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CONSTRUCTION OF LLOGARA TUNNEL

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DETAILED DESIGN

ELECTRICAL POWER SUPPLY

TECHNICAL REPORT

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Contents

1. GENERAL

1.1 Scope of the report

The subjects of this document are the following types of installations:

1. Power supply installations
   - MV power supply
   - LV tunnel power supply
   - Uninterruptible power supply (UPS).
2. Lighting, sockets, cooling and heating of portal buildings and transformer stations in LayBy niches
3. Lightning protection of portal buildings, earthing and equipotential bonding

This document deals with the power supply of tunnel. Powere supply is planned at the 20 kV level from two independent networks.

Primary power supply should be provided from south portal from new substation near to existing one with voltage level of 110/20 kV in Palasa village. Power supply will be provided with 20 kV lines from this new substation. As a back up line is provided a new mix (overhead and underground) 20 kV line from the substation on Vlora side (north portal). The public distribution network to the tunnel transformer stations is not the subject of this project and is provided by the Client.

On both portals of the Llogar tunnel are planned 20(10)/0,4(0,69) kV transformer stations for supply the Llogar tunnel with electricity and five smaller transformer stations in LayBy niches in the main tunnel.

The requirements for materials and installed equipment are given in the following sections. The construction requirements, technical characteristics, installation method, tests and measurements for the installed equipment are given. The equipment supplied and installed must be carried out in compliance with the requirements given in this document.

1.2 Codes and guidelines

[1]	RVS 09.01.24	Structural equipment for operation and safety
[2]	RVS 09.02.22	Operations and maintenance
[3]	RVS 09.02.31	Road tunnel ventilation
[4]	RVS 09.03.11	Methodology of tunnel risk analysis
[5]	RVS 09.02.41	Tunnel Equipment – Lighting
[6]	RVS 09.01.45	Structural fire protection in road traffic structures
[7]	EN IC 62485-2	Safety requrements for secondary battery installations – Part 2: Stationary batteries
[8]	CFPA-E guideline	Panic and emergency exit devices (2002/2004 European guideline)
[9]	EN IEC 61936-1	Power installations exceeding 1 kV a.c. - Part 1: Common rules
[10]	EN 54	Fire detection and fire alarm systems
[11]	VdS 2095	Guidelines for automatic fire detection and fire alarm systems - Planning and Installation

[12]	EN ISO 7010	Graphical symbols - Safety colours and safety signs - Registered safety signs
[13]	EN 60598-2-22	Luminaires - Part 2-22: Particular requirements - Luminaires for emergency lighting
[14]	EN 50171	Central power supply systems
[15]	EN 50172	Emergency escape lighting systems
[16]	EN 1838	Lighting applications - Emergency lighting
[17]	EN 179	Building hardware - Emergency exit devices operated by a lever handle or push pad, for use on escape routes - Requirements and test methods
[18]	EN 1125	Building hardware - Panic exit devices operated by a horizontal bar, for use on escape routes - Requirements and test methods
[19]	EN 13637	Building hardware - Electrically controlled exit systems for use on escape routes - Requirements and test methods
[20]	EN 62305-3	Protection against lightning - Part 3: Physical damages to structures and life hazard
[21]	EN 62561	Lightning Protection System Components (LPSC)
[22]	EN 60364	Low-voltage electrical installations

2. POWER SUPPLY WORKS

2.1 PRIMARY ELECTRIC POWER SUPPLY OF THE TUNNEL

Appropriate transformer stations (TS) will provide the power supply for the tunnel. All TSs will be powered from 20 kV power system. Double sided power supply is planned. Sub voltage relays enable secure and harmless power supply switch from one to the other way. The remote switching of power supply will be done with software programmed blockades and conditions via surveillance computer inside the Command centre. Before the individual power supply switching it is necessary to check the status of all the switches, sub voltage relays, protection and measurement signals as well to check and realize all conditions which are needed for harmless and safe switching on. The return in to previous (normal) state it is necessary to do it manually at the switchyard on the basis of pre-checked conditions which are needed for safe and harmless switching in. The switching on is done by distributer operators.

The computer program for automatic switching must be done so that it will always be:

- possible to simply follow the completion of individual steps and switch functions,
- constant automatic checking of completion of previous steps of the program which are the condition for continuing the switch on flow and
- the switch on flow to always secure the necessary harmlessness on the electro energetic devices and system, as well as in case of malfunction or incorrect operation of individual elements which handle the switch in.

When producing software for the execution of automatic switch on, the functional specification of necessary checks and switch status manipulation, malfunction, alarm situations, time breaks, automatic repeated switch on (APU) of transmission as well as the performance of needed conditions (manipulation) which are needed for safe execution of automatic switch on of power supply must be done.

According to 20 kV Power Supply Scheme (LLO_IBE_DD_EL_TPS_1001_SH_BI_W_01) all transformer stations (2 in Portal Buildings and 5 in Lay BY Niches) will be connected through a 20 kV cable. In case of fall out of distribution power supply from one side, the other side will take over the total tunnel power supply. Inside the tunnel cables are placed on cable trays in tunnel cable channels.

Measuring sets will be placed on MV side in both main Transformer Stations (TS) in both Portal Building (PB). for measuring the consumption of electrical energy.

According to the typisation of Albanina electrical distribution, expected value of short-circuit current in networks with nominal value of 20 kV is 14 kA. All mid-voltage electrical equipment installed into the transformer station should comply with this criteria. Current protection is in the form of grounding. Operation and protection grounding will be joined.

Overcurrent and short-circuit relays, as well as undervoltage relays, overvoltage protection and earthing protection will be installed. Undervoltage relays enable safe and harmless switching of power supply from one direction into another.

Current and voltage measurements are also planned. Control center will receive information about the status of all switches, commands to switch on/off main switches (control), all emergency states, operation of protection relays, malfunctions, voltage and current measuring, transformer power etc. All the signals are transmitted to the control center. Current and voltage measuring signals will be transmitted through measuring converters as analogue signals of 4 to 20 mA.

Overvoltage protection will be multi-leveled. The first level is overvoltage protection on 20 kV side – overvoltage arresters ZnO, 24 kV Raychem.

The second level of overvoltage protection (class 1) are overvoltage arresters in LV switch boards for maximum operation voltage of 280 V, testing dynamic current 100kA for 8/20 impulse, protection level at 50 kA for impulse 10/350 μs. Third overvoltage protection level (class 2) are overvoltage arresters in distribution boxes at electrical niches for maximum operation voltage of 275 V, nominal dividing current at (8/20) is 15 kA, maximum dividing current (8/20) is 40 kA, protection level with 5 kA (8/20 μs). The fourth level (class 3) is the protection inside electric devices which must have a specially delicate overvoltage protection.

2.2 GROUNDING AND EQUIPOTENTIAL BONDING

Independent cable switch-off in case of malfunction will be performed with automatic power supply switch-off in TS or cable cabinets. For automatic switch off in case of malfunction, all conditions must be fulfilled, especially the following ones:

- Grounding resistance in TS area should not exceed the value which could keep touch voltage higher than 50 V.
- Ground short-circuit current should not provoke grounding voltage over 50 V, if such voltage remains for longer than 5 s.

These and other unlisted conditions must be fulfilled and proved with measuring.

Both groundings, protective and operational, will be connected to a joint grounded system in the tranformer station – joint grounding of transformer stations, which also represents the equipotential system.

Longitudinal grounding in tranformer stations is connected with the following:

- All metal parts of MV and LV devices and tranformer,
- metal coat and power cable screens,
- secondary current circuit of measuring tranformers,
- grounding of MV coils of single-poled insulated voltage measuring transformers,
- overvoltage arresters' grounding,
- lighting rod installations,
- PEN conductor (yellow-green),
- Other groundings that could influence the decrease in grounding resistance of protective grounding.

Connections must be executed in a visible place. The grounding is laid next to MV cables, cable duct and overall LV cable networks, and is connected to all metal cable cabinets and PEN conductors in each cabinet.

Joint grounding system, composed of TS grounding, PEN network and consumer conductor grounding, is dimensioned in such a manner that during the operation of grounding in MV part, TS voltage on grounded system does not exceed the value allowed in given switch-off period.

2.3 CABLES – FIRE SAFETY

All cable passages through walls, floor panels of transformer stations and electrical niches must be sealed with fireproof material in order to prevent fire and smoke transfer from one space into another. Cable entrance from tunnel pipes to electrical niches must be fire resistant E90 in addition to preventing rodents and other pest from entering.

All cables must be protected from mechanical damage, from overweight, shortcircuit and overvoltage. Safety system cables must be controlled for interruption and shortcircuit.

3. TRANSFORMER SUBSTATIONS

For the supply Llogara tunnel with electrical power construction of following transformer substations TS

Transformer Substation Portal Building North	T1	1x250 kVA,	20/0,4 kV
	T2	1x2500 kVA,	20/0,69 kV
Transformer Substation EQ1	T1	1x400 kVA,	20/0,4 kV
Transformer Substation EQ2	T1	1x400 kVA,	20/0,4 kV
Transformer Substation EQ3	T1	1x400 kVA,	20/0,4 kV
Transformer Substation EQ4	T1	1x400 kVA,	20/0,4 kV
Transformer Substation EQ5	T1	1x400 kVA,	20/0,4 kV
Transformer Substation Portal Building South	T1	1x250 kVA,	20/0,4 kV
	T2	1x2500 kVA,	20/0,69 kV

Each substation will contain the complete medium voltage block, the transformation of 20/0,4(0,69) kV, a complete low-voltage block, reactive power compensation, metering (energy, current, voltage and cosϕ), protection and all the cable connections.

Peak installed power of all transformer substations is shown in calculation made with software ETAP in Appendix A. For rated diversity factor 1 load summary is approximately 2,9 MVA.

3.1 TRANSFORMER SUBSTATIONS PORTAL BUILDING NORTH/SOUTH 1x250 kVA, 20/0,4 kV; 1x2500 kVA, 20/0,69kV

Transformer substation portal building north(south) will be placed in north(south) portal building on north (south) side of tunnel.

Substation is connected to the 20 kV medium-voltage power network with power cables in accordance with 20 kV Power Supply Scheme (LLO_IBE_DD_EL_TPS_1001_SH_BI_W_01).

Disposition of equipment is shown in drawing Portal building North - transformer station equipment disposition (LLO_IBE_DD_EL_TPS_1002_DI_BI_W_01) and Portal building South - transformer station equipment disposition (LLO_IBE_DD_EL_TPS_1010_DI_BI_W_01).

3.1.1 Energy transformers

To supply consumers of lighting, power and ventilation in tunnel, outdoor lighting, installations in the building, safety systems and signalling/safety devices is provided dry transformers 250 kVA, 20 ± 2x2.5% / 0.40 kV, uk = 4%, in Dyn5 connection.

For the tunnel ventilation supply is provided transformer of 2500 kVA, 20 ± 2x2.5% / 0.69 kV, uk = 6%, in Dyn5 connection.

Transformers must have built-in PT100 thermal probes in the transformer windings and a thermal protection relay installed in the transformer fields of the LV switchgear.

The power transformers on the MV side are protected against short circuit by a protection module, which switches off the MV circuit breaker in the event of a short circuit. The transformers are protected against overload by thermal protection performed with LV circuit breakers, which are set to the permitted current of the transformers. The thermometer and the pressure and oil level meter, if installed on transformers, are also connected to the disconnection of MV circuit breakers in transformer fields.

Manual step voltage regulation in the range of ± 2 x 2.5%, in the no-voltage state on the MV side, is required.

For dry transformers there is provided a connection with cable lugs. The delivery also includes the appropriate number of MV-connected cable plug terminals for the intended cable. It is planned to connect NA2XS (F) 2Y 1x70 mm2, 12/20 kV MV cables to 400 kVA power transformers and cables NA2XS (F) 2Y 1x95/16 mm2, 12/20 kV to 2500 kVA power transformers.

The end connections of LV windings must be made of galvanized aluminum or copper and suitable for connecting the intended LV cables.

Transformer 250 kVA (dry version)

Rated power of the transformer:	250 kVA
Rated voltage:	20/0,40 kV, 50 Hz
Rated current of transformer:	7,2/360 A
Short-circuit voltage:	usc = 4%
Ambient temperature:	40 ° C
Permissible overtemperature	LV/HV: 80/100 K
Cooling mode:	AN
Rated frequency:	50 Hz
Installation height:	up to 1000 m above sea level
Linking group:	Dyn5
Idle losses Po	520 W
Short-circuit losses Psc:	3800 W
Noise:	57 dB
Weight:	approx. 1400 kg
Dimensions (L x W x H):	1.38 x 0.75 x 1.3 m
Equipment:	PT100 therm. probes, therm. protect. Relay

Transformer 2500 kVA (dry version)

Rated power of the transformer:	2500 kVA
Rated voltage:	20/0,69 kV, 50 Hz
Rated current of transformer:	72,2/ 2091 A
Short-circuit voltage:	uk = 6%
Ambient temperature:	40 ° C
Permissible overtemperature	LV/HV: 80/100 K
Cooling mode:	AN
Rated frequency:	50 Hz
Accommodation height:	up to 1000 m above sea level
Linking group:	Dyn5
Idle losses Po:	3100 W
Short-circuit losses Psc:	19000 W
Noise:	71 dB

Weight:	approx. 5800 kg
Dimensions (L x W x H):	2.05 x 1.28 x 2.18 m
Equipment:	PT100 therm. probes, therm. protect. Relay

Other specifications according to BoQ (pos. 12.03.01.01.0009. and 12.03.01.01.0010.) and equivalent for Portal building South from BoQ (pos. 12.03.01.07.0009. and 12.03.01.07.0010.)

3.1.2 Medium Voltage Equipment

Medium voltage switchgear block is with SF6 gas an isolated, fully armoured and protected from hazardous voltage (touch) switchgear of ''Ring Main Unit'' (RMU) design.

By construction, the switchgear is a freestanding cabinet with easily accessible connections and control elements.

The front is equipped with a blind scheme with the signalling status of individual switching devices. Feeder bays are equipped with load break switches with earthing. Transformer insulating fields are equipped with a switch (including earthing) and fuses. All appliances are equipped with auxiliary switches.

Medium-voltage assemblies must be fitted with equipment that will allow remote control from the control centre.

To connect to the TS power supply at the MV level, MV switchgear is designed for a rated voltage of 24 kV, rated current of 630 A and a short-circuit strength of 20 kA (1s).

In the MV premises, standard, factory-made and in accordance with the standards EN 62271-200 and EN 62271-1 type-tested MV switchgear, free-standing versions, with one system of busbars, consisting of an appropriate number of metal-shielded and partitioned ring main feeders, metering panels, bus sectionalizer panels and transformer feeders, will be installed. Ring main feeders and transformer feeders are cable versions for connecting cables from underneath.

LV control cabinet with equipment for control, signalling and measurement of electrical quantities and with control and measuring circuits is mounted on the upper part of each feeder. Ring main feeders are also equipped with a protection and control module. The whole with MV and LV feeder equipment must be wired, parameterized and tested by the manufacturer.

General technical data:

• rated operating voltage	20 kV
• maximum voltage for equipment	24 kV
• rated frequency	50 Hz,
• rated withstand alternating voltage 50Hz	50 kV,
• rated withstand atmospheric voltage	125 kV,
• rated bus current	630 A
• rated branch current	200/630 A
• shock short-circuit current	up to 50 kA
• short-circuit current (up to 3 s)	up to 21 kA
• installation	internal
• cable connectors	at the bottom
• altitude	up to 1000 m
• maximum ambient temperature +	55 °C
• lowest ambient temperature	-25 °C

• humidity	95%
• resistance to open arc according to	EN 60298, appendix AA
• production and testing according to	EN 62271-200
• use under normal operating conditions	acc. to EN 62271-1
• degree of mechanical protection IP3X	acc. to CEI 70-1 (EN 60259)
• control voltage for motor drive, etc.:	230 V AC

Exact configuration is shown in Portal building North - transformer station MV single line diagram (LLO_IBE_DD_EL_TPS_1003_SH_BI_W_01) and Portal building South - transformer station MV single line diagram (LLO_IBE_DD_EL_TPS_1011_SH_BI_W_01).

Other technical specifications according to BoQ (pos. 12.03.01.01.0001. to 12.03.01.01.0006.) and equivalent for Portal building South from BoQ (pos. 12.03.01.07.0001. to 12.03.01.07.0006.).

3.1.3 LV distribution equipment

LV switching block for substation according to drawing Portal building North - transformer substation LV single line diagram (LLO_IBE_DD_EL_TPS_1005_SH_BI_W_01) consists of three LV switching block variants:

=TS PBN+SB-T1-1 (incoming feeder)

=TS PBN+SB-T1-2 (low power and lighting of house installations and tunnel lighting)

=TS PBN+SB-UPS (Uniterruptible power supply for emergency lighting and safety systems)

Exact technical specifications are shown in BoQ (pos. 12.03.01.01.0011. to 12.03.01.01.0013.).

Equivalent to Portal building South - transformer substation LV single line diagram (LLO_IBE_DD_EL_TPS_1013_SH_BI_W_01) consists of three LVSB variants:

=TS PBS+SB-T1-1 (incoming feeder)

=TS PBS+SB-T1-2 (low power and lighting of house installations and tunnel lighting)

=TS PBS+SB-UPS (Uniterruptible power supply for emergency lighting and safety systems)

Exact technical specifications are shown in BoQ (pos. 12.03.01.07.0011. to 12.03.01.07.0013.).

3.1.4 Compensation of reactive power

The installation of compensation of reactive power relieves the transformers, cables and other elements of the transformer substation. Because of this feature at 0.4 kV of the distribution switchgear side of the block, the installation of a suitable automatic filter compensation of 15 kvar is provided.

3.1.5 Earthing and protection against lightning

All facilities will be protected with a device for protection against lightning according to drawing Portal building North - lightning protection system - roof plan (LLO_IBE_DD_EL_TPS_1008_FP_BI_W_01) and Portal building North - lightning protection system – facades (LLO_IBE_DD_EL_TPS_1009_FP_BI_W_01) or equivalent Portal building South - lightning protection system - roof plan (LLO_IBE_DD_EL_TPS_1016_FP_BI_W_01) and Portal building South - lightning protection system – facades (LLO_IBE_DD_EL_TPS_1017_FP_BI_W_01).

On the roof and facades of the building will be placed wire from Stainless Steel fi8 mm. Grounding electrode will be also from Stainless Steel of dimensions 30x3.5 mm. For the implementation of grounding in TS, a special Fe-Zn 25x4 mm strips will be laid on the wall, on which all parts of the TS will be attached (transformers, 20 kV switchyard, NN switchyard, other metal parts of the structure, etc.). On the grounding grid UPS devices will be connected, along with air ducts and air conditioning devices, pumping stations, PE buses, and buses for equipotential bonding, water pipes and all other metal parts.

For lightning protection, all the metal parts on the roof (roof ventilators, roof gutters, etc.) and all metal parts of the facade (windows, doors, safety nets, roof gutters, etc.) will be connected to the earthing grid of the facilities.

Network for grounding the facility will be connected with the network for grounding the tunnel. Network for grounding the tunnel will be performed using the fundamental grounding. In a longitudinal basis on both sides of the tunnel near the site of collection of other drainage waters, a tape Fe-Zn 40x4 mm will be laid. Right and left arm will be connected to each other every 24 m with a cross-connection strip Fe-Zn 40 x 4 mm, which will also be in the basis of the tunnel under the road according to drawing Tunnel - earthing and equipotential bonding (LLO_IBE_DD_EL_TPS_1022_DI_BI_W_01).

At every 24 metres of the longitudinal fundamental grounding, the primary reinforcement concrete ceiling carrier with its steel girders will be connected.

3.1.6 Electrical installation of lighting and switches

Lighting of portal buildings must provide the minimum illumination for the following rooms:

- LV facilities room 400 lx
- MV facilities room 250 lx
- transformer room 200 lx
- auxiliary rooms 150 lx.

Electrical installations for lighting and outlets in the substation are shown in following drawings:

Portal building North - level -2,90 - Lighting & Sockets (LLO_IBE_DD_EL_TEI_1001_FP_BI_W_01)

Portal building North - Ground floor plan - Lighting & Sockets (LLO_IBE_DD_EL_TEI_1002_FP_BI_W_01)

Portal building North - 1st floor plan - Lighting & Sockets (LLO_IBE_DD_EL_TEI_1003_FP_BI_W_01)

Portal building South - Basement floor plan - Lighting & Sockets (LLO_IBE_DD_EL_TEI_1004_FP_BI_W_01)

Portal building South - Ground floor plan - Lighting & Sockets (LLO_IBE_DD_EL_TEI_1005_FP_BI_W_01)

Portal building South - 1st floor plan - Lighting & Sockets (LLO_IBE_DD_EL_TEI_1006_FP_BI_W_01)

3.1.7 Technical calculations

The peak load of both transformers in portal building north (south) is shown in the tables below.

Transformer Station PB - North - T1					
Electrical consumer	**Installed power (kW)**	**RDF (rated diversity factor)**	**Peak power (kW)**	**cos fi**	**Apparent power (kVA)**
Low power and lighting - house instalations +SB-HI	135,0	0,4	56,7	0,80	70,9
Tunnel lighting +SB-TL/N	24,6	1,0	24,6	0,90	27,3
UPS Power supply +SB-UPS	56,5	0,5	29,5	0,90	32,8
Ventilation system +SB-V-GQ1	5,0	1,0	5,0	0,87	5,7
Outdoor lighting	1,0	1,0	1,0	0,90	1,1
Total consumption	**222,1**		**116,8**		**137,8**
Installed transformer				**kVA**	**250,0**
Total consumption of transformer				**%**	**55,1**
Transformer reserve				**%**	**44,9**

Transformer Station PB - North - T2

Electrical consumer	Installed power (kW)	RDF (rated diversity factor)	Peak power (kW)	cos fi	Apparent power (kVA)
Tunnel ventilation system +SB-V-AFN	600,0	1,0	600,0	0,95	631,6
Total consumption	**600,0**		**600,0**		**631,6**
Installed transformer				**kVA**	**2500,0**
Total consumption of transformer				**%**	**25,3**
Transformer reserve				**%**	**74,7**

Transformer Station PB - South - T1

Electrical consumer	Installed power (kW)	RDF (rated diversity factor)	Peak power (kW)	cos fi	Apparent power (kVA)
Low power and lighting - house instalations +SB-HI	66,2	0,5	33,1	0,80	41,4
Tunnel lighting +SB-TL/N	24,6	1,0	24,6	0,90	27,3
UPS Power supply +SB-UPS	28,5	0,7	19,3	0,90	21,4
Outdoor lighting	1,0	1,0	1,0	0,90	1,1
Total consumption	**120,3**		**78,0**		**91,3**
Installed transformer				**kVA**	**250,0**
Total consumption of transformer				**%**	**36,5**
Transformer reserve				**%**	**63,5**

Transformer Station PB - South - T2

Electrical consumer	Installed power (kW)	RDF (rated diversity factor)	Peak power (kW)	cos fi	Apparent power (kVA)
Tunnel ventilation system +SB-V-AFS	600,0	1,0	600,0	0,95	631,6
Total consumption	**600,0**		**600,0**		**631,6**
Installed transformer				**kVA**	**2500,0**
Total consumption of transformer				**%**	**25,3**
Transformer reserve				**%**	**74,7**

3.1.7.1 MV EQUIPMENT

According to the margin value of short circuit in networks of rated voltage of 20 kV is 14 kA, which all electrical equipment on medium voltage installed in the substation should satisfy this criteria.
Provided switchgear units for the 24 kV such as NXPLUS produced by SIEMENS have been tested and certified with 20 kA/1s of thermal short circuit power, or 50 kA of dynamic (impact) short circuit.
Since the expected value of short circuit in the network is 20 kV 14 kA, and expected value of short circuit impact is 36,5 kA we can conclude that the equipment of the MV switchgear unit is satisfactory.

3.1.7.2 LV EQUIPMENT

Short circuit calculations on LV side were made with certified software ETAP and are given in Annex A. With ETAP were checked following parameters of provided equipment:

- Short-Circuit currents,
- BUS loads,
- Branch loads,
- Branch losses,
- Voltage drops.

On the low voltage side of power transformers for the power rating of 2500 kVA, a short-circuit current of up to 35 kA may occur. The selection of electrical equipment was done according to the values of short circuit current. Maximum short circuit in the 0,69 kV network is 72 kA.
Low-voltage switchgear must be declared and certified for thermal short circuit current of 40 kA and the impact of short circuit current of 100 kA.
Since the major electrical equipment (MV and LV switchgear) has been tested and certified according to current IEC standards (IEC 439 for the LV switching blocks and IEC 298 for MV switching blocks), and that the power transformer meets the requirements of the standard IEC 76, it can be concluded that the listed technical parameters are thus verified.

3.1.7.3 CALCULATION OF CONNECTION LV DISTRIBUTION - CABLES

When dimensioning LV power cables between individual power transformers and LV switching blocks the following facts have been taken into account:

1. Operating characteristics of the device controlling the circuit from overloading must satisfy two conditions:

$$I_B \leq I_N \leq I_Z$$

$$I_2 \leq 1{,}45 \,.\, I_Z$$

I_B current load (A))

I_N rated protective device current (A)

I_Z constant current for cable to endure (A)

I_2 current that ensures safe operation of protective equipment (A)

$I_2 = k \,.\, I_N$ - for devices with a fixed shut-off characteristic

$I_2 = k.I_P$ - for devices with an adjustable shut-off characteristic (k = 1,2 to 2,1 … from tables)

2. Short circuit duration:

$$I_k^{\,2} \,.\, t \leq k^2 \,.\, S^2$$

$$t \leq \frac{k^2 . S^2}{I_k^{\,2}}$$

I_k effective value of actual short circuit current (A))

t duration of short circuit (s)

S conductor cross section (mm^2)

k factor of conductor from tables (factor k is obtained from tables for Cu and Al conductors for different insulation materials)

3. Expected value of touch voltage:

$$U_0 \geq I_2 \,.\, Z_0$$

U_0 expected value of touch voltage (V)

I_2 the current ensuring the safe operation of the protective device (A)

Z_0 Resistance of circuit malfunction (Ω)

Calculations were made with software AMPERE PRO and are given in Annex B. With AMPERE PRO were checked following parameters for main LV distribution equipment (cables):

- Coordination Ib<In<Iz [A]
- Indirect touching
- Breaking capacity [kA]
- Short circuit duration: $K^2S^2>I^2t$ [A^2s]
- Voltage Drop [%]
- Fault currents [kA]

3.1.7.1 THE CALCULATION FOR TRANSFORMER COOLING

The cooling of the transformer is foreseen with a natural convection of cold and warm air through the ventilation openings with fixed shutters on the front door.
For calculation purposes, the lower openings with shutters on the substation door are foreseen as inlet hatches. The top opening with blinds and a protective mesh on the front wall are considered as outlets.
The calculations were made assuming a maximum ambient temperature in the chamber is 40 °C and the cold air external temperature is 30 °C.
For calculations of the minimum dimension we use the largest transformer with rated power of 2500 kVA. All openings in the portal buildings are dimensioned to the largesttransformer.

The space for the air ventilation opening is calculated by the formula:

$$A_1 = \sqrt{\frac{13{,}2.P_{uk}{}^2.R}{\Delta\vartheta^3.h}}$$

where:

A_1 - space of air-vent opening (m^2)
P_{uk} - total transformer losses, (kW)
h - height difference between the middle of transformer cauldron and ventilation opening (3,5 m),
$\Delta\vartheta$ - temperature difference between maximum external temperature and air temperature (10 °K),
R - coefficient of resistance to air ventilation (it is 5)

Actuall implemented ventilation openings are bigger than calculated ones, so it can be safely concluded that the natural conditions for natural cooling of transformer have been provided.

3.1.7.2 THE COMPENSATION OF REACTIVE POWER

Like stated in the technical description, we can see that size of compensation device for reactive energy compensation is determined by the maximum load at 0,4 kV distribution of the switching block:

- maximum total load: P_{ist} = 116 kW
  $\cos\varphi_1$ = 0,9
  $\cos\varphi_2$ = 0,95

$P_j = (tg\ \varphi_1 - tg\ \varphi_2)\ .\ P_{ist}$ = (0,484 - 0,329). 480 = 18 kvar

The installation of filtering automatic compensator 15 kvar is foreseen. On 0,69 kV voltage level is provided another compensation device of approximately 150 kvar for compensation of ventilation system.

3.1.7.3 THE CALCULATION OF GROUNDING

In accordance with the technical recommendations, the grounding transformer stations will be dimensioned to work with earthed neutral point of 20 kV with earth fault current of 300 A, for a maximum of 0.5 sec.
According to specific data: I_k = 300 A, U_d = 80V, t=0.5sec, r=0.33 the grounding resistance equals:

$$R_z \le \frac{U_d}{r.I_{zem}} \le \frac{80}{0{,}33.300} \le 0{,}8\,\Omega$$

Calculation of the grounding resistance of the tunnel was made in the project (design) of the electrical installations and equipment of the tunnel. The calculated total resistance of the tunnel and substations basic grounding equals: $R_T = 1{,}78\,\Omega$

Grounding along MV cables up to a total length of 200 m:

$$R_{SN} = \frac{100}{2.\pi.100}.\ln\frac{2.200^2}{0{,}8.0{,}0125} = 1{,}26\,\Omega$$

The total distribution resistance equals:

$$\frac{1}{R_{oz}} = \frac{1}{R_{ozT}} + \frac{1}{R_{SN}}$$

$$R_{oz} = 0{,}74\,\Omega$$

According to previously achieved results, the foreseen grounding enables the accomplishment of the allowed grounding value.

3.2 TRANSFORMER SUBSTATIONS IN LAY-BY NICHES EQ1, EQ2, EQ3, EQ4 AND EQ5 1x400 kVA, 20/0,4 kV

Transformer substations EQ1, EQ2, EQ3, EQ4 and EQ5 1x400 kVA, 20/0,4 kV will be placed in LayBy niches inside of the tunnel every 1000 m.

Substations are connected to the 20 kV medium-voltage power network with power cables in accordance with 20 kV Power Supply Scheme (LLO_IBE_DD_EL_TPS_1001_SH_BI_W_01).

3.2.1 Energy transformers

To supply consumers of lighting, power and ventilation in tunnel, safety systems and signalling/safety devices is provided dry transformer 400 kVA, 20 ± 2x2.5% / 0.40 kV, uk = 4%, in Dyn5 connection.

Transformers must have built-in PT100 thermal probes in the transformer windings and a thermal protection relay installed in the transformer fields of the LV switchgear.

The power transformer is on the MV side protected against short circuit by a protection module, which switches off the MV circuit breaker in the event of a short circuit. The transformers are protected against overload by thermal protection performed with LV circuit breakers, which are set to the permitted current of the transformers. The thermometer and the pressure and oil level meter, if installed on transformer, is also connected to the disconnection of MV circuit breakers in transformer fields.

Manual step voltage regulation in the range of ± 2 x 2.5%, in the no-voltage state on the MV side, is required.

For dry transformers there is provided a connection with cable lugs. The delivery also includes the appropriate number of MV-connected cable plug terminals for the intended cable. It is planned to connect NA2XS (F) 2Y 1x70 mm2, 12/20 kV MV cables to 400 kVA power transformers.

The end connections of LV windings must be made of galvanized aluminum or copper and suitable for connecting the intended LV cables.

Transformer 400 kVA (dry version)

Rated power of the transformer:	400 kVA
Rated voltage:	20/0,40 kV, 50 Hz
Rated current of transformer:	11,5/577 A
Short-circuit voltage:	usc = 4%
Ambient temperature:	40 ° C
Permissible overtemperature	LV/HV: 80/100 K
Cooling mode:	AN
Rated frequency:	50 HZ
Installation height:	up to 1000 m above sea level
Linking group:	Dyn5
Idle losses Po	750 W
Short-circuit losses Psc:	5500 W
Noise:	60 dB
Weight:	approx. 1600 kg
Dimensions (L x W x H):	1.45 x 0.84 x 1.35 m
Equipment:	PT100 therm. probes, therm. protect. relay

Other specifications according to BoQ (pos. 12.03.01.02.0003 for EQ1, pos. 12.03.01.03.0003 for EQ2, pos. 12.03.01.04.0003 for EQ3, pos. 12.03.01.05.0003 for EQ4 and pos. 12.03.01.06.0003 for EQ5).

3.2.2 Medium Voltage Equipment

Medium voltage switchgear block is with SF6 gas an isolated, fully armoured and protected from hazardous voltage (touch) switchgear of ''Ring Main Unit'' (RMU) design.

By construction, the switchgear is a freestanding cabinet with easily accessible connections and control elements.

The front is equipped with a blind scheme with the signalling status of individual switching devices. Feeder bays are equipped with load break switches with earthing. Transformer insulating fields are equipped with a switch (including earthing) and fuses. All appliances are equipped with auxiliary switches.

Medium-voltage assemblies must be fitted with equipment that will allow remote control from the control centre.

To connect to the TS power supply at the MV level, MV switchgear is designed for a rated voltage of 24 kV, rated current of 630 A and a short-circuit strength of 20 kA (1s).

In the MV premises, standard, factory-made and in accordance with the standards EN 62271-200 and EN 62271-1 type-tested MV switchgear, free-standing versions, with one system of busbars, consisting of an appropriate number of metal-shielded and partitioned ring main feeders, metering panels, bus sectionalizer panels and transformer feeders, will be installed. Ring main feeders and transformer feeders are cable versions for connecting cables from underneath.

LV control cabinet with equipment for control, signalling and measurement of electrical quantities and with control and measuring circuits is mounted on the upper part of each feeder. Ring main feeders are also equipped with a protection and control module. The whole with MV and LV feeder equipment must be wired, parameterized and tested by the manufacturer.

General technical data:

• rated operating voltage	20 kV
• maximum voltage for equipment	24 kV
• rated frequency	50 Hz,
• rated withstand alternating voltage 50Hz	50 kV,
• rated withstand atmospheric voltage	125 kV,
• rated bus current	630 A
• rated branch current	200/630 A
• shock short-circuit current	up to 50 kA
• short-circuit current (up to 3 s)	up to 21 kA
• installation	internal
• cable connectors	at the bottom
• altitude	up to 1000 m
• maximum ambient temperature +	55 °C
• lowest ambient temperature	-25 °C
• humidity	95%
• resistance to open arc according to	EN 60298, appendix AA
• production and testing according to	EN 62271-200
• use under normal operating conditions	acc. to EN 62271-1

- degree of mechanical protection IP3X acc. to CEI 70-1 (EN 60259)
- control voltage for motor drive, etc.: 230 V AC

Exact configuration is shown in Lay By Niche - transformer station MV single line diagram (LLO_IBE_DD_EL_TPS_1018_SH_BI_W_01).

Other technical specifications according to BoQ (pos. 12.03.01.02.0001. and 12.03.01.02.0002. for EQ1 and similar for EQ2-EQ5).

3.2.3 LV distribution equipment

LV switching block for substation according to drawing Lay By Niche - transformer station LV single line diagram (LLO_IBE_DD_EL_TPS_1020_SH_BI_W_01) consists of three LV switching block variants:

=TS EQ+SB-T1-1 (incoming feeder)

=TS EQ+SB-T1-2 (tunnel lighting and ventilation system)

=TS EQ+SB-UPS (Uniterruptible power supply for emergency lighting and safety systems)

Exact technical specifications are shown in BoQ (pos. 12.03.01.02.0004. and 12.03.01.02.0005. for EQ1 and similar for EQ2-EQ5).

3.2.4 Compensation of reactive power

The installation of compensation of reactive power relieves the transformers, cables and other elements of the transformer substation. Because of this feature at 0.4 kV of the distribution switchgear side of the block, the installation of a suitable automatic filter compensation of 20 kvar is provided.

3.2.5 Earthing and protection against lightning

Grounding network of Lay By niche will be connected with grounding network of the tunnel. Network for grounding the tunnel will be performed using the fundamental grounding. In a longitudinal basis on both sides of the tunnel near the site of collection of other drainage waters, a tape Fe-Zn 40x4 mm will be laid. Right and left arm will be connected to each other every 24 m with a cross-connection strip Fe-Zn 40 x 4 mm, which will also be in the basis of the tunnel under the road according to drawing Tunnel - earthing and equipotential bonding (LLO_IBE_DD_EL_TPS_1022_DI_BI_W_01). Earthing and equipotential bonding of Lay By niches is shown in Lay By Niche - earthing and equipotential bonding (LLO_IBE_DD_EL_TEI_1008_FP_BI_W_01).

At every 24 metres of the longitudinal fundamental grounding, the primary reinforcement concrete ceiling carrier with its steel girders will be connected.

Steel anchors for anchoring and the grounding of internal TS are also connected to the fundamental grounding electrode which will be carried out the same way as on the TS portal.

3.2.6 Electrical installation of lighting and switches

Lighting of facilities in Lay By niches must provide the minimum illumination for the following rooms:

- LV facilities room 400 lx
- MV facilities room 250 lx
- transformer room 200 lx
- auxiliary rooms 150 lx.

Electrical installations for lighting and outlets in facilities in Lay By niches are shown in following drawing:

Lay By Niche - Lighting & Sockets (LLO_IBE_DD_EL_TEI_1007_FP_BI_W_01)

3.2.7 Technical calculations

The peak loads of transformers in Lay By niches are shown in the tables below.

Transformer Station EQ1 - T1					
Electrical consumer	**Installed power (kW)**	**RDF (rated diversity factor)**	**Peak power (kW)**	**cos fi**	**Apparent power (kVA)**
Tunnel ventilation system +SB-V-EN1	185,0	1,0	185,0	0,95	194,7
Tunnel ventilation system Crosspassage airlock & service tunnel ventilation +SB-V-EQ1	65,0	1,0	65,0	0,95	68,4
Tunnel ventilation system Crosspassage airlock +SB-V-GQ2	5,0	1,0	5,0	0,95	5,3
UPS Power supply +SB-UPS	41,9	0,6	26,1	0,95	27,5
Tunnel lighting	13,7	1,0	13,7	0,95	14,4
Total consumption	**310,6**		**294,7**		**310,3**
Installed transformer				**kVA**	**400,0**
Total consumption of transformer				**%**	**77,6**
Transformer reserve				**%**	**22,4**

Transformer Station EQ2 - T1					
Electrical consumer	**Installed power (kW)**	**RDF (rated diversity factor)**	**Peak power (kW)**	**cos fi**	**Apparent power (kVA)**
Tunnel ventilation system +SB-V-EN2	185,0	1,0	185,0	0,95	194,7
Tunnel ventilation system Crosspassage airlock & service tunnel ventilation +SB-V-EQ2	65,0	1,0	65,0	0,95	68,4
Tunnel ventilation system Crosspassage airlock +SB-V-GQ3	5,0	1,0	5,0	0,95	5,3
UPS Power supply +SB-UPS	41,9	0,6	26,1	0,95	27,5
Tunnel lighting	13,7	1,0	13,7	0,95	14,4
Total consumption	**310,6**		**294,7**		**310,3**
Installed transformer				**kVA**	**400,0**
Total consumption of transformer				**%**	**77,6**
Transformer reserve				**%**	**22,4**

Transformer Station EQ3 - T1					
Electrical consumer	**Installed power (kW)**	**RDF (rated diversity factor)**	**Peak power (kW)**	**cos fi**	**Apparent power (kVA)**
Tunnel ventilation system +SB-V-EN3	185,0	1,0	185,0	0,95	194,7
Tunnel ventilation system Crosspassage airlock +SB-V-EQ3	5,0	1,0	5,0	0,95	5,3
Tunnel ventilation system Crosspassage airlock +SB-V-GQ4	5,0	1,0	5,0	0,95	5,3
UPS Power supply +SB-UPS	43,9	0,6	27,5	0,95	28,9
Tunnel lighting	13,7	1,0	13,7	0,95	14,4
Total consumption	**252,6**		**236,1**		**248,6**
Installed transformer				**kVA**	**400,0**
Total consumption of transformer				**%**	**62,1**
Transformer reserve				**%**	**37,9**

Transformer Station EQ4 - T1					
Electrical consumer	**Installed power (kW)**	**RDF (rated diversity factor)**	**Peak power (kW)**	**cos fi**	**Apparent power (kVA)**
Tunnel ventilation system +SB-V-EN4	185,0	1,0	185,0	0,95	194,7
Tunnel ventilation system Crosspassage airlock +SB-V-EQ4	5,0	1,0	5,0	0,95	5,3
Tunnel ventilation system Crosspassage airlock +SB-V-GQ5	5,0	1,0	5,0	0,95	5,3
UPS Power supply +SB-UPS	41,9	0,6	26,1	0,95	27,5
Tunnel lighting	13,7	1,0	13,7	0,95	14,4
Total consumption	**250,6**		**234,7**		**247,1**
Installed transformer				**kVA**	**400,0**
Total consumption of transformer				**%**	**61,8**
Transformer reserve				**%**	**38,2**

Transformer Station EQ5 - T1					
Electrical consumer	**Installed power (kW)**	**RDF (rated diversity factor)**	**Peak power (kW)**	**cos fi**	**Apparent power (kVA)**
Tunnel ventilation system +SB-V-EN5	185,0	1,0	185,0	0,95	194,7
Tunnel ventilation system Crosspassage airlock & service tunnel ventilation +SB-V-EQ5	65,0	1,0	65,0	0,95	68,4
Tunnel ventilation system Crosspassage airlock +SB-V-GQ6	5,0	1,0	5,0	0,95	5,3
UPS Power supply +SB-UPS	41,9	0,6	26,1	0,95	27,5
Tunnel lighting	13,7	1,0	13,7	0,95	14,4
Total consumption	**310,6**		**294,7**		**310,3**
Installed transformer				**kVA**	**400,0**
Total consumption of transformer				**%**	**77,6**
Transformer reserve				**%**	**22,4**

3.2.7.1 MV Equipment

According to the margin value of short circuit in networks of rated voltage of 20 kV is 14 kA, which all electrical equipment on medium voltage installed in the substation should satisfy this criteria.
Provided switchgear units for the 24 kV such as 8DJH produced by SIEMENS have been tested and certified with 20 kA/1s of thermal short circuit power, or 50 kA of dynamic (impact) short circuit.
Since the expected value of short circuit in the network is 20 kV 14 kA, and expected value of short circuit impact is 36,5 kA we can conclude that the equipment of the MV switchgear unit is satisfactory.

3.2.7.2 LV Equipment

Short circuit calculations on LV side were made with certified software ETAP and are given in Annex A. With ETAP were checked following parameters of provided equipment:

- Short-Circuit currents,
- BUS loads,
- Branch loads,
- Branch losses,
- Voltage drops.

On the low voltage side of power transformer 400 kVA, a short-circuit current of up to 35 kA may occur. The selection of electrical equipment was done according to the values of short circuit current.
Low-voltage switchgear must be declared and certified for thermal short circuit current of 20 kA and the impact of short circuit current of 50 kA.
Since the major electrical equipment (MV and LV switchgear) has been tested and certified according to current IEC standards (IEC 439 for the LV switching blocks and IEC 298 for MV switching blocks), and that the power transformer meets the requirements of the standard IEC 76, it can be concluded that the listed technical parameters are thus verified.

3.2.7.3 Calculation of connection LV distribution - cables

When dimensioning LV power cables between individual power transformers and LV switching blocks the following facts have been taken into account:

1. Operating characteristics of the device controlling the circuit from overloading must satisfy two conditions:

$$I_B \leq I_N \leq I_Z$$

$$I_2 \leq 1{,}45 \, . \, I_Z$$

I_B current load (A))
I_N rated protective device current (A)
I_Z constant current for cable to endure (A)
I_2 current that ensures safe operation of protective equipment (A)

$I_2 = k \cdot I_N$ - for devices with a fixed shut-off characteristic

$I_2 = k.I_P$ - for devices with an adjustable shut-off characteristic (k = 1,2 to 2,1 ... from tables)

2. Short circuit duration:

$$I_k^{\,2} \cdot t \leq k^2 \cdot S^2$$

$$t \leq \frac{k^2 . S^2}{I_k^{\,2}}$$

I_k effective value of actual short circuit current (A))
t duration of short circuit (s)
S conductor cross section (mm^2)
k factor of conductor from tables (factor k is obtained from tables for Cu and Al conductors for different insulation materials)

3. Expected value of touch voltage:

$$U_0 \geq I_2 \cdot Z_0$$

U_0 expected value of touch voltage (V)
I_2 the current ensuring the safe operation of the protective device (A)
Z_0 Resistance of circuit malfunction (Ω)

Calculations were made with software AMPERE PRO and are given in Annex B. With AMPERE PRO were checked following parameters for main LV distribution equipment (cables):

- Coordination Ib<In<Iz [A]
- Indirect touching
- Breaking capacity [kA]
- Short circuit duration: $K^2S^2>I^2t$ [A^2s]
- Voltage Drop [%]
- Fault currents [kA]

3.2.7.4 THE CALCULATION FOR TRANSFORMER COOLING

The cooling of the transformer is foreseen with a natural convection of cold and warm air through the ventilation openings with fixed shutters on the front door.
For calculation purposes, the lower openings with shutters on the substation door are foreseen as inlet hatches. The top opening with blinds and a protective mesh on the front wall are considered as outlets.
The calculations were made assuming a maximum ambient temperature in the chamber is 40 °C and the cold air external temperature is 30 °C.

The space for the air ventilation opening is calculated by the formula:

$$A_1 = \sqrt{\frac{13{,}2.P_{uk}^{\,2}.R}{\Delta\vartheta^3.h}}$$

where:
A_1 - space of air-vent opening (m^2)
P_{uk} - total transformer losses, (kW)
h - height difference between the middle of transformer cauldron and ventilation opening (3,5 m),
$\Delta\vartheta$ - temperature difference between maximum external temperature and air temperature (10 °K),
R - coefficient of resistance to air ventilation (it is 5)

Actuall implemented ventilation openings are bigger than calculated ones, so it can be safely concluded that the natural conditions for natural cooling of transformer have been provided.

3.2.7.5 THE COMPENSATION OF REACTIVE POWER

Like stated in the technical description, we can see that size of compensation device for reactive energy compensation is determined by the maximum load at 0,4 kV distribution of the switching block:

- maximum total load: P_{ist} = 300 kW

$\cos\varphi_1$ = 0,9

$\cos\varphi_2$ = 0,95

$P_j = (\mathrm{tg}\,\varphi_1 - \mathrm{tg}\,\varphi_2)\,.\,P_{ist} = (0{,}484 - 0{,}329).\,300 = 20$ kvar

The installation of filtering automatic compensator 20 kvar is foreseen.

3.2.7.6 THE CALCULATION OF GROUNDING

In accordance with the technical recommendations, the grounding transformer stations will be dimensioned to work with earthed neutral point of 20 kV with earth fault current of 300 A, for a maximum of 0.5 sec. According to specific data: I_k = 300 A, U_d = 80V, t=0.5sec, r=0.33 the grounding resistance equals:

$$R_z \leq \frac{U_d}{r.I_{zem}} \leq \frac{80}{0{,}33.300} \leq 0{,}8\,\Omega$$

Calculation of the grounding resistance of the tunnel was made in the project (design) of the electrical installations and equipment of the tunnel. The calculated total resistance of the tunnel and substations basic grounding equals: $R_T = 1{,}78\,\Omega$

Grounding along MV cables up to a total length of 200 m:

$$R_{SN} = \frac{100}{2.\pi.100}.\ln\frac{2.200^2}{0{,}8.0{,}0125} = 1{,}26\,\Omega$$

The total distribution resistance equals:

$$\frac{1}{R_{oz}} = \frac{1}{R_{ozT}} + \frac{1}{R_{SN}}$$

$$R_{oz} = 0{,}74\,\Omega$$

According to previously achieved results, the foreseen grounding enables the accomplishment of the allowed grounding value.

4. VENTILATION SYSTEM

The design of tunnel ventilation systems is elaborated in Technical Reports and Specifications, Volume 1 – Tunnel Ventilation System. The subject of this document is power supply of the ventilation system.

With project implementation besides the regulation, the following was taken into consideration:

- RVS 09.02.31,
- RVS 09.02.22,

4.1 ELECTRIC DRIVES FOR VENTILATION

The Llogara tunnel will be designed with a semi-transverse ventilation system with an associated exhaust duct. The duct is connected to ventilation stations, one each portal. Where each an 550 kW axial fan is located. Dampers in the false ceiling between the carriageway and the air duct have a standard distance of 100 m. In case of fire the smoke can be punctually extracted in a very efficient way. Air quality and air speed sensors are installed in carriageway.

During normal operation fresh air from one tunnel portal will be pushed into the tunnel to dilute the exhaust gases. At bidirectional traffic, the existing flow direction must be maintained. The flow is forced by 5 pairs of 90 kW jet fans placed in bays outside Lay By niches.

The Llogara tunnel is a one tube tunnel with bidirectional use and one lane per direction. A service tunnel runs parallel to the main tunnel with a much smaller regular cross section. They have connected each other with eleven cross passages (EQ and GQ). These crossings are for exit in case of a fire or other reasons that require an escape. The cross passages will be built as air locks separated by walls, one each side. Every air lock will be pressurized by a separate ventilation system. The VFD-controlled 5 kW fan is operating at a certain speed to create a defined overpressure to the main tube. This prevents contamination by leaks.

The fresh air needed will be drawn from service tube. With this system the escape routes can be kept smoke-free in all operating situations.

Most of time the service tube will ventilate itself by natural ventilation. But in some cases, and during maintenance work inside, a mechanical ventilation system is required get sufficient fresh air inside. A simple longitudinal ventilation system is provided to handle normal operation. Small 30 kW jet fans, air speed and air quality sensors will be installed.

At the end of service tunnel gates are required. During active ventilation in service tunnel these will be opened. To ensure the air supply for air locks during normal and fire operation dampers will be installed beneath the gates.

Basic overview of the semi-transverse ventilation system with axial fans in ventilation stations combined with longitudinal ventilation with jet fans is presented in the Tunnel ventilation system equipment disposition drawing (LLO_IBE_DD_EL_TVE_1001_SH_BI_W_01).

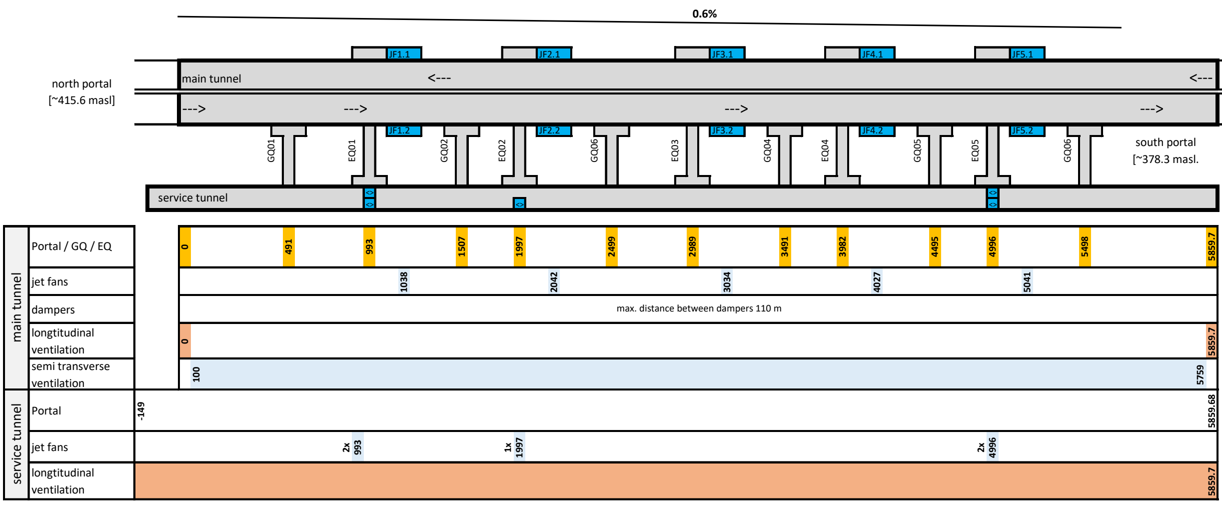


Figure 4-1 Basic overview of ventilation system

For 550 kW axial fans power supply two transformers are planned, each 2500 kVA, 20/0,69 kV, one in the south and other in the north portal building inside transformer stations. In each transformer station two 0,69 kV LV switching blocks are planned for power supply of axial fans.

LV switching block for power supply of semi-transverse ventilation system according to drawing Tunnel ventilation system PB North (LLO_IBE_DD_EL_TVE_1002_SH_BI_W_01 consists of five LV switching blocks:

=TS PBN+SB-V-AFN-1 (incoming feeder)

=TS PBN+SB-V-AFN-2 (compensation of reactive power)

=TS PBN+SB-V-AFN-3 (softstarter with by-pass contactor for 550 kW axial fan)

=TS PBN+SB-V-AFN-4 (0,69/0,4 kV transformer for auxiliary drives)

=TS PBN+SB-V-AFN-5 (exhaust dampers and heaters power supply)

Exact technical specifications are shown in BoQ (pos. 12.03.01.01.0014. to 12.03.01.01.0018.).

Tunnel ventilation system PB South - Single line diagram (LLO_IBE_DD_EL_TVE_1003_SH_BI_W_01) consists of five LV switching blocks:

=TS PBS+SB-V-AFN-1 (incoming feeder)

=TS PBS+SB-V-AFN-2 (compensation of reactive power)

=TS PBS+SB-V-AFN-3 (softstarter with by-pass contactor for 550 kW axial fan)

=TS PBS+SB-V-AFN-4 (0,69/0,4 kV transformer for auxiliary drives)

=TS PBS+SB-V-AFN-5 (exhaust dampers and heaters power supply)

Exact technical specifications are shown in BoQ (pos. 12.03.01.07.0014. to 12.03.01.07.0018.).

Power supply of 90 kW jet fans in main tube is provide from transformer substations in Lay By niches. According to drawing Tunnel ventilation system Lay By Niche - Single line diagram (LLO_IBE_DD_EL_TVE_1004_SH_BI_W_01) LV distribution board consists of four LV switching blocks:

=TS EQ+SB-V-EN1-1 (incoming feeder)

=TS EQ+SB-V-EN1-2 (VFD with by-pass contactor for 90 kW jet fan 1)

=TS EQ+SB-V-EN1-3 (VFD with by-pass contactor for 90 kW jet fan 2)

=TS EQ+SB-V-EN1-4 (exhaust dampers and heaters power supply)

Exact technical specifications are shown in BoQ (pos. 12.03.01.02.0006. to 12.03.01.02.0009.).

Power supply of 30 kW jet fans in service tube is provide from transformer substations in Lay By niches. According to drawing Tunnel ventilation system Crosspassage airlock & service tunnel ventilation - Single line diagram (LLO_IBE_DD_EL_TVE_1006_SH_BI_W_01) LV distribution board consists of tw LV switching blocks:

=TS EQ+SB-V-EQ1-1 (incoming feeder and service tube jet fans power supply)

=TS EQ+SB-V-EQ1-2 (airlock ventilation)

Exact technical specifications are shown in BoQ (pos. 12.03.01.02.0010. to 12.03.01.02.0011.).

Power supply of 5 kW fans for airlock system in crosspassage is provided from transformer substations in Lay By niches. According to drawing Tunnel ventilation system Crosspassage airlock - Single line diagram (LLO_IBE_DD_EL_TVE_1005_SH_BI_W_01) LV distribution board consists of one LV switching blocks:

=TS EQ+SB-V-GQ1 (airlock ventilation)

Exact technical specifications are shown in BoQ (pos. 12.03.01.02.0012.).

All the switching blocks must be equipped with the necessary work equipment for work and protection of motor drives, with automation for automatic operation and signaling of fan statuses.

The fans will be turned on automatically and manually from the switching blocks or from the operational panels from the north portal building. The operational switches must be equipped with keys. The fans have to work automatically to provide the necessary air quality and in accordance with fire protection program.

Fans must be put in motion one at a time to prevent the transformer fall-out at. Besides the automatic motor operation, there must to be temperature engine protection, the vibration protection as well as heating of the winding when the engine is turned off. The automatic ventilation operation will be guided from the command centre via supervision computer, therefore all the necessary signals must be transmitted in to the command center and the commands from the command centre to the switchboards.

Besides the engine management in the command centre all the signalization states will be monitored and the measurements in the ventilation system. For ventilation power supply the cables will be laid in the cable shelves inside the tunnel.

All the cables inside the tunnel tube must be fire resistant according to E30/FE180 DIN 4102-12. The cable shelves and the sheet for covering the slots in the tunnel must be made of stainless steel (quality V4A or 1.4571 in accordance to DIN 4102-12 standard).

4.1.1 Power outage

If there is a power outage of ventilation power supply, the tunnel must be closed for traffic if in the time that is needed to switch from one to another power supply the supply is not enabled.

Upon restoration of power supply the ventilation is in the basic operation mode (the tunnel in that case remains closed until the final state of basic operation mode is implemented).

5. LOW VOLTAGE POWER SUPPLY AND DISTRIBUTION

5.1 Electrical installations

On the LV side it is needed to connect all PE buses inside the distribution cabinets, the cabinet housings on the null points of electrical transformers, main buses for equipotential bonding and all other metal masses.

The protection against indirect touch on the low voltage side is automatic power off of protection inside the TN grounding system. All protection plug contacts and metal parts which don't normally belong to the power circuits must be connected via yellow-green color guide to the PE buses inside the distribution cabinet.

The voltage for management and signaling is 230 V AC. The security source of that voltage is the UPS device power 40 kVA which will be installed inside power stations.

The overcurrent and short-circuit relays as well as sub voltage protection and grounding protection is also planned.

All low voltage switchboards must be equipped with the main switches, other switches, and overcurrent and short-circuit protection, automatic work elements, surge protection, signaling elements, measurements, etc.

Besides the switchboards also the devices for compensation of power factors are installed. The direct devices for compensation of electric power magnetizing are planned as well as automatic compensation devices for compensation of burden reactive electric power.

Besides the switchboards in portal buildings also the switchboards inside the electro niches in the tunnel are provided.

The switchboards inside electro niches supply the tunnel lighting and security devices inside the tunnel (measurements, management, signaling). Five electro niches in Lay By niches are planned. All the switchboards inside electro niches must be equipped with the main and other switches with overcurrent and short-circuit protection, power surge protection, signal elements, automation for automatic work, etc.

Power supply cables for powering the switchboards inside electro niches will be laid inside protective tubes inside tunnel channels.

Signal transfer from the switchboards inside electro niches and the LV switchboards from portal building are planned. Inside the Command centre the status of all LV switchboards, transformer temperature, below the power supply the current electric power and voltage will be monitored.

Surge protection must be done in multiple levels.

LV switchboard equipment is shown in the individual single line diagram:

- Lighting and small power distribution board PB North (LLO_IBE_DD_EL_TEI_1009_SH_BI_W_01)
- Lighting and small power distribution board PB South (LLO_IBE_DD_EL_TEI_1010_SH_BI_W_01)
- Lay By Niche - Lighting & Sockets (LLO_IBE_DD_EL_TEI_1007_SH_BI_W_01)

5.2 Uninterruptible Power Supply (UPS)

For continuous use of the most important devices and systems inside the tunnel, the uniterruptible power supply must be provided.

Therefore are provided seven UPS devices of 40 kVA, one per each portal building and five in electro niches in Lay By niches. Exact technical specifications are shown in BoQ (pos. 12.03.01.01.0024.).
Autonomy of batteries must be 90 minutes (60 minutes at the end of 10 years lifetime). Batteries must be of sealed type (dry). The operation of UPS devices and batteries will be monitored inside the Command centre.

UPS powers:

- security lighting inside main tunnel tube,
- lighting of evacuation routes,
- lighting for direction in case of fire,
- computer surveillance management system,

All cables for UPS system power supply must be fire proof FE 180/E30 for 250ºC in accordance to DIN 4102-12.

5.3 Electrical installation for portal buildings and electro niches

The lighting inside electro niches for SOS call is provided with LED waterproof lighting fixtures which will be turned on locally inside electric niches. Inside SOS niches will always be ON. The lights will be connected to the UPS devices. Besides the lighting each niche will have two single phase and one triple phase power plug each. All lights must be connected to UPS with fire resistant cables. Emergency lighting is also done in the hallways and crosspassages.

In all areas single phase plugs must be installed. In the command area also in parapet channel. Inside MV and LV area single triple phase plug must be installed.

5.4 Cables

All cable passages through walls, floor plates, ceiling plates of command centre, transformer stations, electro niches and SOS niches must be closed with fire resistant mass FLAMRO so that the entrance of fire and smoke is prevented inside the area. The cable entrance from the tunnel channels inside electro niches and tunnel transformer stations must be done with fire resistant resistance E90 and the entrance of rodents and other pest must be prevented.

Fire resistant FE180/E30 must be on all power supply cables and all other safety systems inside the tunnel (UPS device power supply) fire alert cables and cables for transfer of radio connections.

All cables inside tunnel tube must be "halogen free". All cables must be protected from mechanical damage, overload protected, short circuit and surge protected The security systems cables must be controlled for break and shot circuit.

6. MATERIALS

6.1 General

For all products, materials, devices and equipment installed in to LLOGARA tunnel, the Contractor must provide the corresponding evidence of security and functionality to the Investor (certificates, attests, positive expert marks, measurements, tests, etc.). All equipment, installations and materials must comply with all demands regarding regulations, standards and recommendations.

All devices, equipment and construction must be finally processed for predicted conditions of environment and usage. Climate conditions on the location are temperature from -20ºC to +50ºC, relative humidity 95 % and wind speed 25 m/s in any direction.

All products are approved by the Investor and the contractor is responsible for delays which may occur if the contractor suggests unacceptable materials and equipment.

Stainless steel (sheet metal, profiles, constructions, housings, etc.) must be alloy Cr.-Ni-Mo-Ti quality V4A No. 1.4404, 1.4571.

Fixing materials (screws, struts, bases) must be alloy Cr-Ni-Mo quality V6A No. 1.4529 in accordance to EN 10027-2.

"Aluminum alloy" which is listed as a usable material must be Al.Mg - Si05 in accordance to DIN 1725 with hardness F25 i H14 in accordance to DIN 1748 for profiles and AlMg3 in accordance to DIN 1725 for aluminum sheet metal.

“Aluminum" is also the aluminum alloy based on above listed properties unless the project lists otherwise.

Aluminum alloy must always be “sanded”. Galvanized steel can be used only when is explicitly allowed (outside tunnel tube). Galvanized steel is in any case heat galvanized with the coat thickness in accordance to TSE 914 (30 μm).

6.1.1 Painting

The coat and color must be in tune with the Investors decision regarding the use of standard RAL without cost increase.

The metal surfaces need to be pre processed in accordance to DIN 55928 (rust removal, grinding, sanding).

Paint coat structure:

2 coats of base each 40 μm thickness

2 coats of paint each 60 μm thickness

Total coat thickness 200 μm

The paint (lacquer) must be two-component with high net polymerization and low level of capillary development suitable for tunnel environment, salt water proof, highly ultraviolet light resistant, resistant to oil, acid and alkaloids, not sensitive to grease and must not contain heavy metals for temperature area from -30°C to +120°C.

The porosity density must be controlled in accordance to DIN 4681 third part with electrical isolation at least 4000 V at coat thickness 100µm. Net point test must be in accordance to DIN 53151 with result Gto for steel and aluminum.

6.1.2 Cable connections

Only halogen free cables can be used inside the tunnel. The isolation of all cables for ventilation, security light, direction signs lighting power supply, security power supply of electric niches and SOS call niches as well as all other cables which must operate s3afely and maintain its function in case of fire at least 30 minutes more, must be fire resistant in accordance to E0/FE 180.

All cable ends must be clearly marked with plate with reference cable number, cable type and cable section if they are power supply cables.

Cable entries in to the housings must be done with glands to that the entering of humidity, pest, vibration is prevented and the cables are not burdened.

Cables need to be delivered to the construction site in factory colletes, factory sealed and untouched with matching documents. Damaged, ripped or cables with abrasive damage are not allowed to be used.

Vertically laid cables (in slots inside side tunnel walls or other places) need to be mechanically supported by using type support connectors and struts every 30 cm. Besides the cables that are vertically laid need to be heat insulated inside the tunnel tube in accordance to the attached detail.

6.1.3 Surge protection

The contractor must use and do all necessary protection measure for protection of all cables (energetic, signal, managing TK cables and others) and equipment from thunder damage and other surges.

6.1.4 Grounding

All visible metal surfaces and constructions which with electrical circuit do not form the part of electrical circuit including the metal housings of devices and equipment as well as cable shelves must be galvanic connected and grounded.

6.2 Medium voltage devices and installations

Medium voltage (MV) equipment must be supplied including MV switchgear consisting of MV feeders in individual transformer stations, MV power cables and MV cable connections between feeders and transformers.

To connect to the TS power supply at the MV level, MV switchgear is designed for a rated voltage of 24 kV, rated current of 630 A and a short-circuit strength of 14 kA.

In the MV premises, standard, factory-made and in accordance with the standards EN 62271-200 and EN 62271-1 type-tested MV switchgear, free-standing versions, with one system of busbars, consisting of an appropriate number of metal-shielded and partitioned ring main feeders, metering panels, bus sectionalizer panels and transformer feeders, will be installed. Ring main feeders and transformer feeders are cable versions for connecting cables from underneath.

LV control cabinet with equipment for control, signalling and measurement of electrical quantities and with control and measuring circuits is mounted on the upper part of each feeder. Ring main feeders are also equipped with a protection and control module. The whole with MV and LV feeder equipment must be wired, parameterized and tested by the manufacturer.

General technical data:

• rated operating voltage	20 kV
• maximum voltage for equipment	24 kV
• rated frequency	50 Hz,
• rated withstand alternating voltage 50Hz	50 kV,
• rated withstand atmospheric voltage	125 kV,
• rated bus current	630 A
• rated branch current	200/630 A
• shock short-circuit current	up to 50 kA
• short-circuit current (up to 3 s)	up to 21 kA
• installation	internal
• cable connectors	at the bottom
• altitude	up to 1000 m
• maximum ambient temperature +	55 °C
• lowest ambient temperature	-25 °C
• humidity	95%
• resistance to open arc according to	EN 60298, appendix AA
• production and testing according to	EN 62271-200
• use under normal operating conditions	acc. to EN 62271-1
• degree of mechanical protection IP3X	acc. to CEI 70-1 (EN 60259)
• control voltage for motor drive, etc.:	230 V AC

6.3 Transformers

In all TS, to supply consumers of lighting, power and ventilation in tunnel, outdoor lighting, installations in the building, safety systems and signalling/safety devices, must be installed dry transformers 250 kVA or 400 kVA, 20 ± 2x2.5% / 0.40 kV, uk = 4%, in Dyn5 connection.

Two energy dry transformers of 2500 kVA, 20 ± 2x2.5% / 0.69 kV, uk = 6%, in Dyn5 connection, must be installed for the tunnel ventilation supply.

Transformers must have built-in PT100 thermal probes in the transformer windings and a thermal protection relay installed in the transformer fields of the LV switchgear.

The power transformers on the MV side are protected against short circuit by a protection module, which switches off the MV circuit breaker in the event of a short circuit. The transformers are protected against overload by thermal protection performed with LV circuit breakers, which are set to the permitted current of the transformers. The thermometer and the pressure and oil level meter, if installed on transformers, are also connected to the disconnection of MV circuit breakers in transformer fields.

Manual step voltage regulation in the range of ± 2 x 2.5%, in the no-voltage state on the MV side, is required.

For dry transformers there is provided a connection with cable lugs. The delivery also includes the appropriate number of MV-connected cable plug terminals for the intended cable. It is planned to connect NA2XS (F) 2Y 1x70 mm2, 12/20 kV MV cables to 400 kVA power transformers and cables NA2XS (F) 2Y 1x95/16 mm2, 12/20 kV to 2500 kVA power transformers.

The end connections of LV windings must be made of galvanized aluminum or copper and suitable for connecting the intended LV cables.

Transformer 250 kVA (dry version)

Rated power of the transformer:	250 kVA
Rated voltage:	20/0,40 kV, 50 Hz
Rated current of transformer:	7,2/360 A
Short-circuit voltage:	usc = 4%
Ambient temperature:	40 ° C
Permissible overtemperature	LV/HV: 80/100 K
Cooling mode:	AN
Rated frequency:	50 HZ
Installation height:	up to 1000 m above sea level
Linking group:	Dyn5
Idle losses Po	520 W
Short-circuit losses Psc:	3800 W
Noise:	57 dB
Weight:	approx. 1400 kg
Dimensions (L x W x H):	1.38 x 0.75 x 1.3 m
Equipment:	PT100 therm. probes, therm. protect. Relay

Transformer 400 kVA (dry version)

Rated power of the transformer:	400 kVA
Rated voltage:	20/0,40 kV, 50 Hz
Rated current of transformer:	11,5/577 A
Short-circuit voltage:	usc = 4%
Ambient temperature:	40 ° C
Permissible overtemperature	LV/HV: 80/100 K
Cooling mode:	AN
Rated frequency:	50 HZ
Installation height:	up to 1000 m above sea level
Linking group:	Dyn5
Idle losses Po	750 W
Short-circuit losses Psc:	5500 W
Noise:	60 dB
Weight:	approx. 1600 kg
Dimensions (L x W x H):	1.45 x 0.84 x 1.35 m
Equipment:	PT100 therm. probes, therm. protect. relay

Transformer 2500 kVA (dry version)

Rated power of the transformer:	2500 kVA
Rated voltage:	20/0,69 kV, 50 Hz
Rated current of transformer:	72,2/ 2091 A
Short-circuit voltage:	uk = 6%
Ambient temperature:	40 ° C

Permissible overtemperature	LV/HV: 80/100 K
Cooling mode:	AN
Rated frequency:	50 HZ
Accommodation height:	up to 1000 m above sea level
Linking group:	Dyn5
Idle losses Po:	3100 W
Short-circuit losses Psc:	19000 W
Noise:	71 dB
Weight:	approx. 5800 kg
Dimensions (L x W x H):	2.05 x 1.28 x 2.18 m
Equipment:	PT100 therm. probes, therm. protect. Relay

6.4 MV cables

20 kV cable lines must provide a reliable supply of TS intended for the supply of tunnel.

Cables must be manufactured in accordance with HD 620 S2: 2010: Distribution cables with extruded insulation for rated voltages from 3.6/6 (7.2) kV up to and including 20.8/36 (42) kV.

All 20 kV cable connections between TP 20/0.4 kV must be made with single-core shielded Al cables with insulated polyethylene insulation and PVC sheath NA2XS (F) 2Y 1x150/25 mm2, for Un = 12/20 kV. MV cables must be connected with plastic ties in a triangular bundle L1, L2, L3 along the entire length of the route.

Characteristics of 20 kV single-core polyethylene cables 3x NA2XS(F)2Y (1x 150/25) mm2:

- type designation acc. DIN VDE: NA2XS(F)2Y
- rated voltage: U0/U = 12/20 kV
- maximum mains voltage: Um = 24 kV
- test voltage: Ui = 42 kV
- resistance of the cond. at 20 °C: 0.206 Ω/km
- operative capacitance: 0.25 µF/km – cables in triangular bundle
- capacitive current: 0.94 A/km
- operating inductance: 0.39 mH/km – triangular
- short-circuit curr. 1s, 90/250°C 21,4 kA
- current load: 319 A in ground – triangular bundle
- conductor: Al (99,5%) rope 1 x 150mm2, round wire,
- cond. screen: semicond. layer on conduc.
- insulation: (XLPE)
- insulation screen: semiconductor layer on insulation
- separator: semiconductor foam tape
- electrical protection / screen: braid of copper wire
- separator: foam tape
- outer jacket: PE-HD
- standards: HD 620 S2: 2010 Part 10C, IEC 60502-2

6.5 Low voltage devices and installations

All switchgear in the LayBy niches in the main tunnel must be made of the V2A quality construction, and in the portal building (PB) of double pickled sheet metal. The size and colour of all switch gear in the same room must be coordinated.

All work must be performed according to recognized rules of technology. It is necessary to comply with all regulations and standards that apply in the territory of the Republic of Albania international regulations.

All installations in the tunnel must be carried out in a design for damp areas, with a degree of protection of at least IP 65. Special attention must be paid to special loads on materials and devices.

Equipment that will be installed directly in the traffic tube must meet IP 65 protection, temperature range - 20 to + 40 °C and relative humidity up to 100%. All fastening and supporting material for the equipment to be mounted in the tunnel tube must be made of stainless steel V4A, as well as cable shelves and all other metal structures in the tunnel tubes.

The cable trays in the tunnel cable channels must be hot-dip galvanized.

Materials and devices that do not correspond to the loads that occur in the tunnel must be removed free of charge and replaced with appropriate devices or. materials.

All switchgear/cabinets must be made of sheet steel painted with primer and finish paint and equipped with all necessary switching, protective, control, measuring and signalling elements. All switchgear in the LayBy niches must be made in protection IP54, in PB in protection IP43.

All mounting elements of the switchgear are mounted on a mounting frame, mounting rails or mounting plate. It must be possible for the built-in elements to be installed later. A 20% reserve in the switchgear space is also provided. The height and colour of the cabinets in the same room must be the same.

Switchgear must be installed and wired at the factory. All wire connections must be made in PVC ducts. Care must be taken to maintain the separation between the different circuits even in PVC ducts.

All doors of the switchgear which the installation elements are provided must be connected to a protective conductor.

The switchgear must be equipped inside with cover plates for individual instruments, if necessary.

All measuring instruments, switches, lights, must be installed on the front door.

The busbars are supplied with their own covers, the busbars are generally made 5-pole.

All wires and cables must be connected to the terminal blocks in the distributors.

Cable cross-sections larger than 70 mm2 are connected directly to the corresponding switching devices. Care must be taken to ensure that the connected elements of the switchgear are of the correct size, otherwise the connections must be extended and reinforced accordingly.

All protective conductors and potential equalization conductors are connected by means of terminals for protective conductors of the same product.

All busbars of neutral conductors and protective conductors are placed insulated in individual cabinets. All terminals and terminal strips must be marked, as well as all cables using embossed cable marking plates.

All instruments built into the manifold are marked with engraved and permanently affixed nameplates.

In the case of an NH isolator with a fuse, it must be visibly marked with the help of engraved fuse nameplates, which are the maximum permissible for the connected cable. Written plates are permanently glued to the separator.

In each switchgear, it is necessary to provide a set of plans in the plan pocket on the inside of the door.

All wiring is carried out by means of H07V-K - conductors, with insulated cable lugs with pins or connectors (Cu control lines at least 1,5 mm2).

All circuit breakers and circuit breakers must have several auxiliary contacts for status signalling and transmission of conditions in the circuit breaker. All fuses must have contacts that signal the fuses have blown.

Technical characteristics of LV switchgear – transformer 250 kVA

- Ambient temperature — -5 °C to 40 °C, 35 °C 24 hour aver.
- Relative humidity — up to 95%
- Degree of mechanical protection — IP54, in acc. with EN 60529
- Indicated insulation voltage Ui — 690 V
- Indicated voltage Un — 400 V
- Indicated frequency — 50 Hz
- Earthing system — TN-C-S
- Rated current min. — 400 A
- Rated withstand short-circuit current — min. 15 kA
- Rated short-circuit surge current — min. 37,5 kA

Technical characteristics of LV switchgear – transformer 400 kVA

- Ambient temperature — -5 °C to 40 °C, 35 °C 24 hour aver.
- Relative humidity — up to 95%
- Degree of mechanical protection — IP54, in acc. with EN 60529
- Indicated insulation voltage Ui — 690 V
- Indicated voltage Un — 400 V
- Indicated frequency — 50 Hz
- Earthing system — TN-C-S
- Rated current min. — 630 A
- Rated withstand short-circuit current — min. 20 kA
- Rated short-circuit surge current — min. 50 kA

Technical characteristics of LV switchgear – transformer 2500 kVA

- Temperature of surr. — -5°C to 40°C, 35°C 24 hour aver.
- Relative humidity — up to 95%
- Degree of mechanical protection — IP54, acc.to EN 60529
- Indicated insulation voltage Ui — 1200 V
- Indicated voltage Un — 690 V
- Indicated frequency — 50 Hz
- Earthing system — TN-C-S
- Rated current — min. 2500 A
- Rated withstand short-circuit current — min. 40 kA
- Rated short-circuit surge current — min. 100 kA

6.6 LV cable connections

All LV connections are planned to be implemented by cable. The connection to transformer is provided by cables of type FG7R or N2XY. Cables of NYCY or OLFLEX 110 CY type are intended for power, control and signal cables.

Power distribution is performed with LV power cables type NYY-J; for emergency lighting and ventilation cables type NHXH FE180/E30, of appropriate cross-sections will be used. Halogen-free cables of the N2XH type are provided in the tunnel. Single-core and multi-core cables should be used.

Characteristics of cables type FG7R

- type label DIN VDE: FG7R
- rated voltage: 0.6/1 kV
- test voltage: 4 kV
- max. work. conductor temperature 90° C
- max. temperature in short circuit: +250°C, up to 5 s
- conductor copper conductor, class 2
- insulation HPDM HEPR mass
- sheath PVC mass
- standards: CEI- UNEL 35375, CEI 20-13, CEI 20-22 II
- flammability test: CEI 20-35/1-1, EN 50265-2-1
- corrosion and halogen test: CEI 20-37/2-1, EN 50267-2-1
- gas emission test: CEI 20-37/3-0, EN 50268-1

Characteristics of cables type NYCY

- Type designation according to DIN VDE: NYCY
- rated voltage: 0.6/1 kV
- test voltage: 4 kV
- conductor copper wire or rope
- insulation PVC mass
- sheath PVC mass
- standards: IEC 60 502-1, DIN VDE 0276 T 603, HD 603 S1 type 3G1

Characteristics of cables type N2XH

- type label acc. to DIN VDE: N2XH
- rated voltage: 0.6/1 kV
- test voltage: 4 kV
- conductor copper rope
- insulation halogen-free flame retardant XLPE mass
- sheath flame-retardant halogen-free elastomeric
- standards: DIN VDE 0266, IEC 60 502-1
- cable flammability test: IEC 332-3, cat. A
- cable combustion gas test: IEC 360754-2

Characteristics of cables type NHXH FE 180/E30

- rated voltage: 0.6/1 kV
- test voltage: 4 kV
- conductor copper conductor, class 1 and 2
- insulation 1 waterproof halogen-free dielectric

• insulation 2	halogen-free crosslinked polymer, HXI1 acc. to VDE 0266
• sheath	cross-linked thermop. polyolefin mix halogen free, HXI4 acc. to DIN VDE 0276
• standards:	IEC 60502-1, IEC 60331-11/-21(180 min), VDE 0472-Teil 814), DIN 4102-12
• max. conductor working temperature	90° C
• max. short-circuit temperature:	+250° C, up to 5s
• flame retardant, flame spread test:	IEC 60332-1,IEC 60332-3-24, catC (VDE 0482-266-2-4)
• cable insulation fire test:	IEC 60331-11/-21 (180 min), (VDE 0472-p. 814)
• installation functionality fire test:	DIN 4102- Teil 12
• halogen gas test:	IEC 60 754-1 (DIN EN 60754-1)
• halogen gas corrosivity test:	IEC 60 754-2 (DIN EN 60754-2)
• flue gas density test:	EC 61 034 (DIN EN 61034)

6.7 Cable trays

Cable trays in the tunnel must be made of sheet steel in a U-profile made of stainless steel in accordance with material No. 1.4401 according to DIN 17440 (V4A) with a width in accordance with the requirements. The fastenings must be of the same material.

Cable trays in cable channels, LayBy niches, TS are made of hot-dip galvanized sheet steel.

6.8 Cable routes

All works need to be done by recognized rules. Apply all the regulation and standards, which are valid on the territory of Federation B&H as well as VDE, IEC, CEN and EU regulations.

All installation inside the tunnel needs to be done in humid spaces version, protection level at least IP 65, temperature area -20°C ÷ +40°C, humidity 95 %. All portable material and securing material which will be mounted in the tunnel tube needs to be done out of stainless steel material V4A br. 1.4571, as well as shelves for cables and all other metal construction inside the tunnel tube. Materials and devices, which will not suited to the tunnel environment conditions, the contractor will remove free of charge and replace with the appropriate devices or materials.

6.9 Lightning conductors, earthing and equipotential bonding

In TS earthing and equipotential bonding are performed, external TS are also equipped with a lightning rod device. The following materials are used: stainless steel round conductor fi=8 mm, stainless steel 30x3,5 mm, FeZn 25x4 mm and conductor type N2XH of different cross-sections.

All passages of electrical wiring through the walls of fire sections and transverse barriers of cable channels in tunnel tubes shall be made completely fireproof and sealed from flue gas in fire resistance class E30 in accordance with applicable building and fire regulations. Fire-retardant linings must be of such design that new conductors can be easily installed, or old ones replaced at any time.

The cables for the safety supply of the distributors are laid on special cable trays, with fastening and connecting material and covers, or pulled into the pipes or placed on clamps made in accordance with DIN 4102-12. Fireproof cables type E30 FE180 are provided.

Only systems for which this fire resistance class has been proven and certified, are permitted. Certificates must be attached to the offer.

All fireproof coverings are made with cable coverings or conductor linings specified in the test certificates. The cladding/coating material must not tear or even break the cable sheaths.

All cable passages and other openings must be sealed in such a way as to prevent rodents from accessing the cables and devices.

Work in electrical installations may only be carried out in the presence and according to the instructions of a specialist appointed and responsible for these works.

6.10 Uniterruptible power supply (UPS)

This item covers the backup power supply with all necessary equipment, materials, accessories and all parts for the complete backup power supply device.

Uninterruptible power supplies (UPS) for installation in tunnel must be in an industrial, robust design, it must be housed in a metal housing with double protection against electromagnetic influences. The level of mechanical protection of the device must be at least IP31 (occasionally water may drip in some rooms if the tunnel is in wet karst areas, protection against rodents and insects) When the front door is open, the level of protection must be at least IP20. The UPS device must have built-in replaceable dust filters (important especially in areas with a lot of dust), the possibility of protection level IP52. The device must have a high efficiency (UPS alone > 95%, including input transformer> 94%) to reduce ventilation needs. The device must be capable of redundant parallel connections. Batteries should be at least High Performance (10-12 years) according to Eurobat classification. Batteries should be placed on shelves (for better cooling).

The average autonomy should be at least 90 minutes. The UPS must be equipped with a 12-pulse rectifier.

The uninterruptible power supply must work in "continuous operation" mode, which means that the consumers are powered by an inverter. The rectifier provides input current for the inverter as well as for AKU batteries. In the event of a rectifier or inverter fault, the mains must be switched via "by-pass" within <40 ms (electronic). For repair purposes, a "by pass" service is provided (manually).

The UPS must be equipped with a filter for the 5, 7, 11 and 13 harmonic components.

It is further noted that the inverter output must be offered with the following accessories, which are not otherwise usual:

- overload control,
- frequency control.

The device must be able to limit the charging current of the batteries and temperature compensation during charging.

As a protective measure against electric shock, the inverter provides for automatic disconnection of the overcurrent protection in the TN-S earthing system with a separately laid protective conductor.

The inverter must be able to supply resistive loads consumers and LED lamps on and motors (inverter description).

Batteries must be NiCd or lead dry gas tight, long life and manufactured according to IEC 896 and IEC 707 according to the criteria "+10 High Integrity Eurobat Guide to VR lead acid feeders.

AKU batteries can have a maximum of two parallel battery branches.

A battery discharge test must be performed before collection.

The voltages are in line with the needs of the uninterruptible power supply system.

Batteries must be of robust design to ensure operation for harsh conditions for 10 years with low internal resistance and minimal maintenance. The power factor must be 0.95 or better, the necessary compensating devices must be included.

The device must allow fast charging of the batteries, (less than 5 hours for charging at 90% of the capacity) The device must enable temperature compensation of the battery charging.

Battery charging temperature compensation built-in as standard for each individual module.

7. EXECUTION OF WORKS

7.1 General

All devices and electrical parts must be protected in a suitable way in order to provide the security of people. In the areas which are accessible to the public, the equipment must be completely enclosed and housings must be robust so that they can endure the intentional damage, as well as to have the smooth outer surfaces without unnecessary imperfections of slots and openings where humidity and dust might collect.

All elements inside the electrical cabinets and stands or similar must be marked with permanent labels which will be attached to the element and element bearing plate.

Inside all electrical cabinets, the plastic function schematics must be inserted.

All electrical equipment must have the radio wave filters so that it doesn't damage the other equipment and systems in accordance to CENELEC EN 55014 i EN 55015 i CISPR 14 i 15.

All goods and materials must be packed properly so that the damage and environment does not cause damage during transportation and storage.

7.2 Medium voltage devices and installations

MV switchgear will be placed on appropriate metal support structures in MV rooms. These rooms must have a double prefabricated floor in which MV cables are laid, and MV cables are connected to the MV switchgear from below.

7.3 Transformers

Transformers must be placed in transformer rooms on steel support stands. Transformer cooling is done with natural air circulation. Transformer losses must be within the values defined in EN 60076. All connections to the transformer should be performed by cable.

Transformers must be earthed after installation. Special earthing points are provided on the transformer for earth connection. It is also necessary to connect the steel supports on which the transformers are placed at least twice diagonally to the protective earthing.

7.4 MV cables

MV cables must be connected with plastic ties in a triangular bundle L1, L2, L3 along the entire length of the route. The cable line will be laid in the cable shaft, in the cable channels and on the cable trays. MV cables are terminated with cable lugs.

It is mandatory to install cable marking plates at the ends of the laid cable. Single-core cables must not be marked with clamps made of ferromagnetic material. The plates and fastening material for marking cables are made of durable material and must contain the following information about the cable line: cross-section, name of the cable line, voltage level, length, direction, phase designation. When several cables are laid in one channel or pipe or laid in the ground close together, they must be provided with intermediate markings to identify the individual cables.

When building utility lines, it is necessary to ensure the correct order of work. Since electric cables are a relatively sensitive element of underground installations, it is appropriate to first build all the necessary cable sewers with shafts, and only then proceed to the arrangement of other utility lines or the construction.

When pulling cables into the cable duct, the cable manufacturer's instructions for the maximum permissible traction must be observed.

The bending radius for laying must be greater than 15 x D for MV cables, (D - outer diameter of the cable).

When laying cables, it is necessary to follow the regulations regarding the required distances from any other utility lines.

Before filling the cable trench and performing the cable wiring, it is necessary to record the cable routes with staking out (surveying) from fixed points in the field, such as facilities, and from geodetic points and enter them in the technical documentation of the distribution company.

It is necessary to enter more important parts of the cable line in the technical documentation, such as cable joints, various crossings with other municipal lines or other devices, laying in pipes, sewage and the like.

In the substation, the screens of 20 kV cables must be directly connected to the integrated earthing system. Due to earthing and protection against dangerous contact voltage in the area of stations on lines electrified with direct current, cable shields in certain transformer stations are earthed via surge arresters.

7.4.1 Description and laying of MV cables

Cables are transported using cable drums, while smaler quantities can be transported in rolls. Cable endings must be waterproof protected with appropriate caps. Cables should be kept in covered, dark space.

Every cable drum should have a plate with cable information.

It is not recommended to lay cables in temperatures lower than +5°C for paper insulated cables, and -5°C for cables with PVC insulation. If the outside temperature is lower than allowed, cables must be pre-heated in the following ways:

a) Cable heating in dry area; Cable drum is left in closed area if the temperature of the area is:

from +5°C< to +10°C 72 hours,

from +10°C to +20°C 40 to 48 hours

from +20°C to +25°C 24 to 36 hours.

b) Heating using electric energy; All strands apart from neutral (if the cut is smaller) are parallely connected and connected to a welding machine or appropriate transformer 400/230/7 V. Power of heating current is app. 1 A/mm2. Cable surface temperature is controlled using a thermometer. Maximum allowed temperature is:

+40°C for cables up to 1 kV,

+35°C for cables up to 10 kV,

+30°C for cables up to 20 kV.

WARNING: At all values, cable manufacturer's instructions must be observed above all.

Prior to unwinding cable off the drum, it is necessary to consider the manufacturer's instructions:

- regularity of protective caps on cable ends,
- state of outer side of cable coat,
- if there exists a possibility to damage outer coat while unwinding,
- general state of cable drum,
- coordination of cable type and length with accompanying data for specific route.

Mechanical unwinding with motor winder is performed in three ways:

- Pulling using a cable pulling grip attached to the cable coat. Such method is appropriate if the route does not have too much elbows and arches.
- Pulling using couplings connected to cable conductors. This method is appropriate for difficult routes, where more force is required.
- Pulling using coupling connected to cable armouring (uniquely cables with round or flat wire armouring).

These cables will be laid using a cable pulling grip. It is necessary to control the pulling force, which should not exceed the value determined below for 20 kV cables:

for 20 kV cable XHE 49-A 1x240/25 mm2 7200 N

Curve radius when laying highvoltage cables is :

for 20 kV cable XHE 49-A 1 x 240/25 mm2 minimum of 630 mm

When pulling cables into the pipe and cable channels, the following conditions must be fulfilled:

- on the curve route, the minimum curve radius is observed,
- allowed pulling force depending on the cable structure must be observed.

Prior to pulling, normal working conditions must be ensured:

- lifting of manhole cover,
- control of the presence of toxic gasses,
- ventilation,
- lighting,
- cleaning of the manhole and removing of water,
- control of pipe permeability.

Crossings with and proximity of MV cables to other installations and infrastructure

MV power cables intersect or are near the following facilities or devices:

- power cable,
- telecommunication cable line,
- water supply or waste water systems,
- local or transport road.

In case of parallel laying of more MV distribution cables, the smallest allowed distance between cables is 7 cm.

Testing with direct high voltage is recommended. Testing program in course of overtaking MV cables from the manufacturer includes:

- cable: XHE49-A, 12/20 kV, 1 x 240/25 mm2
- standard: SIST HD 620S1, IEC 60502-2
- partial testing, performed on a cable sampled from one chosen drum from the total cable order:
  - measuring of electrical resistance of conductors,
  - measuring of partial de-electrification,
  - voltage testing with alternating voltage,
  - checking of cable structure;
- when overtaking cables, the following documents should be delivered to the ordering party (Client):
  - factory testing protocol on completed testing for all ordered cable lengths,
  - expert opinion on responsibility, with evidence of performed typical testings and declaration of compliance,
  - quality system certificate - ISO 9001
  - cable technical specification.

Table 1: Cable should withstand the following stress

Nominal voltage (kV)	*Alternating voltage (kV)*	*Direct voltage (kV)*	*Duration (min.)*
12/20	30	50,5	5/15
6/10	10,5	24	15
0,6/1	4	12	10

After the testings are performed, trial operation is not necessary.

Testing of a 20 kV rated voltage cable outer coating is performed on installed cable with direct voltage of 5 kV and after the couplings were mounted. Test voltage is applied between the steel cable screen as one electrode and ground, as other electrode.

7.5 LV cables

All low voltage cables, signal, measure and data, need to be delivered in accordance to IEC 502, VDE 0271, VDE 0272, IEC 227, CEN, DIN 4102-12, IEC 331 and other norms.

Cable laying is done:

- inside the tunnel tube on the right side inside the channel underneath the pavement on the cable shelves of various dimensions 0,4 kV cables, signal cables, measurement and management cables, all separately,
- in the area of drive centrals on the platos in the cable pipes below the hardened surfaces,
- in the drive centrals, transformer stations, electro niches and command centre on the cable shelves in the double floor.

Energy cables inside the tunnel tube must be of low level of smoke and halogen free N2XH i N2XCH. Cables for power supply of fans, security lighting and power supply of UPS devices as well as all cables which must maintain its function in case of fire must be of fire resistant version FE 180/E30 in accordance to DIN 4102-12 i IEC 331 (NHXH i NHXCH).

7.6 Low voltage devices and installations

All distribution cabinets must be produced out of matching Al construction or V2A quality construction and sheet metal thickness at least 2.5 mm and equipped by attached pole schematics, twice painted and water sealed IP54 inside electro niches and IP43 in the buildings.

The doors must be closed in three points. The size and color of the cabinet in the same area must be matched.

LV switchgear must be placed on support structures or attached to the wall. The main LV switchgear will be placed in the LV rooms. These rooms have a double prefabricated floor in which LV cables are laid and the cables are connected to the LV switchgear from below.

Laying of LV cables must be carried out on cable trays, in protective pipes and in a double prefabricated floor. Corrosion protection of cable trays must be carried out using a hot-dip galvanizing process.

The cable ends must be protected from moisture. The cables are laid in one length as much as possible. The necessary couplings are installed in an appropriate manner. Couplings must be taken into account in unit prices and are not paid separately. The same is true for cable lugs. When laying, the cables must be pulled over cable drums. Pulling cables on concrete or floors is not permitted.

When laying cables, it is necessary to strictly observe the bending radius, which for multi-core cables with XLPE insulation, can be: $\geqslant$ 10xD or PVC insulation $\geqslant$ 12xD (where D is the outer diameter of the cable diameter).

Only cables of the same voltage should be installed in one pipe/duct.

All listed cable lengths are only approximate. The contractor is responsible for accurate measurements at the construction site before ordering cables. Cable installation is only permitted along the required cable routes. The Contractor is fully responsible for protecting the cables from damage during storage, installation or during working with them.

The contractor shall provide complete information on all cables.

All cable routes are marked on the construction site and approved by the Engineer before continuing with the installation of cable trays.

Before proceeding with any part of the contract, the Contractor shall submit to the Engineer for approval his proposal regarding the layout of the cables and the construction methods. The engineer has the right to reject any proposal without giving reasons.

The Contractor must, at his own expense, provide sufficient and appropriate machinery and equipment necessary for the unloading, handling, transport and installation of all cables. This equipment may not be removed from the construction site without the permission of the Engineer.

7.7 Cable trays

Cable trays can be mounted on the wall or on ceiling brackets. The distance between the supports is determined according to the permissible load capacity which is determined by the shelf manufacturer. The distance between the trays must be in accordance with EMC.

Cable trays must be manufactured and tested in accordance with the EN 61537 standard.

Cable trays for fire resistant cable installation must be manufactured and tested in accordance with DIN 4102

Part 12 and the general manufacturer's instructions. Fastenning screws must be made of stainless steel in accordance with material V6A no. 1.4529. The fire-resistant cable support system can be mounted on the wall or on ceiling brackets.

7.8 Cable routes

All tunnel installations are to be performed according to execution regulations for humid environment; level of mechanical protection is at least IP 65, temperature -20°C to +50°C, humidity 95 %. All carrying material and the material for attaching equipment to be installed in the tunnel must be made of non-corrosive material V4A number 1.4571. The same applies to cable trays and other metal structures inside the tunnel. Those materials and devices that are not suited for pressure produced inside the tunnel will be removed by the Contractor free of charge and replaced with appropriate materials/devices.

Cable endings should be protected from humidity. If possible, cables should be placed in one length. Required couplings are appropriately installed. Couplings are priced per unit and are not separately accounted for. The same is applied to cable endings. During placement, cables should be pulled over a cable drum. Pulling cables over concrete or ground is not allowed. All elements installed and used in project execution, such as switches, fuses, sockets, lamps, clamps, distribution cabinet structures etc., must comply with the required conditions for obtaining appropriate test certificates.

Installation of torsion screws, encompassing clamps as any other fastening material is performed by the Contractor without additional cost.

Fastening material, torsion screws, bolts etc., must be made of stainless steel V6A no 1.4529.

All cable routes are marked at the construction site and confirmed by the Engineer before proceeding to the mounting of cable carriers.

Before continuing with any part of the contract, the Contractor will present to the Engineer the proposition on cable arrangement and construction procedure for approval. The Engineer is entitled to rejecting any part of the proposition without previous explanation.

The Contractor must at its own expense provide satisfactory and appropriate mechanization and equipment required for unloading, manipulation, transport and installation of all cables. The equipment must not be removed from the construction site without the Engineer's approval.

Cables in cable channels

Inside the tunnel, cables are placed in cable channels under the sidewalk.

Cables in double installation floor, on trays and in ducts

In the double installation floor and on cable trays energy and control cables must be placed separately.

Cable channels outside the tunnels

Outside the tunnel pipes, PVC protection pipes for mounting power and control cables up to exterior equipment and operation centers are placed and cemented.

Cable channels must be pressure-resistant and appropriate for in-soil laying according to related standards.

The Contractor shall install the necessary cable manholes. Overall placement of cable channels, including digging and mounting of cable manholes and other ground works (excavations, cementing, backfilling, etc.)

are also executed by the Contractor.

SubContractor's responsibility, which needs to be confirmed in written, is to make sure that all construction works are appropriate for cable laying, including curves, as well as to coordinate with the civil works Contractor for execution of cable manholes.

Cable channels are cemented (15 N/mm2) for mechanical protection. The trench is backfilled with soil afterwards.

Cable trays

Cable trays placed directly into the tunnel pipe are tin, U shaped, stainless steel in accordance with the material V4A number 1.4404, 1.4571.

Fastening screws should be made of stainless steel, material V6A number 1.4529.

Cable trays outside the tunnel should be hot-zincked, the thickness of zinc coat 20 µm.

7.9 Lightning conductors, earthing and equipotential bonding

External facilities must be equipped with lightning conductors on the roof and drains along the facade walls, which are made with stainless steel conductors fi=8 mm. Measuring points must be provided on all drains. They must be connected to an external circular earthing made of stainless steek 30x3.5 mm laid in the ground at 1.00 m distance from the building, with a digging depth of 0.80 to 1.00 m. The earthing element in the ground must be connected to the earthing bond FeZn 25x4 mm laid in the foundations of the buildings or to the earthing element made of FeZn 40x4 mm laid in the lower part of the tunnel in the foundation of the arch on both sides of the tunnel tube and service pipe. All lightning conductors (catch line, lightning rod, etc.) must be adapted to the local wind speed.

In the LV TS room, where the main LV switchgear is planned to be installed, the main equipotential bonding bus (GIP) is installed, to which the earthing system in the foundations of the building, the external earthing system dug next to the building and the internal earthing for equipotential bonding must be connected.

Equipotential bonding busbars must also be connected to the GIP. Manifolds, cabinets, etc. are connected to the mentioned busbars, which are connected to the earthing network. with N2XH conductor. Equipotential bonding conductors are pulled into protective tubes and laid in a double floor.

The equipotential bonding conductor must have at least half the cross-section of the largest protective conductor in the building, but not less than 6 mm2 Cu.

Using copper wire N2XH of cross section 120 mm2, the earthing of tunnels is also connected into the main potential GIP equalizing cabinet.

On all air ducts and various pipelines, it is necessary to perform galvanic bridging of insulating joints with Cu braided wire 35 mm2.

7.10 Uniterruptible power supply (UPS)

The device is power supplied from the LV network with 400/230 V, 50 Hz and powers the equipment via rectifier and inverter. In case of outage of the network voltage the power supply is taken over by batteries.

The rectifier is semiconducting with constant voltage, for input level 400/230 V ± 25 %, 50 Hz ± 2 %, 3 phases and N guide version with power limiter and fast charging equipment. Input power limit to 125 % with the possibility of adjustment from 100 % to 125 %.

The output filter must provide the minimum waves of power charging the bateries, and in any case must be RMS < 3 % and one way power DC must match the needs of the inverter. Rectifier must be able to manage the inverter even if the batteries are off. Recharge of completely empty batteries must be possible in 6 hour time period.

Inverter is semiconductor capable to take over the accumulation power with output 400/230 V ± 1 %, 50 Hz ± 0.5 % with sinus AC/DC voltage with minimal total harmony vitiation < 3 %, three phase, N guide. Listed characteristics are valid for the area from idle to the full load with strength factor 1.

The dynamic regulation must be possible from ± 5 % at the input interruption of AC/DC voltage and ± 10 % for sudden ON or OFF of full load via static switch with the return up to 3 % of stationary voltage sooner than 50 ms and up to 1 % sooner than 100 ms. Input filter on the main lines in accordance to EN 60555.

The overload possibility to 125 % at full load at strength factor 1 in duration of 10 min in 100 % load for gaining heat stability.

Self protective power regulator must limit the output of inverter to 125 % of full load or for short circuit on the output connectors of UPS device. It must be equipped with fast fuses, the cascade outage of semiconductors must be prevented and the fuses must have the fallout alert.

The communication card must be installed for communication with the command centre via serial communication RS 485. Besides that UPS devices:

- must have Ethernet interface and support SNMP protocol and RS 485 communication,
- must have Web interface for remote diagnostics and control besides the enabled control via integral system for surveillance and management,
- must be modular with the possibility of capacity expansion on demand (UPS devices with the possibility of adding additional battery modules).

Protective device UPS must prevent any damage or fallout which might cause overload, short circuit and surge which might occur because of atmosphere discharge or industrial surge or any other conditions.

Semiconductor switch must switch the overload to bypass without power supply interruption in case of malfunction or overload. This switch must automatically return the overload to the UPS after the malfunction or overload is over.

Because of activity of semiconductor switch the losing of management of tunnel systems must not happen, or the loss of communication in work and data transfer of tunnel systems, which means that the time of detection of fallout and switching, must be short.

The switch for manual switching to bypass must be dimensioned for higher level from name parameters of the inverter and must enable the switching of network power supply without interruption with previous synchronization for the needs of maintenance and service. The switch without synchronization must be prevented.

Batteries must be VRLA (Valve-Regulated), long life +10, chosen by IEC896 and IEC 707 per criteria +10 High Integrity Eurobat Guide to VR Lead acid cells. Batteries can have maximum of two parallel battery lines. Before hand out the discharge test needs to be done to check capacity (40 kW at strength factor 1 and 3 hour anatomy). Batteries must be of robust version with minimum maintenance and low inner resistance.

Batteries are set to the open steel construction in one level because of simple access for maintenance. The carrying construction must be electrostatically painted with protection coat which must be acid proof and mechanical damage proof. All used materials must be resistant to the conditions which occur inside batteries areas.

The energy distribution from UPS device is done in the same way as from the general power supply, only it is necessary to provide that the both networks are not connected.

UPS device must be made in such way that the safe power supply of the tunnel systems is provided with minimal time of MTTR outage is less than 3 hours.

Warnings and operating instructions must be located in two separate and correctly marked pockets on the inside of the UPS switchboard, as well as in the battery compartment.

The Contractor shall submit a list of spare parts in accordance with the General Terms and Conditions.

This item contains all the cables, both control and power cables, that are required for the complete installation and operation of the safety power supply.

The backup power supply must be designed for uninterrupted reliable operation so that the "average outage time (failure)" (MTBF) for the individual modules of the uninterruptible power supply (UPS) via rectifier/charging unit, inverter unit and static switch, etc. longer than 20,000 hours.

The minimum time of interruption of operation or. UPS device repairs taking into account the time of arrival of the service technician, fault diagnosis and repair must be less than 4 hours (MTTR). Otherwise, the device must be replaced.

7.11 DOCUMENTATION

The Contractor must handover the project for execution of installation works to the Investor in Albanian language.

The project for execution of installation works must be done on basis of the Main project taking the selected equipment and materials by the Investor into consideration. That project must be done for all systems and must contain all the detailed data and plans which are needed for execution of works.

The program application equipment for automatic operation and management via computer must include all the necessary phase diagrams of process flow, functional descriptions and descriptions of the configuration in whole with the clarification of work and inter connection of different programs as well as the time diagram of flow and critical points. Program application equipment must be documented as a whole, together with standard and genuine original protocols.

For machine equipment of the process system it is also needed to produce the execution project which will contain all standard units for component (modular) processor and all belonging peripheral devices (units). The elaborate must include the detailed description of processor system, the mode of inclusion of peripheral units, information transfer, and data transfer system.

For complete program application equipment and systems as well as for the complete peripheral and machine equipment it is needed to perform the necessary tests and trial work. For some individual programs as well as the whole.

Those tests must confirm the appropriate functioning, correct function and suitable capacities and work speed. It is needed to perform the factory (F.A.T) tests and building tests (S.A.T) in accordance to program and time schedule which must be sent to the Investor for approval.

For systems, program equipment and machine equipment it is needed to do the corresponding manuals. The following must be done:

- program equipment manual,
- programming manual,
- manual for machine equipment, maintenance and service, including all equipment and
- tunnel operator manual.

The manuals must besides the detailed descriptions of the system, individual units, equipment, workflow description and time protocols and events, data interaction display, logic diagrams, single functions and tasks in the operational system including the execution, surveillance and management, work schematic block, include the instructions for needed steps for errors and error removal, alarm states (fire alarm and all other alarms), the instructions for equipment usage at the command stands and everything else which must enable easy and fast use, service and maintenance of computer system for managing the LLOGARA tunnel.

In the manual production besides the standard equipment must be included the documentation which is protected with copyrights. The manuals must be adequate for constant use.

Project od works done must be done for all systems and parts of the tunnel. It has to be done in that way so that in the project for execution of installation works all changes that happened during installation or during trial works are written as well as all the details which have been solved during the execution works.

That project must show the actual final state of the system and individual components. Before the final handover the project must be approved by the Investor.

The instructions for management and maintenance must be done for all installed systems, devices and installations, and have to give the detailed description for managing all the systems as well as the program for regular maintenance and maintenance in case of malfunction.

It is especially crucial to produce:

- Approval program (test) of the integral system, where the tests will be defined by both the Investor and the Contractor.
- The documentation with management and maintenance procedures as well as the procedures for actions in emergency situations
- API documentation (Application Programming Interface) if they are the part of the program modules of management and surveillance.

Prior to works initiation, all the necessary bases for devices should be delivered:

- lists with the most important technical data,
- specification lists,
- obligatory measuring drafts,
- testing reports and instructions,
- all lists of individual devices, for ex. terminal switches etc.,
- coupling schemes, coupling drafts,
- functional description,
- installation instructions,
- maintenance and monitoring instructions,
- commissioning instructions.

For switching cabinets, relay cabinets, control cabinet panels, control desks, control area:

- obligatory arrangements and disposition drawings,
- dimension drawings,
- installation and structural drawings,
- lists of devices with specific technical data,
- measuring protocols,
- construction documents,
- calculations of thermal shortcircuit firmness for cables and collectors,
- main and current schemes,
- connection drawings,
- passage drawings with elevations, cable branching and protection piping drawings, current circuits marking etc.,
- survey of cable drawings and cable lists with cable marking,
- cable route drawings and disposition drawings.

For partial or final device taking over:

- all the necessary basic documents, corrected in terms of actual situation,
- functionality description,
- instructions for commissioning,
- maintenance lists and regulations,
- measuring protocols for ex. circuit resistance, insulation resistance etc.,
- testing protocols for ex. short-circuit, selective etc.

7.12 Measurements, test and trial works

Measurements, test and trial works are divided in to three parts:

1.) Factory measurements, test and trial works (F.A.T) which must be done inside the factory before the delivery to the construction site,

2.) Measurements, test and trial works on the building (S.A.T) which must be done in the building after the installation and

3.) Conclusion measurements, test and trial works which must be done after the completion of all works.

The contractor must handover to the Investor the list and procedures for all equipment with the list of necessary tests, measurements and trial works with preset deadlines for performance.

All costs in relation to the repetition of measures, tests and trials are paid by the Contractor. The Investor must have unlimited access to the areas of the contractor and supplier where the measures and tests are done. All costs derived from that (transport, accommodation and stay) for Investors specialists is paid by the Contractor.

All measurements, tests and trial works must be done in accordance to the valid standards, regulations and laws.

7.13 Staff education

Contractor must make objects, factory systems, equipment, specialists available to access to the location for necessary courses in order to secure the education of the Investor staff for complete maintenance, management, error detection and complete knowledge of all sights of surveillance for the building, system and traffic management, complete tunnel technology process including the equipment for “parametering” and software production for computers.

The Investor must provide the list of staff for education and the contractor must do the education at its own expense which is included in the contract rates.

The Contractor must handover to the Investor the program of staff education forehand for coordination and approval.

7.14 Guarantee, maintenance, spare parts

The Contractor must handover all guarantees to the Investor as per contract. Besides that the Contractor must provide the full maintenance (regular and because of possible malfunction) including the necessary spare parts until the end of guarantee period. All costs that emerge from the guarantee maintenance must be included in the contract rates. Also, in the contract rates all costs that emerge from the return of equipment or materials beck to the factory in order to be repaired to the end of the guarantee period. Contractor must handover the list of the nearest factories to the Investor which might take over the service of equipment and materials.

For all equipment and materials the contractor must handover to the Investor the list and unit prices for all necessary spare parts for three-year maintenance outside guarantee period. That price must be included into the agreed price of the building. Unit price (piece) for spare parts must be separate from the materials price (delivery) and for the necessary works price.

The prices for spare parts must be fixed to the deadline set by the Investor.

The contractor must list the minimum period in which he guarantees the delivery of spare parts and equipment. That period must not be less than 10 years.

Contractor must deliver the instructions for cleaning of equipment and areas. Until the handover of the building to the Investor the cleaning is the obligation of the Contractor.

Annex A

Short-Circuit Calculation

Calculation and verification of:

- Shor-Circuit Currents
- BUS Loads
- Branch Loads
- Branch Losses
- Voltage Drops

for main LV boards and cables.

Calculations were made with software ETAP.

REPUBLIKA E SHQIPERISË
REPUBLIC OF ALBANIA

Ministria e Infrastrukturës dhe Energjisë
Ministry of Infrastructure and Energy

Konsorciumi i Projektit të Tunelit të Llogarasë
Llogara Tunnel Design Consortium

iC Consulenten
Ziviltechniker GesmbH

Elea iC d.o.o.
Engineering and consulting

IBE d.d.
Svetovanje, projektiranje in inženiring

SEED Consulting sh.p.k.
Smart Environment Engineering Design

InfraKonsult sh.p.k.
konsulence inxhinierike

Përshkrimi i ndryshimit/ Change Description	Data/ Date	Projektoi/ Desiger	Aprovoi/ Approved	Ver. Nr./ Rev. No.

Projekti/ Project

Rishikim i Studimit të Fizibilitetit dhe Hartimi i Projektit të Detajuar Inxhinierik Ndërtimi i Tunelit të Llogarasë

Review of the Feasibility Study and Engineering Detailed Design of Llogara Tunnel

Faza e projektit/ Project stage

Projekt Zbatim
Detailed Design

Disiplina e projektit/ Design discipline

Projekti Elektrik
Electrical Design

Emërtimi i Vizatimit/ Drawing title

/
Annex A - Short-Circuit Calculation (Page 1/12)

Punuar nga/ Elaborated by

IBE, d.d., svetovanje, projektiranje in inženiring
Ljubljana, Slovenija

Data/ Date	Projektoi/ Designed	Nënshkrimi/ Signat.
20.3.2021	A. Klemen, E.E.	
Data/ Date	Kontrolloi/ Checked	Nënshkrimi/ Signat.
20.3.2021	A. Korak, M.Sc.	
Data/ Date	Aprovoi/ Approved	Nënshkrimi/ Signat.
20.3.2021	U. Mikoš, M.Sc.	

Dosja e vizatimit/ Drawing folder	Nr. i viz./ Draw. No.	Lloji i viz./ Draw. typ.	Gjuha/ Language	Stat. i viz/ D. Status	Rishikimi/ Revision
LLO_IBE_DD_EL_TPS	1000	RP	BI	W	02

Shkalla/ Scale	Skedari i vizatimit/ Drawing File
/	LLO_IBE_DD_EL_TPS_1000_RP_BI_W_02.dwg

Short-Circuit Summary Report

3-Phase Fault Currents

Bus		Device		Device Capacity (kA)				Short-Circuit Current (kA)					
				Making									
ID	kV	ID	Type	Peak	Ib sym	Ib asym	Idc	I"k	ip	Ib sym	Ib asym	Idc	Ik
PS_PBS_SB-V-AFS	0.690	PS_PBS_SB-V-AFS	Bus					35.321	72.626				31.922
	0.690	TS_PBS-T2-1Q1	CB	88.000	42.000	42.721		35.321	72.626	34.701	35.231	6.091	
RTP Palasa	20.000	RTP Palasa	Bus					14.434	35.640				14.434
RTP Vlora	20.000	RTP Vlora	Bus					14.832	36.399				14.434
	20.000	RTPV-J40-Q1	CB	40.000	16.000	17.515	7.125	14.832	36.399	14.665	15.208	4.029	
TS PBN	20.000	TS PBN	Bus					12.574	24.504				12.156
	20.000	TS_PBN-J01-Q1	CB	40.000	16.000	17.515	7.125	12.574	24.504	12.397	12.397	0.074	
	20.000	TS_PBN-J06-Q1	CB	40.000	16.000	17.515	7.125	12.574	24.504	12.397	12.397	0.074	
	20.000	TS_PBN-J05-Q1	CB	40.000	16.000	17.515	7.125	12.574	24.504	12.397	12.397	0.074	
	20.000	TS_PBN-J04-Q1	CB	40.000	16.000	17.515	7.125	12.574	24.504	12.397	12.397	0.074	
TS PBS	20.000	TS PBS	Bus					7.712	12.153				7.443
	20.000	TS_PBS-J01-Q1	CB	40.000	16.000	17.515	7.125	7.712	12.153	7.603	7.603	0.000	
	20.000	TS_PBS-J06-Q1	CB	40.000	16.000	17.515	7.125	7.712	12.153	7.603	7.603	0.000	
	20.000	TS_PBS-J05-Q1	CB	40.000	16.000	17.515	7.125	7.712	12.153	7.603	7.603	0.000	
	20.000	TS_PBS-J04-Q1	CB	40.000	16.000	17.515	7.125	7.712	12.153	7.603	7.603	0.000	
TS-PBN_SB-T1	0.400	TS-PBN_SB-T1	Bus					8.754	19.085				8.749
	0.400	TS_PBN-T1-1Q1	CB	88.000	42.000	42.721		8.754	19.085	8.754	9.070	2.375	
TS_EQ1	20.000	TS_EQ1	Bus					11.520	20.990				11.120
	20.000	TS_EQ1-J01-Q1	CB	40.000	16.000	17.515	7.125	11.520	20.990	11.351	11.351	0.014	
	20.000	TS_EQ1-J02-Q1	CB	40.000	16.000	17.515	7.125	11.520	20.990	11.351	11.351	0.014	
	20.000	TS_EQ1-J03-Q1	CB	40.000	16.000	17.515	7.125	11.520	20.990	11.351	11.351	0.014	
TS_EQ1_SB-T1	0.400	TS_EQ1_SB-T1	Bus					16.042	26.608				13.811
	0.400	TS_EQ1-T1-1Q1	CB	88.000	42.000	42.721		16.042	26.608	15.422	15.423	0.193	
TS_EQ2	20.000	TS_EQ2	Bus					10.567	18.348				10.190
	20.000	TS_EQ2-J01-Q1	CB	40.000	16.000	17.515	7.125	10.567	18.348	10.408	10.408	0.003	
	20.000	TP3.1-J01-Q1	CB	40.000	16.000	17.515	7.125	10.567	18.348	10.408	10.408	0.003	
	20.000	TS_EQ2-J03-Q1	CB	40.000	16.000	17.515	7.125	10.567	18.348	10.408	10.408	0.003	
TS_EQ2_SB-T1	0.400	TS_EQ2_SB-T1	Bus					16.005	26.530				13.772
	0.400	TS_EQ2-T1-1Q1	CB	88.000	42.000	42.721		16.005	26.530	15.385	15.386	0.190	
TS_EQ3	20.000	TS_EQ3	Bus					9.716	16.289				9.366
	20.000	TS_EQ3-J01-Q1	CB	40.000	16.000	17.515	7.125	9.716	16.289	9.569	9.569	0.001	
	20.000	TS_EQ3-J02-Q1	CB	40.000	16.000	17.515	7.125	9.716	16.289	9.569	9.569	0.001	
	20.000	TS_EQ3-J03-Q1	CB	40.000	16.000	17.515	7.125	9.716	16.289	9.569	9.569	0.001	
TS_EQ3_SB-T1	0.400	TS_EQ3_SB-T1	Bus					15.693	34.478				13.908
	0.400	TS_EQ3-T1-1Q1	CB	88.000	42.000	42.721		15.693	34.478	15.158	15.909	4.829	

3-Phase Fault Currents

Bus		Device		Device Capacity (kA)				Short-Circuit Current (kA)					
ID	kV	ID	Type	Making Peak	Ib sym	Ib asym	Idc	I"k	ip	Ib sym	Ib asym	Idc	Ik
TS_EQ4	20.000	TS_EQ4	Bus					8.964	14.640				8.641
	20.000	TS_EQ4-J01-Q1	CB	40.000	16.000	17.515	7.125	8.964	14.640	8.830	8.830	0.000	
	20.000	TS_EQ4-J02-Q1	CB	40.000	16.000	17.515	7.125	8.964	14.640	8.830	8.830	0.000	
	20.000	TS_EQ4-J03-Q1	CB	40.000	16.000	17.515	7.125	8.964	14.640	8.830	8.830	0.000	
TS_EQ4_SB-T1	0.400	TS_EQ4_SB-T1	Bus					15.658	34.315				13.882
	0.400	TS_EQ4-T1-1Q1	CB	88.000	42.000	42.721		15.658	34.315	15.124	15.844	4.721	
TS_EQ5	20.000	TS_EQ5	Bus					8.300	13.287				8.004
	20.000	TS_EQ5-J01-Q1	CB	40.000	16.000	17.515	7.125	8.300	13.287	8.178	8.178	0.000	
	20.000	TS_EQ5-J02-Q1	CB	40.000	16.000	17.515	7.125	8.300	13.287	8.178	8.178	0.000	
	20.000	TS_EQ5-J03-Q1	CB	40.000	16.000	17.515	7.125	8.300	13.287	8.178	8.178	0.000	
TS_EQ5_SB-T1	0.400	TS_EQ5_SB-T1	Bus					16.084	35.016				13.855
	0.400	TS_EQ5-T1-1Q1	CB	88.000	42.000	42.721		16.084	35.016	15.465	16.154	4.668	
TS_PBN_SB-V-AFN	0.690	TS_PBN_SB-V-AFN	Bus					36.797	80.010				33.446
	0.690	TS_PBN-T2-1Q1	CB	88.000	42.000	42.721		36.797	80.010	36.183	37.606	10.249	
TS_PBS_SB-T1	0.400	TS_PBS_SB-T1	Bus					8.691	18.766				8.685
	0.400	TS_PBS-LV-T1-1Q1	CB	88.000	42.000	42.721		8.691	18.766	8.691	8.963	2.188	

ip is calculated using method C
Ib does not include decay of non-terminal faulted induction motors
Ik is the maximum steady state fault current
Idc is based on X/R from Method C and Ib as specified above

LV CB duty determined based on service rating.
Total through current is used for device duty.

* Indicates a device with calculated duty exceeding the device capability.

\# Indicates a device with calculated duty exceeding the device marginal limit. (95 % times device capability)

Short-Circuit Summary Report

		Device Capacity			3-Phase Short-Circuit Duty Results		
Bus ID	Device ID	Ithr (kA)	Tkr (sec.)	Rated Thermal Energy (MJ)	Ith (kA)	Tkr (sec.)	Thermal Energy (MJ)
PS_PBS_SB-V-AFS	TS_PBS-T2-1Q1	42.000	1.00	1764.00	33.788	1.00	1141.63
RTP Vlora	RTPV-J40-Q1	16.000	3.00	768.00	14.912	3.00	667.10
TS PBN	TS_PBN-J01-Q1	16.000	3.00	768.00	12.596	3.00	475.95
TS PBN	TS_PBN-J06-Q1	16.000	3.00	768.00	12.596	3.00	475.95
TS PBN	TS_PBN-J05-Q1	16.000	3.00	768.00	12.596	3.00	475.95
TS PBN	TS_PBN-J04-Q1	16.000	3.00	768.00	12.596	3.00	475.95
TS PBS	TS_PBS-J01-Q1	16.000	3.00	768.00	7.718	3.00	178.69
TS PBS	TS_PBS-J06-Q1	16.000	3.00	768.00	7.718	3.00	178.69
TS PBS	TS_PBS-J05-Q1	16.000	3.00	768.00	7.718	3.00	178.69
TS PBS	TS_PBS-J04-Q1	16.000	3.00	768.00	7.718	3.00	178.69
TS-PBN_SB-T1	TS_PBN-T1-1Q1	42.000	1.00	1764.00	8.825	1.00	77.88
TS_EQ1	TS_EQ1-J01-Q1	16.000	3.00	768.00	11.536	3.00	399.23
TS_EQ1	TS_EQ1-J02-Q1	16.000	3.00	768.00	11.536	3.00	399.23
TS_EQ1	TS_EQ1-J03-Q1	16.000	3.00	768.00	11.536	3.00	399.23
TS_EQ1_SB-T1	TS_EQ1-T1-1Q1	42.000	1.00	1764.00	15.096	1.00	227.89
TS_EQ2	TS_EQ2-J01-Q1	16.000	3.00	768.00	10.579	3.00	335.72
TS_EQ2	TP3.1-J01-Q1	16.000	3.00	768.00	10.579	3.00	335.72
TS_EQ2	TS_EQ2-J03-Q1	16.000	3.00	768.00	10.579	3.00	335.72
TS_EQ2_SB-T1	TS_EQ2-T1-1Q1	42.000	1.00	1764.00	15.059	1.00	226.78
TS_EQ3	TS_EQ3-J01-Q1	16.000	3.00	768.00	9.726	3.00	283.77
TS_EQ3	TS_EQ3-J02-Q1	16.000	3.00	768.00	9.726	3.00	283.77
TS_EQ3	TS_EQ3-J03-Q1	16.000	3.00	768.00	9.726	3.00	283.77
TS_EQ3_SB-T1	TS_EQ3-T1-1Q1	42.000	1.00	1764.00	14.973	1.00	224.18
TS_EQ4	TS_EQ4-J01-Q1	16.000	3.00	768.00	8.972	3.00	241.50
TS_EQ4	TS_EQ4-J02-Q1	16.000	3.00	768.00	8.972	3.00	241.50
TS_EQ4	TS_EQ4-J03-Q1	16.000	3.00	768.00	8.972	3.00	241.50
TS_EQ4_SB-T1	TS_EQ4-T1-1Q1	42.000	1.00	1764.00	14.939	1.00	223.16
TS_EQ5	TS_EQ5-J01-Q1	16.000	3.00	768.00	8.307	3.00	207.02
TS_EQ5	TS_EQ5-J02-Q1	16.000	3.00	768.00	8.307	3.00	207.02
TS_EQ5	TS_EQ5-J03-Q1	16.000	3.00	768.00	8.307	3.00	207.02
TS_EQ5_SB-T1	TS_EQ5-T1-1Q1	42.000	1.00	1764.00	15.227	1.00	231.88
TS_PBN_SB-V-AFN	TS_PBN-T2-1Q1	42.000	1.00	1764.00	35.317	1.00	1247.30

		Device Capacity			3-Phase Short-Circuit Duty Results		
Bus ID	Device ID	Ithr (kA)	Tkr (sec.)	Rated Thermal Energy (MJ)	Ith (kA)	Tkr (sec.)	Thermal Energy (MJ)
TS_PBS_SB-T1	TS_PBS-LV-T1-1Q1	42.000	1.00	1764.00	8.759	1.00	76.72

Ithr = Rated short-time withstand current (Icw for low voltage circuit breaker)
Tkr = Rated short-time
Ith = Thermal equivalent short-time current

* Indicates a device with calculated duty exceeding the device capability.

\# Indicates a device with calculated duty exceeding the device marginal limit . (95 % times device capability)

Bus Loading Summary Report

Bus			Directly Connected Load								Total Bus Load			
			Constant kVA		Constant Z		Constant I		Generic					
ID	kV	Rated Amp	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MVA	% PF	Amp	Percent Loading
RTP Palasa	20.000													
PS_PBN-LV-T2	0.690										0.632	95.0	533.6	
PS_PBS-LV-T2	0.690										0.632	95.0	535.1	
PS_PBS_SB-V-AFS	0.690		0.600	0.197							0.632	95.0	535.1	
RTP Vlora	20.000										2.917	95.4	84.2	
TS PBN	20.000										2.921	95.1	84.5	
TS PBS	20.000										0.728	93.6	21.1	
TS-PBN_SB-T1	0.400				0.118	0.073					0.139	85.0	199.6	
TS_EQ1	20.000										2.151	95.6	62.3	
TS_EQ1-LV_T1	0.400										0.310	95.0	449.1	
TS_EQ1-MV-T1	20.000										0.318	94.3	9.2	
TS_EQ1_SB-T1	0.400		0.236	0.077	0.058	0.019					0.310	95.0	449.1	
TS_EQ2	20.000										1.837	95.5	53.2	
TS_EQ2-MV-T2	20.000										0.318	94.3	9.2	
TS_EQ2_LV_T1	0.400										0.310	95.0	449.2	
TS_EQ2_SB-T1	0.400		0.236	0.077	0.058	0.019					0.310	95.0	449.2	
TS_EQ3	20.000										1.523	95.5	44.1	
TS_EQ3-MV-T1	20.000										0.253	94.3	7.3	
TS_EQ3_LV_T1	0.400										0.250	95.0	357.0	
TS_EQ3_SB-T1	0.400		0.189	0.062	0.048	0.016					0.249	95.0	357.0	
TS_EQ4	20.000										1.275	95.3	37.0	
TS_EQ4-MV-T1	20.000										0.251	94.3	7.3	
TS_EQ4_LV_T1	0.400										0.248	95.0	354.9	
TS_EQ4_SB-T1	0.400		0.188	0.062	0.048	0.016					0.248	95.0	354.9	
TS_EQ5	20.000										1.029	95.1	29.8	
TS_EQ5-MV-T1	20.000										0.316	94.1	9.2	
TS_EQ5_LV_T1	0.400										0.311	95.0	446.6	
TS_EQ5_SB-T1	0.400		0.236	0.077	0.059	0.020					0.311	95.0	446.6	
TS_PBN-LV-T1	0.400										0.139	85.0	199.6	
TS_PBN-MV-T1	20.000										0.141	84.1	4.1	
TS_PBN-MV-T2	20.000										0.636	94.6	18.4	
TS_PBN_SB-V-AFN	0.690		0.600	0.197							0.632	95.0	533.6	
TS_PBS-LV-T1	0.400										0.093	85.0	133.6	
TS_PBS-MV-T1	20.000										0.094	84.4	2.7	
TS_PBS-MV-T2	20.000										0.636	94.6	18.5	
TS_PBS_SB-T1	0.400				0.079	0.049					0.093	85.0	133.6	

* Indicates operating load of a bus exceeds the bus critical limit (100.0% of the Continuous Ampere rating).
# Indicates operating load of a bus exceeds the bus marginal limit (95.0% of the Continuous Ampere rating).

Branch Loading Summary Report

CKT / Branch		Busway / Cable & Reactor			Transformer				
					Capability (MVA)	Loading (input)		Loading (output)	
ID	Type	Ampacity (Amp)	Loading Amp	%		MVA	%	MVA	%
TS_EQ1_NN-T1	Cable	929.44	449.06	48.31					
TS_EQ3_J03-T1	Cable	220.80	7.32	3.31					
TS_EQ4_J03-T1	Cable	220.80	7.28	3.30					
TS_EQ5_J03-T1	Cable	220.80	9.16	4.15					
W_TS_EQ1-TS_EQ2	Cable	275.65	53.20	19.30					
W_TS_EQ1_J03-T1	Cable	220.80	9.21	4.17					
W_TS_EQ2-TS_EQ3	Cable	275.65	44.14	16.01					
W_TS_EQ2_J03-T1	Cable	220.80	9.21	4.17					
W_TS_EQ2_LV-T1	Cable	1165.44	449.23	38.55					
W_TS_EQ3-TS_EQ4	Cable	275.65	36.96	13.41					
W_TS_EQ3_LV-T1	Cable	1165.44	356.96	30.63					
W_TS_EQ4-TS_EQ5	Cable	275.65	29.83	10.82					
W_TS_EQ4_LV-T1	Cable	1165.44	354.92	30.45					
W_TS_EQ5-PSPBS	Cable	275.65	20.83	7.56					
W_TS_EQ5_LV-T1	Cable	1165.44	446.64	38.32					
W_TS_PBN-J04-T1	Cable	220.80	4.09	1.85					
W_TS_PBN-J05-T2	Cable	220.80	18.41	8.34					
W_TS_PBN-LV-T1	Cable	477.83	199.55	41.76					
W_TS_PBN-LV-T2	Cable	2330.88	533.57	22.89					
W_TS_PBN-PS_EQ1	Cable	275.65	62.27	22.59					
W_TS_PBS-J04-T1	Cable	220.80	2.74	1.24					
W_TS_PBS-J05-T2	Cable	220.80	18.46	8.36					
W_TS_PBS-LV-T1	Cable	477.83	133.62	27.96					
W_TS_PBS-LV-T2	Cable	2330.88	535.12	22.96					
W_Vlora-PS_PBN	Cable	275.65	84.48	30.65					
W_TS_PBs-RTP Palasa	Cable	275.65	0.91	0.33					
PS_PBS-T2	Transformer				2.500	0.636	25.5	0.632	25.3
TS_EQ1-T1	Transformer				0.400	0.318	79.5	0.310	77.5
TS_EQ2-T1	Transformer				0.400	0.318	79.5	0.310	77.5
TS_EQ3-T1	Transformer				0.400	0.253	63.1	0.250	62.4
TS_EQ4-T1	Transformer				0.400	0.251	62.7	0.248	62.0
TS_EQ5-T1	Transformer				0.400	0.316	78.9	0.311	77.8
TS_PBN-T1	Transformer				0.250	0.141	56.6	0.139	55.7

CKT / Branch		Busway / Cable & Reactor			Transformer				
					Capability	Loading (input)		Loading (output)	
ID	Type	Ampacity (Amp)	Loading Amp	%	(MVA)	MVA	%	MVA	%
TS_PBN-T2	Transformer				2.500	0.636	25.5	0.632	25.3
TS_PBS-T1	Transformer				0.250	0.094	37.8	0.093	37.4

* Indicates a branch with operating load exceeding the branch capability.

Branch Losses Summary Report

Branch ID	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
PS_PBS-T2	-0.600	-0.197	0.602	0.207	1.6	9.7	98.8	99.5	0.72
TS_EQ1_NN-T1	0.294	0.097	-0.294	-0.097	0.3	0.3	99.6	99.5	0.12
TS_EQ1-T1	-0.294	-0.097	0.300	0.105	5.6	8.5	99.6	99.7	0.10
TS_EQ2-T1	0.300	0.105	-0.294	-0.097	5.6	8.5	99.7	99.6	0.10
TS_EQ3_J03-T1	0.238	0.084	-0.238	-0.084	0.0	-0.2	99.6	99.6	0.00
TS_EQ3-T1	0.238	0.084	-0.237	-0.078	0.9	6.4	99.6	100.9	1.30
TS_EQ4_J03-T1	0.237	0.084	-0.237	-0.084	0.0	-0.2	99.6	99.6	0.00
TS_EQ4-T1	0.237	0.084	-0.236	-0.078	0.9	6.3	99.6	100.9	1.30
TS_EQ5_J03-T1	0.297	0.107	-0.297	-0.107	0.0	-0.2	99.5	99.5	0.00
TS_EQ5-T1	0.297	0.107	-0.295	-0.097	1.5	10.0	99.5	100.5	0.99
TS_PBN-T1	-0.118	-0.073	0.119	0.077	0.6	3.2	100.7	99.8	0.93
TS_PBN-T2	-0.600	-0.197	0.602	0.207	1.6	9.6	99.1	99.8	0.72
TS_PBS-T1	-0.079	-0.049	0.080	0.051	0.3	1.4	101.0	99.5	1.44
W_TS_EQ1_J03-T1	0.300	0.105	-0.300	-0.105	0.0	-0.2	99.7	99.7	0.00
W_TS_EQ1-TS_EQ2	1.756	0.528	-1.755	-0.544	1.0	-15.3	99.7	99.7	0.06
W_TS_EQ2_J03-T1	0.300	0.105	-0.300	-0.105	0.0	-0.2	99.7	99.7	0.00
W_TS_EQ2_LV-T1	0.294	0.097	-0.294	-0.097	0.3	0.3	99.6	99.5	0.12
W_TS_EQ2-TS_EQ3	1.455	0.438	-1.454	-0.454	0.7	-15.4	99.7	99.6	0.05
W_TS_EQ3_LV-T1	0.237	0.078	-0.237	-0.078	0.2	0.2	100.9	100.8	0.09
W_TS_EQ3-TS_EQ4	1.216	0.370	-1.216	-0.385	0.5	-15.5	99.6	99.6	0.04
W_TS_EQ4_LV-T1	0.236	0.078	-0.235	-0.077	0.2	0.2	100.9	100.8	0.09
W_TS_EQ4-TS_EQ5	0.979	0.302	-0.979	-0.317	0.3	-15.6	99.6	99.5	0.03
W_TS_EQ5_LV-T1	0.295	0.097	-0.295	-0.097	0.3	0.3	100.5	100.4	0.12
W_TS_EQ5-PSPBS	-0.682	-0.226	0.682	0.210	0.2	-15.6	99.5	99.5	0.02
W_TS_PBN-J04-T1	0.119	0.076	-0.119	-0.077	0.0	-0.2	99.8	99.8	0.00
W_TS_PBN-J05-T2	0.602	0.207	-0.602	-0.207	0.0	-0.2	99.8	99.8	0.00
W_TS_PBN-LV-T1	-0.118	-0.073	0.118	0.073	0.1	0.1	100.6	100.7	0.11
W_TS_PBN-LV-T2	0.600	0.197	-0.600	-0.197	0.2	0.2	99.1	99.0	0.04
W_TS_PBN-PS_EQ1	2.057	0.618	-2.056	-0.634	1.4	-15.1	99.8	99.7	0.07
W_TS_PBS-J04-T1	0.080	0.050	-0.080	-0.051	0.0	-0.2	99.5	99.5	0.00
W_TS_PBS-J05-T2	0.602	0.207	-0.602	-0.207	0.0	-0.2	99.5	99.5	0.00
W_TS_PBS-LV-T1	0.079	0.049	-0.079	-0.049	0.1	0.0	101.0	100.9	0.08
W_TS_PBS-LV-T2	0.600	0.197	-0.600	-0.197	0.2	0.2	98.8	98.8	0.04
W_TS_PBs-RTP Palasa	0.000	-0.031	0.000	0.000	0.0	-31.4	99.5	99.5	0.00

Branch ID	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
W_Vlora-PS_PBN	2.783	0.872	-2.778	-0.902	5.2	-29.2	100.0	99.8	0.19
					29.8	-90.2			

* This Transmission Line includes Series Capacitor.

Alert Summary Report

	% Alert Settings	
	Critical	**Marginal**
Loading		
Bus	100.0	95.0
Cable / Busway	100.0	95.0
Reactor	100.0	95.0
Line	100.0	95.0
Transformer	100.0	95.0
Panel	100.0	95.0
Protective Device	100.0	95.0
Generator	100.0	95.0
Inverter/Charger	100.0	95.0
Bus Voltage		
OverVoltage	105.0	102.0
UnderVoltage	95.0	98.0
Generator Excitation		
OverExcited (Q Max.)	100.0	95.0
UnderExcited (Q Min.)	100.0	

SUMMARY OF TOTAL GENERATION , LOADING & DEMAND

	MW	Mvar	MVA	% PF
Source (Swing Buses):	2.783	0.872	2.917	95.42 Lagging
Source (Non-Swing Buses):	0.000	0.000	0.000	
Total Demand:	2.783	0.872	2.917	95.42 Lagging
Total Motor Load:	2.284	0.751	2.404	95.00 Lagging
Total Static Load:	0.469	0.212	0.515	91.15 Lagging
Total Constant I Load:	0.000	0.000	0.000	
Total Generic Load:	0.000	0.000	0.000	
Apparent Losses:	0.030	-0.090		
System Mismatch:	0.000	0.000		

Number of Iterations: 3

Annex B

Cable Calculation

Calculation and verification of:

- Coordination Ib<In<Iz [A]
- Indirect touching
- Breaking capacity [kA]
- $K^2S^2>I^2t$ [A^2s]
- Voltage Drop [%]
- Fault currents [kA]

for main LV cables.

Calculations were made with software AMPERE PRO.

1 2 3 4

REPUBLIKA E SHQIPERISË
REPUBLIC OF ALBANIA

Ministria e Infrastrukturës dhe Energjisë
Ministry of Infrastructure and Energy

MINISTRIA E INFRASTRUKTURËS DHE ENERGJISË

Konsorciumi i Projektit të Tunelit të Llogarasë
Llogara Tunnel Design Consortium

iC Consulenten
Ziviltechniker GesmbH

Elea iC d.o.o.
Engineering and consulting

IBE d.d.
Svetovanje, projektiranje in inženiring

SEED Consulting sh.p.k.
Smart Environment Engineering Design

InfraKonsult sh.p.k.
konsulence inxhinierike

Përshkrimi i ndryshimit/ Change Description	Data/ Date	Projektoi/ Desiger	Aprovoi/ Approved	Ver. Nr./ Rev. No.

Projekti/ Project

Rishikim i Studimit të Fizibilitetit dhe Hartimi i Projektit të Detajuar Inxhinierik Ndërtimi i Tunelit të Llogarasë

Review of the Feasibility Study and Engineering Detailed Design of Llogara Tunnel

Faza e projektit/ Project stage

Projekt Zbatim

Detailed Design

Disiplina e projektit/ Design discipline

Projekti Elektrik

Electrical Design

Emërtimi i Vizatimit/ Drawing title

/

Annex B - Cable Calculation (Page 1/22)

Punuar nga/ Elaborated by

IBE, d.d., svetovanje, projektiranje in inženiring Ljubljana, Slovenija

Data/ Date	Projektoi/ Designed	Nënshkrimi/ Signat.
20.3.2021	A. Klemen, E.E.	
Data/ Date	**Kontrolloi/ Checked**	**Nënshkrimi/ Signat.**
20.3.2021	A. Korak, M.Sc.	
Data/ Date	**Aprovoi/ Approved**	**Nënshkrimi/ Signat.**
20.3.2021	U. Mikoš, M.Sc.	

Dosja e vizatimit/ Drawing folder	Nr. i viz./ Draw. No.	Lloji i viz./ Draw. typ.	Gjuha/ Language	Stat. i viz/ D. Status	Rishikimi/ Revision
LLO_IBE_DD_EL_TPS	1000	RP	BI	W	02

Shkalla/ Scale	Skedari i vizatimit/ Drawing File
/	LLO_IBE_DD_EL_TPS_1000_RP_BI_W_02.dwg

1 2 3 4

Units status

Data: 6. 03. 2021

Responsable:

Unit

+=TS PBN.+SB-T1-2Q1 SB-T1-2/2W1

Coord. Ib<Ins<Iz [A]

	Ib	<=	Ins	<=	Iz
Phase	101,001		112		122,4
Neutral	5,154		112		122,4

1) Unit +=TS PBN.+SB-T1-2Q1: Ins = 112 [A] (thermal release)

Verification of indirect touching

	Verified
Ia i.t. [A]	4872,406
Breaking time delay [s]	5
VT for Ia i.t.. [V]	82,041
VT for Ikft [V]	82,041

Distribution system: TN-S
(Note: The analysis ends at the first useful protection found)
The unitprotection +=TS PBN.+SB-T1-2Q1
trip by time-current curve (part LR, T = 5 s); I prot. = 950,352 <= Ia i.t. = 4872,406

Breaking capacity [kA]

Transient at beginnig of line Verified

BC	>=	Ikm max	/_Ikm max [°]
55		8,877	62,593
		DeltaIkm max	/_DeltaIkm max [°]
		0,57	177,192

Mag. rel.<Imagmax [A]

		Verified
Mag. rel.	<	Imagmax
1600		4872,406

Cable

Designation	NYY-J
Formation	4x50+1G25
Cable temperature by Ib [°C]	30 <= 57 <= 70
Cable temperature by In [°C]	30 <= 63 <= 70

K^2S^2>I^2t [A^2s]

	Verified
K^2S^2 phase conductor	$3,306*10^7$
K^2S^2 neutral	$3,306*10^7$
K^2S^2 PE	$8,266*10^6$

Voltage drop [%]

Rated voltage [V] 400

VD (Ib)	VDTot (Ib)	VD max
0,297	2,036	4
VD (In)	VDTot (In)	
0,336	2,448	

Fault currents [kA]

Steady-state downstr. line, Peak upstr. line

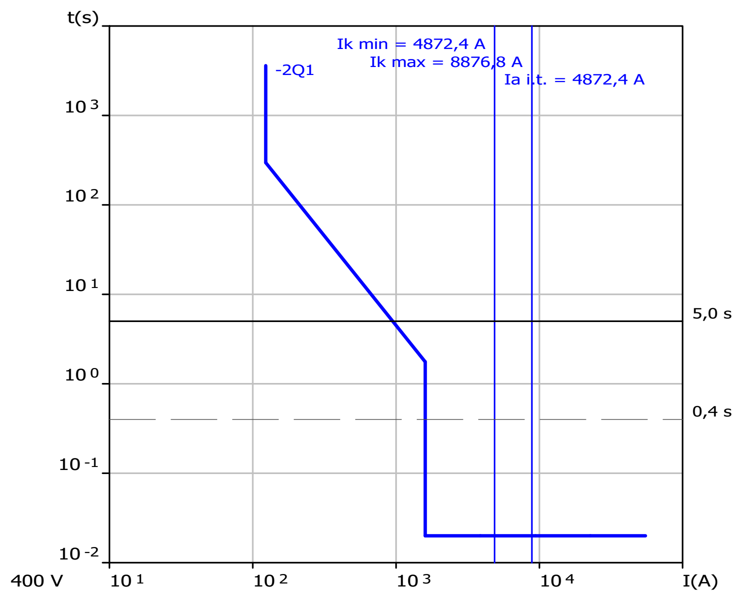
	Max	Min	Peak
Threephase	7,172	6,622	15,685
Line-to-line	6,211	5,735	13,583
Line-to-line-N	7,344	6,762	15,946
Line-to-line-PE	7,352	6,728	15,946
Line-to-N	6,158	5,52	15,116
Line-to-PE	5,546	4,872	15,116

At transient at the end of line

Ikv max	/_Ikv max [°]
7,754	46,077

Protection

SIEMENS - 3VA21 M ETU320 LI B/T - 160 A



Units status

Data: 6. 03. 2021

Responsable:

Unit

+=TS PBN.+SB-T1-2Q2 SB-T1-2/2W2

Coord. Ib<Ins<Iz [A]

	Ib	<=	Ins	<=	Iz
Phase	39,404		50		100,8
Neutral	0,001		50		100,8

1) Unit +=TS PBN.+SB-T1-2Q2: Ins = 50 [A] (thermal release)

Verification of indirect touching

	Verified
Ia i.t. [A]	4883,035
Breaking time delay [s]	5
VT for Ia i.t.. [V]	85,185
VT for Ikft [V]	85,185

Distribution system: TN-S
(Note: The analysis ends at the first useful protection found)
The unitprotection +=TS PBN.+SB-T1-2Q2
trip by time-current curve (part LR, T = 5 s); I prot. = 424,264 <= Ia i.t. = 4883,035

Breaking capacity [kA]

Transient at beginnig of line Verified

BC	>=	Ikm max	/_Ikm max [°]
55		8,877	62,593
		DeltaIkm max	/_DeltaIkm max [°]
		0,57	177,192

Mag. rel.<Imagmax [A]

		Verified
Mag. rel.	<	Imagmax
1200		4883,035

Cable

Designation	NYY-J					
Formation	4x35+1G16					
Cable temperature by Ib [°C]	30	<=	36	<=	70
Cable temperature by In [°C]	30	<=	40	<=	70

K²S²>I²t [A²s]

	Verified
K²S² phase conductor	$1,62*10^7$
K²S² neutral	$1,62*10^7$
K²S² PE	$3,386*10^6$

Voltage drop [%]

Rated voltage [V] 400

VD (Ib)	VDTot (Ib)	VD max
0,102	1,841	4
VD (In)	VDTot (In)	
0,132	2,244	

Fault currents [kA]

Steady-state downstr. line, Peak upstr. line

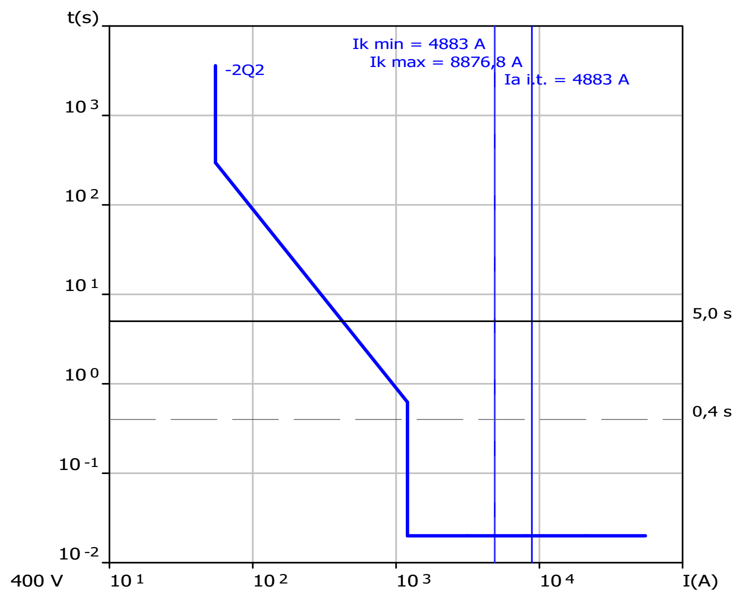
	Max	Min	Peak
Threephase	7,259	6,706	15,685
Line-to-line	6,287	5,808	13,583
Line-to-line-N	7,459	6,869	15,946
Line-to-line-PE	7,453	6,817	15,946
Line-to-N	6,28	5,631	15,116
Line-to-PE	5,569	4,883	15,116

At transient at the end of line

Ikv max	/_Ikv max [°]
7,881	46,058

Protection

SIEMENS - 3VA20 M ETU320 LI B/T - 100 A



Units status

Data: 6. 03. 2021

Responsable:

Unit

+=TS PBN.+SB-T1-2Q4 SB-T1-2/2W4

Coord. Ib<Ins<Iz [A]

	Ib	<=	Ins	<=	Iz
Phase	39,304		80		100,8
Neutral	0		80		100,8

1) Unit +=TS PBN.+SB-T1-2Q4: Ins = 80 [A] (thermal release)

Verification of indirect touching

	Verified
Ia i.t. [A]	3452,202
Breaking time delay [s]	5
VT for Ia i.t.. [V]	110,26
VT for Ikft [V]	110,26

Distribution system: TN-S
(Note: The analysis ends at the first useful protection found)
The unitprotection +=TS PBN.+SB-T1-2Q4
trip by time-current curve (part LR, T = 5 s); I prot. = 678,823 <= Ia i.t. = 3452,202

Breaking capacity [kA]

Transient at beginnig of line Verified

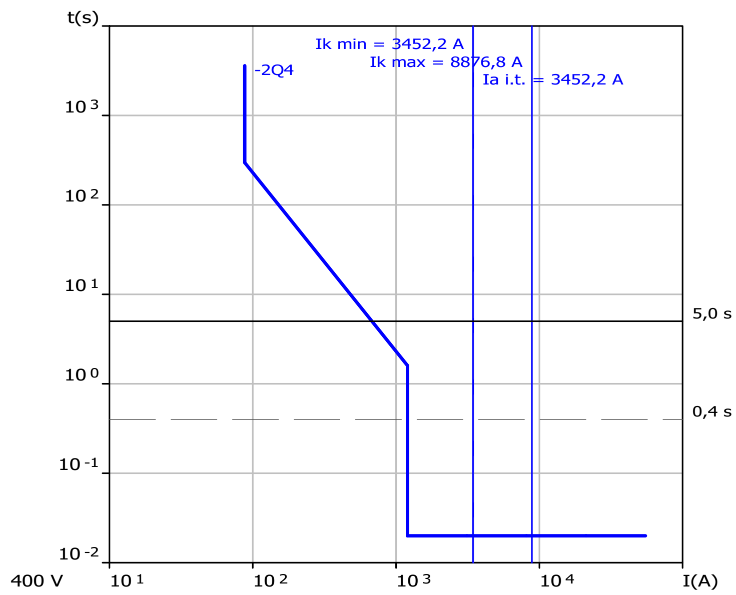
BC	>=	Ikm max	/_Ikm max [°]
55		8,877	62,593
		DeltaIkm max	/_DeltaIkm max [°]
		0,57	177,192

Mag. rel.<Imagmax [A]

		Verified
Mag. rel.	<	Imagmax
1200		3452,202

Protection

SIEMENS - 3VA20 M ETU320 LI B/T - 100 A



Cable

Designation	NYY-J
Formation	4x35+1G16
Cable temperature by Ib [°C]	30 <= 36 <= 70
Cable temperature by In [°C]	30 <= 55 <= 70

K²S²>I²t [A²s]

	Verified
K²S² phase conductor	$1{,}62*10^7$
K²S² neutral	$1{,}62*10^7$
K²S² PE	$3{,}386*10^6$

Voltage drop [%]

Rated voltage [V] 400

VD (Ib)	VDTot (Ib)	VD max
0,208	1,947	4
VD (In)	VDTot (In)	
0,453	2,566	

Fault currents [kA]

Steady-state downstr. line, Peak upstr. line

	Max	Min	Peak
Threephase	6,463	5,847	15,685
Line-to-line	5,597	5,064	13,583
Line-to-line-N	6,516	5,844	15,946
Line-to-line-PE	6,397	5,712	15,946
Line-to-N	5,058	4,392	15,116
Line-to-PE	4,085	3,452	15,116

At transient at the end of line

Ikv max	/_Ikv max [°]
6,818	35,76

Units status

Data: 6. 03. 2021

Responsable:

Unit

+=TS PBN.+SB-T1-2Q8 SB-T1-2/2W8

Coord. Ib<Ins<Iz [A]

	Ib	<=	Ins	<=	Iz
Phase	5,155		37,8		123,2
Neutral	0		37,8		123,2

1) Unit +=TS PBN.+SB-T1-2Q8: Ins = 37,8 [A] (thermal release)

Verification of indirect touching

	Verified
Ia i.t. [A]	230,389
Breaking time delay [s]	5
VT for Ia i.t.. [V]	144,73
VT for Ikft [V]	144,73

Distribution system: TN-S
(Note: The analysis ends at the first useful protection found)
The unitprotection +=TS PBN.+SB-T1-2Q8
trip by time-current curve (part CR-IST, T = 5 s); I prot. = 226,8 <= Ia i.t. = 230,389

Breaking capacity [kA]

Transient at beginnig of line Verified

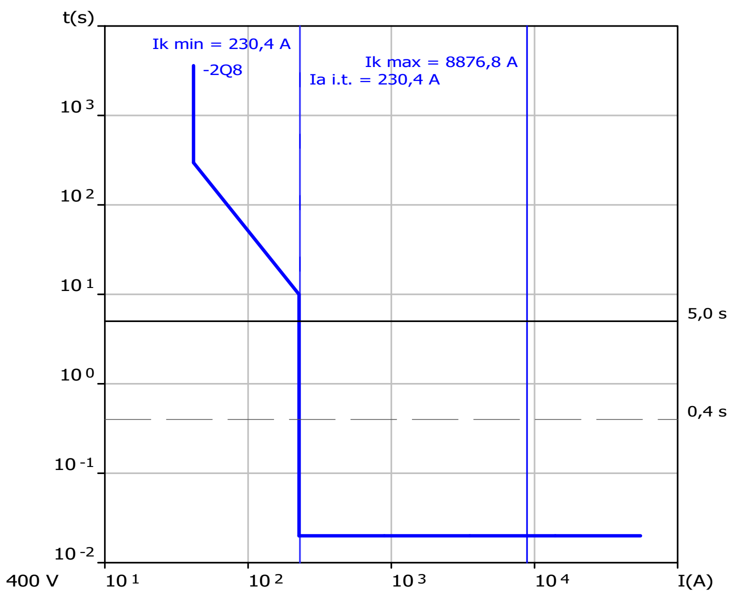
BC	>=	Ikm max	/_Ikm max [°]
55		8,877	62,593
		Deltalkm max	/_Deltalkm max [°]
		0,57	177,192

Mag. rel.<Imagmax [A]

Mag. rel.	<	Imagmax
		Verified
226,8		230,389

Protection

SIEMENS - 3VA20 M ETU320 LI B/T - 63 A



Cable

Designation	NHXH-J					
Formation	4x50+1G25					
Cable temperature by Ib [°C]	30	<=	30	<=	90
Cable temperature by In [°C]	30	<=	36	<=	90

K²S²>I²t [A²s]

	Verified
K²S² phase conductor	$5,112*10^7$
K²S² neutral	$5,112*10^7$
K²S² PE	$1,278*10^7$

Voltage drop [%]

Rated voltage [V] 400

VD (Ib)	VDTot (Ib)	VD max
0,526	2,264	5
VD (In)	VDTot (In)	
3,941	6,054	

Fault currents [kA]

Steady-state downstr. line, Peak upstr. line

	Max	Min	Peak
Threephase	0,878	0,667	15,685
Line-to-line	0,761	0,578	13,583
Line-to-line-N	0,791	0,598	15,946
Line-to-line-PE	0,782	0,591	15,946
Line-to-N	0,456	0,343	15,116
Line-to-PE	0,308	0,23	15,116

At transient at the end of line

Ikv max	/_Ikv max [°]
0,882	15,238

Units status

Data: 6. 03. 2021

Responsable:

Unit

+=TS PBN.-J-T1 SB-T1-1/1W1

Coord. Ib<Ins<Iz [A]

	Ib	<=	Ins	<=	Iz
Phase	187,083		219,1		621,32
Neutral	5,153		219,1		621,32

1) Unit +=TS PBN.+SB-T1-2Q4: Ins = 219,1 [A] (thermal release)
Note: Protected by downstream

Verification of indirect touching

	Verified
Ia i.t. [A]	18539,384
Breaking time delay [s]	5
VT for Ia i.t.. [V]	50
VT for Ikft [V]	19,999

Distribution system: TN-C
(Note: The analysis ends at the first useful protection found)
+=TS PBN.-J-TR1: has transformer or UPS, end of the procedure.
Verification of indirect touching over the power supply is not applicable.

Cable

Designation	N2XY-J
Formation	3x(1x240)+1G240
Cable temperature by Ib [°C]	30 <= 35 <= 85
Cable temperature by In [°C]	30 <= 37 <= 85

$K^2S^2>I^2t$ [A²s]

	Verification: n.d..
K²S² phase conductor	$1{,}178 \cdot 10^9$
K²S² neutral	$1{,}178 \cdot 10^9$

Voltage drop [%]

Rated voltage [V] 400

VD (Ib)	VDTot (Ib)	VD max
0,194	1,728	4
VD (In)	VDTot (In)	
0,228	2,099	

Fault currents [kA]

Steady-state downstr. line, Peak upstr. line

	Max	Min	Peak
Threephase	8,19	7,725	17,641
Line-to-line	7,092	6,69	15,278
Line-to-line-N	8,328	7,902	17,944
Line-to-N	7,924	7,415	18,159

At transient at the end of line

Ikv max	/_Ikv max [°]
8,898	62,867

Units status

Data: 6. 03. 2021

Responsable:

Unit

+=TP PBN.+SB-V-AFN-3Q1 SB-T2-3/3W1

Coord. Ib<Ins<Iz [A]

	Ib	<=	Ins	<=	Iz
Phase	595,5		600		945,6

1) Unit +=TP PBN.+SB-V-AFN-3Q1: Ins = 600 [A] (thermal release)

Verification of indirect touching

	Verified
Ia i.t. [A]	23269
Breaking time delay [s]	5
VT for Ia i.t.. [V]	87,09
VT for Ikft [V]	87,1

Distribution system: TN-S
(Note: The analysis ends at the first useful protection found)
The unitprotection +=TP PBN.+SB-V-AFN-3Q1
trip by time-current curve (part LR, T = 5 s); I prot. = 5091,169 <= Ia i.t. = 23268,892

Breaking capacity [kA]

Transient at beginnig of line Verified

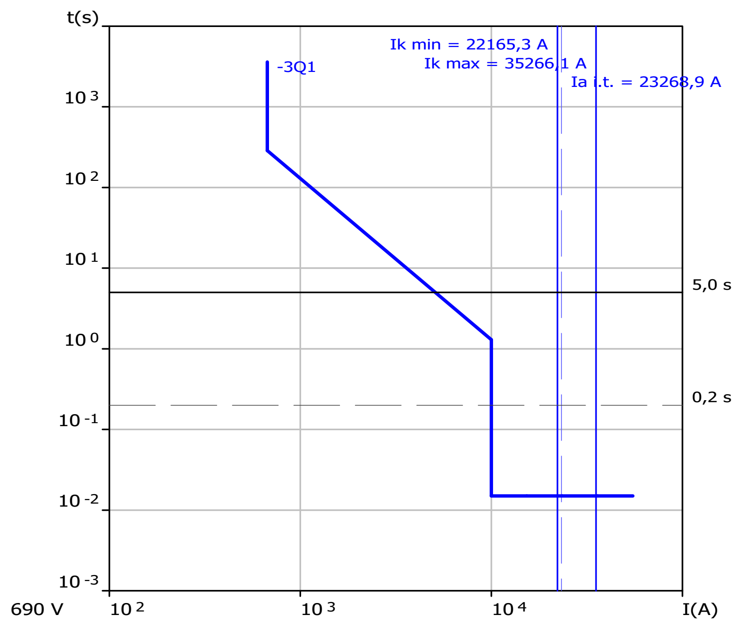
BC	Ikm max	/_Ikm max [°]
55	35,3	81,9
	Deltalkm max	/_Deltalkm max [°]
	2,81	79,9

Mag. rel.<Imagmax [A]

Mag. rel.	<	Imagmax
		Verified
10000		22165

Protection

SIEMENS - 3WL11 10 N ETU76B 2012 - 1000 A



Cable

Designation	NHXH-J					
Formation	3x[4G150]					
Cable temperature by Ib [°C]	30	<=	53,8	<=	85
Cable temperature by In [°C]	30	<=	54,2	<=	85

K²S²>I²t [A²s]

	Verified
K²S² phase conductor	$4,141*10^9$
K²S² PE	$4,141*10^9$

Voltage drop [%]

Rated voltage [V] 690

VD (Ib)	VDTot (Ib)	VD max
0,376	1,43	4
VD (In)	VDTot (In)	
0,379	1,48	
	VD mot.	Max voltage drop
	13,4	15

Fault currents [kA]

Steady-state downstr. line, Peak upstr. line

	Max	Min	Peak
Threephase	27,9	25,6	84,8
Line-to-line	24,2	22,2	73,4
Line-to-line-PE	29,9	27,6	85,8
Line-to-PE	27	23,3	86,9

At transient at the end of line

Ikv max	/_Ikv max [°]
35,6	66,8

Units status

Data: 6. 03. 2021

Responsable:

Unit

+=TS PBS.+SB-T1-2Q1 SB-T1-2/2W1

Coord. Ib<Ins<Iz [A]

	Ib	<=	Ins	<=	Iz
Phase	56,704		64		100,8
Neutral	0		64		100,8

1) Unit +=TS PBS.+SB-T1-2Q1: Ins = 64 [A] (thermal release)

Verification of indirect touching

	Verified
Ia i.t. [A]	4069,842
Breaking time delay [s]	5
VT for Ia i.t.. [V]	99,992
VT for Ikft [V]	99,992

Distribution system: TN-S
(Note: The analysis ends at the first useful protection found)
The unitprotection +=TS PBS.+SB-T1-2Q1
trip by time-current curve (part LR, T = 5 s); I prot. = 543,058 <= Ia i.t. = 4069,842

Breaking capacity [kA]

Transient at beginnig of line Verified

BC	>=	Ikm max	/_Ikm max [°]
55		8,877	62,593
		DeltaIkm max	/_DeltaIkm max [°]
		0,57	177,192

Mag. rel.<Imagmax [A]

Mag. rel.	<	Imagmax
		Verified
1600		4069,842

Cable

Designation	NYY-J				
Formation	4x35+1G16				
Cable temperature by Ib [°C]	30	<=	43	<=	70
Cable temperature by In [°C]	30	<=	46	<=	70

K²S²>I²t [A²s]

	Verified
K²S² phase conductor	$1{,}62 \cdot 10^7$
K²S² neutral	$1{,}62 \cdot 10^7$
K²S² PE	$3{,}386 \cdot 10^6$

Voltage drop [%]

Rated voltage [V] 400

VD (Ib)	VDTot (Ib)	VD max
0,208	1,392	4
VD (In)	VDTot (In)	
0,237	1,654	

Fault currents [kA]

Steady-state downstr. line, Peak upstr. line

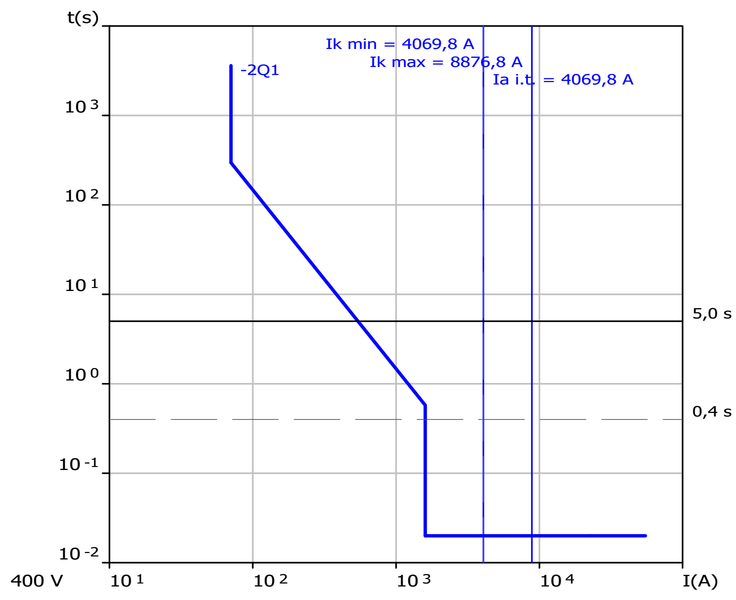
	Max	Min	Peak
Threephase	6,865	6,274	15,685
Line-to-line	5,945	5,434	13,583
Line-to-line-N	6,994	6,351	15,946
Line-to-line-PE	6,913	6,24	15,946
Line-to-N	5,633	4,963	15,116
Line-to-PE	4,744	4,07	15,116

At transient at the end of line

Ikv max	/_Ikv max [°]
7,353	40,556

Protection

SIEMENS - 3VA21 M ETU320 LI B/T - 160 A



Units status

Data: 6. 03. 2021

Responsable:

Unit

+=TS PBS.+SB-T1-2Q2 SB-T1-2/2W2

Coord. Ib<Ins<Iz [A]

	Ib	<=	Ins	<=	Iz
Phase	39,404		70		100,8
Neutral	0,001		70		100,8

1) Unit +=TS PBS.+SB-T1-2Q2: Ins = 70 [A] (thermal release)

Verification of indirect touching

	Verified
Ia i.t. [A]	4062,111
Breaking time delay [s]	5
VT for Ia i.t.. [V]	100,286
VT for Ikft [V]	100,286

Distribution system: TN-S
(Note: The analysis ends at the first useful protection found)
The unitprotection +=TS PBS.+SB-T1-2Q2
trip by time-current curve (part LR, T = 5 s); I prot. = 593,97 <= Ia i.t. = 4062,111

Breaking capacity [kA]

Transient at beginnig of line Verified

BC	>=	Ikm max	/_Ikm max [°]
55		8,877	62,593
		DeltaIkm max	/_DeltaIkm max [°]
		0,57	177,192

Mag. rel.<Imagmax [A]

Mag. rel.	<	Imagmax
		Verified
1200		4062,111

Cable

Designation NYY-J
Formation 4x35+1G16
Cable temperature by Ib [°C] 30 <= 36 <= 70
Cable temperature by In [°C] 30 <= 49 <= 70

K^2S^2>I^2t [A^2s]

	Verified
K^2S^2 phase conductor	$1{,}62*10^7$
K^2S^2 neutral	$1{,}62*10^7$
K^2S^2 PE	$3{,}386*10^6$

Voltage drop [%]

Rated voltage [V] 400

VD (Ib)	VDTot (Ib)	VD max
0,15	1,335	4
VD (In)	VDTot (In)	
0,279	1,696	

Fault currents [kA]

Steady-state downstr. line, Peak upstr. line

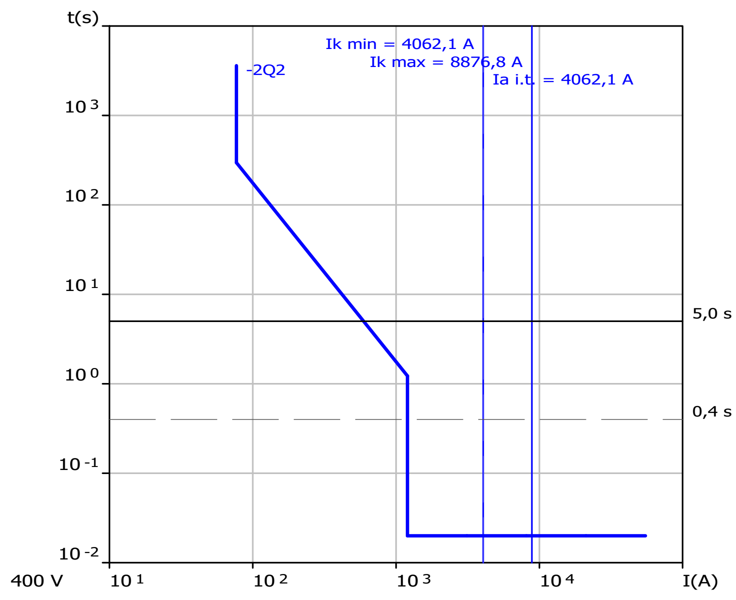
	Max	Min	Peak
Threephase	6,85	6,261	15,685
Line-to-line	5,932	5,422	13,583
Line-to-line-N	6,976	6,335	15,946
Line-to-line-PE	6,896	6,225	15,946
Line-to-N	5,621	4,952	15,116
Line-to-PE	4,734	4,062	15,116

At transient at the end of line

Ikv max	/_Ikv max [°]
7,333	40,407

Protection

SIEMENS - 3VA20 M ETU320 LI B/T - 100 A



Units status

Data: 6. 03. 2021

Responsable:

Unit

+=TS PBS.+SB-T1-2Q4 SB-T1-2/2W4

Coord. Ib<Ins<Iz [A]

	Ib	<=	Ins	<=	Iz
Phase	35,963		80		100,8
Neutral	0		80		100,8

1) Unit +=TS PBS.+SB-T1-2Q4: Ins = 80 [A] (thermal release)

Verification of indirect touching

	Verified
Ia i.t. [A]	3452,202
Breaking time delay [s]	5
VT for Ia i.t.. [V]	110,26
VT for Ikft [V]	110,26

Distribution system: TN-S
(Note: The analysis ends at the first useful protection found)
The unitprotection +=TS PBS.+SB-T1-2Q4
trip by time-current curve (part LR, T = 5 s); I prot. = 678,823 <= Ia i.t. = 3452,202

Breaking capacity [kA]

Transient at beginnig of line Verified

BC	>=	Ikm max	/_Ikm max [°]
55		8,877	62,593
		DeltaIkm max	/_DeltaIkm max [°]
		0,57	177,192

Mag. rel.<Imagmax [A]

		Verified
Mag. rel.	<	Imagmax
1200		3452,202

Cable

Designation	NYY-J					
Formation	4x35+1G16					
Cable temperature by Ib [°C]	30	<=	35	<=	70	
Cable temperature by In [°C]	30	<=	55	<=	70	

K²S²>I²t [A²s]

	Verified
K²S² phase conductor	$1,62*10^7$
K²S² neutral	$1,62*10^7$
K²S² PE	$3,386*10^6$

Voltage drop [%]

Rated voltage [V]		400
VD (Ib)	VDTot (Ib)	VD max
0,19	1,375	4
VD (In)	VDTot (In)	
0,453	1,871	

Fault currents [kA]

Steady-state downstr. line, Peak upstr. line

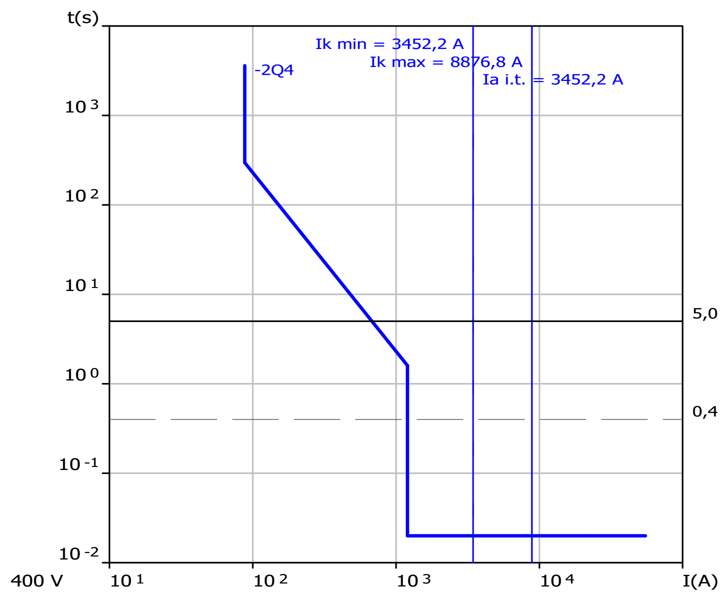
	Max	Min	Peak
Threephase	6,463	5,847	15,685
Line-to-line	5,597	5,064	13,583
Line-to-line-N	6,516	5,844	15,946
Line-to-line-PE	6,397	5,712	15,946
Line-to-N	5,058	4,392	15,116
Line-to-PE	4,085	3,452	15,116

At transient at the end of line

Ikv max	/_Ikv max [°]
6,818	35,76

Protection

SIEMENS - 3VA20 M ETU320 LI B/T - 100 A



Units status

Data: 6. 03. 2021

Responsable:

Unit

+=TS PBS.-J-T1 SB-T1-1/1W1

Coord. Ib<Ins<Iz [A]

	Ib	<=	Ins	<=	Iz
Phase	130		150		621,32
Neutral	0,001		150		621,32

1) Unit +=TS PBS.-J-Unit20: Ins = 150 [A] (theoretical value of overload) (Transf. ratio = 50)

Verification of indirect touching

	Verified
Ia i.t. [A]	18539,384
Breaking time delay [s]	5
VT for Ia i.t.. [V]	50
VT for Ikft [V]	19,999

Distribution system: TN-C
(Note: The analysis ends at the first useful protection found)
+=TS PBS.-J-TR1: has transformer or UPS, end of the procedure.
Verification of indirect touching over the power supply is not applicable.

Cable

Designation	N2XY-J					
Formation	3x(1x240)+1G240					
Cable temperature by Ib [°C]	30	<=	33	<=	85
Cable temperature by In [°C]	30	<=	33	<=	85

$K^2S^2>I^2t$ [A^2s]

	Verification: n.d..
K^2S^2 phase conductor	$1,178*10^9$
K^2S^2 neutral	$1,178*10^9$

Voltage drop [%]

Rated voltage [V] 400

VD (Ib)	VDTot (Ib)	VD max
0,129	1,177	4
VD (In)	VDTot (In)	
0,149	1,409	

Fault currents [kA]

Steady-state downstr. line, Peak upstr. line

	Max	Min	Peak
Threephase	8,19	7,725	17,641
Line-to-line	7,092	6,69	15,278
Line-to-line-N	8,328	7,902	17,944
Line-to-N	7,924	7,415	18,159

At transient at the end of line

Ikv max	/_Ikv max [°]
8,898	62,867

Units status

Data: 6. 03. 2021

Responsable:

Unit

+=TP PBS.+SB-V-AFS-3Q1 SB-T2-3/3W1

Coord. Ib<Ins<Iz [A]

	Ib	<=	Ins	<=	Iz
Phase	595,5		724,64		945,6

1) Unit +=TP PBS.GTP-Unit20: Ins = 724,64 [A] (theoretical value of overload) (Transf. ratio = 28,99)

Verification of indirect touching

	Verified
Ia i.t. [A]	23269
Breaking time delay [s]	5
VT for Ia i.t.. [V]	87,09
VT for Ikft [V]	87,1

Distribution system: TN-S
(Note: The analysis ends at the first useful protection found)
The unitprotection +=TP PBS.+SB-V-AFS-3Q1
trip by time-current curve (part LR, T = 5 s); I prot. = 6788,225 <= Ia i.t. = 23268,892

Breaking capacity [kA]

Transient at beginnig of line Verified

BC	Ikm max	/_Ikm max [°]
55	35,3	81,9
	Deltalkm max	/_Deltalkm max [°]
	2,81	79,9

Mag. rel.<Imagmax [A]

Mag. rel.	<	Imagmax
		Verified
10000		22165

Cable

Designation	NHXH-J					
Formation	3x[4G150]					
Cable temperature by Ib [°C]	30	<=	53,8	<=	85
Cable temperature by In [°C]	30	<=	65,2	<=	85

K²S²>I²t [A²s]

	Verified
K²S² phase conductor	$4,141*10^9$
K²S² PE	$4,141*10^9$

Voltage drop [%]

Rated voltage [V] 690

VD (Ib)	VDTot (Ib)	VD max
0,376	1,43	4
VD (In)	VDTot (In)	
0,457	1,79	
	VD mot.	Max voltage drop
	13,4	15

Fault currents [kA]

Steady-state downstr. line, Peak upstr. line

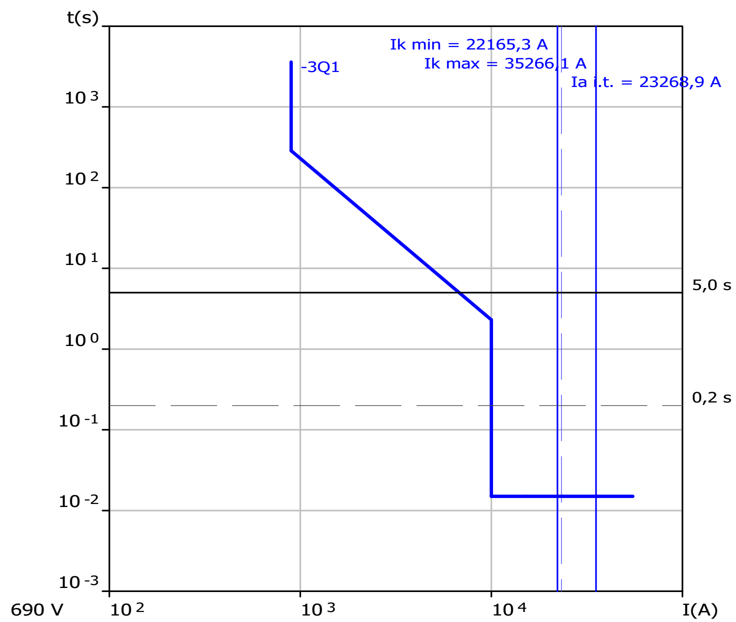
	Max	Min	Peak
Threephase	27,9	25,6	84,8
Line-to-line	24,2	22,2	73,4
Line-to-line-PE	29,9	27,6	85,8
Line-to-PE	27	23,3	86,9

At transient at the end of line

Ikv max	/_Ikv max [°]
35,6	66,8

Protection

SIEMENS - 3WL11 10 N ETU76B 2012 - 1000 A



Units status

Data: 6. 03. 2021

Responsable:

Unit

+=TS EQ1.+SB-T1-2Q1 SB-T1-2/2W1

Coord. Ib<Ins<Iz [A]

	Ib	<=	Ins	<=	Iz
Phase	310,116		400		426,4
Neutral	0		400		426,4

1) Unit +=TS EQ1.+SB-T1-2Q1: Ins = 400 [A] (thermal release)

Verification of indirect touching

	Verified
Ia i.t. [A]	20455,102
Breaking time delay [s]	5
VT for Ia i.t.. [V]	50
VT for Ikft [V]	28,004

Distribution system: TN-S
(Note: The analysis ends at the first useful protection found)
The unitprotection +=TS EQ1.+SB-T1-2Q1
trip by time-current curve (part LR, T = 5 s); I prot. = 3394,113 <= Ia i.t. = 20455,102

Breaking capacity [kA]

Transient at beginnig of line Verified

BC	>=	Ikm max	/_Ikm max [°]
55		15,941	71,994
		Deltalkm max	/_Deltalkm max [°]
		1,81	179,561

Mag. rel.<Imagmax [A]

Mag. rel.	<	Imagmax
		Verified
4000		10490,326

Cable

Designation NHXH-J
Formation 4x(1x185)+1G185
Cable temperature by Ib [°C] 30 <= 62 <= 90
Cable temperature by In [°C] 30 <= 83 <= 90

K²S²>I²t [A²s]

	Verified
K²S² phase conductor	$6{,}999 \cdot 10^{8}$
K²S² neutral	$6{,}999 \cdot 10^{8}$
K²S² PE	$1{,}06 \cdot 10^{9}$

Voltage drop [%]

Rated voltage [V] 400

VD (Ib)	VDTot (Ib)	VD max
0,258	2,659	4
VD (In)	VDTot (In)	
0,35	3,314	

Fault currents [kA]

Steady-state downstr. line, Peak upstr. line

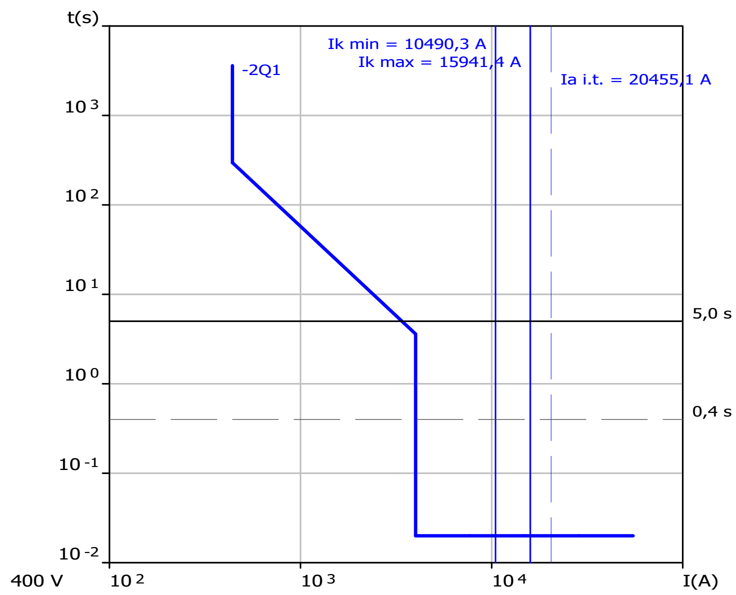
	Max	Min	Peak
Threephase	12,855	12,113	35,038
Line-to-line	11,133	10,49	30,343
Line-to-line-N	13,199	12,519	34,377
Line-to-line-PE	13,199	12,519	34,377
Line-to-N	12,284	11,457	33,415
Line-to-PE	12,284	11,457	33,415

At transient at the end of line

Ikv max	/_Ikv max [°]
16,645	67,992

Protection

SIEMENS - 3VA23 M ETU320 LI L/T - 400 A



Units status

Data: 6. 03. 2021

Responsable:

Unit

+=TS EQ1.+SB-T1-2Q2 SB-T1-2/2W2

Coord. Ib<Ins<Iz [A]

	Ib	<=	Ins	<=	Iz
Phase	115,332		250		268
Neutral	0		250		268

1) Unit +=TS EQ1.+SB-T1-2Q2: Ins = 250 [A] (thermal release)

Verification of indirect touching

	Verified
Ia i.t. [A]	3573,796
Breaking time delay [s]	5
VT for Ia i.t.. [V]	116,919
VT for Ikft [V]	116,919

Distribution system: TN-S
(Note: The analysis ends at the first useful protection found)
The unitprotection +=TS EQ1.+SB-T1-2Q2
trip by time-current curve (part LR, T = 5 s); I prot. = 2121,32 <= Ia i.t. = 3573,796

Breaking capacity [kA]

Transient at beginnig of line Verified

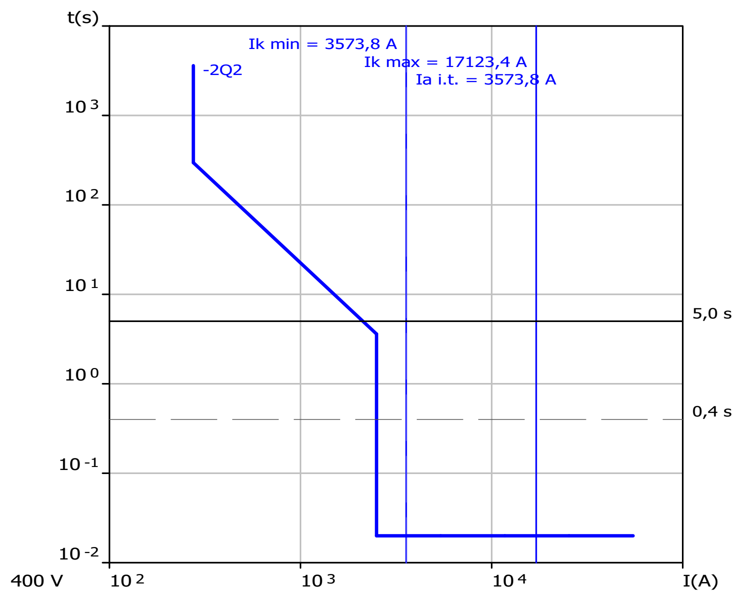
BC	>=	Ikm max	/_Ikm max [°]
55		17,123	71,913
		DeltaIkm max	/_DeltaIkm max [°]
		3,218	66,845

Mag. rel.<Imagmax [A]

Mag. rel.	<	Imagmax
		Verified
2500		3573,796

Protection

SIEMENS - 3VA22 M ETU320 LI L/T - 250 A



Cable

Designation	NHXH-J
Formation	4x120+1G70
Cable temperature by Ib [°C]	30 <= 41 <= 90
Cable temperature by In [°C]	30 <= 82 <= 90

K²S²>I²t [A²s]

	Verified
K²S² phase conductor	$2,945*10^8$
K²S² neutral	$2,945*10^8$
K²S² PE	$1,002*10^8$

Voltage drop [%]

Rated voltage [V] 400

VD (Ib)	VDTot (Ib)	VD max
0,862	3,263	4
VD (In)	VDTot (In)	
2,101	5,065	

Fault currents [kA]

Steady-state downstr. line, Peak upstr. line

	Max	Min	Peak
Threephase	7,779	6,724	35,038
Line-to-line	6,737	5,823	30,343
Line-to-line-N	7,569	6,471	34,377
Line-to-line-PE	7,51	6,396	34,377
Line-to-N	5,333	4,366	33,415
Line-to-PE	4,481	3,574	33,415

At transient at the end of line

Ikv max	/_Ikv max [°]
9,405	46,612

Units status

Data: 6. 03. 2021

Responsable:

Unit

+=TS EQ1.+SB-T1-2Q3 SB-T1-2/2W3

Coord. Ib<Ins<Iz [A]

	Ib	<=	Ins	<=	Iz
Phase	11,07		44,1		154
Neutral	0		44,1		154

1) Unit +=TS EQ1.+SB-T1-2Q3: Ins = 44,1 [A] (thermal release)

Verification of indirect touching

	Verified
Ia i.t. [A]	281,678
Breaking time delay [s]	5
VT for Ia i.t.. [V]	145,604
VT for Ikft [V]	145,604

Distribution system: TN-S
(Note: The analysis ends at the first useful protection found)
The unitprotection +=TS EQ1.+SB-T1-2Q3
trip by time-current curve (part CR-IST, T = 5 s); I prot. = 252 <= Ia i.t. = 281,678

Breaking capacity [kA]

Transient at beginnig of line Verified

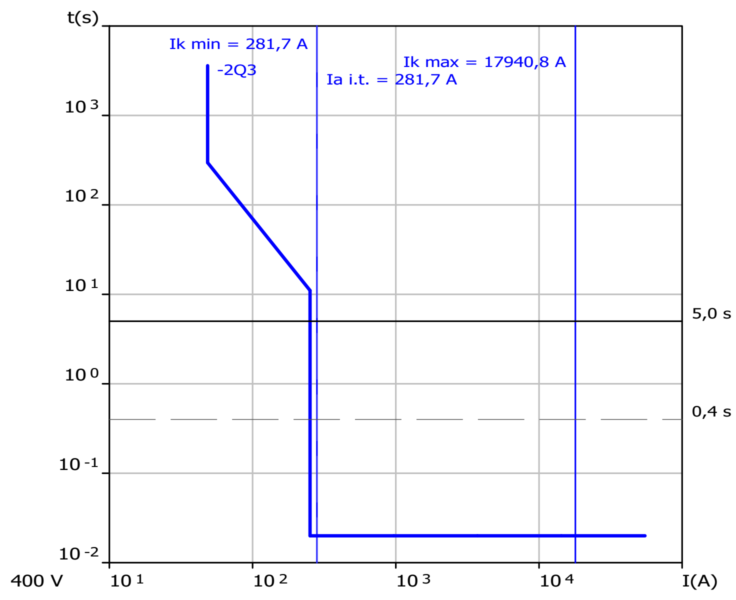
BC	>=	Ikm max	/_Ikm max [°]
55		17,941	71,457
		DeltaIkm max	/_DeltaIkm max [°]
		4,044	65,853

Mag. rel.<Imagmax [A]

Mag. rel.	<	Imagmax
		Verified
252		281,678

Protection

SIEMENS - 3VA20 M ETU320 LI B/T - 63 A



Cable

Designation	NHXH-J
Formation	4x50+1G25
Cable temperature by Ib [°C]	30 <= 30 <= 90
Cable temperature by In [°C]	30 <= 35 <= 90

K²S²>I²t [A²s]

	Verified
K²S² phase conductor	$5,112*10^7$
K²S² neutral	$5,112*10^7$
K²S² PE	$1,278*10^7$

Voltage drop [%]

Rated voltage [V] 400

VD (Ib)	VDTot (Ib)	VD max
0,941	3,341	4
VD (In)	VDTot (In)	
3,817	6,78	

Fault currents [kA]

Steady-state downstr. line, Peak upstr. line

	Max	Min	Peak
Threephase	1,094	0,827	35,038
Line-to-line	0,948	0,716	30,343
Line-to-line-N	0,982	0,739	34,377
Line-to-line-PE	0,972	0,731	34,377
Line-to-N	0,562	0,421	33,415
Line-to-PE	0,378	0,282	33,415

At transient at the end of line

Ikv max	/_Ikv max [°]
1,128	15,194

Units status

Data: 6. 03. 2021

Responsable:

Unit

+=TS EQ1.+SB-T1-2Q4 SB-T1-2/2W4

Coord. Ib<Ins<Iz [A]

	Ib	<=	Ins	<=	Iz
Phase	38,499		80		126,4
Neutral	0		80		126,4

1) Unit +=TS EQ1.+SB-T1-2Q4: Ins = 80 [A] (thermal release)

Verification of indirect touching

	Verified
Ia i.t. [A]	4096,581
Breaking time delay [s]	5
VT for Ia i.t.. [V]	129,551
VT for Ikft [V]	129,551

Distribution system: TN-S

(Note: The analysis ends at the first useful protection found)

The unitprotection +=TS EQ1.+SB-T1-2Q4

trip by time-current curve (part LR, T = 5 s); I prot. = 678,823 <= Ia i.t. = 4096,581

Breaking capacity [kA]

Transient at beginnig of line Verified

BC	>=	Ikm max	/_Ikm max [°]
55		17,98	71,44
		DeltaIkm max	/_DeltaIkm max [°]
		4,084	65,832

Mag. rel.<Imagmax [A]

Mag. rel.	<	Imagmax
		Verified
1200		4096,581

Cable

Designation	N2XH-J					
Formation	4x35+1G16					
Cable temperature by Ib [°C]	30	<=	36	<=	90	
Cable temperature by In [°C]	30	<=	54	<=	90	

K²S²>I²t [A²s]

	Verified
K²S² phase conductor	$2{,}505*10^7$
K²S² neutral	$2{,}505*10^7$
K²S² PE	$5{,}235*10^6$

Voltage drop [%]

Rated voltage [V] 400

VD (Ib)	VDTot (Ib)	VD max
0,205	2,606	4
VD (In)	VDTot (In)	
0,455	3,419	

Fault currents [kA]

Steady-state downstr. line, Peak upstr. line

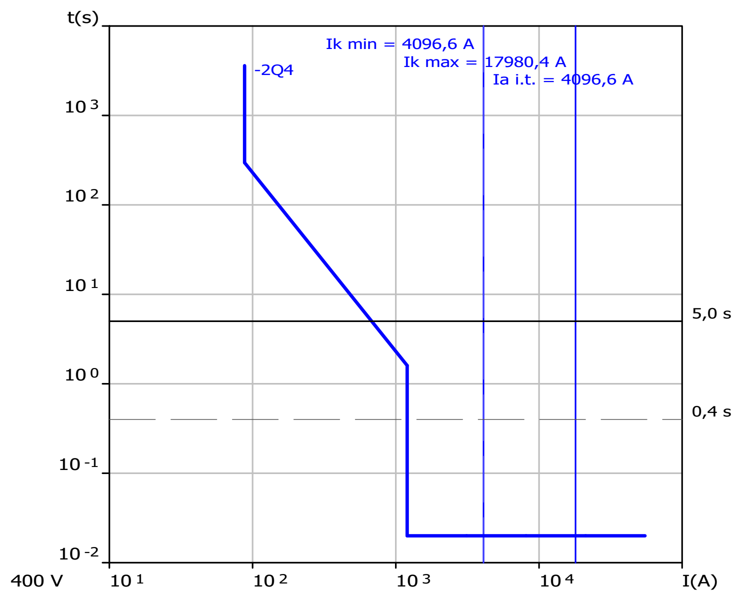
	Max	Min	Peak
Threephase	9,693	8,409	35,038
Line-to-line	8,394	7,282	30,343
Line-to-line-N	9,685	8,268	34,377
Line-to-line-PE	9,383	7,997	34,377
Line-to-N	7,021	5,725	33,415
Line-to-PE	5,21	4,097	33,415

At transient at the end of line

Ikv max	/_Ikv max [°]
11,14	41,057

Protection

SIEMENS - 3VA20 M ETU320 LI B/T - 100 A



ELECTRO GRAPHICS

Units status

Data: 6. 03. 2021

Responsable:

Unit

+=TS EQ1.+SB-T1-2Q8 SB-T1-2/2W8

Coord. Ib<Ins<Iz [A]

	Ib	<=	Ins	<=	Iz
Phase	21,891		44,1		99
Neutral	0,000		44,1		99

1) Unit +=TS EQ1.+SB-T1-2Q8: Ins = 44,1 [A] (thermal release)

Verification of indirect touching

	Verified
Ia i.t. [A]	3071,536
Breaking time delay [s]	5
VT for Ia i.t.. [V]	136,226
VT for Ikft [V]	136,226

Distribution system: TN-S
(Note: The analysis ends at the first useful protection found)
The unitprotection +=TS EQ1.+SB-T1-2Q8
trip by time-current curve (part LR, T = 5 s); I prot. = 374,201 <= Ia i.t. = 3071,536

Breaking capacity [kA]

Transient at beginnig of line Verified

BC	>=	Ikm max	/_Ikm max [°]
55		17,98	71,44
		DeltaIkm max	/_DeltaIkm max [°]
		4,084	65,832

Mag. rel.<Imagmax [A]

Mag. rel.	<	Imagmax
		Verified
756		3071,536

Cable

Designation NYY-J
Formation 4x35+1G16
Cable temperature by Ib [°C] 30 <= 32 <= 70
Cable temperature by In [°C] 30 <= 38 <= 70

K²S²>I²t [A²s]

	Verified
K²S² phase conductor	$1,62*10^7$
K²S² neutral	$1,62*10^7$
K²S² PE	$3,386*10^6$

Voltage drop [%]

Rated voltage [V] 400

VD (Ib)	VDTot (Ib)	VD max
0,161	2,561	4
VD (In)	VDTot (In)	
0,331	3,294	

Fault currents [kA]

Steady-state downstr. line, Peak upstr. line

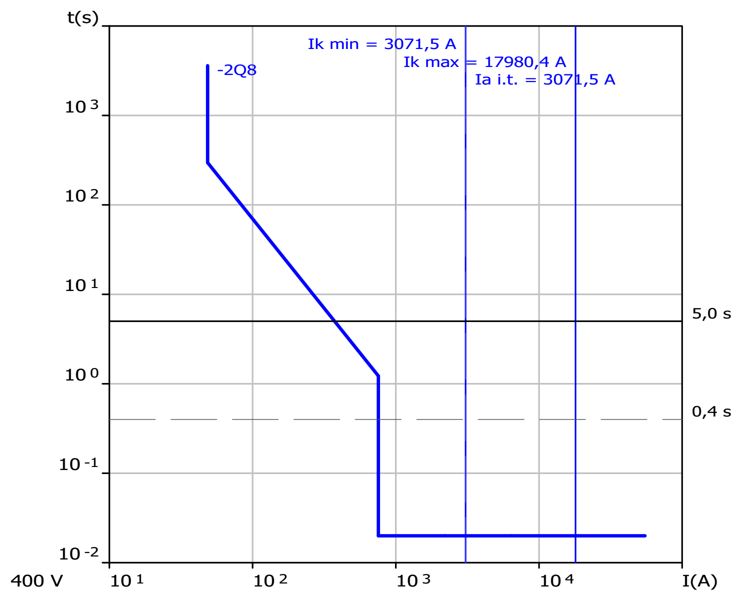
	Max	Min	Peak
Threephase	8,146	7,079	35,038
Line-to-line	7,055	6,131	30,343
Line-to-line-N	7,926	6,809	34,377
Line-to-line-PE	7,68	6,601	34,377
Line-to-N	5,374	4,474	33,415
Line-to-PE	3,77	3,072	33,415

At transient at the end of line

Ikv max	/_Ikv max [°]
9,047	34,494

Protection

SIEMENS - 3VA20 M ETU320 LI B/T - 63 A



Units status

Data: 6. 03. 2021

Responsable:

Unit

+=TS EQ1.-J-T1 SB-T1-1/1W1

Coord. Ib<Ins<Iz [A]

	Ib	<=	Ins	<=	Iz
Phase	494,906		600		922,74
Neutral	0,000		600		922,74

1) Unit +=TS EQ1.-J-Unit20: Ins = 600 [A] (theoretical value of overload) (Transf. ratio = 50)

Verification of indirect touching

	Verified
Ia i.t. [A]	157129,991
Breaking time delay [s]	5
VT for Ia i.t.. [V]	50
VT for Ikft [V]	4,278

Distribution system: TN-C
(Note: The analysis ends at the first useful protection found)
+=TS EQ1.-J-TR1: has transformer or UPS, end of the procedure.
Verification of indirect touching over the power supply is not applicable.

Cable

Designation NYCY
Formation 3x(2x240)+2G240

Cable temperature by Ib [°C]	30	<=	42	<=	70
Cable temperature by In [°C]	30	<=	47	<=	70

K²S²>I²t [A²s]

	Verification: n.d..
K²S² phase conductor	$3{,}047*10^9$
K²S² neutral	$3{,}047*10^9$

Voltage drop [%]

Rated voltage [V] 400

VD (Ib)	VDTot (Ib)	VD max
0,062	2,384	4
VD (In)	VDTot (In)	
0,076	2,944	

Fault currents [kA]

Steady-state downstr. line, Peak upstr. line

	Max	Min	Peak
Threephase	13,942	13,235	35,908
Line-to-line	12,074	11,462	31,097
Line-to-line-N	14,2	13,502	35,115
Line-to-N	14,175	13,446	34,812

At transient at the end of line

Ikv max	/_Ikv max [°]
18	71,682

Units status

Data: 6. 03. 2021

Responsable:

Unit

+=TS EQ1.+SB-V-EN1-2Q1 SB-V-EN1-2/2W1

Coord. Ib<Ins<Iz [A]

	Ib	<=	Ins	<=	Iz
Phase	151,774		175		233
Neutral	0		175		233

1) Unit +=TS EQ1.+SB-V-EN1-2Q1: Ins = 175 [A] (thermal release)

Verification of indirect touching

	Verified
Ia i.t. [A]	4250,433
Breaking time delay [s]	5
VT for Ia i.t.. [V]	116,011
VT for Ikft [V]	116,011

Distribution system: TN-S
(Note: The analysis ends at the first useful protection found)
The unitprotection +=TS EQ1.+SB-V-EN1-2Q1
trip by time-current curve (part LR, T = 5 s); I prot. = 1484,924 <= Ia i.t. = 4250,433

Breaking capacity [kA]

Transient at beginnig of line Verified

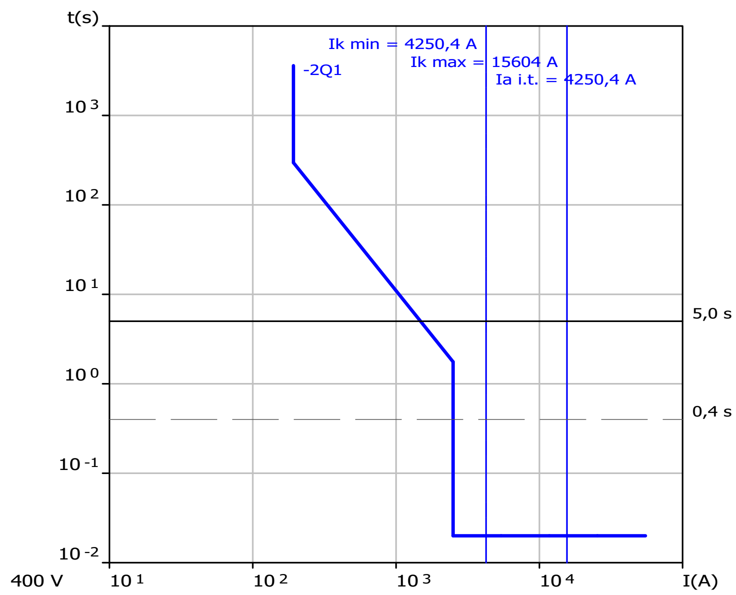
BC	>=	Ikm max	/_Ikm max [°]
55		15,604	62,187
		DeltaIkm max	/_DeltaIkm max [°]
		2,559	163,869

Mag. rel.<Imagmax [A]

Mag. rel.	<	Imagmax
		Verified
2500		4250,433

Protection

SIEMENS - 3VA22 M ETU320 LI L/T - 250 A



Cable

Designation	NHXH-J				
Formation	4x95+1G50				
Cable temperature by Ib [°C]	30	<=	55	<=	90
Cable temperature by In [°C]	30	<=	64	<=	90

K²S²>I²t [A²s]

	Verified
K²S² phase conductor	$1,846*10^8$
K²S² neutral	$1,846*10^8$
K²S² PE	$5,112*10^7$

Voltage drop [%]

Rated voltage [V]		400
VD (Ib)	VDTot (Ib)	VD max
0,8	3,459	4
VD (In)	VDTot (In)	
0,945	4,259	
	VD mot.	Max voltage drop
	12,928	15

Fault currents [kA]

Steady-state downstr. line, Peak upstr. line

	Max	Min	Peak
Threephase	8,793	7,714	30,872
Line-to-line	7,615	6,68	26,736
Line-to-line-N	8,682	7,531	30,643
Line-to-line-PE	8,593	7,419	30,643
Line-to-N	6,35	5,271	27,2
Line-to-PE	5,283	4,25	27,2

At transient at the end of line

Ikv max	/_Ikv max [°]
10,908	49,279

Units status

Data: 6. 03. 2021

Responsable:

Unit

+=TS EQ1.+SB-V-EN1-3Q1 SB-V-EN1-3/3W1

Coord. Ib<Ins<Iz [A]

	Ib	<=	Ins	<=	Iz
Phase	151,774		175		233
Neutral	0		175		233

1) Unit +=TS EQ1.+SB-V-EN1-3Q1: Ins = 175 [A] (thermal release)

Verification of indirect touching

	Verified
Ia i.t. [A]	3506,999
Breaking time delay [s]	5
VT for Ia i.t.. [V]	121,741
VT for Ikft [V]	121,741

Distribution system: TN-S

(Note: The analysis ends at the first useful protection found)

The unitprotection +=TS EQ1.+SB-V-EN1-3Q1

trip by time-current curve (part LR, T = 5 s); I prot. = 1484,924 <= Ia i.t. = 3506,999

Breaking capacity [kA]

Transient at beginnig of line Verified

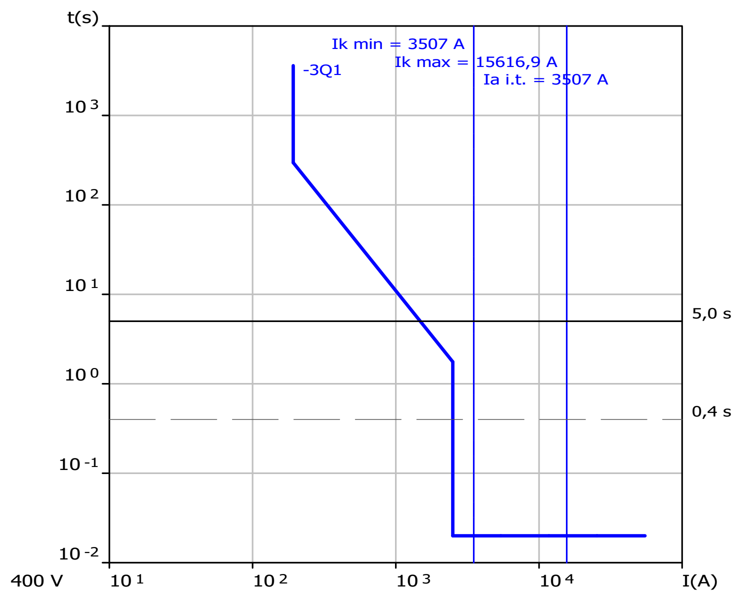
BC	>=	Ikm max	/_Ikm max [°]
55		15,617	62,211
		DeltaIkm max	/_DeltaIkm max [°]
		2,569	164,097

Mag. rel.<Imagmax [A]

Mag. rel.	<	Imagmax
		Verified
2500		3506,999

Protection

SIEMENS - 3VA22 M ETU320 LI L/T - 250 A



Cable

Designation	NHXH-J
Formation	4x95+1G50
Cable temperature by Ib [°C]	30 <= 55 <= 90
Cable temperature by In [°C]	30 <= 64 <= 90

K²S²>I²t [A²s]

	Verified
K²S² phase conductor	$1,846*10^8$
K²S² neutral	$1,846*10^8$
K²S² PE	$5,112*10^7$

Voltage drop [%]

Rated voltage [V]		400
VD (Ib)	VDTot (Ib)	VD max
1,035	3,694	4
VD (In)	VDTot (In)	
1,224	4,538	
	VD mot.	Max voltage drop
	13,805	15

Fault currents [kA]

Steady-state downstr. line, Peak upstr. line

	Max	Min	Peak
Threephase	7,95	6,86	30,872
Line-to-line	6,885	5,941	26,736
Line-to-line-N	7,751	6,611	30,643
Line-to-line-PE	7,658	6,507	30,643
Line-to-N	5,464	4,462	27,2
Line-to-PE	4,424	3,507	27,2

At transient at the end of line

Ikv max	/_Ikv max [°]
9,818	46,524

Units status

Data: 6. 03. 2021

Responsable:

Unit

+=TS EQ1.+SB-V-EQ1-2Q1 +SB-V-EQ1-1/2W1

Coord. Ib<Ins<Iz [A]

	Ib	<=	Ins	<=	Iz
Phase	51,924		63		102,4
Neutral	0		63		102,4

1) Unit +=TS EQ1.+SB-V-EQ1-2Q1: Ins = 63 [A] (thermal release)

Verification of indirect touching

	Verified
Ia i.t. [A]	2253,991
Breaking time delay [s]	5
VT for Ia i.t.. [V]	77,832
VT for Ikft [V]	77,832

Distribution system: TN-S

(Note: The analysis ends at the first useful protection found)

The unitprotection +=TS EQ1.+SB-V-EQ1-2Q1

trip by time-current curve (part LR, T = 5 s); I prot. = 385,982 <= Ia i.t. = 2253,991

Breaking capacity [kA]

Transient at beginnig of line Verified

BC	>=	Ikm max	/_Ikm max [°]
50		9,008	45,791
		DeltaIkm max	/_DeltaIkm max [°]
		1,272	31,806

Mag. rel.<Imagmax [A]

		Verified
Mag. rel.	<	Imagmax
819		1828,647

Cable

Designation	NHXH-J					
Formation	4x35					
Cable temperature by Ib [°C]	30	<=	45	<=	90
Cable temperature by In [°C]	30	<=	53	<=	90

K²S²>I²t [A²s]

	Verified
K²S² phase conductor	$2,505*10^7$
K²S² neutral	$2,505*10^7$

Voltage drop [%]

Rated voltage [V]		400
VD (Ib)	VDTot (Ib)	VD max
0,681	3,944	5
VD (In)	VDTot (In)	
0,846	5,91	
	VD mot.	Max voltage drop
	9,179	15

Fault currents [kA]

Steady-state downstr. line, Peak upstr. line

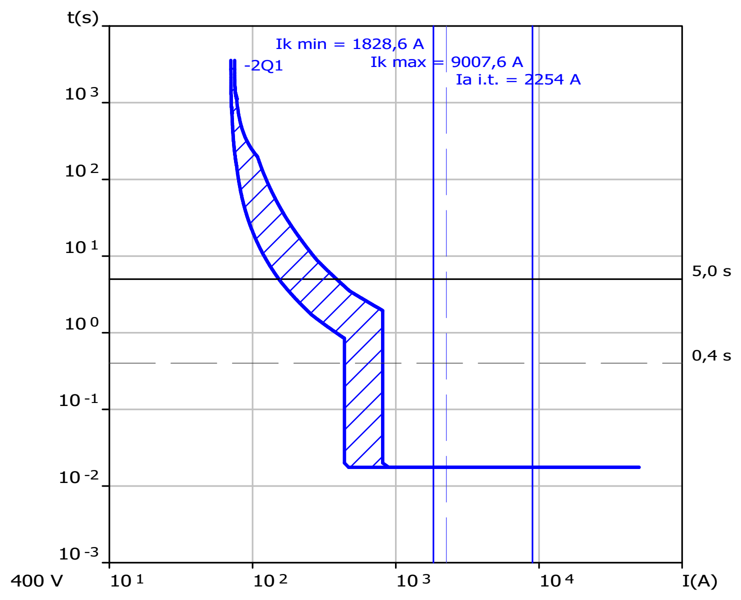
	Max	Min	Peak
Threephase	4,163	3,309	14,332
Line-to-line	3,605	2,866	12,412
Line-to-line-N	3,859	3,041	13,667
Line-to-line-PE	3,932	3,099	13,582
Line-to-N	2,377	1,829	8,85
Line-to-PE	2,903	2,254	7,306

At transient at the end of line

Ikv max	/_Ikv max [°]
4,762	28,451

Protection

SIEMENS - 3RV10 41-4JA10 - 63 A



Units status

Data: 6. 03. 2021

Responsable:

Unit

+=TS EQ1.+SB-V-EQ1-2Q2 +SB-V-EQ1-1/2W2

Coord. Ib<Ins<Iz [A]

	Ib	<=	Ins	<=	Iz
Phase	51,924		63		102,4
Neutral	0		63		102,4

1) Unit +=TS EQ1.+SB-V-EQ1-2Q2: Ins = 63 [A] (thermal release)

Verification of indirect touching

	Verified
Ia i.t. [A]	2253,991
Breaking time delay [s]	5
VT for Ia i.t.. [V]	77,832
VT for Ikft [V]	77,832

Distribution system: TN-S
(Note: The analysis ends at the first useful protection found)
The unitprotection +=TS EQ1.+SB-V-EQ1-2Q2
trip by time-current curve (part LR, T = 5 s); I prot. = 385,982 <= Ia i.t. = 2253,991

Breaking capacity [kA]

Transient at beginnig of line Verified

BC	>=	Ikm max	/_Ikm max [°]
50		9,008	45,791
		DeltaIkm max	/_DeltaIkm max [°]
		1,272	31,806

Mag. rel.<Imagmax [A]

Mag. rel.	<	Imagmax
		Verified
819		1828,647

Cable

Designation NHXH-J
Formation 4x35

Cable temperature by Ib [°C]	30	<=	45	<=	90
Cable temperature by In [°C]	30	<=	53	<=	90

K²S²>I²t [A²s]

	Verified
K²S² phase conductor	$2{,}505 \cdot 10^7$
K²S² neutral	$2{,}505 \cdot 10^7$

Voltage drop [%]

Rated voltage [V] 400

VD (Ib)	VDTot (Ib)	VD max
0,681	3,944	5
VD (In)	VDTot (In)	
0,846	5,91	
	VD mot.	Max voltage drop
	9,179	15

Fault currents [kA]

Steady-state downstr. line, Peak upstr. line

	Max	Min	Peak
Threephase	4,163	3,309	14,332
Line-to-line	3,605	2,866	12,412
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Line-to-line-PE	3,932	3,099	13,582
Line-to-N	2,377	1,829	8,85
Line-to-PE	2,903	2,254	7,306

At transient at the end of line

Ikv max	/_Ikv max [°]
4,762	28,451

Protection

SIEMENS - 3RV10 41-4JA10 - 63 A