification in accordance with Article 19 of the Occupational Safety and Health Act (ZVZD-1, Official Gazette of the RS, No. 43/11), provisions of Article 29(1) point 6 of ZVZD-

1 (Official Gazette of the RS, No. 43/11), and provisions of Article 9(1) of the Regulation on Safety and Health in the Use of Work Equipment (Official Gazette of the RS, No. 101/04 and 43/11 – ZVZD-1).

- The individuals responsible for managing the assigned tasks on-site, particularly those responsible for implementing safety measures, must be specified by name.
- Valid proof of worker competence for safe work in accordance with Article 38 of the Occupational Safety and Health Act (ZVZD-1, Official Gazette of the RS, No. 43/11) must be available for all workers.
- In addition to the provisions of the Safety Plan, all special rules of the Client and the responsible facility operator for safe work shall also be considered during construction planning and execution.
- All work outside the fenced construction site area shall be allowed only after the operator/supervisor's written approval.

The content of the Technological Construction Plan shall contain at least the following:

- definition and detailed method statement description all types of works, including measures to meet the requirements of the Safety Plan and the time schedule for the implementation of all specified types of works;
- organization and construction site management, including descriptions of technology and machinery, manpower, safety at work requirements and measures, and a description of actions and measures to restore the construction site area to its previous state.
- descriptions of all materials and products to be used, including the certification and documentation system for compliance with harmonized technical standards or technical approvals;
- definition and description of the quality assurance and control system.
- definition and description of the waste management system and measures for environmental protection (fulfilling at least the requirements of the SIST EN ISO 14001 standard).

In addition to the above, the Technological Construction Plan shall also include relevant appendices, such as material and product certificates, declarations of conformity, the program of test frequency for internal control, reports on initial material tests, certificates of production facilities, etc.

7.5.3 Construction Site Organization Plan

Based on the design documentation for obtaining opinions and building permits (DGD) and design documentation for construction (PZI), the Technological Construction Plan, and Safety Plan, the Contractor shall prepare and submit to the Client the Construction Site Organization Plan.

The Construction Site Organization Plan shall be prepared in accordance with the requirements of valid legislation and the above-mentioned design documentation, as well as the requirements of the Construction Site Regulations (Official Gazette of the RS, No. 55/08, 54/09 – corr., 61/17 – GZ, and 199/21 – GZ-1).
The Construction Site Organization Plan shall be submitted to the Client as a mandatory attachment to the construction start application.

7.5.4 *Physical security of the construction site outside working hours*

The Contractor is obligated to ensure physical security of the construction site outside working hours. The physical security provider (Contractor or it's Subcontractor) shall meet the conditions stipulated by the Private Security Act ZZasV-1 (Official Gazette of the Republic of Slovenia, No. 17/11). According to Article 3 of ZZasV-1, private security, based on a contractual relationship, is carried out by a commercial company or a self-employed individual who has a registered activity, a valid license, and fulfils the conditions for providing private security in accordance with this law.

7.5.5 *Survey and Survey Report, Survey Support during construction and Survey Plan of the as built state*

For construction phase the Contractor shall provide:

- survey of all buildings, structures, and utilities in accordance with the design documentation for construction (PZI) within his scope,
- survey report for the purposes of construction start application, and
- survey plan of the as built state after construction in accordance with the provisions of the Rules on land survey plan (Official Gazette of the Republic of Slovenia, No. 40/04).

The survey report shall include data on survey coordinates, axes, elevations, and other survey points, information on the building permit under which the surveying was conducted, details about the company and the authorized engineer who performed the surveying, and information about any discrepancies between the actual on-site conditions and the conditions in the building permit.
A sketch of the surveying is also an integral part of the report.

The survey plan of the as built state shall be delivered to the Client in digital format (dwg format).

In addition to the above, for construction needs, the Contractor will provide continuous survey monitoring of the construction, including the arrangement and restoration of all survey points and profiles. Additionally, surveying of the as built state for all buried utility systems shall be performed in concurrence with work progress and prior to the earth works start.

/	/	/	
Sprememba:	Opis spremembe:	Datum spr.:	Podpis:

Investitor: ELES	Facility: RTP 400/220/220 kV Podlog Sistem za regulacijo moči (SSSC) v RTP Podlog
Izdelovalec: IBE, svetovanje, projektiranje in inženiring Ljubljana, Slovenija	Part of facility/system: Supply and Erection of Flexible Serial Compensation – SSSC in Podlog SS
/	Type of design: TECHNICAL SPECIFICATION

	Ime in priimek:	Ident. št.:
Approved by:	mag. Marko Testen, univ. dipl. inž. el.	E-1293
Confirmed by:	mag. Marko Testen, univ. dipl. inž. el.	E-1293
Checked by:		
Designed by:	Damjan Lenarčič, univ. dipl. inž. el.	E-0076
11.2023		

Title of document:

8. IMPLEMENTATION

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8. IMPLEMENTATION

8.1 ORGANIZATIONAL REQUIREMENTS

8.1.1 Schedules

8.1.1.1 Schedule in the tendering phase

The Tender must be accompanied by a schedule harmonized with the requirements of the Tender document and in which the Tenderer will show the main stages of the implementation of the dimensioning, design, manufacture and installation of the offered device. The schedule will include activities from signing the contract to the launch and must cover at least the following activities:

- Studies that are required to demonstrate the suitability of the proposed solutions and are needed prior to ordering the equipment are requested in other parts of this document;
- Production of equipment. Every component with a long delivery date must be shown as a separate task and contain following separate sub-tasks:
  - Planning and Manufacturing Equipment
  - Factory tests, factory acceptance tests
  - Packing and transport
- Installation of equipment. Important assemblies ((VSC, serial transformer, HV and MV equipment, C & P equipment, auxiliary supply equipment, etc.) must be displayed as separate tables;
- Commissioning;
- Construction work:
  - Preparation of construction Site,
  - Demolitions if any,
  - Construction of a building if needed,
  - Construction of the foundation of the serial TR and foundations and supporting constructions for outdoor devices,
  - Construction of sound-proof structures, if they are needed,
  - Construction and rebuilding of existing cable ducts.

8.1.1.2 Schedules in the implementation phase

After signing the contract, the Contractor will prepare a detailed general schedule/Master plan within 4 weeks, which will show separately each study activity, project activity, the order, the production of each component of the equipment, its testing and field installation and field tests, the preparation of documentation for construction work and for their implementation. In all activities, the terms for reviewing and validating documentation from the subscriber will also be displayed.

For the individual stages of the implementation of the activities, the detailed plans for the production of equipment will be elaborated within the deadlines foreseen in the general schedule, which will be harmonized with the general schedule. The contractor will have to submit an updated forward schedule every 4 weeks indicating the actual progress of the works on the contract and

proving that the delivery deadline has not changed.
Six weeks before the start of the tests, the Contractor will also prepare Testing procedures/protocols and Master test plan, which will show the final phases or testing and taking over of individual equipment. The minimum activities to be covered by the Master test plan are covered in point: “Master Test Plan (MTP)”.
All schedules in the implementation phase will be subject to confirmation by the client.

8.1.2 Meetings

During the Project implementation phase, meetings will be held that will include the Employer, the Contractor and the Contractor's subcontractors over the entire Contract implementation period. Meetings, which may be teleconferencing, meetings with the manufacturer, meetings with the Employer and field meetings at the time of construction, will be indicated. The Contractor will be responsible for the convening and reporting of these meetings. Frequency of meetings in Studies phase, production of equipment phase and site implementation phase must be evident from general schedule/Master plan.
Contractor must provide the suitable meeting space (containers) within the substation with all the necessary equipment (heating, cooling, tables, storage for documentation, power supply, TV on stand and computer for presentation, etc.).

8.1.3 Contractor’s Personnel

All members of the Contractor’s personnel who have functional contact with the Employer shall have good command of spoken and written English.

8.1.4 Collaborative Engagement for Simulations, Testing, and Design

8.2 AT LEAST TWO ELES ENGINEERS MUST BE FORESEEN TO ACTIVELY PARTICIPATE IN SIMULATIONS, TESTING, AND DESIGN ACTIVITIES WITH THE MANUFACTURER. ELES WILL COVER ALL ASSOCIATED COSTS, AND FROM THE SELECTED CONTRACTOR IS EXPECTED TO FACILITATE THESE ACTIVITIES.ERECTION WORKS AND ERECTION SUPERVISION

8.2.1 Civil works

Civil works as required per Contractors design (buildings, foundations, steel support structures, etc) shall be performed as required in Chapter 7 (R4PO01-6E1007).

8.2.2 Erection works

The erection of the supplied equipment shall be performed by skilled Contractor’s personnel. Reference lists shall be submitted for key staff which is going to be involved. The program of the erection work shall fit in with the general implementation time schedule.

The erection comprises all equipment handling, i.e. transport to the Site, installation, assembly and testing upon completed erection, insurance as well as all other works necessary for the

Employer to obtain the equipment in such a condition which assures normal, safe and reliable operation.

The Contractor shall visit the Site and obtain all information on the conditions on the Site. The Contractor shall have no additional requirements to the Employer due to the lack of any information on the Site.

The Contractor shall organize and perform the erection work without disturbing the operation of the existing equipment to the least possible extent. In the event of interfering with the erection work into the area of operating equipment, the Contractor shall previously inform the Employer and acquire his permission.

Within the scope of the erection work on the Site, the Contractor shall be responsible for:

1. Observance of all applicable regulations regarding safety on Site to ensure the safety of his staff, of the neighboring buildings as well as of the building itself, the Works, installations, equipment and materials.
2. Compliance with the documents on the basis of which the Site permit and building permit have been obtained.
3. Execution of the Works according to the construction drawings, technical regulations and standards in force for construction of such plants.
4. Collaboration with the Employer in Site organization.

The Contractor shall co-ordinate the erection work with the general implementation time schedule of the Employer, with the erection works of other equipment Suppliers and with the civil work Contractor.

In performing the erection works, the Contractor shall take into consideration all labor regulations currently in force in Slovenia (health and safety regulations, safety at work, fire protection, etc.).

The Employer shall ensure that first aid facilities are available on the Site all the time.

The Contractor shall be responsible for all administration matters related to the use of working appliances, employment of Contractor’s personnel on the Site and outside the Site. The Contractor shall also bear the costs.

Prior to the commencement of the erection work the Contractor shall establish whether the scope of the works performed so far meets the time schedule. The Contractor shall hand over to the Employer one copy of the protocol on the previously performed works taken over.

The Contractor shall be responsible for the order and cleanness on the Site. Surplus material shall be taken to a disposal Site. Until the Technical Inspection at the latest the Contractor shall clear the Site and remove all surplus materials and rubbish, appliances, tools, etc.

According to regulations in force in the Republic of Slovenia related to the safety at work (and based on Directive 92/57/EEC), the Employer shall prepare Safety and Health Plan. Prior to the commencement of the works, the Contractor shall sign an agreement with the Employer and other participants regarding the safety precautions on the Site.

The Contractor shall maintain a daily log on the erection progress in compliance with the Construction Act. (GZ)

The Contractor shall supply all the materials for connecting individual parts of the equipment, such as: cables, wires, bus bars with iinsulators, steel structures, etc. The Contractor shall supply all auxiliary materials for the erection, such as: oxygen, acetylene, argon, oil, grease, cleaning agents, compressed air, electrodes and other welding materials, materials for supporting and leveling and other auxiliary materials, such as: pouring and brazing materials, cable clamps, fine materials for erection, wiring, screws, etc.
Sealing of cable passages in cable ducts between spaces of different fire sectors, and between the building and external cable ducts, must be implemented with products of renowned manufacturers such as Roxtec or equivalent.

The above materials together with the equipment supplied shall represent the whole necessary package so that no additional supplies by the Employer will be needed.

The erection work also comprises the necessary coatings and other processes required in accordance with the regulations for technical measures and conditions for protection of steel structures against corrosion. This responsibility also applies for all repairs. The quality and thickness of protective coatings shall meet all the requirements of the above regulations, and apart from that, any requirements related to the technological function of individual elements (temperature, heating media, etc.).

The Contractor shall supply and provide all erection equipment and materials, vehicles, tools, tackles, scaffolds, bases, etc.

8.2.3 Erection supervision

The Contractor shall organize the erection supervision which has to assure that:

1. the erection will be performed in compliance with the design and the requirements for quality assurance,
2. the erection will be performed by skilled workers,
3. only the materials the quality of which has been proved will be used in the erection,
4. all the required checks and tests will be carried out,
5. suitable handling of the equipment on the Site will be provided,
6. safety at work will be assured,
7. erection will be performed according to the time schedule,
8. erection will be performed in accordance with the building permit.

Erection Supervisor will currently check the erection work and regularly submit the protocols on the checks performed to the Employer. Erection Supervisor will take part also in equipment testing and commissioning. The erection shall not be completed and the plant shall not start-up without an approval from the erection Supervisor.

The Contractor shall be represented on the Site by an Site manager or in his absence by his representative from the commencement of the civil and erection works till completion and issuing of the Taking-Over Certificate. The Contractor's representative on the Site may decide about the erection only within the contractual provisions. The Site manager shall be qualified and acquainted with the current legislation and safety regulations.

8.3 QUALITY ASSURANCE

8.3.1 Quality assurance system

Four weeks after signing the Contract, the Contractor shall submit to Employer QA project manual, which is a matter of Employer's approvement.

Without limiting the Contractor's obligations the Contractor shall have available a quality assurance system, by which it can be shown and determined that the requirements of the Contract will be complied with. The quality assurance system shall comply with the latest revision of ISO 9001. The Employer has the right to perform assessments on the quality assurance system of the Contractor and/or its Subcontractors, without prior notification.

8.3.2 Quality assurance supervision

The Employer's Representative shall be entitled to supervise or to have supervised quality assurance of the Contractor with respect to the Works in all phases of the project (design, material handling, manufacturing, testing, inspection, construction and erection, commissioning).

The supervision of quality assurance shall be based on quality control plans to be submitted by the Contractor and to be approved by the Employer's Representative. When execution of parts of the Works need high care, the Contractor shall make available also specific procedures if applicable.

Within the Tender, the Tenderer is required to list the subcontractors that will participate in the design, production and construction of the SSSC. For all subcontractors that will produce the equipment, it is also necessary to indicate in which country the equipment is going to be manufactured.

Before ordering the Contractor shall ask for the Employer's Representative's approval.

8.3.3 Quality control plan

Four weeks after signing the Contract, the Contractor shall submit to Employer QC Plan, which is a matter of Employer's approvement.

The quality control plan shall contain the procedure for the release of the design.

The Contractor shall submit a schedule of the release of designs and the considerations for release. These considerations shall deal with the requirements of the Contract. Considerations might be calculations, tests or certificates. The quality control plan shall state what the considerations will be.

The final released designs shall be submitted to the Employer's Representative for approval. The Employer's Representative shall be entitled to review certain items at his initiative and discretion. The information needed for this review shall be made available by the Contractor.

The procedure for ordering and material testing methods shall be shown in the quality control plan.

Before starting erection, the Plant and Materials shall be checked with regard to their dimensions, cleanliness and possible transportation damage. During erection, special attention shall be paid to cleanliness and compliance with the erection instructions.

In case test results or other characteristics of similar Plant and Materials or parts deviate much from each other, the Employer's Representative shall be entitled to reject these components.

8.3.4 Tests

Tests shall respectively be carried out in accordance with the appropriate IEC publications, unless stated otherwise. All tests shall be specified in the quality inspection and test plan and shall have been passed before delivery of the relevant Plant and Materials.

Apart of the requirements listed in below articles tests shall be realized also in accordance with requirements listed in other chapters of this tender document:

- Transformer tests (if applicable),
- HV, MV equipment tests,
- Converter tests,
- Control and protection.

8.3.4.1 Testing of components

Type tests shall be performed on one high-voltage equipment of each type to be delivered. Type tests are not required if the Contractor provides type test reports for the specific equipment, provided the type tests are fully applicable to the specific equipment.

The Employer and the Employer's Representative can witness testing of Plant and Materials (Type, Routine, FAT). The scope and details of Type (if any), routine and FAT tests shall be submitted to the Employer, where after the final scope and details of all testing shall be agreed with the Employer. The Contractor shall give a 28 day advance notification of the date and location of planned tests.

All functional testing shall be executed and recorded on the Plant and Materials installed during the commissioning, under normal and possible fault conditions.

8.3.4.2 SSSC Testing

Inspection and test requirements consist of testing the Works (type and routine tests), Site acceptance tests (SAT) for main components and sub-systems, commissioning tests, performance verification and acceptance tests as well as extended performance acceptance tests. General procedures consist of development and submission of Test Plans to the Employer for review and comments, successful completion of the tests by the Contractor, and submission of test reports by performing each test, in accordance with the requirements of this specification and the General Conditions of Contract.

General procedures include the provision of:

1. Master Test Plan,
2. Specific Test Plans (FAT, type, routine),
3. Site Acceptance Test Plan,
4. Commissioning Test Plan,
5. Performance Verification and Acceptance Test Plan

The scope and details of items (2) to (5) above shall be submitted to the Employer, where after the final scope and details of all testing shall be agreed with the Employer. In addition to the tests called for, the Contractor shall submit proposals for tests to demonstrate the capability of the complete SSSC device to meet the required duty.

The Contractor shall furnish all the necessary labor and test equipment to perform all tests and inspections that are in the Contractor's responsibility.

8.3.4.3 Testing Responsibilities

The Contractor shall perform all testing except for the performance verification and acceptance tests and the extended verification and acceptance tests, which will be conducted by the Employer. All tests that require connection of the SSSC to the Employer's main transmission system (AD 03 feeder) shall be done under the supervision of the Employer and in accordance with the Employer’s safety requirements and operating regulations. Energized system testing shall be kept to a minimum.

The Contractor shall provide energization procedures as a part of the Commissioning Test Plan.

8.3.4.4 Master Test Plan (MTP)

The Master Test Plan shall be in accordance with these Employer’s Requirements including all Annexes, and shall cover all aspects of testing and inspection. The preliminary and detailed MTP shall be submitted to the Employer as specified. As a minimum, the following plant and material shall be included in the Master Test Plan:

1. Capacitors,
2. VSC valves, including sub-assemblies,
3. Valve cooling systems,
4. VSC multiple valve units (MVUs), including structures,
5. VSC Phase units,
6. Reactors,

7. Bushings,
8. Surge arresters,
9. Instrument transformers,
10. Auxiliary supplies and systems,
11. Interlocks,
12. Power circuit breakers, if any,
13. 220 kV equipment, if any:
14. Disconnectors, if any,
15. Outdoor insulators,
16. Serial power transformer, if any,
17. Control, protection and monitoring systems,
18. Control and power cables,
19. Pumps,
20. Pump controls,
21. Heat exchangers,
22. Building,
23. Plant and material supports,
24. Serial transformer foundation with connection to oil pit and with oil separator,
25. Noise barriers if any,
26. Cable conduits.

8.3.4.5 Site Acceptance Tests (SAT)

Tests on completion of erection (after all the plant and material has been installed and set up on Site) shall be carried out by the Contractor in accordance with relevant standards and for the requirements listed below. The Site acceptance test plan must be reviewed by the Employer before any plant and material is installed at the Site. The purpose of these tests is to:

1. Provide the Employer with comparative plant and material data for a benchmark;
2. To verify that no shipping damage has occurred;
3. To verify that the plant and material or system was assembled correctly;
4. To ascertain the plant and material is ready for energized testing.

The Contractor's test engineer shall advise the Employer's Representative at the end of each week which tests he will be performing during the next week (weekly time schedule).

At the time of Site access of the Site supplies (AC and DC) which will be required for the operation, the Contractor shall advise the Employer in writing of the test equipment in order to enable the Employer to provide these supplies or to agree to alternative arrangements if necessary.

All tests shall receive verification by the Employer that the tests have been performed and the results were acceptable. These tests shall include all tests that require joint testing of the Employer and the Contractor.

8.3.4.6 SAT Requirements

All tests that require interfacing to the Employer's plant and material shall be conducted jointly with the Employer’s staff. Tests shall include, but not be limited to the following:

1. Control and protection including remote control and primary injection tests
2. Cable Inspection and Testing
3. Capacitors
4. Capacitor banks
5. SSSC
6. Cooling System
7. HV equipment
8. Identification and Nameplates; Verification of accuracy of nameplate information and application
9. Communication system, including the complete testing of all signals through the Substation Control System Interface
10. SSSC Yard control, protection and indication
11. Substation Auxiliary system including AC and DC inverters

8.3.4.7 Commissioning Tests

The Contractor shall provide experienced test personnel as well as an experienced and competent test engineer to undertake and supervise all the Site commissioning tests on a full time basis. The test engineer shall work in conjunction with the Employer's representatives on Site and shall co-operate at all times with these representatives, particularly in coordinating tests that will involve plant and material supplied under other contracts. The commissioning tests shall only commence after all the SATs have been completed successfully and accepted by the Employer. The Employer reserves the right to act interactively with the Contractor during the testing and the commissioning period.

The Contractor's test engineer shall be available in Slovenia until starting of commercial operation to assist the Employer's Site representatives in carrying out complete operational checks of the overall substation control, protection and tele-control of plant and material including the SSSC. The cost of the Contractor's test engineer remaining on Site for this period and assisting the Employer's Site representatives shall be included in the Contract price.

Commissioning Tests include all tests that require connection of the SSSC to the Employer's main transmission system. Final energization authority and outage coordination will be the responsibility of the Employer. The Contractor shall submit a request for an outage at least 14 days prior to any energized testing. These tests are under the jurisdiction of the Employer's' Grid Control Centre and may be delayed or discontinued if required by the system conditions. All operational tests shall receive verification by the Employer that the tests have been performed and the results were acceptable. Energized system tests shall be scheduled during the week from Monday to Friday, 7:30 am to 4:30 pm unless otherwise agreed or requested by the Employer. The commissioning program shall last at least 1 week per SSSC unless agreed otherwise with the Employer. Final energization shall only commence after all the pre-energization tests have been completed and accepted by the Employer.

If the SSSC shall fail any test and/or modifications or changes are made, the Employer may elect to restart the commissioning tests or request the Contractor to repeat any test without compensation to the Contractor.

The Employer expects to have a group of engineers present at the commissioning tests. As a minimum, the following shall be included as commissioning tests:

1. Verify the SSSC operation at nominal voltage, current, power and frequency;
2. Verify the automatic shutdown sequences and the manual shutdown;
3. Verify the automatic sequences of blocking and unblocking the valves;
4. Verify the performance of the SSSC with normal system conditions and with acceptable line outages;
5. Full load test - maximum continuously injected capacitive voltage for at least 6 hours during the day, followed by maximum continuously injected inductive voltage for at least 6 hours during the day, or until thermal stability is reached, i.e. temperature rises less than 3°C in a period of one hour;
6. Measure the current unbalance in individual phases.;
7. Measure the protection control functions, e.g. current limitation;
8. Other control functions as specified.

8.3.4.8 Performance Verification and Acceptance Tests

After successful completion of all of the SAT and Commissioning Tests, the performance verification and acceptance tests shall be conducted in accordance with the Employer-developed and the Contractor-reviewed test plan. The Contractor shall include a minimum of 2 weeks for the Employer to conduct these tests as part of the Programs.

The system, including transmission lines and shunt devices that are available, will be configured to produce the most severe test condition. In the performance of these tests, the SSSC and protective plant and material shall be required to function in accordance with the requirements detailed in these specifications.

The Contractor will provide test and recording equipment and personnel for conducting the tests. The Contractor will be notified of the type and time that a performance acceptance test is to be performed by the Employer. The Contractor shall have a representative present to act as a technical advisor should test or plant and material problems be encountered. These tests are under the jurisdiction of the Employer’s Grid National Control Centre and may be delayed or discontinued if required by the system conditions. The test program which will be developed by the Employer will include, but is not limited to the following:

1. Scope of tests will be clarified between the Employer and the Contractor during the Offer phase;
2. Performance tests - measurement of the electrical sound at the - RI, and broadband communication frequencies.

If plant and material supplied or systems designed and/or specified furnished by the Contractor fail during the performance verification testing, they shall be repaired and defective parts replaced or redesigned and replaced without any compensation to the Contractor. However, after determination of a major failure and the failure review, it may be necessary to perform additional commissioning and performance verification and acceptance tests to verify that the design meets the intended application.

8.3.5 Provisional Acceptance Certificate (PAC) and Final Acceptance Certificate (FAC)

PAC will be signed by the Employer and the Contractor at the starting date of the Commercial Operation (including eventual "punch list" of minor issues not relevant for commercial operation).

Final acceptance certificate (FAC) will be signed at the end of contract when the punch list is resolved between the Employer and the Contractor.

8.3.6 Health, Safety and Environmental Protection (HS&E) Plan

8.3.6.1 General Standards

Contractor is obliged to consider international and Slovenian Standards and Regulations listed in Chapter 3 general Requirements article 3.3. Legislation, Regulations and Standards

8.3.6.2 Health, Safety & Environmental Plan

Without limiting the Contractor's obligations under the Contract, the Contractor shall prepare a HS&E plan to safeguard health, safety and the environment (HS&E) for the Contractor's Personnel, the personnel of other Parties present at the Site, the general public and the immediate environment of the Works. This HS&E plan shall be submitted for approval of the Employer's Representative not later than 60 days prior to work commencing.

8.4 TRAINING

The Contractor shall provide formal structured training for the Employer's personnel. The training courses shall be comprehensive to enable the Employer to operate and fully maintain the system as offered. The training program shall be structured to include both in-factory and onsite training. The training shall include instruction on theory and hands-on exposure to plant and material. Personnel providing the training shall be well qualified and knowledgeable about the system. The course description, outline and a schedule shall be submitted to the Employer for review and comments 8 weeks prior to the start of classes. Training shall be designed and executed so that all trainees can accomplish all diagnosing, isolating, and repairing of failed components and all routine or special maintenance required to keep the SSSC systems performing at their guaranteed values.

8.4.1 Factory Training Requirements

The personnel attending the SSSC factory testing will be Transmission engineers and technicians specialized on Design, Protection, Telecommunication, Measurements and Control and Maintenance departments.

8.4.1.1 In-Factory Training during Factory Real Time Digital Power System Simulation

Tests

The Contractor will enable the Employer to be present in the preparation and implementation of tests in a real-time digital power system simulation environment.

Training period: to be agreed jointly between SSSC Contractor and the Employer

Number of Trainees: 2 Transmission Engineers

8.4.1.2 In-Factory Training on the Maintenance of SSSC Substation Equipment

Training shall cover but not be limited to the following:

1. Theory of operation and control of the SSSC equipment;
2. Basic equipment design requirement and applicable international standards for electrical testing and test analysis reports;
3. Hands-on training in maintenance of SSSC equipment;
4. Troubleshooting techniques and understanding of the event, alarm and trip signals;
5. All relevant manuals and drawings.

Training period: 1 Week (to be agreed jointly between SSSC Contractor and the Employer)

Number of Trainees: 8 Transmission Engineers and/or Technicians

Focus areas:

1. SSSC Control and protection, including HMI, and SCADA GWS interface;
2. SSSC Power Electronic valves;
3. SSSC Valve cooling system, including SSSC cooling control

8.4.1.3 In-Factory Training on the Maintenance of Protective Relaying and Controller

Training shall cover but not be limited to the following:

1. General theory of all protective relays, controllers and control systems installed in this project;
2. Understanding of the AC and DC schematic of all protective relays and controllers installed in the project;
3. Understanding of the interconnections between various electrical equipment and various schemes. Also how to trace by using means of wire and cable tracing;
4. Be able to conduct an acceptance and routine tests on all relays, controllers and instrument transformers;
5. Be able to conduct functional testing for all protective relays and controllers;
6. Be able to understand all the alarms and indication as a result of mal-operation;
7. Be able to operate and maintain the voltage and current measuring devices;
8. Be able to maintain and operate any signaling equipment involved in this project.

Training period: 1 Week

Number of Trainees: 8 Transmission Engineers and/or Technicians

Focus areas:

1. SSSC Control and protection, including HMI, and SCADA GWS interface;
2. SSSC Power Electronic valves;
3. SSSC Valve cooling system, including SSSC cooling control.

8.4.2 OnSite Training Requirements

The personnel attending the SSSC training can be split into four levels:

Level 1: Orientation training

Level 2: Dispatch Centre operators/controllers

Level 3: Substation operating staff

Level 4: Transmission Engineers and Technicians specialized on: Protection, Telecommunication, Measurements and Control, Maintenance, Operations and Design

The reason for the split training levels is due mainly to the types of jobs and responsibilities each of the above have. The training has therefore to be aimed at a level of understanding comfortable to each grade of the trainee. Therefore, the training for Levels 2 and 3 will be lower with reference to technology and complexity, whilst that for Level 4 will be progressively more difficult. The level of difficulty will be based on the depth of the material presented, what each group must know, and more importantly also be applicable to each person's level of responsibility.

8.4.3 Training Objectives

The trainees shall:

1. Be instructed on the theory, operation, and maintenance of the SSSC hardware and software components to be furnished by the Contractor;
2. Receive instruction in all aspects of the operator/maintenance interface subsystems used in the SSSC system;
3. Receive in-depth instruction on troubleshooting tools available in the controller;
4. Receive an orientation to all the visual problem indicators (lights, LED's, printouts, etc.) followed by a detailed study of the meaning and use of the various tools available in the system to isolate hardware failures.

The training shall include hands-on demonstrations on the SSSC covering routine servicing, testing, adjusting and calibrating, fault diagnosis, use of special tools and instruments and replacement of faulted sub-assemblies.

8.4.4 Training Outline

The training outline shall consist of a list of all the subjects covered in a session. Each subject shall be broken down into items covered for that subject. Each item shall be labeled with the objective or goal of the instruction regarding that item.

8.4.5 Training Schedule

For Level 2 personnel the training shall start at least 4 weeks prior to the first energization of the

SSSC, subject to co-ordination with the Employer.

In all types of training, two sessions shall be held, so that missed class periods may be made up at the second session. Each session shall not overlap the other sessions. The Contractor shall provide training materials for at least 12 trainees per session for level 1 – Orientation Training and 8 trainees per session for levels 2, 3 and 4..

The length of each course shall be as follows:

1. Orientation training: 1-2 days
2. Dispatch center operators/controllers -1- 2 days
3. Substation operations staff - 5 days
4. All in Level 4 - 2 weeks. (This excludes the time for detailed training on the different software application used in the SSSC system)

Whilst it is important that the time table for the training has a certain amount of flexibility, it must in no way interfere with the installation, commissioning or testing program. Therefore, in order to avoid this, the Contractor shall suggest dates for each course to be held.

8.4.6 Training Facility

The Employer will provide training facilities such as a lecture room with overhead and slide projectors at the agreed venue in Ljubljana or Podlog, Slovenia. The exception to this is whenever the Contractor's training program requires the use of specialized equipment pertinent to the Contractor's systems, such aids shall be provided by the Contractor. The practical part of courses (levels 3 and 4) is to be held at the SSSC Site.

8.4.7 Training during Erection/Testing

The Contractor shall allow a limited number of the Employer's maintenance personnel to observe the installation sequences of major plant and material and controls on an informal basis. Examples may be transformer bushing and accessory installation, VSC valve installation, cooling system installation, EHV AC safety-related system checkout. The Employer will observe but may not participate in the physical construction process.

8.4.8 Course Materials: Manuals and Documentation

The Contractor shall provide background lecture notes at least 1 (one) week before the start of the courses for the training course in order to supplement the information contained in the instruction manuals supplied as a part of the Contract.

Each participant shall be provided with individual copies of the course notes and materials adequate for instruction and hands-on training and hands-on experience on the various systems. The course material shall be written in a format that is easily understandable. A further five copies shall be supplied to the Employer as a part of the Contract documentation.

One copy of each slide, overhead transparency and any other audio-visual record shown during training course shall be supplied to the Employer as a part of the Contract documentation.

All course material shall be in English. The medium of instruction shall be English.

8.4.9 Course Qualification

The Contractor shall also conduct examinations to test the skills and knowledge of the trainees on completion of the courses. The examination will include practical and written examinations.

8.4.10 Tuition and documentation costs

The Contractor's costs shall include the cost of tuition and documentation, but shall exclude all traveling and accommodation costs for trainees, as these shall be borne by the Employer.

8.4.11 Contents of Training

1. Training shall be structured to target the four different levels of users. A suggested structure is:
    a. A systems overview and basic operations course
    b. A detailed operation and system maintenance course

2. The lectures and tutorials shall include but not be limited to the following topics:
    a. SSSC - basic theory
    b. Power electronics, power electronics modules, snubber circuits, prevention of over-voltages, cooling
    c. Control scheme
    d. Control plant and material: Principles of operation function diagrams, schematic diagrams, layout and sub-assemblies
    e. Testing, adjusting and calibrating of control plant and material
    f. Protection: principles of operation logic diagrams, relays and associated apparatus, protection settings and calculations, protection testing
    g. Alarms and indicating plant and material
    h. Auxiliary plant and material - cooling plant and material, AC/DC supplies, air conditioning
    i. Routine maintenance of the SSSC, use of special tools and test equipment
    j. Fault diagrams, replacement of sub-assemblies, repair and test of sub-assemblies in the workshop
    k. Review of contract drawings, component specifications, and manuals.

8.4.12 Orientation Course

The Contractor shall provide two orientation training sessions. It is anticipated that each session will last 1-2 days. These sessions shall be suitable for managers, supervisors, professional and technical personnel. Each session will be limited to a maximum of 12 people. The orientation training sessions shall be scheduled before commencing SSSC commissioning. An outline for this orientation training shall be submitted to the Employer 90 days ahead of the actual date of training.

8.4.13 Course Content for Level 2 (Dispatch Centre Operators/Controllers)

Minimum training for the Employer's Dispatch Centre Operators/Controllers shall include the following, though it should not be seen as complete, but should form the basis of the training for SCADA staff:

1. An overview of the function and theory of operation of the SSSC system.
2. What is an SSSC?
3. What does an SSSC do and why is it required on the network? What does the SSSC achieve in this case?
4. What are the components that make up the SSSC?
5. Describe the single diagram of the SSSC and provide a brief overview of each component.
6. Describe the operating philosophy with particular attention to:
    a. EHV/HV and MV configuration
    b. EHV/HV and MV disconnectors
    c. grounding
    d. transformer (if required)
    e. capacitors or filters (if required)
7. Overview of switching and clearance arrangements
8. Voltage control
9. Operation of auxiliary plant and material
10. General protection block diagram
11. Protection settings: deviation of settings and implementation
12. Interpretation of all alarms and trips, and action required
13. Automatic switching of external shunt devices
14. Interpretation and changing of voltage set points and slope
15. Level of information available on SCADA
16. SSSC operating modes i.e. normal and degraded
17. Capabilities and limitations of SSSC, especially current limits

8.4.14 Course Content for Level 3 (Substation operating staff)

Training for The Employer's Substation operating staff shall include the following as a minimum:

1. An overview of the function and theory of operation of the system covering all functions provided by the system;
2. Instruction shall use all provided documentation on the installation, operation, and maintenance of the system;
3. Switching and clearance arrangements;
4. Identification of malfunctions;
5. Use of mimic, printers, DFR, SER, security, and fire alarm protection.

8.4.15 Course Content for Level 4

The training course will be attended by Transmission Engineers and Technicians specialized on Protection, Telecommunication, Measurements and Control, Maintenance, Operations and Design and the lectures should be aimed at this level. The training shall include the following, as a minimum:

1. An overview of the function and theory of operation of the SSSC system covering all functions provided by the system.

2. Instruction on installation, set-up, and calibration procedures. Hands-on experience on set-up, calibration, and alignment of the plant and material to be supplied shall be provided for each trainee.
3. Instruction on proper operation of all system features and operator interfaces, including the development of programs, databases, and documentation tools.
4. Instruction on proper maintenance and testing of the system, both as a whole and on a module basis. This shall include routine maintenance procedures necessary to troubleshoot and repair the system.
5. Instruction shall use all provided documentation on the installation, operation, and maintenance of the system.
6. Background and instruction on software operation and development tools used for this application.
7. Instruction on reconfiguring or modification techniques used in devices or systems that utilize programmable controllers and HMI interfaces
8. Time for discussion of questions and answers.

The following training topics are common for Levels 3 and 4. The only difference is depth of discussion for each topic.

1. What is a SSSC
2. What does a SSSC do and why is it required on the network? What does the SSSC achieve in this case?
3. What are components that make up the SSSC?
4. Describe a single diagram of the SSSC and provide a brief overview of each component.
5. Describe the operating philosophy with particular attention to:
   a. the EHV/HV and MV configuration
   b. the EHV/HV and MV disconnectors
   c. grounding
   d. transformer (if required)
   e. capacitors or filters (if required)
6. In-depth discussions on:
   a. mimic
   b. controls available
   c. diagnostic ability
   d. effective use of the above to identify and isolate and rectify faults
7. Disturbance Fault Recorder.
8. Sequence of event recorder.
9. Identification of problem and any special steps that may be required including personnel authorized to work on problem.
10. Documentation, drawings and manuals.
11. Discussion of symbols used.
12. How to read the drawings.
13. How manuals are put together and methodology in gaining maximum use of information contained therein. Structure of manuals.
14. Installation, operation and maintenance manuals.
15. SSSC Plant and material.

16. VSC modules.
17. Open and Closed loop control:
    a. operation
    b. indications
    c. functions
    d. interface/documentation
18. Protection systems:
    a. operation
    b. logic diagrams
    c. relays and associated apparatus
    d. settings/calculations
    e. testing
19. Auxiliary supplies:
    a. AC Systems
    b. DC Systems
20. Cooling system:
    a. operation
    b. indications
    c. functions
    d. maintenance on line & off-line
    e. heat exchangers
21. Routine maintenance of SSSC:
    a. Use of special tools
    b. Use of test equipment
    c. Switching and clearance arrangements
    d. Security monitoring and controlled access
22. Fire alarm protection systems.
23. Air conditioning.
24. Testing, adjusting and calibrating of control plant and material.
25. Safety in SSSC yard and control building.
26. Automatic switching of external shunt capacitor banks or reactors by the SSSC controller.

8.5 DOCUMENTS AND DRAWINGS

8.5.1 Documentation and Drawings

8.5.1.1 Documentation to be included in the Tender

In addition to the detailed information requested elsewhere in this specification, the Tenderer shall submit all technical documentation necessary to give a detailed and clear picture of the proposed delivery. The Tender documentation shall further provide ample proof of the Tenderer's compliance with all aspects of this specification.

The following guidelines apply for the presentation of technical documentation being part of the Tender:

1. A statement that the technical characteristics of the equipment as requested in lots 3/2 (HV equipment), 3/3 (220 kV cables) and 3/4 (Control and protection) are suitable for SSSC connection.
2. A descriptive document shall be included, which presents the proposed SSSC configuration, and its compliance with the rating and functional requirements. Assumptions and methodology used for calculation of fundamental frequency and harmonic stresses and performance shall be presented within this paper.
3. The country of production and technical characteristics of the main components of SSSC (capacitors, IGBT's and other power solid state elements, filter components, serial transformer, cooling system, MV equipment, etc).
4. Completed tables of the technical specifications of Chapter 09.
5. A single-line diagram of the SSSC including 220 kV equipment supplied by Contractor if any..
6. A protection block diagram of the SSSC.
7. A protection block diagram with protection coordination between protection of SSSC and protection of OHL line,
8. The losses of the proposed SSSC, as a function of reactive voltage injection (can be included in 2.) above)
9. The audible noise levels, with consideration the Employer's requirements, and the proposed SSSC layout (can be included in 2.) above). This description shall also give the principles of the methodology used for calculation of noise levels.
10. The reliability and availability of the proposed SSSC shall be addressed. Results of availability calculations shall be presented, along with the assumptions taken and methodology used.
11. A layout drawing showing the proposed SSSC Site and location of the main components. Also a plan of the SSSC building shall be provided if any.
12. Preliminary Inspection and Test Plans shall be provided for the Factory tests of VSC Converters and SSSC Control System, the Commissioning tests, and the Field Verification Tests.

All documentation, including quality plans, test specifications and test reports and correspondence shall be uniquely identified and written in English language.

8.5.1.2 General

Supply of the following documentation shall be part of the Contractor's Scope of Works:

All drawings, plans, instructions and manuals necessary to operate and maintain the SSSC and associated equipment. The drawings shall include a complete set of plans, elevations, sections, details, wiring, schematics, piping, etc. of the complete SSSC system. Specifically, separate documents shall be delivered according to the following list:

1. Overall Preventive Maintenance Plan
2. Maintenance/Trouble Shooting Manual for Serial Transformer
3. Maintenance/Trouble Shooting Manual for Capacitor Banks
4. Maintenance/Trouble Shooting Manual for VSC Converters

5. Maintenance/Trouble Shooting Manual for HV, MV Circuit Breakers
6. Maintenance/Trouble Shooting Manual for HV, MV Disconnectors
7. Maintenance/Trouble Shooting Manual for converter Cooling System
8. Maintenance/Trouble Shooting Manual for Control System
9. Maintenance/Trouble Shooting Manual for Relay Protections
10. MMI Manual for SSSC Control and Monitoring System

The maintenance and troubleshooting documents shall be written in the Slovenian language. They shall include step-by-step instructions on specific activities, unique to the equipment, and being part of the maintenance plan and/or trouble shooting manual.

The Tenderer is expected to deliver the model of all SSSC equipment in an open BIM 3D format (IFC format) - (LOD 400). In addition to the 3D view of all SSSC elements, the mentioned BIM model must include other technical data (voltage, weight, etc.) that will be specified by the Customer before the start of the work.

Documentation shall include at least drawings of electrical equipment, single-pole schemes, three-pole schemes and connection schemes, tables of cable/optical connections between supplied equipment, technical reports and specifications of equipment. Documentation will serve also as a basis for the production of project documentation produced by other contractors (Design for obtaining Building Permit and Detail Design for the connections of SSSC to existing substation installations, all in accordance with Slovenian legislation). Documentation shall be submitted in electronic form, which will allow further editing with the Autocad, .ifc (BIM), .STP and Microsoft Office programs.

Electrical schemes must be produced generally in accordance with IEC 61082 and prepared by the Contractor in a manner that will allow further editing with the Autocad program.

Calculations and dimensioning of the designed equipment, installations and systems must be included in the documentation.

8.5.1.3 Administrative information

The Contractor shall prepare and maintain:

1. a list with the names and addresses of persons, representing the Contractor, the Employer's Representative and the Employer,
2. a project organization schedule of the Contractor,
3. a procedure for coding of correspondence, approval and distribution of documents and drawings.

The Contractor shall prepare and update a schedule of documents and drawings with their status. This schedule shall be submitted every month to the Employer's Representative as a part of the monthly progress report.

8.5.1.4 Drawings

Drawings shall show:

1. name of Employer,
2. name of project,
3. name of equipment or installation,
4. cross references, wherever applicable,
5. drawing number and revision,
6. code,
7. date of release.

The drawing size shall be A1, A2, A3 or A4.

Standard formats and templates of drawings are to be supplied to the Contractor after the Contract Date by the Employer.

8.5.1.5 Document marking

The Contractor shall submit the Contractor's Documents marked either:

1. for approval (to be approved by the Employer's Representative),
2. for information,
3. for obtaining Building Permit
4. for construction (approved by the Employer's Representative),
5. as-built.

8.5.2 Contractor's Documents to be approved by the Employer's Representative

The Contractor shall submit the following Contractor's documents for approval by the Employer's Representative:

1. design report proving that the design complies with the safety requirements; a design report proving that under worst-case conditions, the conductor temperatures comply with the limits,
2. studies as requested in chapters: Tender studies, Engineering Studies, Protection Co-ordination Study and Other Studies.
3. design report proving that the high-voltage installation complies with the mechanical requirements,
4. design report proving the design of grounding and lightning protection system
5. detailed protection co-ordination study,
6. for each substation, drawings, specifications and reports marked as "For approval",
7. contact & project organization data,
8. detailed Programs showing design, manufacturing, transportation, construction and erection, (pre-)commissioning,
9. schedule of the Contractor's Documents to be supplied, showing committed delivery dates for all design reports, specifications, data and drawings,
10. full test & inspection plan for the Works containing an overview of all quality assurance measures that will be performed on the Plant and Materials, installation and during final SAT testing (engineering release, type testing, routine testing (hold and witness points), after shipment checks, installation verification, functional testing, integral testing) including references (IEC, working procedures, test procedures) with clear pass/fail criteria,
11. quality control plan,
12. Health, Safety and Environmental Plan,

13. protection and control diagrams,
14. setting lists of protection devices,
15. interlocking diagrams,
16. certificates of tests, test reports,
17. commissioning program/manual/protocols,
18. a final list of spare parts,
19. operation and maintenance manuals.

8.5.3 Contractor's Documents to be submitted to the Employer's Representative for information

The Contractor shall submit the following Contractor's Documents for information to the Employer's Representative:

1. drawings, specifications and reports marked as "For information",
2. specifications and data sheets of the equipment,
3. manufacturing reports,
4. dimensional equipment sketches,
5. construction and assembly drawings and instructions,
6. schematic diagrams,
7. cable lists,
8. electric consumer lists,
9. connection diagrams,
10. as-built drawings.
11. test results of the resistances of the high-voltage installation,

8.5.4 Operation and maintenance manuals

8.5.4.1 General

Operation and maintenance manuals shall contain all information needed to operate the installation under normal and abnormal conditions, to maintain the installation in a proper way, to repair or modify the installation.

Four (4) copies shall be provided plus a pdf version on a read-only electronic media.

8.5.4.2 Contents

The manuals shall contain at least the following information:

1. description of the installation,
2. construction and assembly instructions,
3. design considerations,
4. procedures for all possible normal and abnormal conditions, including failure assessment,
5. maintenance schemes and instructions,
6. data sheets and specifications,
7. as-built drawings,
8. manufacture, type, rating, serial number and test reports of each part of the installation,
9. settings of trips and alarms,

10. local and remote control functions and procedures,
11. completed commissioning manual,
12. parts manual,
13. proposed minimum quantity of spare parts.

8.5.5 Appointed times for the delivery of technical documentation

8.5.5.1 At the submission of the Tender

In addition to all the documentation required under the general tender conditions and documents required in chapter “Documentation and Drawings”, the integral part of the tender dossier must be the following:

1. a quotation,
2. a list of spare parts,
3. a detailed list of equipment and services,
4. detailed block diagrams of the control and protection systems,
5. technical data lists,
6. producers documentation for devices and equipment,
7. a list of certificates and type tests for each device,
8. a planned schedule for the supply and installation of equipment.

8.5.5.2 After signing the contract

The Supplier is obliged to deliver four (4) copies + copy on digital media of documentation for each of the following items:

1. a list of documentation,
2. producer’s confirmed documentation for devices and equipment,
3. templates for the project documentation produced by others,
4. manuals for parameterization and configuration, installation, commissioning, operation and maintenance,
5. final list of spare parts,
6. documentation for training,
7. statements and certificates and
8. schedule for delivery and erection, confirmed by the Employer.

The deadlines for delivery of the documentation will be agreed upon at the time of signing the contract for the supply of SSSC.

8.5.5.3 Documents necessary for production of building permit documentation

10 weeks after signing the Contract, the Contractor is obliged to deliver four (4) copies of documentation for each of the following items:

1. a list of documentation,
2. producer’s confirmed documentation for devices and equipment,
3. all technical documentation as requested in other parts of this tender document as:
   a) static calculations for the building and foundations
   b) civil drawings (without reinforcement drawings)

c) basic electrical calculations
d) EMC and Noise reports
e) fire protection study

8.5.6 Before the acceptance tests at the factory (FAT)

The Contractor is obliged to supply the documentation for each of the following items two weeks before commencement of FAT:

1. a list of devices and equipment to be accepted,
2. reports on the inspection and testing at the factory,
3. templates for the production of AS BUILT documentation,
4. templates for the operating and maintenance instructions.

8.5.7 Before the assembly and acceptance tests at the Site (SAT)

The documentation required for the assembly and installation of the equipment at the installation Site must include all necessary instructions, drawings, schemes, diagrams, quality assurance documentation, list and procedures of the necessary tests and similar documents of the supplied equipment necessary for its proper assembly, installation, commissioning, operation and maintenance.

The Supplier is obliged to deliver the following documentation before commencement of transport of the equipment to Site:

1. Final FAT report for the equipment to be delivered;
2. Updated detail technical documentation (with any potential changes identified during the FAT period entered);
3. Bill of materials for individual shipments, instructions for loading, unloading and handling of shipments and instructions for storage specificities (6 copies);
4. SAT test programs (6 copies).

8.5.8 Before the technical inspection

The Contractor is obliged to provide the documentation for each of the following items four weeks before commencement of technical inspection:

1. handover record, including final FAT and SAT reports and Reliability proof record as necessary for Technical inspection
2. declarations and supporting evidence.

/	/	/	
Revision:	Revision note:	Revision date:	Signature:

Investor: ELES	Facility: RTP 400/220/220 kV Podlog Sistem za regulacijo moči (SSSC) v RTP Podlog
Design engineer: IBE, svetovanje, projektiranje in inženiring Ljubljana, Slovenija	Part of facility/system: Supply and Erection of Flexible Serial Compensation – SSSC in Podlog SS
/	Type of design: TECHNICAL SPECIFICATION

	First name/Name:	Id. No.:
Approved by:	mag. Marko Testen, univ. dipl. inž. el.	E-1293
Confirmed by:	mag. Marko Testen, univ. dipl. inž. el.	E-1293
Checked by:		
Designed by:	mag. M. Testen, univ. dip. in.e., D. Lenarčič, univ. dip. in. el.	E-1293, E-0076
11.2023		

Title of document:

9. Drawings

Design doc. No.:	R4PO01-A025/597	Type of documentation:	DZR
Classification No.:	C D	Page/ pages:	1/3
Identification No.:	R 4 P O 0 1 - 6 E 1 0 0 9	Spr.:	

CONTENTS:

9 DRAWINGS

Single line diagram - existing state
Single line diagram - after erection of SSSC
Arrangement drawing of AD03 after reconstruction works
Layout of Podlog S/S with the indicated avalible area for 220 kV SSSC and storage areas
Layout of RTP Podlog (existing conditions) with Tender documentation scope division
220 kV Swtichyard New underground rainwater sewer, LV and HV electrical system layout

TEHNIČNI PRIKAZI

INVESTITOR		
INVESTITOR 1		
ime in priimek ali naziv družbe		**ELES, d.o.o.**
naslov ali poslovni naslov družbe		**Hajdrihova ulica 2,1000 LJUBLJANA**
PODATKI O GRADNJI		
naziv gradnje		**RTP 400/220/110 kV Podlog / Sistem za regulacijo moči (SSSC) v RTP Podlog**
PODATKI O PROJEKTNI DOKUMENTACIJI		
vrsta dokumentacije		**Dokumentacija za razpis (DZR)**
številka projekta		**R4PO01-A025/597**
strokovno področje načrta	**3**	**NAČRT S PODROČJA ELEKTROTEHNIKE**
naziv načrta	**3/1**	**SSSC**
številka načrta		**R4PO01-6E/01A**

110 kV TOKOVNI TRANSFORMATORJI

POLJE	OZNAKA	TIP	ŠT. JEDRA	RAZMERJE (A)	NAZIVNA MOČ (VA)	RAZRED
=AC00	-T94	AGU 123 Končar	1	1000/1	5	0.2SFS10
			2	1000/1	10	0.2SFS10
			3	1000/1	30	5P30
			4	1000/1	30	5P30
			5	1000/1	30	5P30

110 kV KOMBINIRANI TRANSFORMATORJI

POLJE	OZNAKA	TIP	ŠT. JEDRA	RAZMERJE (A)	NAZIVNA MOČ (VA)	RAZRED
=AE04	-T1,-T5	VAU 123 Končar	1	110/√3/0.1/√3	10	0.2
			2	110/√3/0.1/√3	15	0.2
			3	110/√3/0.1/√3	30	0,2/3P
			4	110/√3/0.1/√3	30	0,2/3P
			1	200/1	5	0.2SFS10
			2	200/1	10	0.2SFS10
			3	200/1	30	5P30
			4	200/1	30	5P30
			5	1000/1	30	5P30

R4PO01-6E3001_3003_Enopolna shema - Obstoječe stanje.dwg

/	/	/	
Revision:	Revision note:	Revision date:	Signature:

Client: ELES

Facility: RTP 400/220/110 kV Podlog / System for power regulation (SSSC) in RTP Podlog

Design engineer: IBE, d.d., svetovanje, projektiranje in inženiring Ljubljana, Slovenija

Part of facility/system: /

/

Type of design: 3 ELECTRICAL DESIGN

	First name/Name:	Id. No.:
Approved by:	mag. Marko Testen, univ. dipl. inž. el.	E-1293
Confirmed by:	mag. Marko Testen, univ. dipl. inž. el.	E-1293
Checked by:	/	/
Designed by:	/	/
Date: 11.2023	Scale: /	

Title of document: Single line diagram - existing state

Design doc. No.:	R4PO01-A025/597	Type of documentation:	DZR
Classification No.:	Y D	Page/pages:	1/1
Identification No.:	R 4 P O 0 1 - 6 E 3 0 0 3	Rev.:	

110 kV TOKOVNI TRANSFORMATORJI

POLJE	OZNAKA	TIP	ŠT. JEDRA	RAZMERJE (A)	NAZIVNA MOČ (VA)	RAZRED
=AC00	-T94	AGU 123 Končar	1	1000/1	5	0.2SFS10
			2	1000/1	10	0.2SFS10
			3	1000/1	30	5P30
			4	1000/1	30	5P30
			5	1000/1	30	5P30

110 kV KOMBINIRANI TRANSFORMATORJI

POLJE	OZNAKA	TIP	ŠT. JEDRA	RAZMERJE (A)	NAZIVNA MOČ (VA)	RAZRED
=AE04	-T1,-T5	VAU 123 Končar	1	110/√3/0.1/√3	10	0.2
			2	110/√3/0.1/√3	15	0.2
			3	110/√3/0.1/√3	30	0,2/3P
			4	110/√3/0.1/√3	30	0,2/3P
			1	200/1	5	0.2SFS10
			2	200/1	10	0.2SFS10
			3	200/1	30	5P30
			4	200/1	30	5P30
			5	1000/1	30	5P30

110 kV TOKOVNI TRANSFORMATORJI

POLJE	OZNAKA	TIP	ŠT. JEDRA	RAZMERJE (A)	NAZIVNA MOČ (VA)	RAZRED
=AE01,05, 07,09	-T1	AGU 123 Končar	1	2x300/1	5	0.2S,Fs10
			2	2x300/1	10	0.2S,Fs10
			3	2x300/1	30	5P20
			4	2x300/1	30	5P20
=AE06,11	-T1	AGU 123 Končar	1	2000/1	5	0.2SFS10
			2	2000/1	10	0.2SFS10
			3	2000/1	30	5P30
			4	2000/1	30	5P30
			5	2000/1	30	5P30
=AE10	-T1	AGU 123 Končar	1	4x150/1	30	0.2,Fs10
			2	4x150/1	30	0.5,Fs10
			3	4x150/1	60	10P10
			4	4x150/1	60	10P10
=AE02,03	-T1	JOF 123 Pfiffner	1	300-600/1	5	0.2,FS5
			2	300-600/1	10	0.5,FS5
			3	300-600/1	30	5P20
			4	300-600/1	30	5P20
=AE08 (TR212)	-T1	KOTEF 123 Ritz	1	2x600/1	5	0.2,FS10
			2	2x1000/1	10	0.5,FS10
			3	2x1000/1	30	5P20
			4	2x1000/1	30	5P20
			5	2x1000/1	30	5P20
=AE12	-T1	OSKF 123 Ritz	1	2x300/1	5	0.2,FS10
			2	2x300/1	10	0.2,FS10
			3	2x300/1	30	5P20
			4	2x300/1	30	5P20

110 kV NAPETOSTNI TRANSFORMATORJI

POLJE	OZNAKA	TIP	NAVITJE	NAZ. SEK. NAP. (kV)	NAZIVNA MOČ (VA)	RAZRED
=AE01,05,06, 07,09,11	-T5	VPU 123 Končar	1	110/√3/0.1/√3	10	0.2
			2	110/√3/0.1/√3	15	0.2
			3	110/√3/0.1/√3	30	3P
			4	110/√3/0.1/3	30	3P
=AE10	-T5	VPU 123 Končar	1	110/√3/0.1/√3	30	0.2
			2	110/√3/0.1/√3	30	0.5
			3	110/√3/0.1/√3	60	3P
			4	110/√3/0.1/3	60	3P
=AE02,03,12	-T5	OTEF 123 Ritz	1	110/√3/0.1/√3	10/750	0.2
			2	110/√3/0.1/√3	15/750	0.2
			3	110/√3/0.1/√3	30/750	3P
			4	110/√3/0.1/3	30/500	3P
=AE08	-T5	KOTEF 123 Ritz	1	110/√3/0.1/√3	10/750	0.2
			2	110/√3/0.1/√3	15/750	0.5
			3	110/√3/0.1/√3	30/750	3P
			4	110/√3/0.1/3	30/500	3P

OZNAKA	TIP
110 kV DV polja =AE01, =AE07, =AE12	
-Q1, -Q2	Alstom, S2DA, 123 kV, 1600 A, 31.5 kA
-Q0	Magrini Galileo, SB6 123, 123 kV, 3150A, 31.5 kA
-Q8/-Q9	Alstom, S2DAT, 123 kV, 1600 A, 31.5 kA
-F1	Ohio Brass, HUBBELL, 98 kV
110 kV DV polja =AE10	
-Q1, -Q2	Alstom, S2DA, 123 kV, 1600 A, 31.5 kA
-Q0	Magrini Galileo, SB6 123, 123 kV, 3150A, 31.5 kA
-Q8/-Q9	Alstom, S2DAT, 123 kV, 1600 A, 31.5 kA
-F1	ABB, Pexlim Q096, WH123, ZnO 98 kV, 10 kA
110 kV DV polja =AE09	
-Q1, -Q2	Alstom, S2DAT, 123 kV, 1600 A, 31.5 kA
-Q0	Alstom, S2DAT, 123 kV, 1600 A, 31.5 kA
-Q8/-Q9	Alstom, S2DAT, 123 kV, 1600 A, 31.5 kA
-F1	Ohio Brass HUBBELL, 98 kV
110 kV DV polja =AE02, =AE03, =AE05	
-Q1, -Q2	Alstom,D300-121 641 M/H, 123 kV, 1600 A, 31.5 kA
-Q0	Magrini Galileo, SB6 123, 123 kV, 3150 A, 31.5 kA
-Q8/-Q9	Alstom, D300-121 641 M/H, 123 kV, 1600 A, 31.5 kA
-F1	Ohio Brass HUBBELL, 98 kV
110 kV zvezno polje =AE06	
-Q1, -Q2	GE, S2DA, 123 kV, 2000A, 40 kA
-Q0	GE, GL312F1 123 kV, 3150 A, 40 kA
110 kV TR polje =AE04, =AE08	
-Q1, -Q2	Alstom, S2DA, 123 kV, 1600A, 31.5 kA
-Q0	Magrini Gallileo, SB6m 123, 123 kV, 3150 A, 31.5 kA
-F1	-
110 kV TR polje =AE11	
-Q1, -Q2	GE, S2DA, 123 kV, 2000A, 40 kA
-Q0	GE, GL312F1 123 kV, 3150 A, 40 kA
-Q8/-Q9	GE, S2DAT, 123 kV, 2000 A, 40 kA
-Q81	GE, STA, 123 kV, 40 kA
-Q6	GE, STA, 123 kV, 40 kA
-F6	PEXLIM Q072-YN123
-F1	PEXLIM Q108-YN123

110 kV merilno in ozemljilno polje =AE03a

OZNAKA	TIP	NAVITJE	NAZ. SEK. NAP. (kV)	NAZIVNA MOČ (VA)	RAZRED
-Q10/-Q16	Alstom, S2DAT, 123 kV, 1600 A, 31.5 kA				
-T15	Končar, VPU 123	1	110/√3/0.1/√3	10	0.2
		2	110/√3/0.1/√3	15	0.5
		3	110/√3/0.1/√3	30	3P
		4	110/√3/0.1/3	30	3P

110 kV merilno in ozemljilno polje =AE04a

OZNAKA	TIP	NAVITJE	NAZ. SEK. NAP. (kV)	NAZIVNA MOČ (VA)	RAZRED
-Q20/-Q26	Alstom S2DAT, 123 kV, 1600 A, 31.5 kA				
-T25	Končar, VPU 123	1	110/√3/0.1/√3	10	0.2
		2	110/√3/0.1/√3	15	0.5
		3	110/√3/0.1/√3	30	3P
		4	110/√3/0.1/3	30	3P

220 kV TOKOVNI TRANSFORMATORJI

POLJE	OZNAKA	TIP	ŠT. JEDRA	RAZMERJE (A)	NAZIVNA MOČ (VA)	RAZRED
=AD01,03, 04,05,06,10	-T1	VAU 245 Končar	1	2x300/1	5	0.2S Fs10
			2	2x500/1	10	0.2S Fs10
			3	2x500/1	30	5P20
			4	2x500/1	30	5P20
			5	2x500/1	30	5P20
=AD16	-T1	VAU 245 Končar	1	2x300/1	5	0.2S Fs10
			2	2x500/1	10	0.5 Fs10
			3	2x500/1	30	5P20
			4	2x500/1	30	5P20

220 kV NAPETOSTNI TRANSFORMATORJI

POLJE	OZNAKA	TIP	NAVITJE	NAZ. SEK. NAP. (kV)	NAZIVNA MOČ (VA)	RAZRED
=AD01,03,04, 05,06	-T5	VAU 245 Končar	1	220/√3/0,1/√3	10	0.2
			2	220/√3/0,1/√3	15	0.2
			3	220/√3/0,1/√3	30	0.5/3P
			4	220/√3/0,1/√3	30	0.5/3P
=AD10	-T5	VAU 245 Končar	1	220/√3/0,1/√3	10	0.2
			2	220/√3/0,1/√3	15	0.5
			3	220/√3/0,1/√3	30	3P
			4	220/√3/0,1/√3	30	3P
=AD16	-T5	VPU 420 Končar	1	220/√3/0,1/√3	10	0.2
			2	220/√3/0,1/√3	15	0.5
			3	220/√3/0,1/√3	30	3P
			4	220/√3/0,1/√3	30	3P

OZNAKA	TIP
220 kV DV polje =AD01, =AD03 ,=AD05, =AD06,	
-Q0	ABB, HPL 245B1, 245 kV, 2500 A, 40 kA
-Q1,-Q2	Alstom, S2DA, 245 kV, 1600 A, 40 kA
-Q8	Alstom, S2DAT, 245 kV, 40 kA
-Q9	Alstom, S2DAT, 245 kV, 1600 A, 40 kA
-F1	/
220 kV zvezno polje =AD04	
-Q0	ABB, HPL 245B1, 245 kV, 2500 A, 40 kA
-Q1,-Q2	Alstom, S2DA, 245 kV, 2500 A, 40 kA
220 kV TR polje 211 =AD08	
-Q0	ABB, LTB 245E1, 245 kV, 4000 A, 50 kA
-Q1,-Q2	Alstom, S2DA, 245 kV, 1600 A, 40 kA
-F1	/
220 kV TR polje 212 =AD10	
-Q0	ABB, HPL 245B1, 245 kV, 4000 A, 50 kA
-Q1,-Q2	Alstom, S2DA, 245 kV, 1600 A, 40 kA
-F1	/
220 kV TR polje 421 =AD16	
-Q0	ABB, HPL 245B1, 245 kV, 4000 A, 50 kA
-Q1,-Q2	Alstom, S2DA, 245 kV, 1600 A, 31.5 kA
-F1	/

220 kV merilno ozemljilno polje =AD01a

OZNAKA	TIP	NAVITJE	NAZ. SEK. NAP. (kV)	NAZIVNA MOČ (VA)	RAZRED
-Q20, -Q26	Alstom, S2DAT, 245 kV, 1600 A, 40 kA				
-T25	Končar, VPU 245	1	220/√3/0,1/√3	10	0.2
		2	220/√3/0,1/√3	15	0.2
		3	220/√3/0,1/√3	30	0.5/3P
		4	220/√3/0,1/√3	30	0.5/3P

220 kV merilno ozemljilno polje =AD03a

OZNAKA	TIP	NAVITJE	NAZ. SEK. NAP. (kV)	NAZIVNA MOČ (VA)	RAZRED
-Q10, -Q16	Alstom, S2DAT, 245 kV, 1600 A, 40 kA				
-T15	Končar, VPU 245	1	220/√3/0,1/√3	10	0.2
		2	220/√3/0,1/√3	15	0.5
		3	220/√3/0,1/√3	30	3P
		4	220/√3/0,1/√3	30	3P

400 kV TOKOVNI TRANSFORMATORJI

POLJE	OZNAKA	TIP	ŠT. JEDRA	RAZMERJE (A)	NAZIVNA MOČ (VA)	RAZRED
=AC01,04,05	-T1	IOSK 420 Trench	1	2x500/1	5	0.2 Fs10
			2	2x800/1	10	0.2 Fs10
			3	2x800/1	30	5P20
			4	2x800/1	30	5P20
			5	2x800/1	30	5P20
=AC00	-T1	AGU 420 Končar	1	500/1	5	0.2S Fs10
			2	500/1	10	0.2S Fs10
			3	500/1	30	5P30
			4	500/1	30	5P30
			5	500/1	30	5P30
=AC02	-T1	IOSK 420 Trench	1	2x500/1	5	0.2S Fs5
			2	2x800/1	10	0.2S Fs5
			3	2x800/1	30	5P20
			4	2x800/1	30	5P20
			5	2x800/1	30	5P20

OZNAKA	TIP
400 kV TR polje =AC01	
-Q1/-Q51	Areva S2DAT, 420 kV, 3150 A, 50 kA
-Q2	Areva S2DA, 420 kV, 3150 A, 50 kA
-Q0	Areva GL316, 420 kV, 3150 kA, 50 kA
-Q9/-Q52	Areva S2DAT, 420 kV, 3150 A, 50 kA
-Q7	Areva S2DA, 420 kV, 3150 A, 50 kA
-Q8	Areva STB420, 420 kV, 50 kA
-F1	SEDIVER 396 kV
400 kV zvezno, merilno in ozemljilno polje =AC03	
-Q1/-Q51	Areva S2DAT, 420 kV, 3150 A, 50 kA
-Q2	Areva S2DA, 420 kV, 3150 A, 50 kA
-Q0	Areva GL316, 420 kV, 3150 A, 50 kA
-Q7	Areva S2DA, 420 kV, 3150 A, 50 kA
-Q20/-Q52	Areva S2DAT, 420 kV, 3150 A, 50 kA
-Q15,-Q25, -Q75	GE STB420, 420 kV, 40 kA
-Q16,-Q26, -Q76	Areva STB420, 420 kV, 50 kA
400 kV DV polje =AC02,=AC04,=AC05	
-Q1/-Q51	Areva S2DAT, 420 kV, 3150 A, 50 kA
-Q2	Areva S2DA, 420 kV, 3150 A, 50 kA
-Q0	Areva GL316, 420 kV, 3150 A, 50 kA
-Q9/-Q52	Areva S2DAT, 420 kV, 3150 A, 50 kA
-Q7/-Q8	Areva S2DAT, 420 kV, 3150 A, 50 kA
Terciar T211	
-Q8/-Q8	E.I. RZ-11F, 123 kV, 630 A
-F6/-F6	Minel, VOP 117, 10 kA
-F1	Asea, XMQ 14,48 Harpuna
-Q0	Ločilno stikalo z varovalko 50 A, TSN, OL 12/630 A
-T1	
-Q01	WD, 630 A
-T5	Končar, 3 VPA, 10/√3/0,1/√3/0,1/3, 50VA, 0,5/3P

400 kV KOMBINIRANI TRANSFORMATORJI

POLJE	OZNAKA	TIP	ŠT. JEDRA	RAZMERJE (A)	NAZIVNA MOČ (VA)	RAZRED
=AC03	-T1/-T5	VAU 420 Končar	1	400/√3/0.1/√3	10	0.2
			2	400/√3/0.1/√3	15	0.5
			3	400/√3/0.1/√3	30	3P
			4	400/√3/0.1/√3	30	3P
			1	2x500/1	5	0.2S Fs10
			2	2x800/1	10	0.2S Fs10
			3	2x800/1	30	5P20
			4	2x800/1	30	5P20
			5	2x800/1	30	5P20

400 kV NAPETOSTNI TRANSFORMATORJI

POLJE	OZNAKA	TIP	NAVITJE	NAZ. SEK. NAP. (kV)	NAZIVNA MOČ (VA)	RAZRED
=AC01,02,05	-T5	OTEF 420 Ritz	1	400/√3/0.1/√3	10	0.2
			2	400/√3/0.1/√3	15	0.5
=AC03	-T15,-T25		3	400/√3/0.1/√3	30	3P
			4	400/√3/0.1/√3	30	3P
=AC00	-T5	VPU 420 Končar	1	400/√3/0.1/√3	10	0.2
			2	400/√3/0.1/√3	15	0.2
			3	400/√3/0.1/√3	30	0.5/3P
			4	400/√3/0.1/√3	30	0.5/3P
=AC04	-T5	OTEF 420 Ritz	1	400/√3/0.1/√3	10	0.2
			2	400/√3/0.1/√3	15	0.5
			3	400/√3/0.1/√3	30	0.5/3P
			4	400/√3/0.1/√3	30	0.5/3P

OZNAKA	TIP
Terciar T212	
-Q8/-Q8	E.I. VRV-11F, 1250 A
-F6/-F6	Minel, HML 120, 10 kA
-F1	Asea, XMQ 14,48 Harpuna
-Q0	Ločilno stikalo z varovalko 50 A, TSN, OL 12/630 A
-T1	STEN 061, 1000/5 A
-Q01	WDB, 1000 A
-T5	Končar, 4 VPA, 10/√3/0,1/√3/0,1/3, 30/25VA, 3P/6P
400 kV TR polje =AC00	
-Q1/-Q51	GE S2DAT, 420 kV, 2000 A, 40 kA
-Q2	GE S2DA, 420 kV, 2000 A, 40 kA
-Q0	GE GL316, 420 kV, 3150 kA, 40 kA
-Q9/-Q52	GE S2DAT, 420 kV, 2000 A, 40 kA
-Q7/Q8	GE S2DAT, 420 kV, 2000 A, 40 kA
-F1	ABB PEXLIM P336-XH420
Energetski transformatorji	
-T411	Kolektor Etra; RT 300000-400/115/10,5 YNyn0+d5; ONAN/ONAF 60/100%
-T421	1ABZ 400000-420s; 400/400/100MVA; 400/231/31,5 kV
-T212	Energoinvest; RT 150/150/50MVA; 220±12x1,25% / 115 / (10,5) kV; YY0, Yd5;
-T121	Kolektor Etra;BT 4000-119/21 YNd5

LEGEND:

LOT 1

LOT 2

LOT 3

Revision:	Revision note:	Revision date:	Signature:
/	/	/	

Client: ELES	Facility: RTP 400/220/110 kV Podlog / System for power regulation (SSSC) in RTP Podlog
Design engineer: IBE, d.d., svetovanje, projektiranje in inženiring Ljubljana, Slovenija	Part of facility/system: /
/	Type of design: 3 ELECTRICAL DESIGN

	First name/Name:	Id. No.:
Approved by:	mag. Marko Testen, univ. dipl. inž. el.	E-1293
Confirmed by:	mag. Marko Testen, univ. dipl. inž. el.	E-1293
Checked by:	/	/
Designed by:	/	/
Date: 11.2023	Scale: /	

Title of document: Single line diagram - after erection of SSSC

Design doc. No.:	R4PO01-A025/597	Type of documentation:	DZR
Classification No.:	Y D	Page/ pages:	1/1
Identification No.:	R4PO01-6E3004	Rev.:	

R4PO01-6E3002_3004_Enopolna shema - Stanje po obnovi.dwg

LEGEND:

NEW HV EQUIPMENT

REMARK:

All wires are ACSR 490-AL1/64-ST1A

Revision:	Revision note:	Revision date:	Signature:
/	/	/	

Client: ELES	Facility: RTP 400/220/110 kV Podlog / System for power regulation (SSSC) in RTP Podlog
Design engineer: IBE, d.d., svetovanje, projektiranje in inženiring Ljubljana, Slovenija	Part of facility/system: /
/	Type of design: 3 ELECTRICAL DESIGN

	First name/Name:	Id. No.:
Approved by:	mag. Marko Testen, univ. dipl. inž. el.	E-1293
Confirmed by:	mag. Marko Testen, univ. dipl. inž. el.	E-1293
Checked by:	/	/
Designed by:	I. Ebner	
Date: 11.2023	Scale: 1:100	

Title of document: Arangement drawing of AD03 after reconstriction works

Design doc. No.:	R4PO01-A025/597	Type of documentation:	DZR
Classification No.:	Y D	Page/pages:	1/1
Identification No.:	R 4 P O 0 1 - 6 E 4 1 0 9	Rev.:	

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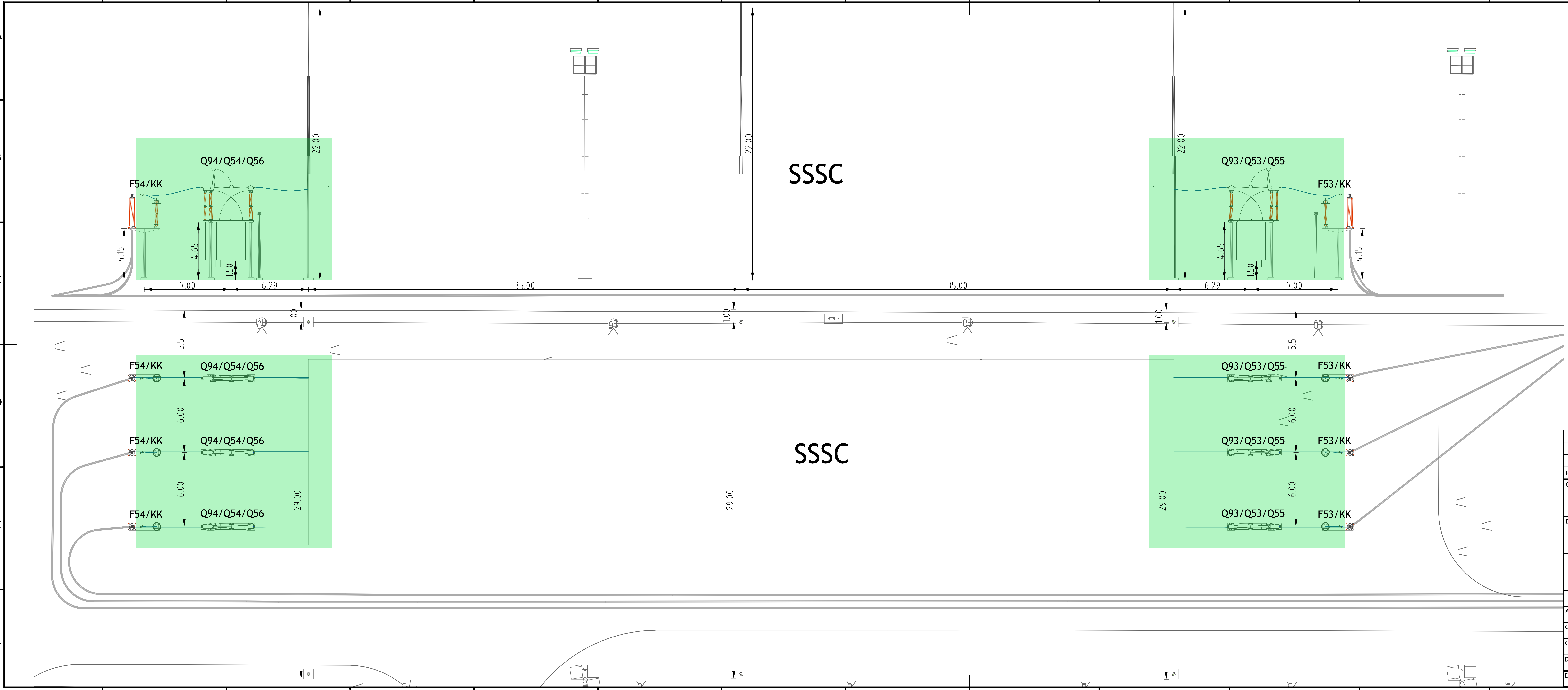
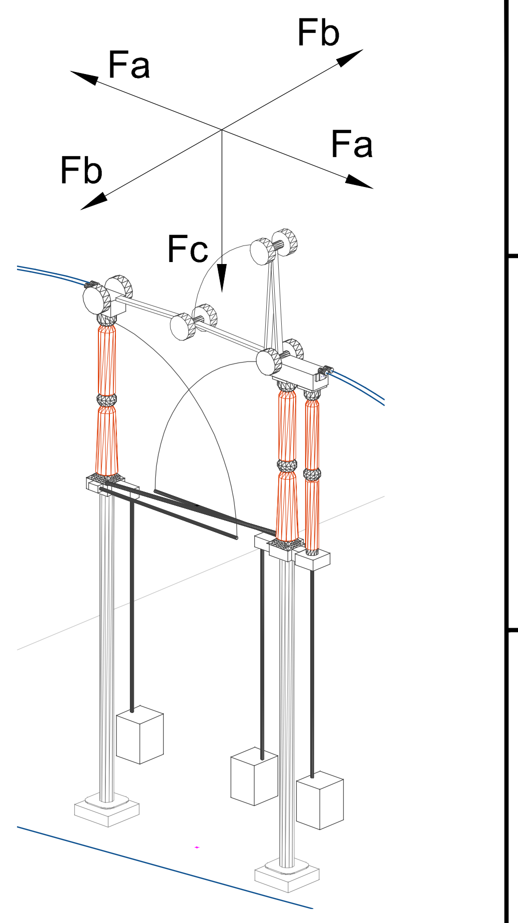




LEGEND:

Subject to delivery and installation

Revision:	Revision note:	Revision date:	Signature:
/	/	/	

Client: ELES	Facility: RTP 400/220/110 kV Podlog / System for power regulation (SSSC) in RTP Podlog
Design engineer: IBE, d.d., svetovanje, projektiranje in inženiring Ljubljana, Slovenija	Part of facility/system: /
/	Type of design: 3 ELECTRICAL DESIGN

	First name/Name:	Id. No.:
Approved by:	mag. Marko Testen, univ. dipl. inž. el.	E-1293
Confirmed by:	mag. Marko Testen, univ. dipl. inž. el.	E-1293
Checked by:	/	/
Designed by:	I. Ebner	/
Date: 11.2023	Scale: 1:100	

Title of document:

220 kV bay SSSC
installation of HV equipment in the SSSC area
floor plan and side view

Design doc. No.:	R4PO01-A025/597	Type of documentation:	DZR
Classification No.:	Y D	Page/pages:	1/1
Identification No.:	R 4 P O 0 1 - 6 E 4 1 1 0	Rev.:	

LEGEND:

220 kV SSSC AREA

STORAGE AREAS

Revision: /	Revision note: /		Revision date: /	Signature:
Client: ELES			Facility: RTP 400/220/110 kV Podlog / System for power regulation (SSSC) in RTP Podlog	
Design engineer: IBE, d.d., svetovanje, projektiranje in inženiring Ljubljana, Slovenija			Part of facility/system: /	
/			Type of design: 3 ELECTRICAL DESIGN	
	First name/Name:	Id. No.:	Title of document: Layout of Podlog S/S with the indicated avalible area for 220 kV SSSC and storage areas	
Approved by:	mag. Marko Testen, univ. dipl. inž. el.	E-1293		
Confirmed by:	mag. Marko Testen, univ. dipl. inž. el.	E-1293		
Checked by:	/	/	Design doc. No.: R4PO01-A025/597	Type of documentation: DZR
Designed by:	I. Ebner		Classification No.: Y D	Page/pages: 1/1
Date: 11.2023	Scale: 1:500		Identification No.: R4PO01-6E4003	Rev.:

R4PO01-6E4003_layout SSSC.dwg

LEGEND

MM1 Noise measurment point

Revision:	Revision note:	Revision date:	Signature:
/	/	/	

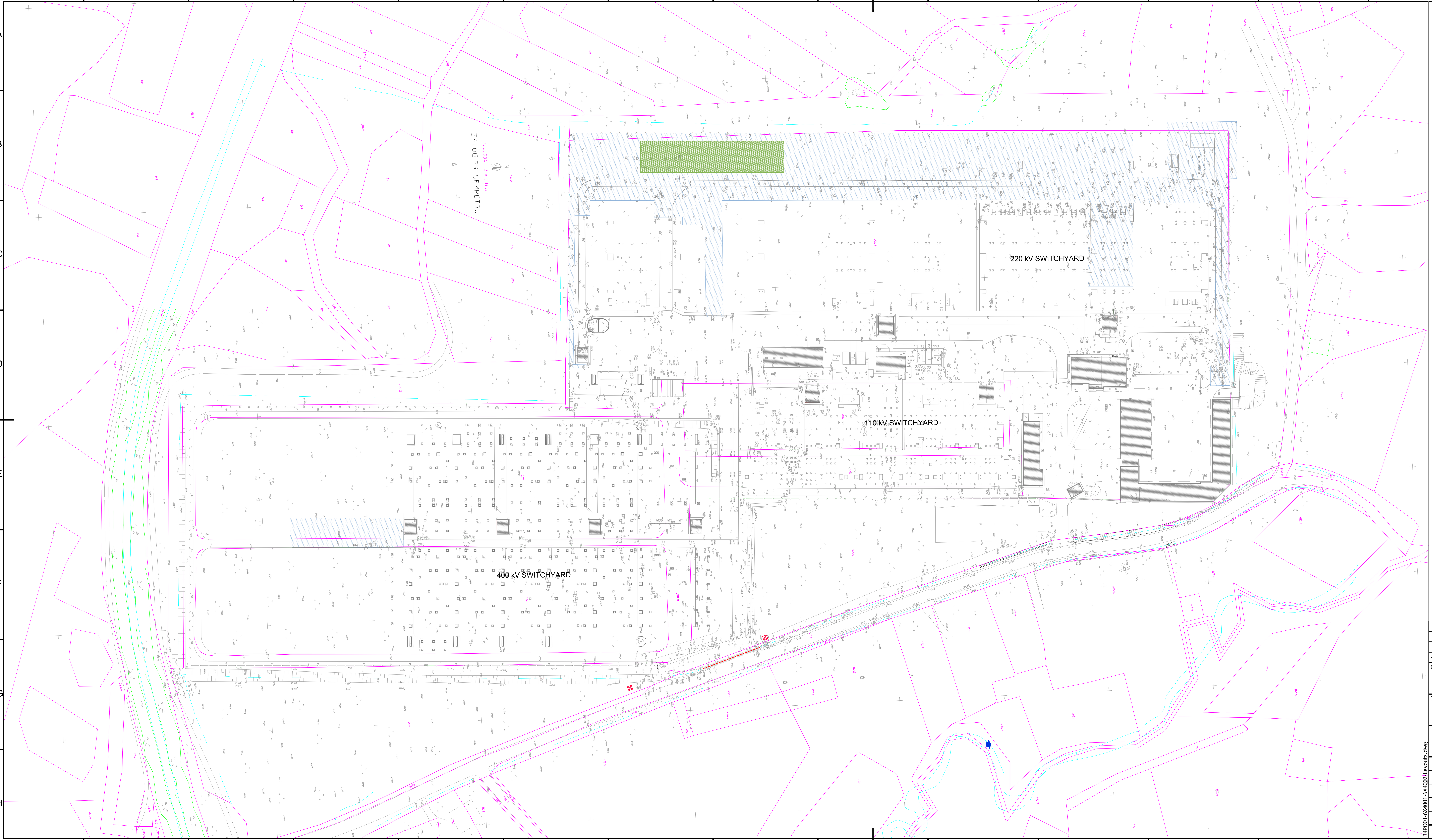
Client: ELES	Facility: RTP 400/220/110 kV Podlog / System for power regulation (SSSC) in RTP Podlog
Design engineer: IBE, d.d., svetovanje, projektiranje in inženiring Ljubljana, Slovenija	Part of facility/system: SSSC
/	Type of design: 3 ELECTRICAL DESIGN

	First name/Name:	Id. No.:
Approved by:	mag. Marko Testen, univ. dipl. inž. el.	E-1293
Confirmed by:	mag. Marko Testen, univ. dipl. inž. el.	E-1293
Checked by:	/	/
Designed by:	/	/
Date: 03.2023	Scale: /	

Title of document: Noise measurment points

Design doc. No.:	R4PO01-A025/597	Type of documentation:	DZR
Classification No.:	Y D	Page/ pages:	1/1
Identification No.:	R4PO01-6E4004	Rev.:	

R4PO01-6E4002_Tloris celotnega stikališča, dogradnja SSSC+merilna mesta 08122023_A.dwg



LEGENDA

PODATKI	VIR PODATKOV	INSTITUCIJA	DATUM	NATANČNOST
Topografska vsebina in višinska predstavitev terena	Tahimetrična in GNSS geodetska izmera	IBE, d.d., Hajdrihova 4, 1000 Ljubljana	Oktober 2023	Natančnost ustreza merilu 1:500.
Topografska vsebina in višinska predstavitev terena	Terestrično lasersko skeniranje	IBE, d.d., Hajdrihova 4, 1000 Ljubljana	Oktober 2023	Natančnost ustreza merilu 1:500.
Topografska vsebina in višinska predstavitev terena	Tahimetrična in GNSS geodetska izmera	IBE, d.d., Hajdrihova 4, 1000 Ljubljana	Julij 2019, Maj 2016	Natančnost ustreza merilu 1:500.
Topografska vsebina in višinska predstavitev terena	Terestrično lasersko skeniranje	GP GEO d.o.o.; Cesta v Dolenje 26; 1235 Radomlje	Maj 2016	Natančnost ustreza merilu 1:1000.
Topografska vsebina in višinska predstavitev terena	Tahimetrična in GNSS geodetska izmera	APOLONIJ d.o.o.; Medvedova ulica 25; 1241 Kamnik	Maj 2015	Natančnost ustreza merilu 1:1000.
Topografska vsebina - GJI	Zbirni kataster gospodarske javne infrastrukture (ZK GJI): električna energija, zemeljski plin, vodovod, kanalizacija, elektronske komunikacije	Geodetska uprava RS, Zemljemerska ulica 12, 1000 Ljubljana	Oktober 2023	Natančnost ustreza merilu 1:2000.
Zemljiško katastrska vsebina	Zemljiški kataster	Geodetska uprava RS	Oktober 2023	Položajna točnost parcelnih mej je na območju predvidenega objekta, kjer meje opredeljujejo točke s terensko določenimi koordinatami, boljša od ±0.12 m. Za ostale meje je položajna točnost ocenjena v splošnem kot boljša od ±3.00 m.

LEGEND

N

EXISTING BUILDINGS

AD03 BAY RECONSTRUCTION, UNDERGROUND UTILITIES, NEW BUILDINGS (scope of doc. no. R4PO01-6E/02 to R4PO01-6E/06 and R4PO01-6G/01 to R4PO01-6G/02).

SSSC FACILITY AREA (scope of doc. no. R4PO01-6E/01)

Revision:	Revision note:	Revision date:	Signature:
/	/	/	

Client: ELES

Facility: RTP 400/220/110 kV Podlog / System for power regulation (SSSC) in RTP Podlog

Design engineer: IBE, d.d., svetovanje, projektiranje in inženiring Ljubljana, Slovenija

Part of facility/system: /

/

Type of design: 2 CIVIL DESIGN

	First name/Name:	Id. No.:
Approved by:	mag. Marko Testen, univ. dipl. el. inž.	E-1293
Confirmed by:	mag. Marko Testen, univ. dipl. el. inž.	E-1293
Checked by:		
Designed by:	Barbara Bukvič, univ. dipl. inž. grad.	G-3015

Date: sept. 2023 Scale: 1:1000

Title of document: Layout of RTP Podlog (existing conditions) with Tender documentation scope division

Design doc. No.: R4PO01-A025/597 Type of documentation: DZR

Classification No.: Page/pages: 1/1

Identification No.: R4PO01-6X4001 Rev.: -

R4PO01-6X4001-6X4002-Layouts.dwg

LEGENDA

Symbol	Description
	FOUNDATIONS FOR NEW HV EQUIPMENT
	EXISTING FOUNDATIONS
	EXISTING BUILDINGS
	NEW BUILDINGS
	SSSC FACILITY AREA
	CONCRETE PLATFORMS
	ASPHALT SURFACES (CLEAN/NOT POLUTED)
	ASPHALT SURFACES (POLUTED)

220 kV SWITCHYARD

1 EXISTING STEEL PORTAL FRAME

01 DISCONECTOR WITH EARTHING SWITCH - PARALLEL TYPE
02 SUPPORT INSULATOR
03 DISCONECTOR - PARALLEL TYPE
04 CIRCUIT BREAKER
05 COMBINED INSTRUMENT TRANSFORMER
06 DISCONECTOR WITH EARTHING SWITCH - CENTRAL BREAK TYPE
07 CABLE TERMINATION AND SURGE ARESSTOR
08 SURGE ARRESTOR
09 DISCONECTOR WITH EARTHING SWITCH - KNEE TYPE
10 LIGHTNING POLE

N

NEW UNDERGROUND SYSTEMS

Symbol	Description
	RAINWATER SEWER SYSTEM (CELAN)
	SURFACE WATER SEWER SYSTEM (CONTAMINATED)
	LV ELECTRICAL SYSTEM (UNDERGROUND)
	HV ELECTRICAL SYSTEM (UNDERGROUND)
KIMO...	OIL SEPARATOR WITH COALESCENT FILTER
	REVISION SHAFTS, GULLIES

Revision:	Revision note:	Revision date:	Signature:
/	/	/	

Client: ELES	Facility: RTP 400/220/110 kV Podlog / System for power regulation (SSSC) in RTP Podlog
Design engineer: IBE, d.d., svetovanje, projektiranje in inženiring Ljubljana, Slovenija	Part of facility/system: /
/	Type of design: 2 CIVIL DESIGN

	First name/Name:	Id. No.:
Approved by:	mag. Marko Testen, univ. dipl. el. inž.	E-1293
Confirmed by:	mag. Marko Testen, univ. dipl. el. inž.	E-1293
Checked by:		
Designed by:	Barbara Bukvič, univ. dipl. inž. grad.	G-3015
Date: sept. 2023	Scale:	1:200

Title of document: 200 kV Swtichyard
New underground rainwater sewer, LV and HV electrical system layout

Design doc. No.:	R4PO01-A025/597	Type of documentation:	DZR
Classification No.:		Page/ pages:	1/1
Identification No.:	R4PO01-6X4002	Rev.:	-

R4PO01-6X4001-6X4002-Layouts.dwg