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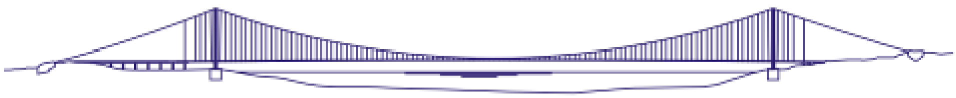
PONTE SULLO STRETTO DI MESSINA



PROGETTO DEFINITIVO

EUROLINK S.C.p.A.

IMPREGILO S.p.A. (MANDATARIA)
SOCIETÀ ITALIANA PER CONDOTTE D'ACQUA S.p.A. (MANDANTE)
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IL PROGETTISTA	IL CONTRAENTE GENERALE	STRETTO DI MESSINA	STRETTO DI MESSINA
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Opera - tratto d'opera - parte d'opera	Management and Control	
Titolo del documento	Mechanical and Electrical System, Calculation Report	

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Abbreviations

AC	Alternating Current - corrente alternata
ASTM	American Society for Testing and Materials
BAN	Bridge Area Network
Bridge	Messina Strait Bridge
BS	British Standard
CCTV	Closed Circuit TeleVision
CEI	Comitato Elettrotecnico Italiano
CMS	Control and Monitoring System
dB	deciBel
dBi	Gain relative to isotropic antenna
dBm	Power level relative to 1 mW
DC	Direct Current - corrente continua
EBB	Equipotential Bonding Bar -Barra equipotenziale
EMC	ElectroMagnetic Compatibility - Compatibilità elettromagnetica
EN	Europa Norm
ENEL	Italian Electrical Power Utility
ETSI	Europeam Telecommunications Standard Institute

GBIC	Gigabit Interface Converter
General Contractor	Eurolink
HV	High Voltage
IEC	International Electrical Commission
LAN	Local Area Network
LCC	Life Cycle Cost
LEMP	Lightning Electromagnetic Pulse - impulso elettromagnetico
LPS	Lightning Protection System - Sistema di protezione contro i fulmini
LPZ	Lightning Protection Zone (zone di protezione da fulminazione)
LV	Low Voltage
MDIX	Medium Dependent Interface
M&E	Mechanical and Electrical
MMI	Man Machine Interface
NIC	Network Interface Controller
PBX	Private Branche eXchange
PDS	Premises Distribution System
PE	Conduttore di protezione
PEN	Conduttore di protezione e neutro
PMS	Power Management System
PSTN	Public Switched Telephone Network
RCD	Residual Currentprotective Device - dispositivo di protezione a corrente differenziale
SCADA	Supervisory Control and Data Acquisition system
SHMS	Structural Health Monitoring System
SI	System of Units
SILS	Serviceability level of the Bridge: Extreme accidental and environmental loading conditions
SLS 1 and 2	Serviceability level of the Bridge (Normal use)
SPD	Surge Protective Device (protezione contro le sovratensioni)
TETRA	TErrestrial Trunked RAdio

UNI	Ente Nazionale Italiano di Unificazione
UPS	Uninterruptible Power Supply - alimentazione continua
VLAN	Virtual Local Area Network
VoIP	Voice Over internet Protocol
WAN	Wide Area Network
Ω	Ohm

1 Introduction

The Calculation Report gives an overview of the results of the design calculations witch has been carried out for the Progetto Definitivo, Mechanical and Electrical systems. Lighting calculations are presented in report no. CG1000-P4RDPITE2SI000000-01.

2 Power supply

2.1 Purpose of calculation

A power system study of the electrical network for the Messina Strait Bridge has been performed. The aim of the power system study is to verify that:

- the voltage will be kept within the guidelines of CEI 64\8
- the electrical network can be built of standard equipment

The followring calculations are performed to verify that the above requriments are fullfiled:

- Load study
- Loadflow calculations
- Short circuit calculations

Selectivity calculations will be performed during the Projetto Esecutivo phase.

The power system study covers the electrical network from the 20kV incomers in substation QMT-SS-Sicilia and QMT-SS-Calabria, the entire 6kV distribution network and critical parts of the low voltage network. The critical parts are circuits or switchboards where the highest or lowest voltages and short circuits levels are identified.

2.2 Calculation basis

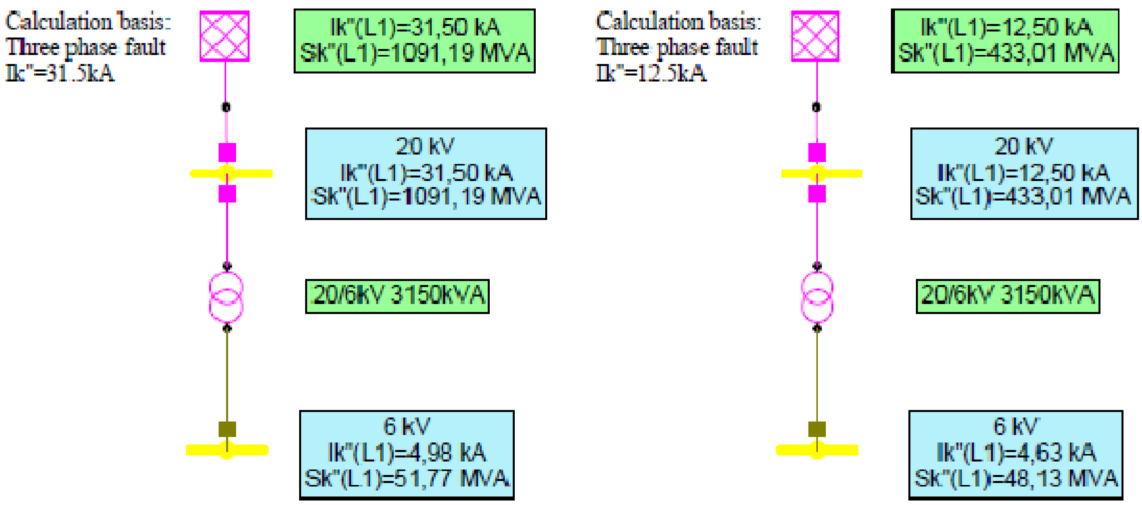
Electric power for the Messina Strait Bridge is distributed along the bridge deck through two 6kV cables connecting the two substations QMT-G-Sicilia and QMT-G-Calabria. Radials feed from the two substations QMT-G-Sicilia and QMT-G-Calabria are supplying substations in anchor blocks, towers and in the fire and drainage houses.

Power suppliers to the network are:

1. ENEL utility supply to the substation QMT-SS-Sicily at 20kV.
2. ENEL utility supply at the substation QMT-SS-Calabria at 20kV.
3. Emergency generators located in substation QMT-G-Sicily and in substation QMT-G-Calabria

The present maximum short circuit level of the ENEL power supply is I_k=12.5kA. To prepare the power supply system for future extension of the ENEL utility network, a maximum short circuit level of I_k=31.5kA have been used for the calculations.

A check calculation with I_k=12.5kA and I_k=31.5kA have been performed in order to analyse influence of the ENEL short circuit level on the calculation results.



It is concluded that the value for the short circuit level will have very limited and no significant influence on the system calculation result and will not influence design of the 6kV network and its components. The short circuit current will only influence design requirement for the 20 kV switchgear. In order to comply with todays short circuit level at 20 kV feeder the switchgear may be provided with 16 kA short circuit design level (Corrente di breve durata 1s (kA)). In order to allow for future increase of short circuit level in the ENEL grid the required short circuit withstand current for main substation 20kV switchgear will be either 20 kA or 31.5kA and final decision will be taken after negotiations with ENEL in the Projetto Esecutivo phase.

The voltage variation of the ENEL power supply is assumed to be less than ±1% of U_n.

The power distribution system can be operated under different conditions. Calculations are performed for the following three operation scenarios:

Operation scenario 1: The coupling configuration at normal operation. The distribution network is supplied from both the Sicily and Calabria side. The two cables connecting QMT-G-Sicily and QMT-G-Calabria are operated as an open ring as shown in Figure 1.

Operation scenario 2: Fault or maintenance coupling configuration with utility supply from one side only. The power supply from either QMT-SS-Sicily or QMT-SS-Calabria is interrupted and the entire bridge will be supplied from one side only as shown in Figure 2.

Operation scenario 3: Fault or maintenance coupling configuration with emergency generators supplying the network. The 6kV incomers at QMT-G-Sicily or QMT-G-Calabria are open and the two cable systems crossing the bridge is operated as an open ring. The Sicily and Calabria side of the distribution network are feed from their own 1.6MVA generator as shown in Figure 3.

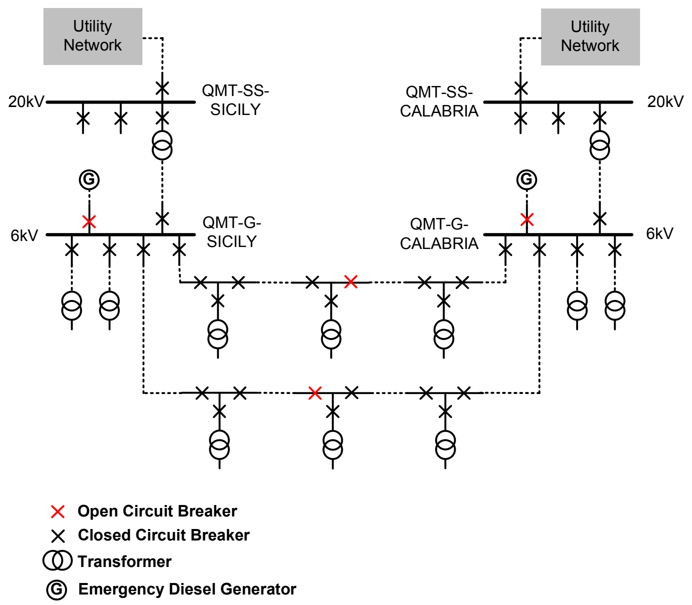


Figure 1- Operation scenario 1.

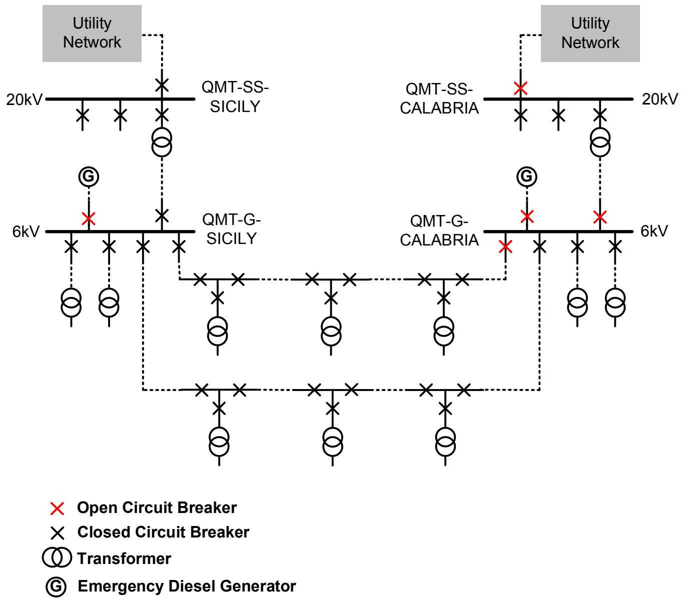


Figure 2 – Operation scenario 2.

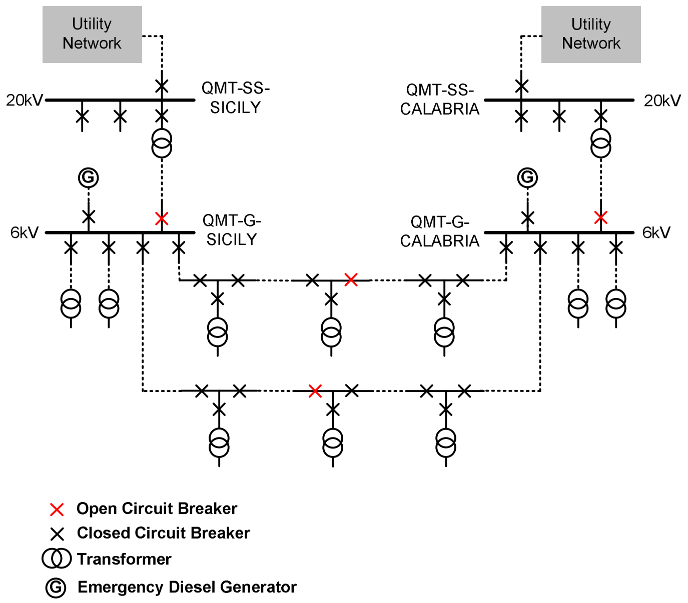


Figure 3 – Operation scenario 3.

2.3 Load study

Power demand is calculated for night and daylight periods for operation scenario 1 and 2.

Table 1 summarizes the results of the load study. The largest load demand is determined to be

2400kW for operation scenario 1 at night time when both road and architectural lighting is on.

Tables sumerizing the load demand for the main low voltage switchboard and the main UPS switchbord in each substation are also shown. The switchbords are BLA01, BNB01, BLA02, BNB02, BLA03, BNB03, BLA04, BNB04 BLA05, BNB05, BLA06, BNB06, BLA07, BNB07, BLA08, BNB08, BLA11, BNB11, BLA12, BNB12, BLA13, BNB13, BLA14, BLA21, BNB21, BLA22, BNB22, BLA23, BNB23, BLA24, BLA31, BNB31, BLA41, BNB41, BHA10, BNB10, BHA20, BNB20, BHA51 and BHA61. Switchboards named BLAXX or BHAXX is the main low voltage switchboard of each substation and BHBXX is the main UPS-supplied switchboard of each substation.

The load distributed on transformers are presented in Table 2. Diversity coefficients are determined as the average diversity coefficients of the equipment supplied by each transformer. The diversity coefficients are lowest for transformers on the bridge deck where a large part of the connected load is internal lighting which is rarely on. The capacity utilization rate of the transformers is between 14% and 98%.

The capacity utilization of the transformers installed in the fire and drainage houses (BLT13, BLT14, BLT23 and BLT24) is only about 30%, since each transformer is sized to backup up the entire load demand of the fire and drainage house where it is installed. In a backup situation where one transformer is interrupted the utilization of the remaining transformer will be approximately 60%.

Total loads															
Description	Con-nected Load [kW]	Cos(phi) [-]	Effi-ciency (η) [-]	Essen-tial Load	Normal Day			Normal Night			Generator Day		Generator Night		
					Div. co.	Load [kW]	Load [kVA]	Div. co.	Load [kW]	Load [kVA]	Load [kW]	Load [kVA]	Load [kW]	Load [kVA]
Road lighting														
Main lighting along main bridge	117	0,90	0,95	x	0,0	0	0	1,0	123	137	0	0	123	137
Service lane lighting														
Service lane lighting	54	0,90	0,95	x	0,0	0	0	1,0	57	63	0	0	57	63
Internal lighting														
Girder lighting	180	0,90	0,95	x	0,1	19	21	0,1	19	21	19	21	19	21
Cross girder lighting	132	0,90	0,95	x	0,1	14	15	0,1	14	15	14	15	14	15
Ladder lighting tower	51	0,90	0,95	x	0,1	5	6	0,1	5	6	5	6	5	6
Stair case lighting	28	0,90	0,95	x	0,1	3	3	0,1	3	3	3	3	3	3
Cross beam lighting	16	0,90	0,95	x	0,1	2	2	0,1	2	2	2	2	2	2
Lighting in Subtations on land	6	0,90	0,95	x	0,1	1	1	0,1	1	1	1	1	1	1
Architectural lighting														
Tower lighting	96	0,90	0,95		0,0	0	0	1,0	101	112	0	0	0	0
Bridge	104	0,90	0,95		0,0	0	0	1,0	109	122	0	0	0	0
Navigation and Aeronautical lighting														
Navigation lighting	0,3	0,90	0,95	x	1,0	0,3	0,3	1,0	0,3	0,3	0,3	0,3	0,3	0,3
Aeronautical lighting	14	0,90	0,95	x	1,0	14	16	1,0	14	16	14	16	14	16
Mechanical installations														
Buffers	2	0,80	0,95	x	1,0	2	3	1,0	2	3	2	3	2	3
Dehumidification	603	0,80	0,95		0,4	254	317	0,4	254	317	0	0	0	0
Utility water pumps	442	0,80	0,95	x	0,2	93	116	0,2	93	116	93	116	93	116
Fire and jockey pumps	475	0,80	0,95	x	1,0	500	624	1,0	500	624	500	624	500	624
Elevators	484	0,80	0,95	x	0,1	51	64	0,1	51	64	51	64	51	64
Cooling and ventilation	66	0,80	0,95	x	0,5	35	43	0,5	35	43	35	43	35	43
TMS, Communication & Monitoring														
TMS portals	80	0,90	0,95	x	1,0	84	94	0,5	42	47	84	94	42	47
CMS	29	0,90	0,95	x	1,0	30	33	1,0	30	33	30	33	30	33
Network switches	36	0,90	0,95	x	1,0	38	42	1,0	38	42	38	42	38	42
Heat tracing and fire hydrants	60	0,90	0,95	x	1,0	63	70	1,0	63	70	63	70	63	70
Health monitoring	17	0,90	0,95	x	1,0	18	20	1,0	18	20	18	20	18	20
Radio communication	26	0,90	0,95	x	1,0	27	30	1,0	27	30	27	30	27	30
Other loads														
Socket outlets	360	0,90	0,95		0,1	38	42	0,1	38	42	0	0	0	0
Generator related load	6	0,90	0,95	x	1,0	6	7	1,0	6	7	6	7	6	7
Switchgear related load	54	0,90	0,95	x	1,0	56	63	1,0	56	63	56	63	56	63
Transformers related load	279	0,90	0,95	x	1,0	293	326	1,0	293	326	293	326	293	326
Total bridge load	3816					1647	1960		1995	2347	1355	1600	1493	1753
Land installations														
Land installations Sicily	2200	0,90	0,95		1,0	2316	2573	1,0	2316	2573	0	0	0	0
Land installations Calabria	1000	0,90	0,95		1,0	1053	1170	1,0	1053	1170	0	0	0	0
Total	7016					5015	5702		5364	6089	1355	1600	1493	1753

Table 1 – Summary of load study.

Substation QMT-A1	Busbar BLA01													
Description	Con-nected Load [kW]	Cos(phi) [-]	Effi-ciency (η) [-]	Essen-tial Load	Normal Day			Normal Night			Generator Day		Generator Night	
					Div. co.	Load [kW]	Load [kVA]	Div. co.	Load [kW]	Load [kVA]	Load [kW]	Load [kVA]	Load [kW]	Load [kVA]
Road lighting														
Main lighting along main bridge	10,0	0,90	0,95	x	0,0	0	0	1,0	11	12	0	0	11	12
Service lane lighting														
Service lane lighting	4,5	0,90	0,95	x	0,0	0	0	1,0	5	5	0	0	5	5
Internal lighting														
Girder lighting	15,0	0,90	0,95	x	0,1	2	2	0,1	2	2	2	2	2	2
Cross girder lighting	11,0	0,90	0,95	x	0,1	1	1	0,1	1	1	1	1	1	1
Ladder lighting tower	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Stair case lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross beam lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Lighting in Subtations on land	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Architectural lighting														
Tower lighting	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Bridge	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Navigation and Aeronautical lighting														
Navigation lighting	0,0	0,90	0,95	x	1,0	0,0	0,0	1,0	0,0	0,0	0,0	0,0	0,0	0,0
Aeronautical lighting	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Mechanical installations														
Buffers	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Dehumidification	85,1	0,80	0,95		0,4	36	45	0,4	36	45	0	0	0	0
Utility water pumps	0,0	0,80	0,95	x	0,2	0	0	0,2	0	0	0	0	0	0
Fire and jockey pumps	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Elevators	0,0	0,80	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cooling and ventilation	3,0	0,80	0,95	x	0,5	2	2	0,5	2	2	2	2	2	2
TMS, Communication & Monitoring														
TMS portals	10,0	0,90	0,95	x	1,0	11	12	0,5	5	6	11	12	5	6
CMS	1,5	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Network switches	2,0	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Heat tracing and fire hydrants	5,0	0,90	0,95	x	1,0	5	6	1,0	5	6	5	6	5	6
Health monitoring	1,2	0,90	0,95	x	1,0	1	1	1,0	1	1	1	1	1	1
Radio communication	1,9	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Other loads														
Socket outlets	30,2	0,90	0,95		0,1	3	4	0,1	3	4	0	0	0	0
Generator related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Switchgear related load	3,1	0,90	0,95	x	1,0	3	4	1,0	3	4	3	4	3	4
Transformers related load	0,3	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Total load busbar BLA01	183,8					70	83		80	94	31	34	41	45

Substation QMT-01	**Busbar BNB01**													
Description	**Con-nected Load [kW]**	**Cos(phi) [-]**	**Effi-ciency (η) [-]**	**Essen-tial Load**	**Normal Day**			**Normal Night**			**Generator Day**		**Generator Night**	
					Div. co.	**Load [kW]**	**Load [kVA]**	**Div. co.**	**Load [kW]**	**Load [kVA]**	**Load [kW]**	**Load [kVA]**	**Load [kW]**	**Load [kVA]**
Road lighting														
Main lighting along main bridge	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Service lane lighting														
Service lane lighting	1,5	0,90	0,95	x	0,0	0	0	1,0	2	2	0	0	2	2
Internal lighting														
Girder lighting	7,5	0,90	0,95	x	0,1	1	1	0,1	1	1	1	1	1	1
Cross girder lighting	8,0	0,90	0,95	x	0,1	1	1	0,1	1	1	1	1	1	1
Ladder lighting tower	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Stair case lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross beam lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Lighting in Subtations on land	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Architectural lighting														
Tower lighting	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Bridge	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Navigation and Aeronautical lighting														
Navigation lighting	0,0	0,90	0,95	x	1,0	0,0	0,0	1,0	0,0	0,0	0,0	0,0	0,0	0,0
Aeronautical lighting	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Mechanical installations														
Buffers	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Dehumidification	0,0	0,80	0,95		0,4	0	0	0,4	0	0	0	0	0	0
Utility water pumps	0,0	0,80	0,95	x	0,2	0	0	0,2	0	0	0	0	0	0
Fire and jockey pumps	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Elevators	0,0	0,80	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cooling and ventilation	0,0	0,80	0,95	x	0,5	0	0	0,5	0	0	0	0	0	0
TMS, Communication & Monitoring														
TMS portals	10,0	0,90	0,95	x	1,0	11	12	0,5	5	6	11	12	5	6
CMS	1,5	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Network switches	2,0	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Heat tracing and fire hydrants	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Health monitoring	1,2	0,90	0,95	x	1,0	1	1	1,0	1	1	1	1	1	1
Radio communication	1,9	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Other loads														
Socket outlets	0,0	0,90	0,95		0,1	0	0	0,1	0	0	0	0	0	0
Generator related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Switchgear related load	1,0	0,90	0,95	x	1,0	1	1	1,0	1	1	1	1	1	1
Transformer related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Total load busbar BNB01	34,6					20	22		16	18	20	22	16	18

Substation QMT-A2	Busbar BLA02													
Description	Con-nected Load [kW]	Cos(phi) [-]	Effi-ciency (η) [-]	Essen-tial Load	Normal Day Div. co.	Normal Day Load [kW]	Normal Day Load [kVA]	Normal Night Div. co.	Normal Night Load [kW]	Normal Night Load [kVA]	Generator Day Load [kW]	Generator Day Load [kVA]	Generator Night Load [kW]	Generator Night Load [kVA]
Road lighting														
Main lighting along main bridge	17,0	0,90	0,95	x	0,0	0	0	1,0	18	20	0	0	18	20
Service lane lighting														
Service lane lighting	8,1	0,90	0,95	x	0,0	0	0	1,0	9	9	0	0	9	9
Internal lighting														
Girder lighting	27,0	0,90	0,95	x	0,1	3	3	0,1	3	3	3	3	3	3
Cross girder lighting	19,8	0,90	0,95	x	0,1	2	2	0,1	2	2	2	2	2	2
Ladder lighting tower	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Stair case lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross beam lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Lighting in Subtations on land	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Architectural lighting														
Tower lighting	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Bridge	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Navigation and Aeronautical lighting														
Navigation lighting	0,0	0,90	0,95	x	1,0	0,0	0,0	1,0	0,0	0,0	0,0	0,0	0,0	0,0
Aeronautical lighting	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Mechanical installations														
Buffers	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Dehumidification	0,0	0,80	0,95		0,4	0	0	0,4	0	0	0	0	0	0
Utility water pumps	0,0	0,80	0,95	x	0,2	0	0	0,2	0	0	0	0	0	0
Fire and jockey pumps	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Elevators	0,0	0,80	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cooling and ventilation	3,0	0,80	0,95	x	0,5	2	2	0,5	2	2	2	2	2	2
TMS, Communication & Monitoring														
TMS portals	10,0	0,90	0,95	x	1,0	11	12	0,5	5	6	11	12	5	6
CMS	1,5	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Network switches	2,0	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Heat tracing and fire hydrants	9,0	0,90	0,95	x	1,0	9	11	1,0	9	11	9	11	9	11
Health monitoring	1,2	0,90	0,95	x	1,0	1	1	1,0	1	1	1	1	1	1
Radio communication	1,9	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Other loads														
Socket outlets	54,0	0,90	0,95		0,1	6	6	0,1	6	6	0	0	0	0
Generator related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Switchgear related load	2,3	0,90	0,95	x	1,0	2	3	1,0	2	3	2	3	2	3
Transformers related load	0,3	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Total load busbar BLA02	157,1					42	47		63	70	36	40	57	64

Substation QMT-A2	**Busbar BNB02**													
Description	**Con-nected Load [kW]**	**Cos(phi) [-]**	**Effi-ciency (η) [-]**	**Essen-tial Load**	**Normal Day**			**Normal Night**			**Generator Day**		**Generator Night**	
					Div. co.	**Load [kW]**	**Load [kVA]**	**Div. co.**	**Load [kW]**	**Load [kVA]**	**Load [kW]**	**Load [kVA]**	**Load [kW]**	**Load [kVA]**
Road lighting														
Main lighting along main bridge	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Service lane lighting														
Service lane lighting	2,7	0,90	0,95	x	0,0	0	0	1,0	3	3	0	0	3	3
Internal lighting														
Girder lighting	13,5	0,90	0,95	x	0,1	1	2	0,1	1	2	1	2	1	2
Cross girder lighting	14,4	0,90	0,95	x	0,1	2	2	0,1	2	2	2	2	2	2
Ladder lighting tower	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Stair case lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross beam lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Lighting in Subtations on land	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Architectural lighting														
Tower lighting	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Bridge	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Navigation and Aeronautical lighting														
Navigation lighting	0,0	0,90	0,95	x	1,0	0,0	0,0	1,0	0,0	0,0	0,0	0,0	0,0	0,0
Aeronautical lighting	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Mechanical installations														
Buffers	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Dehumidification	0,0	0,80	0,95		0,4	0	0	0,4	0	0	0	0	0	0
Utility water pumps	0,0	0,80	0,95	x	0,2	0	0	0,2	0	0	0	0	0	0
Fire and jockey pumps	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Elevators	0,0	0,80	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cooling and ventilation	0,0	0,80	0,95	x	0,5	0	0	0,5	0	0	0	0	0	0
TMS, Communication & Monitoring														
TMS portals	10,0	0,90	0,95	x	1,0	11	12	0,5	5	6	11	12	5	6
CMS	1,5	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Network switches	2,0	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Heat tracing and fire hydrants	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Health monitoring	1,2	0,90	0,95	x	1,0	1	1	1,0	1	1	1	1	1	1
Radio communication	1,9	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Other loads														
Socket outlets	0,0	0,90	0,95		0,1	0	0	0,1	0	0	0	0	0	0
Generator related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Switchgear related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Transformers related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Total load busbar BNB02	47,2					20	23		18	20	20	23	18	20

Substation QMT-A3	Busbar BLA03													
Description	Con- nected Load [kW]	Cos(phi) [-]	Effi- ciency (η) [-]	Essen- tial Load	Normal Day			Normal Night			Generator Day		Generator Night	
					Div. co.	Load [kW]	Load [kVA]	Div. co.	Load [kW]	Load [kVA]	Load [kW]	Load [kVA]	Load [kW]	Load [kVA]
Road lighting														
Main lighting along main bridge	16,0	0,90	0,95	x	0,0	0	0	1,0	17	19	0	0	17	19
Service lane lighting														
Service lane lighting	7,2	0,90	0,95	x	0,0	0	0	1,0	8	8	0	0	8	8
Internal lighting														
Girder lighting	24,0	0,90	0,95	x	0,1	3	3	0,1	3	3	3	3	3	3
Cross girder lighting	17,6	0,90	0,95	x	0,1	2	2	0,1	2	2	2	2	2	2
Ladder lighting tower	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Stair case lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross beam lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Lighting in Subtations on land	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Architectural lighting														
Tower lighting	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Bridge	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Navigation and Aeronautical lighting														
Navigation lighting	0,2	0,90	0,95	x	1,0	0,2	0,2	1,0	0,2	0,2	0,2	0,2	0,2	0,2
Aeronautical lighting	1,6	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Mechanical installations														
Buffers	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Dehumidification	0,0	0,80	0,95		0,4	0	0	0,4	0	0	0	0	0	0
Utility water pumps	0,0	0,80	0,95	x	0,2	0	0	0,2	0	0	0	0	0	0
Fire and jockey pumps	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Elevators	0,0	0,80	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cooling and ventilation	3,0	0,80	0,95	x	0,5	2	2	0,5	2	2	2	2	2	2
TMS, Communication & Monitoring														
TMS portals	10,0	0,90	0,95	x	1,0	11	12	0,5	5	6	11	12	5	6
CMS	1,5	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Network switches	2,0	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Heat tracing and fire hydrants	8,0	0,90	0,95	x	1,0	8	9	1,0	8	9	8	9	8	9
Health monitoring	1,2	0,90	0,95	x	1,0	1	1	1,0	1	1	1	1	1	1
Radio communication	1,9	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Other loads														
Socket outlets	48,0	0,90	0,95		0,1	5	6	0,1	5	6	0	0	0	0
Generator related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Switchgear related load	2,1	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Transformers related load	0,3	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Total load busbar BLA03	144,5					41	46		60	67	36	40	55	62

Substation QMT-A3	**Busbar BNB03**													
Description	**Con-nected Load [kW]**	**Cos(phi) [-]**	**Effi-ciency (η) [-]**	**Essen-tial Load**	**Normal Day**			**Normal Night**			**Generator Day**		**Generator Night**	
					Div. co.	**Load [kW]**	**Load [kVA]**	**Div. co.**	**Load [kW]**	**Load [kVA]**	**Load [kW]**	**Load [kVA]**	**Load [kW]**	**Load [kVA]**
Road lighting														
Main lighting along main bridge	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Service lane lighting														
Service lane lighting	2,4	0,90	0,95	x	0,0	0	0	1,0	3	3	0	0	3	3
Internal lighting														
Girder lighting	12,0	0,90	0,95	x	0,1	1	1	0,1	1	1	1	1	1	1
Cross girder lighting	12,8	0,90	0,95	x	0,1	1	1	0,1	1	1	1	1	1	1
Ladder lighting tower	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Stair case lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross beam lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Lighting in Subtations on land	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Architectural lighting														
Tower lighting	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Bridge	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Navigation and Aeronautical lighting														
Navigation lighting	0,2	0,90	0,95	x	1,0	0,2	0,2	1,0	0,2	0,2	0,2	0,2	0,2	0,2
Aeronautical lighting	1,6	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Mechanical installations														
Buffers	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Dehumidification	0,0	0,80	0,95		0,4	0	0	0,4	0	0	0	0	0	0
Utility water pumps	0,0	0,80	0,95	x	0,2	0	0	0,2	0	0	0	0	0	0
Fire and jockey pumps	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Elevators	0,0	0,80	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cooling and ventilation	0,0	0,80	0,95	x	0,5	0	0	0,5	0	0	0	0	0	0
TMS, Communication & Monitoring														
TMS portals	10,0	0,90	0,95	x	1,0	11	12	0,5	5	6	11	12	5	6
CMS	1,5	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Network switches	2,0	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Heat tracing and fire hydrants	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Health monitoring	1,2	0,90	0,95	x	1,0	1	1	1,0	1	1	1	1	1	1
Radio communication	1,9	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Other loads														
Socket outlets	0,0	0,90	0,95		0,1	0	0	0,1	0	0	0	0	0	0
Generator related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Switchgear related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Transformers related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Total load busbar BNB03	45,5					22	24		19	21	22	24	19	21

Substation QMT-04	Busbar BLA04													
Description	Con-nected Load [kW]	Cos(phi) [-]	Effi-ciency (η) [-]	Essen-tial Load	Normal Day			Normal Night			Generator Day		Generator Night	
					Div. co.	Load [kW]	Load [kVA]	Div. co.	Load [kW]	Load [kVA]	Load [kW]	Load [kVA]	Load [kW]	Load [kVA]
Road lighting														
Main lighting along main bridge	16,0	0,90	0,95	x	0,0	0	0	1,0	17	19	0	0	17	19
Service lane lighting														
Service lane lighting	7,2	0,90	0,95	x	0,0	0	0	1,0	8	8	0	0	8	8
Internal lighting														
Girder lighting	24,0	0,90	0,95	x	0,1	3	3	0,1	3	3	3	3	3	3
Cross girder lighting	17,6	0,90	0,95	x	0,1	2	2	0,1	2	2	2	2	2	2
Ladder lighting tower	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Stair case lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross beam lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Lighting in Subtations on land	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Architectural lighting														
Tower lighting	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Bridge	52,0	0,90	0,95		0,0	0	0	1,0	55	61	0	0	0	0
Navigation and Aeronautical lighting														
Navigation lighting	0,0	0,90	0,95	x	1,0	0,0	0,0	1,0	0,0	0,0	0,0	0,0	0,0	0,0
Aeronautical lighting	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Mechanical installations														
Buffers	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Dehumidification	60,0	0,80	0,95		0,4	25	32	0,4	25	32	0	0	0	0
Utility water pumps	0,0	0,80	0,95	x	0,2	0	0	0,2	0	0	0	0	0	0
Fire and jockey pumps	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Elevators	0,0	0,80	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cooling and ventilation	3,0	0,80	0,95	x	0,5	2	2	0,5	2	2	2	2	2	2
TMS, Communication & Monitoring														
TMS portals	10,0	0,90	0,95	x	1,0	11	12	0,5	5	6	11	12	5	6
CMS	1,5	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Network switches	2,0	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Heat tracing and fire hydrants	8,0	0,90	0,95	x	1,0	8	9	1,0	8	9	8	9	8	9
Health monitoring	1,2	0,90	0,95	x	1,0	1	1	1,0	1	1	1	1	1	1
Radio communication	1,9	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Other loads														
Socket outlets	48,0	0,90	0,95		0,1	5	6	0,1	5	6	0	0	0	0
Generator related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Switchgear related load	2,3	0,90	0,95	x	1,0	2	3	1,0	2	3	2	3	2	3
Transformer related load	0,3	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Total load busbar BLA04	255,0					65	76		139	158	35	39	54	60

Substation QMT-A4	**Busbar BNB04**													
Description	**Con-nected Load [kW]**	**Cos(phi) [-]**	**Effi-ciency (η) [-]**	**Essen-tial Load**	**Normal Day**			**Normal Night**			**Generator Day**		**Generator Night**	
					Div. co.	**Load [kW]**	**Load [kVA]**	**Div. co.**	**Load [kW]**	**Load [kVA]**	**Load [kW]**	**Load [kVA]**	**Load [kW]**	**Load [kVA]**
Road lighting														
Main lighting along main bridge	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Service lane lighting														
Service lane lighting	2,4	0,90	0,95	x	0,0	0	0	1,0	3	3	0	0	3	3
Internal lighting														
Girder lighting	12,0	0,90	0,95	x	0,1	1	1	0,1	1	1	1	1	1	1
Cross girder lighting	12,8	0,90	0,95	x	0,1	1	1	0,1	1	1	1	1	1	1
Ladder lighting tower	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Stair case lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross beam lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Lighting in Subtations on land	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Architectural lighting														
Tower lighting	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Bridge	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Navigation and Aeronautical lighting														
Navigation lighting	0,0	0,90	0,95	x	1,0	0,0	0,0	1,0	0,0	0,0	0,0	0,0	0,0	0,0
Aeronautical lighting	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Mechanical installations														
Buffers	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Dehumidification	0,0	0,80	0,95		0,4	0	0	0,4	0	0	0	0	0	0
Utility water pumps	0,0	0,80	0,95	x	0,2	0	0	0,2	0	0	0	0	0	0
Fire and jockey pumps	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Elevators	0,0	0,80	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cooling and ventilation	0,0	0,80	0,95	x	0,5	0	0	0,5	0	0	0	0	0	0
TMS, Communication & Monitoring														
TMS portals	10,0	0,90	0,95	x	1,0	11	12	0,5	5	6	11	12	5	6
CMS	1,5	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Network switches	2,0	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Heat tracing and fire hydrants	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Health monitoring	1,2	0,90	0,95	x	1,0	1	1	1,0	1	1	1	1	1	1
Radio communication	1,9	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Other loads														
Socket outlets	0,0	0,90	0,95		0,1	0	0	0,1	0	0	0	0	0	0
Generator related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Switchgear related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Transformers related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Total load busbar BNB04	43,8					20	22		17	19	20	22	17	19

Substation QMT-05	Busbar BLA05													
Description	Con-nected Load [kW]	Cos(phi) [-]	Effi-ciency (η) [-]	Essen-tial Load	Normal Day			Normal Night			Generator Day		Generator Night	
					Div. co.	Load [kW]	Load [kVA]	Div. co.	Load [kW]	Load [kVA]	Load [kW]	Load [kVA]	Load [kW]	Load [kVA]
Road lighting														
Main lighting along main bridge	16,0	0,90	0,95	x	0,0	0	0	1,0	17	19	0	0	17	19
Service lane lighting														
Service lane lighting	7,2	0,90	0,95	x	0,0	0	0	1,0	8	8	0	0	8	8
Internal lighting														
Girder lighting	24,0	0,90	0,95	x	0,1	3	3	0,1	3	3	3	3	3	3
Cross girder lighting	17,6	0,90	0,95	x	0,1	2	2	0,1	2	2	2	2	2	2
Ladder lighting tower	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Stair case lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross beam lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Lighting in Subtations on land	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Architectural lighting														
Tower lighting	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Bridge	52,0	0,90	0,95		0,0	0	0	1,0	55	61	0	0	0	0
Navigation and Aeronautical lighting														
Navigation lighting	0,0	0,90	0,95	x	1,0	0,0	0,0	1,0	0,0	0,0	0,0	0,0	0,0	0,0
Aeronautical lighting	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Mechanical installations														
Buffers	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Dehumidification	84,1	0,80	0,95		0,4	35	44	0,4	35	44	0	0	0	0
Utility water pumps	0,0	0,80	0,95	x	0,2	0	0	0,2	0	0	0	0	0	0
Fire and jockey pumps	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Elevators	0,0	0,80	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cooling and ventilation	3,0	0,80	0,95	x	0,5	2	2	0,5	2	2	2	2	2	2
TMS, Communication & Monitoring														
TMS portals	10,0	0,90	0,95	x	1,0	11	12	0,5	5	6	11	12	5	6
CMS	1,5	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Network switches	2,0	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Heat tracing and fire hydrants	8,0	0,90	0,95	x	1,0	8	9	1,0	8	9	8	9	8	9
Health monitoring	1,2	0,90	0,95	x	1,0	1	1	1,0	1	1	1	1	1	1
Radio communication	1,9	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Other loads														
Socket outlets	48,0	0,90	0,95		0,1	5	6	0,1	5	6	0	0	0	0
Generator related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Switchgear related load	1,9	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Transformer related load	0,3	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Total load busbar BLA05	278,7					75	88		149	170	34	38	53	59

Substation QMT-A5	Busbar BNB05													
Description	Con-nected Load [kW]	Cos(phi) [-]	Effi-ciency (η) [-]	Essen-tial Load	Normal Day			Normal Night			Generator Day		Generator Night	
					Div. co.	Load [kW]	Load [kVA]	Div. co.	Load [kW]	Load [kVA]	Load [kW]	Load [kVA]	Load [kW]	Load [kVA]
Road lighting														
Main lighting along main bridge	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Service lane lighting														
Service lane lighting	2,4	0,90	0,95	x	0,0	0	0	1,0	3	3	0	0	3	3
Internal lighting														
Girder lighting	12,0	0,90	0,95	x	0,1	1	1	0,1	1	1	1	1	1	1
Cross girder lighting	12,8	0,90	0,95	x	0,1	1	1	0,1	1	1	1	1	1	1
Ladder lighting tower	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Stair case lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross beam lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Lighting in Subtations on land	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Architectural lighting														
Tower lighting	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Bridge	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Navigation and Aeronautical lighting														
Navigation lighting	0,0	0,90	0,95	x	1,0	0,0	0,0	1,0	0,0	0,0	0,0	0,0	0,0	0,0
Aeronautical lighting	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Mechanical installations														
Buffers	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Dehumidification	0,0	0,80	0,95		0,4	0	0	0,4	0	0	0	0	0	0
Utility water pumps	0,0	0,80	0,95	x	0,2	0	0	0,2	0	0	0	0	0	0
Fire and jockey pumps	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Elevators	0,0	0,80	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cooling and ventilation	0,0	0,80	0,95	x	0,5	0	0	0,5	0	0	0	0	0	0
TMS, Communication & Monitoring														
TMS portals	10,0	0,90	0,95	x	1,0	11	12	0,5	5	6	11	12	5	6
CMS	1,5	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Network switches	2,0	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Heat tracing and fire hydrants	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Health monitoring	1,2	0,90	0,95	x	1,0	1	1	1,0	1	1	1	1	1	1
Radio communication	1,9	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Other loads														
Socket outlets	0,0	0,90	0,95		0,1	0	0	0,1	0	0	0	0	0	0
Generator related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Switchgear related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Transformers related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Total load busbar BNB05	43,8					20	22		17	19	20	22	17	19

Substation QMT-A6	Busbar BLA06													
Description	Con-nected Load [kW]	Cos(phi) [-]	Effi-ciency (η) [-]	Essen-tial Load	Normal Day			Normal Night			Generator Day		Generator Night	
					Div. co.	Load [kW]	Load [kVA]	Div. co.	Load [kW]	Load [kVA]	Load [kW]	Load [kVA]	Load [kW]	Load [kVA]
Road lighting														
Main lighting along main bridge	16,0	0,90	0,95	x	0,0	0	0	1,0	17	19	0	0	17	19
Service lane lighting														
Service lane lighting	7,2	0,90	0,95	x	0,0	0	0	1,0	8	8	0	0	8	8
Internal lighting														
Girder lighting	24,0	0,90	0,95	x	0,1	3	3	0,1	3	3	3	3	3	3
Cross girder lighting	17,6	0,90	0,95	x	0,1	2	2	0,1	2	2	2	2	2	2
Ladder lighting tower	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Stair case lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross beam lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Lighting in Subtations on land	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Architectural lighting														
Tower lighting	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Bridge	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Navigation and Aeronautical lighting														
Navigation lighting	0,1	0,90	0,95	x	1,0	0,1	0,1	1,0	0,1	0,1	0,1	0,1	0,1	0,1
Aeronautical lighting	1,6	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Mechanical installations														
Buffers	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Dehumidification	0,0	0,80	0,95		0,4	0	0	0,4	0	0	0	0	0	0
Utility water pumps	0,0	0,80	0,95	x	0,2	0	0	0,2	0	0	0	0	0	0
Fire and jockey pumps	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Elevators	0,0	0,80	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cooling and ventilation	3,0	0,80	0,95	x	0,5	2	2	0,5	2	2	2	2	2	2
TMS, Communication & Monitoring														
TMS portals	10,0	0,90	0,95	x	1,0	11	12	0,5	5	6	11	12	5	6
CMS	1,5	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Network switches	2,0	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Heat tracing and fire hydrants	8,0	0,90	0,95	x	1,0	8	9	1,0	8	9	8	9	8	9
Health monitoring	1,2	0,90	0,95	x	1,0	1	1	1,0	1	1	1	1	1	1
Radio communication	1,9	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Other loads														
Socket outlets	48,0	0,90	0,95		0,1	5	6	0,1	5	6	0	0	0	0
Generator related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Switchgear related load	2,1	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Transformers related load	0,3	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Total load busbar BLA06	144,5					41	46		60	67	36	40	55	62

Substation QMT-A6	Busbar BNB06													
Description	Con-nected Load [kW]	Cos(phi) [-]	Effi-ciency (η) [-]	Essen-tial Load	Normal Day			Normal Night			Generator Day		Generator Night	
					Div. co.	Load [kW]	Load [kVA]	Div. co.	Load [kW]	Load [kVA]	Load [kW]	Load [kVA]	Load [kW]	Load [kVA]
Road lighting														
Main lighting along main bridge	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Service lane lighting														
Service lane lighting	2,4	0,90	0,95	x	0,0	0	0	1,0	3	3	0	0	3	3
Internal lighting														
Girder lighting	12,0	0,90	0,95	x	0,1	1	1	0,1	1	1	1	1	1	1
Cross girder lighting	12,8	0,90	0,95	x	0,1	1	1	0,1	1	1	1	1	1	1
Ladder lighting tower	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Stair case lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross beam lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Lighting in Subtations on land	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Architectural lighting														
Tower lighting	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Bridge	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Navigation and Aeronautical lighting														
Navigation lighting	0,1	0,90	0,95	x	1,0	0,1	0,1	1,0	0,1	0,1	0,1	0,1	0,1	0,1
Aeronautical lighting	1,6	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Mechanical installations														
Buffers	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Dehumidification	0,0	0,80	0,95		0,4	0	0	0,4	0	0	0	0	0	0
Utility water pumps	0,0	0,80	0,95	x	0,2	0	0	0,2	0	0	0	0	0	0
Fire and jockey pumps	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Elevators	0,0	0,80	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cooling and ventilation	0,0	0,80	0,95	x	0,5	0	0	0,5	0	0	0	0	0	0
TMS, Communication & Monitoring														
TMS portals	10,0	0,90	0,95	x	1,0	11	12	0,5	5	6	11	12	5	6
CMS	1,5	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Network switches	2,0	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Heat tracing and fire hydrants	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Health monitoring	1,2	0,90	0,95	x	1,0	1	1	1,0	1	1	1	1	1	1
Radio communication	1,9	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Other loads														
Socket outlets	0,0	0,90	0,95		0,1	0	0	0,1	0	0	0	0	0	0
Generator related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Switchgear related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Transformers related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Total load busbar BNB06	45,5					22	24		19	21	22	24	19	21

Substation QMT-A7	**Busbar BLA07**														
Description	**Con-nected Load [kW]**	**Cos(phi) [-]**	**Effi-ciency (η) [-]**	**Essen-tial Load**	**Normal Day**			**Normal Night**			**Generator Day**		**Generator Night**		
					Div. co.	**Load [kW]**	**Load [kVA]**	**Div. co.**	**Load [kW]**	**Load [kVA]**	**Load [kW]**	**Load [kVA]**	**Load [kW]**	**Load [kVA]**
Road lighting														
Main lighting along main bridge	17,0	0,90	0,95	x	0,0	0	0	1,0	18	20	0	0	18	20
Service lane lighting														
Service lane lighting	8,1	0,90	0,95	x	0,0	0	0	1,0	9	9	0	0	9	9
Internal lighting														
Girder lighting	27,0	0,90	0,95	x	0,1	3	3	0,1	3	3	3	3	3	3
Cross girder lighting	19,8	0,90	0,95	x	0,1	2	2	0,1	2	2	2	2	2	2
Ladder lighting tower	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Stair case lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross beam lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Lighting in Subtations on land	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Architectural lighting														
Tower lighting	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Bridge	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Navigation and Aeronautical lighting														
Navigation lighting	0,0	0,90	0,95	x	1,0	0,0	0,0	1,0	0,0	0,0	0,0	0,0	0,0	0,0
Aeronautical lighting	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Mechanical installations														
Buffers	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Dehumidification	0,0	0,80	0,95		0,4	0	0	0,4	0	0	0	0	0	0
Utility water pumps	0,0	0,80	0,95	x	0,2	0	0	0,2	0	0	0	0	0	0
Fire and jockey pumps	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Elevators	0,0	0,80	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cooling and ventilation	3,0	0,80	0,95	x	0,5	2	2	0,5	2	2	2	2	2	2
TMS, Communication & Monitoring														
TMS portals	10,0	0,90	0,95	x	1,0	11	12	0,5	5	6	11	12	5	6
CMS	1,5	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Network switches	2,0	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Heat tracing and fire hydrants	9,0	0,90	0,95	x	1,0	9	11	1,0	9	11	9	11	9	11
Health monitoring	1,2	0,90	0,95	x	1,0	1	1	1,0	1	1	1	1	1	1
Radio communication	1,9	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Other loads														
Socket outlets	54,0	0,90	0,95		0,1	6	6	0,1	6	6	0	0	0	0
Generator related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Switchgear related load	2,3	0,90	0,95	x	1,0	2	3	1,0	2	3	2	3	2	3
Transformers related load	0,3	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Total load busbar BLA07	157,1					42	47		63	70	36	40	57	64

Substation QMT-A7	Busbar BNB07													
Description	Con-nected Load [kW]	Cos(phi) [-]	Effi-ciency (η) [-]	Essen-tial Load	Normal Day Div. co.	Normal Day Load [kW]	Normal Day Load [kVA]	Normal Night Div. co.	Normal Night Load [kW]	Normal Night Load [kVA]	Generator Day Load [kW]	Generator Day Load [kVA]	Generator Night Load [kW]	Generator Night Load [kVA]
Road lighting														
Main lighting along main bridge	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Service lane lighting														
Service lane lighting	2,7	0,90	0,95	x	0,0	0	0	1,0	3	3	0	0	3	3
Internal lighting														
Girder lighting	13,5	0,90	0,95	x	0,1	1	2	0,1	1	2	1	2	1	2
Cross girder lighting	14,4	0,90	0,95	x	0,1	2	2	0,1	2	2	2	2	2	2
Ladder lighting tower	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Stair case lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross beam lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Lighting in Subtations on land	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Architectural lighting														
Tower lighting	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Bridge	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Navigation and Aeronautical lighting														
Navigation lighting	0,0	0,90	0,95	x	1,0	0,0	0,0	1,0	0,0	0,0	0,0	0,0	0,0	0,0
Aeronautical lighting	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Mechanical installations														
Buffers	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Dehumidification	0,0	0,80	0,95		0,4	0	0	0,4	0	0	0	0	0	0
Utility water pumps	0,0	0,80	0,95	x	0,2	0	0	0,2	0	0	0	0	0	0
Fire and jockey pumps	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Elevators	0,0	0,80	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cooling and ventilation	0,0	0,80	0,95	x	0,5	0	0	0,5	0	0	0	0	0	0
TMS, Communication & Monitoring														
TMS portals	10,0	0,90	0,95	x	1,0	11	12	0,5	5	6	11	12	5	6
CMS	1,5	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Network switches	2,0	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Heat tracing and fire hydrants	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Health monitoring	1,2	0,90	0,95	x	1,0	1	1	1,0	1	1	1	1	1	1
Radio communication	1,9	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Other loads														
Socket outlets	0,0	0,90	0,95		0,1	0	0	0,1	0	0	0	0	0	0
Generator related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Switchgear related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Transformers related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Total load busbar BNB07	47,2					20	23		18	20	20	23	18	20

Substation QMT-A8	**Busbar BLA08**													
Description	**Con-nected Load [kW]**	**Cos(phi) [-]**	**Effi-ciency (η) [-]**	**Essen-tial Load**	**Normal Day**			**Normal Night**			**Generator Day**		**Generator Night**	
					Div. co.	**Load [kW]**	**Load [kVA]**	**Div. co.**	**Load [kW]**	**Load [kVA]**	**Load [kW]**	**Load [kVA]**	**Load [kW]**	**Load [kVA]**
Road lighting														
Main lighting along main bridge	9,0	0,90	0,95	x	0,0	0	0	1,0	9	11	0	0	9	11
Service lane lighting														
Service lane lighting	4,5	0,90	0,95	x	0,0	0	0	1,0	5	5	0	0	5	5
Internal lighting														
Girder lighting	15,0	0,90	0,95	x	0,1	2	2	0,1	2	2	2	2	2	2
Cross girder lighting	11,0	0,90	0,95	x	0,1	1	1	0,1	1	1	1	1	1	1
Ladder lighting tower	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Stair case lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross beam lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Lighting in Subtations on land	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Architectural lighting														
Tower lighting	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Bridge	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Navigation and Aeronautical lighting														
Navigation lighting	0,0	0,90	0,95	x	1,0	0,0	0,0	1,0	0,0	0,0	0,0	0,0	0,0	0,0
Aeronautical lighting	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Mechanical installations														
Buffers	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Dehumidification	62,8	0,80	0,95		0,4	26	33	0,4	26	33	0	0	0	0
Utility water pumps	0,0	0,80	0,95	x	0,2	0	0	0,2	0	0	0	0	0	0
Fire and jockey pumps	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Elevators	0,0	0,80	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cooling and ventilation	3,0	0,80	0,95	x	0,5	2	2	0,5	2	2	2	2	2	2
TMS, Communication & Monitoring														
TMS portals	10,0	0,90	0,95	x	1,0	11	12	0,5	5	6	11	12	5	6
CMS	1,5	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Network switches	2,0	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Heat tracing and fire hydrants	5,0	0,90	0,95	x	1,0	5	6	1,0	5	6	5	6	5	6
Health monitoring	1,2	0,90	0,95	x	1,0	1	1	1,0	1	1	1	1	1	1
Radio communication	1,9	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Other loads														
Socket outlets	30,0	0,90	0,95		0,1	3	4	0,1	3	4	0	0	0	0
Generator related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Switchgear related load	1,9	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Transformers related load	0,3	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Total load busbar BLA08	159,1					59	69		68	79	29	33	38	43

Substation QMT-A8	Busbar BNB08													
Description	Con-nected Load [kW]	Cos(phi) [-]	Effi-ciency (η) [-]	Essen-tial Load	Normal Day			Normal Night			Generator Day		Generator Night	
					Div. co.	Load [kW]	Load [kVA]	Div. co.	Load [kW]	Load [kVA]	Load [kW]	Load [kVA]	Load [kW]	Load [kVA]
Road lighting														
Main lighting along main bridge	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Service lane lighting														
Service lane lighting	1,5	0,90	0,95	x	0,0	0	0	1,0	2	2	0	0	2	2
Internal lighting														
Girder lighting	7,5	0,90	0,95	x	0,1	1	1	0,1	1	1	1	1	1	1
Cross girder lighting	8,0	0,90	0,95	x	0,1	1	1	0,1	1	1	1	1	1	1
Ladder lighting tower	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Stair case lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross beam lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Lighting in Subtations on land	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Architectural lighting														
Tower lighting	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Bridge	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Navigation and Aeronautical lighting														
Navigation lighting	0,0	0,90	0,95	x	1,0	0,0	0,0	1,0	0,0	0,0	0,0	0,0	0,0	0,0
Aeronautical lighting	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Mechanical installations														
Buffers	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Dehumidification	0,0	0,80	0,95		0,4	0	0	0,4	0	0	0	0	0	0
Utility water pumps	0,0	0,80	0,95	x	0,2	0	0	0,2	0	0	0	0	0	0
Fire and jockey pumps	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Elevators	0,0	0,80	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cooling and ventilation	0,0	0,80	0,95	x	0,5	0	0	0,5	0	0	0	0	0	0
TMS, Communication & Monitoring														
TMS portals	10,0	0,90	0,95	x	1,0	11	12	0,5	5	6	11	12	5	6
CMS	1,5	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Network switches	2,0	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Heat tracing and fire hydrants	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Health monitoring	1,2	0,90	0,95	x	1,0	1	1	1,0	1	1	1	1	1	1
Radio communication	1,9	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Other loads														
Socket outlets	0,0	0,90	0,95		0,1	0	0	0,1	0	0	0	0	0	0
Generator related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Switchgear related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Transformers related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Total load busbar BNB08	33,6					19	21		15	17	19	21	15	17

Substation QMT-11	Busbar BLA11													
Description	Con-nected Load [kW]	Cos(phi) [-]	Effi-ciency (η) [-]	Essen-tial Load	Normal Day Div. co.	Normal Day Load [kW]	Normal Day Load [kVA]	Normal Night Div. co.	Normal Night Load [kW]	Normal Night Load [kVA]	Generator Day Load [kW]	Generator Day Load [kVA]	Generator Night Load [kW]	Generator Night Load [kVA]
Road lighting														
Main lighting along main bridge	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Service lane lighting														
Service lane lighting	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Internal lighting														
Girder lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross girder lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Ladder lighting tower	17,1	0,90	0,95	x	0,1	2	2	0,1	2	2	2	2	2	2
Stair case lighting	9,0	0,90	0,95	x	0,1	1	1	0,1	1	1	1	1	1	1
Cross beam lighting	5,4	0,90	0,95	x	0,1	1	1	0,1	1	1	1	1	1	1
Lighting in Subtations on land	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Architectural lighting														
Tower lighting	48,0	0,90	0,95		0,0	0	0	1,0	51	56	0	0	0	0
Bridge	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Navigation and Aeronautical lighting														
Navigation lighting	0,0	0,90	0,95	x	1,0	0,0	0,0	1,0	0,0	0,0	0,0	0,0	0,0	0,0
Aeronautical lighting	5,2	0,90	0,95	x	1,0	5	6	1,0	5	6	5	6	5	6
Mechanical installations														
Buffers	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Dehumidification	80,6	0,80	0,95		0,4	34	42	0,4	34	42	0	0	0	0
Utility water pumps	0,0	0,80	0,95	x	0,2	0	0	0,2	0	0	0	0	0	0
Fire and jockey pumps	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Elevators	0,0	0,80	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cooling and ventilation	3,0	0,80	0,95	x	0,5	2	2	0,5	2	2	2	2	2	2
TMS, Communication & Monitoring														
TMS portals	0,0	0,90	0,95	x	1,0	0	0	0,5	0	0	0	0	0	0
CMS	1,5	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Network switches	2,0	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Heat tracing and fire hydrants	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Health monitoring	1,2	0,90	0,95	x	1,0	1	1	1,0	1	1	1	1	1	1
Radio communication	1,9	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Other loads														
Socket outlets	0,0	0,90	0,95		0,1	0	0	0,1	0	0	0	0	0	0
Generator related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Switchgear related load	1,6	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Transformer related load	0,3	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Total load busbar BLA11	176,8					53	64		104	120	19	22	19	22

Substation QMT-11	**Busbar BNB11**													
Description	**Con-nected Load [kW]**	**Cos(phi) [-]**	**Effi-ciency (η) [-]**	**Essen-tial Load**	**Normal Day Div. co.**	**Normal Day Load [kW]**	**Normal Day Load [kVA]**	**Normal Night Div. co.**	**Normal Night Load [kW]**	**Normal Night Load [kVA]**	**Generator Day Load [kW]**	**Generator Day Load [kVA]**	**Generator Night Load [kW]**	**Generator Night Load [kVA]**
Road lighting														
Main lighting along main bridge	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Service lane lighting														
Service lane lighting	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Internal lighting														
Girder lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross girder lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Ladder lighting tower	17,1	0,90	0,95	x	0,1	2	2	0,1	2	2	2	2	2	2
Stair case lighting	2,2	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross beam lighting	1,8	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Lighting in Subtations on land	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Architectural lighting														
Tower lighting	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Bridge	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Navigation and Aeronautical lighting														
Navigation lighting	0,0	0,90	0,95	x	1,0	0,0	0,0	1,0	0,0	0,0	0,0	0,0	0,0	0,0
Aeronautical lighting	5,2	0,90	0,95	x	1,0	5	6	1,0	5	6	5	6	5	6
Mechanical installations														
Buffers	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Dehumidification	0,0	0,80	0,95		0,4	0	0	0,4	0	0	0	0	0	0
Utility water pumps	0,0	0,80	0,95	x	0,2	0	0	0,2	0	0	0	0	0	0
Fire and jockey pumps	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Elevators	0,0	0,80	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cooling and ventilation	0,0	0,80	0,95	x	0,5	0	0	0,5	0	0	0	0	0	0
TMS, Communication & Monitoring														
TMS portals	0,0	0,90	0,95	x	1,0	0	0	0,5	0	0	0	0	0	0
CMS	1,5	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Network switches	2,0	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Heat tracing and fire hydrants	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Health monitoring	1,2	0,90	0,95	x	1,0	1	1	1,0	1	1	1	1	1	1
Radio communication	1,9	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Other loads														
Socket outlets	0,0	0,90	0,95		0,1	0	0	0,1	0	0	0	0	0	0
Generator related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Switchgear related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Transformer related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Total load busbar BNB11	32,9					15	16		15	16	15	16	15	16

Substation QMT-12	**Busbar BLA12**													
Description	**Con-nected Load [kW]**	**Cos(phi) [-]**	**Effi-ciency (η) [-]**	**Essen-tial Load**	**Normal Day**			**Normal Night**			**Generator Day**		**Generator Night**	
					Div. co.	**Load [kW]**	**Load [kVA]**	**Div. co.**	**Load [kW]**	**Load [kVA]**	**Load [kW]**	**Load [kVA]**	**Load [kW]**	**Load [kVA]**
Road lighting														
Main lighting along main bridge	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Service lane lighting														
Service lane lighting	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Internal lighting														
Girder lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross girder lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Ladder lighting tower	8,6	0,90	0,95	x	0,1	1	1	0,1	1	1	1	1	1	1
Stair case lighting	5,1	0,90	0,95	x	0,1	1	1	0,1	1	1	1	1	1	1
Cross beam lighting	2,7	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Lighting in Subtations on land	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Architectural lighting														
Tower lighting	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Bridge	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Navigation and Aeronautical lighting														
Navigation lighting	0,0	0,90	0,95	x	1,0	0,0	0,0	1,0	0,0	0,0	0,0	0,0	0,0	0,0
Aeronautical lighting	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Mechanical installations														
Buffers	1,0	0,80	0,95	x	1,0	1	1	1,0	1	1	1	1	1	1
Dehumidification	63,0	0,80	0,95		0,4	27	33	0,4	27	33	0	0	0	0
Utility water pumps	0,0	0,80	0,95	x	0,2	0	0	0,2	0	0	0	0	0	0
Fire and jockey pumps	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Elevators	242,0	0,80	0,95	x	0,1	25	32	0,1	25	32	25	32	25	32
Cooling and ventilation	3,0	0,80	0,95	x	0,5	2	2	0,5	2	2	2	2	2	2
TMS, Communication & Monitoring														
TMS portals	0,0	0,90	0,95	x	1,0	0	0	0,5	0	0	0	0	0	0
CMS	1,5	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Network switches	2,0	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Heat tracing and fire hydrants	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Health monitoring	1,2	0,90	0,95	x	1,0	1	1	1,0	1	1	1	1	1	1
Radio communication	1,9	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Other loads														
Socket outlets	0,0	0,90	0,95		0,1	0	0	0,1	0	0	0	0	0	0
Generator related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Switchgear related load	0,8	0,90	0,95	x	1,0	1	1	1,0	1	1	1	1	1	1
Transformer related load	0,3	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Total load busbar BLA12	333,1					64	79		64	79	38	46	38	46

Substation QMT-12	**Busbar BNB12**													
Description	**Con-nected Load [kW]**	**Cos(phi) [-]**	**Effi-ciency (η) [-]**	**Essen-tial Load**	**Normal Day** Div. co.	**Normal Day** Load [kW]	**Normal Day** Load [kVA]	**Normal Night** Div. co.	**Normal Night** Load [kW]	**Normal Night** Load [kVA]	**Generator Day** Load [kW]	**Generator Day** Load [kVA]	**Generator Night** Load [kW]	**Generator Night** Load [kVA]
Road lighting														
Main lighting along main bridge	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Service lane lighting														
Service lane lighting	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Internal lighting														
Girder lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross girder lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Ladder lighting tower	8,6	0,90	0,95	x	0,1	1	1	0,1	1	1	1	1	1	1
Stair case lighting	1,3	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross beam lighting	0,9	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Lighting in Subtations on land	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Architectural lighting														
Tower lighting	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Bridge	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Navigation and Aeronautical lighting														
Navigation lighting	0,0	0,90	0,95	x	1,0	0,0	0,0	1,0	0,0	0,0	0,0	0,0	0,0	0,0
Aeronautical lighting	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Mechanical installations														
Buffers	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Dehumidification	0,0	0,80	0,95		0,4	0	0	0,4	0	0	0	0	0	0
Utility water pumps	0,0	0,80	0,95	x	0,2	0	0	0,2	0	0	0	0	0	0
Fire and jockey pumps	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Elevators	2,0	0,80	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cooling and ventilation	0,0	0,80	0,95	x	0,5	0	0	0,5	0	0	0	0	0	0
TMS, Communication & Monitoring														
TMS portals	0,0	0,90	0,95	x	1,0	0	0	0,5	0	0	0	0	0	0
CMS	1,5	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Network switches	2,0	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Heat tracing and fire hydrants	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Health monitoring	1,2	0,90	0,95	x	1,0	1	1	1,0	1	1	1	1	1	1
Radio communication	1,9	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Other loads														
Socket outlets	0,0	0,90	0,95		0,1	0	0	0,1	0	0	0	0	0	0
Generator related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Switchgear related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Transformer related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Total load busbar BNB12	19,3					8	9		8	9	8	9	8	9

Substation QMT-A13	Busbar BLA13													
Description	Con-nected Load [kW]	Cos(phi) [-]	Effi-ciency (η) [-]	Essen-tial Load	Normal Day			Normal Night			Generator Day		Generator Night	
					Div. co.	Load [kW]	Load [kVA]	Div. co.	Load [kW]	Load [kVA]	Load [kW]	Load [kVA]	Load [kW]	Load [kVA]
Road lighting														
Main lighting along main bridge	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Service lane lighting														
Service lane lighting	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Internal lighting														
Girder lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross girder lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Ladder lighting tower	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Stair case lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross beam lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Lighting in Subtations on land	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Architectural lighting														
Tower lighting	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Bridge	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Navigation and Aeronautical lighting														
Navigation lighting	0,0	0,90	0,95	x	1,0	0,0	0,0	1,0	0,0	0,0	0,0	0,0	0,0	0,0
Aeronautical lighting	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Mechanical installations														
Buffers	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Dehumidification	0,0	0,80	0,95		0,4	0	0	0,4	0	0	0	0	0	0
Utility water pumps	73,6	0,80	0,95	x	0,2	15	19	0,2	15	19	15	19	15	19
Fire and jockey pumps	158,2	0,80	0,95	x	1,0	167	208	1,0	167	208	167	208	167	208
Elevators	0,0	0,80	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cooling and ventilation	3,0	0,80	0,95	x	0,5	2	2	0,5	2	2	2	2	2	2
TMS, Communication & Monitoring														
TMS portals	0,0	0,90	0,95	x	1,0	0	0	0,5	0	0	0	0	0	0
CMS	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Network switches	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Heat tracing and fire hydrants	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Health monitoring	1,2	0,90	0,95	x	1,0	1	1	1,0	1	1	1	1	1	1
Radio communication	1,9	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Other loads														
Socket outlets	0,0	0,90	0,95		0,1	0	0	0,1	0	0	0	0	0	0
Generator related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Switchgear related load	0,3	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Transformers related load	0,3	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Total load busbar BLA13	238,5					187	234		187	234	187	234	187	234

Substation QMT-A13	Busbar BNB13													
Description	Con-nected Load [kW]	Cos(phi) [-]	Effi-ciency (η) [-]	Essen-tial Load	Normal Day			Normal Night			Generator Day		Generator Night	
					Div. co.	Load [kW]	Load [kVA]	Div. co.	Load [kW]	Load [kVA]	Load [kW]	Load [kVA]	Load [kW]	Load [kVA]
Road lighting														
Main lighting along main bridge	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Service lane lighting														
Service lane lighting	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Internal lighting														
Girder lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross girder lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Ladder lighting tower	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Stair case lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross beam lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Lighting in Subtations on land	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Architectural lighting														
Tower lighting	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Bridge	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Navigation and Aeronautical lighting														
Navigation lighting	0,0	0,90	0,95	x	1,0	0,0	0,0	1,0	0,0	0,0	0,0	0,0	0,0	0,0
Aeronautical lighting	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Mechanical installations														
Buffers	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Dehumidification	0,0	0,80	0,95		0,4	0	0	0,4	0	0	0	0	0	0
Utility water pumps	0,0	0,80	0,95	x	0,2	0	0	0,2	0	0	0	0	0	0
Fire and jockey pumps	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Elevators	0,0	0,80	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cooling and ventilation	0,0	0,80	0,95	x	0,5	0	0	0,5	0	0	0	0	0	0
TMS, Communication & Monitoring														
TMS portals	0,0	0,90	0,95	x	1,0	0	0	0,5	0	0	0	0	0	0
CMS	1,5	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Network switches	2,0	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Heat tracing and fire hydrants	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Health monitoring	1,2	0,90	0,95	x	1,0	1	1	1,0	1	1	1	1	1	1
Radio communication	1,9	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Other loads														
Socket outlets	0,0	0,90	0,95		0,1	0	0	0,1	0	0	0	0	0	0
Generator related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Switchgear related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Transformers related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Total load busbar BNB13	6,6					7	8		7	8	7	8	7	8

Substation QMT-A14	**Busbar BLA14**													
Description	**Con-nected Load [kW]**	**Cos(phi) [-]**	**Effi-ciency (η) [-]**	**Essen-tial Load**	**Normal Day**			**Normal Night**			**Generator Day**		**Generator Night**	
					Div. co.	**Load [kW]**	**Load [kVA]**	**Div. co.**	**Load [kW]**	**Load [kVA]**	**Load [kW]**	**Load [kVA]**	**Load [kW]**	**Load [kVA]**
Road lighting														
Main lighting along main bridge	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Service lane lighting														
Service lane lighting	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Internal lighting														
Girder lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross girder lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Ladder lighting tower	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Stair case lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross beam lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Lighting in Subtations on land	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Architectural lighting														
Tower lighting	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Bridge	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Navigation and Aeronautical lighting														
Navigation lighting	0,0	0,90	0,95	x	1,0	0,0	0,0	1,0	0,0	0,0	0,0	0,0	0,0	0,0
Aeronautical lighting	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Mechanical installations														
Buffers	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Dehumidification	0,0	0,80	0,95		0,4	0	0	0,4	0	0	0	0	0	0
Utility water pumps	147,2	0,80	0,95	x	0,2	31	39	0,2	31	39	31	39	31	39
Fire and jockey pumps	79,1	0,80	0,95	x	1,0	83	104	1,0	83	104	83	104	83	104
Elevators	0,0	0,80	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cooling and ventilation	3,0	0,80	0,95	x	0,5	2	2	0,5	2	2	2	2	2	2
TMS, Communication & Monitoring														
TMS portals	0,0	0,90	0,95	x	1,0	0	0	0,5	0	0	0	0	0	0
CMS	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Network switches	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Heat tracing and fire hydrants	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Health monitoring	1,2	0,90	0,95	x	1,0	1	1	1,0	1	1	1	1	1	1
Radio communication	1,9	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Other loads														
Socket outlets	0,0	0,90	0,95		0,1	0	0	0,1	0	0	0	0	0	0
Generator related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Switchgear related load	0,3	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Transformers related load	0,3	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Total load busbar BLA14	233,0					120	149		120	149	120	149	120	149

Substation QMT-21	**Busbar BLA21**													
Description	**Con-nected Load [kW]**	**Cos(phi) [-]**	**Effi-ciency (η) [-]**	**Essen-tial Load**	**Normal Day Div. co.**	**Normal Day Load [kW]**	**Normal Day Load [kVA]**	**Normal Night Div. co.**	**Normal Night Load [kW]**	**Normal Night Load [kVA]**	**Generator Day Load [kW]**	**Generator Day Load [kVA]**	**Generator Night Load [kW]**	**Generator Night Load [kVA]**
Road lighting														
Main lighting along main bridge	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Service lane lighting														
Service lane lighting	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Internal lighting														
Girder lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross girder lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Ladder lighting tower	17,1	0,90	0,95	x	0,1	2	2	0,1	2	2	2	2	2	2
Stair case lighting	9,0	0,90	0,95	x	0,1	1	1	0,1	1	1	1	1	1	1
Cross beam lighting	5,4	0,90	0,95	x	0,1	1	1	0,1	1	1	1	1	1	1
Lighting in Subtations on land	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Architectural lighting														
Tower lighting	48,0	0,90	0,95		0,0	0	0	1,0	51	56	0	0	0	0
Bridge	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Navigation and Aeronautical lighting														
Navigation lighting	0,0	0,90	0,95	x	1,0	0,0	0,0	1,0	0,0	0,0	0,0	0,0	0,0	0,0
Aeronautical lighting	5,2	0,90	0,95	x	1,0	5	6	1,0	5	6	5	6	5	6
Mechanical installations														
Buffers	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Dehumidification	80,6	0,80	0,95		0,4	34	42	0,4	34	42	0	0	0	0
Utility water pumps	0,0	0,80	0,95	x	0,2	0	0	0,2	0	0	0	0	0	0
Fire and jockey pumps	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Elevators	0,0	0,80	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cooling and ventilation	3,0	0,80	0,95	x	0,5	2	2	0,5	2	2	2	2	2	2
TMS, Communication & Monitoring														
TMS portals	0,0	0,90	0,95	x	1,0	0	0	0,5	0	0	0	0	0	0
CMS	1,5	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Network switches	2,0	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Heat tracing and fire hydrants	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Health monitoring	1,2	0,90	0,95	x	1,0	1	1	1,0	1	1	1	1	1	1
Radio communication	1,9	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Other loads														
Socket outlets	0,0	0,90	0,95		0,1	0	0	0,1	0	0	0	0	0	0
Generator related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Switchgear related load	1,6	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Transformer related load	0,3	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Total load busbar BLA21	176,8					53	64		104	120	19	22	19	22

Substation QMT-21	**Busbar BNB21**														
Description	**Con-nected Load [kW]**	**Cos(phi) [-]**	**Effi-ciency (η) [-]**	**Essen-tial Load**	**Normal Day Div. co.**	**Normal Day Load [kW]**	**Normal Day Load [kVA]**	**Normal Night Div. co.**	**Normal Night Load [kW]**	**Normal Night Load [kVA]**	**Generator Day Load [kW]**	**Generator Day Load [kVA]**	**Generator Night Load [kW]**	**Generator Night Load [kVA]**
Road lighting														
Main lighting along main bridge	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Service lane lighting														
Service lane lighting	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Internal lighting														
Girder lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross girder lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Ladder lighting tower	17,1	0,90	0,95	x	0,1	2	2	0,1	2	2	2	2	2	2
Stair case lighting	2,2	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross beam lighting	1,8	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Lighting in Subtations on land	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Architectural lighting														
Tower lighting	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Bridge	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Navigation and Aeronautical lighting														
Navigation lighting	0,0	0,90	0,95	x	1,0	0,0	0,0	1,0	0,0	0,0	0,0	0,0	0,0	0,0
Aeronautical lighting	5,2	0,90	0,95	x	1,0	5	6	1,0	5	6	5	6	5	6
Mechanical installations														
Buffers	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Dehumidification	0,0	0,80	0,95		0,4	0	0	0,4	0	0	0	0	0	0
Utility water pumps	0,0	0,80	0,95	x	0,2	0	0	0,2	0	0	0	0	0	0
Fire and jockey pumps	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Elevators	0,0	0,80	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cooling and ventilation	0,0	0,80	0,95	x	0,5	0	0	0,5	0	0	0	0	0	0
TMS, Communication & Monitoring														
TMS portals	0,0	0,90	0,95	x	1,0	0	0	0,5	0	0	0	0	0	0
CMS	1,5	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Network switches	2,0	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Heat tracing and fire hydrants	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Health monitoring	1,2	0,90	0,95	x	1,0	1	1	1,0	1	1	1	1	1	1
Radio communication	1,9	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Other loads														
Socket outlets	0,0	0,90	0,95		0,1	0	0	0,1	0	0	0	0	0	0
Generator related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Switchgear related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Transformer related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Total load busbar BNB21	32,9					15	16		15	16	15	16	15	16

Substation QMT-22	**Busbar BLA22**													
Description	**Con-nected Load [kW]**	**Cos(phi) [-]**	**Effi-ciency (η) [-]**	**Essen-tial Load**	**Normal Day**			**Normal Night**			**Generator Day**		**Generator Night**	
					Div. co.	**Load [kW]**	**Load [kVA]**	**Div. co.**	**Load [kW]**	**Load [kVA]**	**Load [kW]**	**Load [kVA]**	**Load [kW]**	**Load [kVA]**
Road lighting														
Main lighting along main bridge	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Service lane lighting														
Service lane lighting	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Internal lighting														
Girder lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross girder lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Ladder lighting tower	8,6	0,90	0,95	x	0,1	1	1	0,1	1	1	1	1	1	1
Stair case lighting	5,1	0,90	0,95	x	0,1	1	1	0,1	1	1	1	1	1	1
Cross beam lighting	2,7	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Lighting in Subtations on land	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Architectural lighting														
Tower lighting	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Bridge	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Navigation and Aeronautical lighting														
Navigation lighting	0,0	0,90	0,95	x	1,0	0,0	0,0	1,0	0,0	0,0	0,0	0,0	0,0	0,0
Aeronautical lighting	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Mechanical installations														
Buffers	1,0	0,80	0,95	x	1,0	1	1	1,0	1	1	1	1	1	1
Dehumidification	63,0	0,80	0,95		0,4	27	33	0,4	27	33	0	0	0	0
Utility water pumps	0,0	0,80	0,95	x	0,2	0	0	0,2	0	0	0	0	0	0
Fire and jockey pumps	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Elevators	242,0	0,80	0,95	x	0,1	25	32	0,1	25	32	25	32	25	32
Cooling and ventilation	3,0	0,80	0,95	x	0,5	2	2	0,5	2	2	2	2	2	2
TMS, Communication & Monitoring														
TMS portals	0,0	0,90	0,95	x	1,0	0	0	0,5	0	0	0	0	0	0
CMS	1,5	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Network switches	2,0	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Heat tracing and fire hydrants	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Health monitoring	1,2	0,90	0,95	x	1,0	1	1	1,0	1	1	1	1	1	1
Radio communication	1,9	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Other loads														
Socket outlets	0,0	0,90	0,95		0,1	0	0	0,1	0	0	0	0	0	0
Generator related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Switchgear related load	0,8	0,90	0,95	x	1,0	1	1	1,0	1	1	1	1	1	1
Transformer related load	0,3	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Total load busbar BLA22	333,1					64	79		64	79	38	46	38	46

Substation QMT-22	Busbar BNB22													
Description	**Con-nected Load [kW]**	**Cos(phi) [-]**	**Effi-ciency (η) [-]**	**Essen-tial Load**	**Normal Day Div. co.**	**Normal Day Load [kW]**	**Normal Day Load [kVA]**	**Normal Night Div. co.**	**Normal Night Load [kW]**	**Normal Night Load [kVA]**	**Generator Day Load [kW]**	**Generator Day Load [kVA]**	**Generator Night Load [kW]**	**Generator Night Load [kVA]**
Road lighting														
Main lighting along main bridge	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Service lane lighting														
Service lane lighting	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Internal lighting														
Girder lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross girder lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Ladder lighting tower	8,6	0,90	0,95	x	0,1	1	1	0,1	1	1	1	1	1	1
Stair case lighting	1,3	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross beam lighting	0,9	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Lighting in Subtations on land	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Architectural lighting														
Tower lighting	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Bridge	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Navigation and Aeronautical lighting														
Navigation lighting	0,0	0,90	0,95	x	1,0	0,0	0,0	1,0	0,0	0,0	0,0	0,0	0,0	0,0
Aeronautical lighting	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Mechanical installations														
Buffers	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Dehumidification	0,0	0,80	0,95		0,4	0	0	0,4	0	0	0	0	0	0
Utility water pumps	0,0	0,80	0,95	x	0,2	0	0	0,2	0	0	0	0	0	0
Fire and jockey pumps	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Elevators	2,0	0,80	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cooling and ventilation	0,0	0,80	0,95	x	0,5	0	0	0,5	0	0	0	0	0	0
TMS, Communication & Monitoring														
TMS portals	0,0	0,90	0,95	x	1,0	0	0	0,5	0	0	0	0	0	0
CMS	1,5	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Network switches	2,0	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Heat tracing and fire hydrants	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Health monitoring	1,2	0,90	0,95	x	1,0	1	1	1,0	1	1	1	1	1	1
Radio communication	1,9	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Other loads														
Socket outlets	0,0	0,90	0,95		0,1	0	0	0,1	0	0	0	0	0	0
Generator related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Switchgear related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Transformer related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Total load busbar BNB22	19,3					8	9		8	9	8	9	8	9

Substation QMT-A23	**Busbar BLA23**													
Description	**Con-nected Load [kW]**	**Cos(phi) [-]**	**Effi-ciency (η) [-]**	**Essen-tial Load**	**Normal Day Div. co.**	**Normal Day Load [kW]**	**Normal Day Load [kVA]**	**Normal Night Div. co.**	**Normal Night Load [kW]**	**Normal Night Load [kVA]**	**Generator Day Load [kW]**	**Generator Day Load [kVA]**	**Generator Night Load [kW]**	**Generator Night Load [kVA]**
Road lighting														
Main lighting along main bridge	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Service lane lighting														
Service lane lighting	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Internal lighting														
Girder lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross girder lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Ladder lighting tower	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Stair case lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross beam lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Lighting in Subtations on land	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Architectural lighting														
Tower lighting	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Bridge	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Navigation and Aeronautical lighting														
Navigation lighting	0,0	0,90	0,95	x	1,0	0,0	0,0	1,0	0,0	0,0	0,0	0,0	0,0	0,0
Aeronautical lighting	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Mechanical installations														
Buffers	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Dehumidification	0,0	0,80	0,95		0,4	0	0	0,4	0	0	0	0	0	0
Utility water pumps	73,6	0,80	0,95	x	0,2	15	19	0,2	15	19	15	19	15	19
Fire and jockey pumps	158,2	0,80	0,95	x	1,0	167	208	1,0	167	208	167	208	167	208
Elevators	0,0	0,80	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cooling and ventilation	3,0	0,80	0,95	x	0,5	2	2	0,5	2	2	2	2	2	2
TMS, Communication & Monitoring														
TMS portals	0,0	0,90	0,95	x	1,0	0	0	0,5	0	0	0	0	0	0
CMS	1,5	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Network switches	2,0	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Heat tracing and fire hydrants	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Health monitoring	1,2	0,90	0,95	x	1,0	1	1	1,0	1	1	1	1	1	1
Radio communication	1,9	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Other loads														
Socket outlets	0,0	0,90	0,95		0,1	0	0	0,1	0	0	0	0	0	0
Generator related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Switchgear related load	0,3	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Transformer related load	0,3	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Total load busbar BLA23	242,0					191	238		191	238	191	238	191	238

Substation QMT-A23 — **Busbar BNB23**

Description	Connected Load [kW]	Cos(phi) [-]	Efficiency (η) [-]	Essential Load	Normal Day Div. co.	Normal Day Load [kW]	Normal Day Load [kVA]	Normal Night Div. co.	Normal Night Load [kW]	Normal Night Load [kVA]	Generator Day Load [kW]	Generator Day Load [kVA]	Generator Night Load [kW]	Generator Night Load [kVA]
Road lighting														
Main lighting along main bridge	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Service lane lighting														
Service lane lighting	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Internal lighting														
Girder lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross girder lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Ladder lighting tower	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Stair case lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross beam lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Lighting in Subtations on land	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Architectural lighting														
Tower lighting	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Bridge	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Navigation and Aeronautical lighting														
Navigation lighting	0,0	0,90	0,95	x	1,0	0,0	0,0	1,0	0,0	0,0	0,0	0,0	0,0	0,0
Aeronautical lighting	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Mechanical installations														
Buffers	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Dehumidification	0,0	0,80	0,95		0,4	0	0	0,4	0	0	0	0	0	0
Utility water pumps	0,0	0,80	0,95	x	0,2	0	0	0,2	0	0	0	0	0	0
Fire and jockey pumps	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Elevators	0,0	0,80	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cooling and ventilation	0,0	0,80	0,95	x	0,5	0	0	0,5	0	0	0	0	0	0
TMS, Communication & Monitoring														
TMS portals	0,0	0,90	0,95	x	1,0	0	0	0,5	0	0	0	0	0	0
CMS	1,5	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Network switches	2,0	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Heat tracing and fire hydrants	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Health monitoring	1,2	0,90	0,95	x	1,0	1	1	1,0	1	1	1	1	1	1
Radio communication	1,9	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Other loads														
Socket outlets	0,0	0,90	0,95		0,1	0	0	0,1	0	0	0	0	0	0
Generator related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Switchgear related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Transformer related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Total load busbar BNB23	6,6					7	8		7	8	7	8	7	8

Substation QMT-A24	Busbar BLA24													
Description	Con-nected Load [kW]	Cos(phi) [-]	Effi-ciency (η) [-]	Essen-tial Load	Normal Day			Normal Night			Generator Day		Generator Night	
					Div. co.	Load [kW]	Load [kVA]	Div. co.	Load [kW]	Load [kVA]	Load [kW]	Load [kVA]	Load [kW]	Load [kVA]
Road lighting														
Main lighting along main bridge	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Service lane lighting														
Service lane lighting	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Internal lighting														
Girder lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross girder lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Ladder lighting tower	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Stair case lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross beam lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Lighting in Subtations on land	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Architectural lighting														
Tower lighting	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Bridge	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Navigation and Aeronautical lighting														
Navigation lighting	0,0	0,90	0,95	x	1,0	0,0	0,0	1,0	0,0	0,0	0,0	0,0	0,0	0,0
Aeronautical lighting	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Mechanical installations														
Buffers	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Dehumidification	0,0	0,80	0,95		0,4	0	0	0,4	0	0	0	0	0	0
Utility water pumps	147,2	0,80	0,95	x	0,2	31	39	0,2	31	39	31	39	31	39
Fire and jockey pumps	79,1	0,80	0,95	x	1,0	83	104	1,0	83	104	83	104	83	104
Elevators	0,0	0,80	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cooling and ventilation	3,0	0,80	0,95	x	0,5	2	2	0,5	2	2	2	2	2	2
TMS, Communication & Monitoring														
TMS portals	0,0	0,90	0,95	x	1,0	0	0	0,5	0	0	0	0	0	0
CMS	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Network switches	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Heat tracing and fire hydrants	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Health monitoring	1,2	0,90	0,95	x	1,0	1	1	1,0	1	1	1	1	1	1
Radio communication	1,9	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Other loads														
Socket outlets	0,0	0,90	0,95		0,1	0	0	0,1	0	0	0	0	0	0
Generator related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Switchgear related load	0,3	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Transformer related load	0,3	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Total load busbar BLA24	233,0					120	149		120	149	120	149	120	149

Substation QMT-A31	Busbar BLA31													
Description	Con-nected Load [kW]	Cos(phi) [-]	Effi-ciency (η) [-]	Essen-tial Load	Normal Day			Normal Night			Generator Day		Generator Night	
					Div. co.	Load [kW]	Load [kVA]	Div. co.	Load [kW]	Load [kVA]	Load [kW]	Load [kVA]	Load [kW]	Load [kVA]
Road lighting														
Main lighting along main bridge	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Service lane lighting														
Service lane lighting	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Internal lighting														
Girder lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross girder lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Ladder lighting tower	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Stair case lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross beam lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Lighting in Subtations on land	3,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Architectural lighting														
Tower lighting	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Bridge	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Navigation and Aeronautical lighting														
Navigation lighting	0,0	0,90	0,95	x	1,0	0,0	0,0	1,0	0,0	0,0	0,0	0,0	0,0	0,0
Aeronautical lighting	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Mechanical installations														
Buffers	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Dehumidification	10,2	0,80	0,95		0,4	4	5	0,4	4	5	0	0	0	0
Utility water pumps	0,0	0,80	0,95	x	0,2	0	0	0,2	0	0	0	0	0	0
Fire and jockey pumps	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Elevators	0,0	0,80	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cooling and ventilation	3,0	0,80	0,95	x	0,5	2	2	0,5	2	2	2	2	2	2
TMS, Communication & Monitoring														
TMS portals	0,0	0,90	0,95	x	1,0	0	0	0,5	0	0	0	0	0	0
CMS	1,5	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Network switches	2,0	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Heat tracing and fire hydrants	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Health monitoring	1,2	0,90	0,95	x	1,0	1	1	1,0	1	1	1	1	1	1
Radio communication	1,9	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Other loads														
Socket outlets	0,0	0,90	0,95		0,1	0	0	0,1	0	0	0	0	0	0
Generator related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Switchgear related load	0,5	0,90	0,95	x	1,0	1	1	1,0	1	1	1	1	1	1
Transformer related load	0,3	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Total load busbar BLA31	23,6					14	16		14	16	10	11	10	11

Substation QMT-A31	**Busbar BNB31**													
Description	**Con-nected Load [kW]**	**Cos(phi) [-]**	**Effi-ciency (η) [-]**	**Essen-tial Load**	**Normal Day**			**Normal Night**			**Generator Day**		**Generator Night**	
					Div. co.	**Load [kW]**	**Load [kVA]**	**Div. co.**	**Load [kW]**	**Load [kVA]**	**Load [kW]**	**Load [kVA]**	**Load [kW]**	**Load [kVA]**
Road lighting														
Main lighting along main bridge	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Service lane lighting														
Service lane lighting	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Internal lighting														
Girder lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross girder lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Ladder lighting tower	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Stair case lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross beam lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Lighting in Subtations on land	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Architectural lighting														
Tower lighting	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Bridge	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Navigation and Aeronautical lighting														
Navigation lighting	0,0	0,90	0,95	x	1,0	0,0	0,0	1,0	0,0	0,0	0,0	0,0	0,0	0,0
Aeronautical lighting	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Mechanical installations														
Buffers	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Dehumidification	0,0	0,80	0,95		0,4	0	0	0,4	0	0	0	0	0	0
Utility water pumps	0,0	0,80	0,95	x	0,2	0	0	0,2	0	0	0	0	0	0
Fire and jockey pumps	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Elevators	0,0	0,80	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cooling and ventilation	0,0	0,80	0,95	x	0,5	0	0	0,5	0	0	0	0	0	0
TMS, Communication & Monitoring														
TMS portals	0,0	0,90	0,95	x	1,0	0	0	0,5	0	0	0	0	0	0
CMS	1,5	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Network switches	2,0	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Heat tracing and fire hydrants	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Health monitoring	1,2	0,90	0,95	x	1,0	1	1	1,0	1	1	1	1	1	1
Radio communication	1,9	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Other loads														
Socket outlets	0,0	0,90	0,95		0,1	0	0	0,1	0	0	0	0	0	0
Generator related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Switchgear related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Transformer related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Total load busbar BNB31	6,6					7	8		7	8	7	8	7	8

Substation QMT-A41	Busbar BLA41													
Description	Con-nected Load [kW]	Cos(phi) [-]	Effi-ciency (η) [-]	Essen-tial Load	Normal Day			Normal Night			Generator Day		Generator Night	
					Div. co.	Load [kW]	Load [kVA]	Div. co.	Load [kW]	Load [kVA]	Load [kW]	Load [kVA]	Load [kW]	Load [kVA]
Road lighting														
Main lighting along main bridge	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Service lane lighting														
Service lane lighting	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Internal lighting														
Girder lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross girder lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Ladder lighting tower	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Stair case lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross beam lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Lighting in Subtations on land	3,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Architectural lighting														
Tower lighting	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Bridge	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Navigation and Aeronautical lighting														
Navigation lighting	0,0	0,90	0,95	x	1,0	0,0	0,0	1,0	0,0	0,0	0,0	0,0	0,0	0,0
Aeronautical lighting	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Mechanical installations														
Buffers	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Dehumidification	10,2	0,80	0,95		0,4	4	5	0,4	4	5	0	0	0	0
Utility water pumps	0,0	0,80	0,95	x	0,2	0	0	0,2	0	0	0	0	0	0
Fire and jockey pumps	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Elevators	0,0	0,80	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cooling and ventilation	3,0	0,80	0,95	x	0,5	2	2	0,5	2	2	2	2	2	2
TMS, Communication & Monitoring														
TMS portals	0,0	0,90	0,95	x	1,0	0	0	0,5	0	0	0	0	0	0
CMS	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Network switches	2,0	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Heat tracing and fire hydrants	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Health monitoring	1,2	0,90	0,95	x	1,0	1	1	1,0	1	1	1	1	1	1
Radio communication	1,9	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Other loads														
Socket outlets	0,0	0,90	0,95		0,1	0	0	0,1	0	0	0	0	0	0
Generator related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Switchgear related load	0,5	0,90	0,95	x	1,0	1	1	1,0	1	1	1	1	1	1
Transformer related load	0,3	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Total load busbar BLA41	22,1					12	15		12	15	8	9	8	9

Substation QMT-A41	Busbar BNB41													
Description	Con-nected Load [kW]	Cos(phi) [-]	Effi-ciency (η) [-]	Essen-tial Load	Normal Day			Normal Night			Generator Day		Generator Night	
					Div. co.	Load [kW]	Load [kVA]	Div. co.	Load [kW]	Load [kVA]	Load [kW]	Load [kVA]	Load [kW]	Load [kVA]
Road lighting														
Main lighting along main bridge	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Service lane lighting														
Service lane lighting	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Internal lighting														
Girder lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross girder lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Ladder lighting tower	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Stair case lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross beam lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Lighting in Subtations on land	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Architectural lighting														
Tower lighting	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Bridge	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Navigation and Aeronautical lighting														
Navigation lighting	0,0	0,90	0,95	x	1,0	0,0	0,0	1,0	0,0	0,0	0,0	0,0	0,0	0,0
Aeronautical lighting	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Mechanical installations														
Buffers	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Dehumidification	0,0	0,80	0,95		0,4	0	0	0,4	0	0	0	0	0	0
Utility water pumps	0,0	0,80	0,95	x	0,2	0	0	0,2	0	0	0	0	0	0
Fire and jockey pumps	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Elevators	0,0	0,80	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cooling and ventilation	0,0	0,80	0,95	x	0,5	0	0	0,5	0	0	0	0	0	0
TMS, Communication & Monitoring														
TMS portals	0,0	0,90	0,95	x	1,0	0	0	0,5	0	0	0	0	0	0
CMS	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Network switches	2,0	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Heat tracing and fire hydrants	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Health monitoring	1,2	0,90	0,95	x	1,0	1	1	1,0	1	1	1	1	1	1
Radio communication	1,9	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Other loads														
Socket outlets	0,0	0,90	0,95		0,1	0	0	0,1	0	0	0	0	0	0
Generator related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Switchgear related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Transformer related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Total load busbar BNB41	5,1					5	6		5	6	5	6	5	6

Substation QMT-G-SICILIA	**Busbar BHA10**													
Description	**Con-nected Load [kW]**	**Cos(phi) [-]**	**Effi-ciency (η) [-]**	**Essen-tial Load**	**Normal Day**			**Normal Night**			**Generator Day**		**Generator Night**	
					Div. co.	**Load [kW]**	**Load [kVA]**	**Div. co.**	**Load [kW]**	**Load [kVA]**	**Load [kW]**	**Load [kVA]**	**Load [kW]**	**Load [kVA]**
Road lighting														
Main lighting along main bridge	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Service lane lighting														
Service lane lighting	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Internal lighting														
Girder lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross girder lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Ladder lighting tower	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Stair case lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross beam lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Lighting in Subtations on land	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Architectural lighting														
Tower lighting	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Bridge	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Navigation and Aeronautical lighting														
Navigation lighting	0,0	0,90	0,95	x	1,0	0,0	0,0	1,0	0,0	0,0	0,0	0,0	0,0	0,0
Aeronautical lighting	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Mechanical installations														
Buffers	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Dehumidification	0,0	0,80	0,95		0,4	0	0	0,4	0	0	0	0	0	0
Utility water pumps	0,0	0,80	0,95	x	0,2	0	0	0,2	0	0	0	0	0	0
Fire and jockey pumps	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Elevators	0,0	0,80	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cooling and ventilation	3,0	0,80	0,95	x	0,5	2	2	0,5	2	2	2	2	2	2
TMS, Communication & Monitoring														
TMS portals	0,0	0,90	0,95	x	1,0	0	0	0,5	0	0	0	0	0	0
CMS	1,5	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Network switches	2,0	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Heat tracing and fire hydrants	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Health monitoring	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Radio communication	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Other loads														
Socket outlets	0,0	0,90	0,95		0,1	0	0	0,1	0	0	0	0	0	0
Generator related load	2,0	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Switchgear related load	5,3	0,90	0,95	x	1,0	6	6	1,0	6	6	6	6	6	6
Transformer related load	0,3	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Total load busbar BHA10	14,1					13	15		13	15	13	15	13	15

Substation QMT-G-SICILIA	**Busbar BNB10**													
Description	**Con-nected Load [kW]**	**Cos(phi) [-]**	**Effi-ciency (η) [-]**	**Essen-tial Load**	**Normal Day**			**Normal Night**			**Generator Day**		**Generator Night**	
					Div. co.	**Load [kW]**	**Load [kVA]**	**Div. co.**	**Load [kW]**	**Load [kVA]**	**Load [kW]**	**Load [kVA]**	**Load [kW]**	**Load [kVA]**
Road lighting														
Main lighting along main bridge	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Service lane lighting														
Service lane lighting	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Internal lighting														
Girder lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross girder lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Ladder lighting tower	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Stair case lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross beam lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Lighting in Subtations on land	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Architectural lighting														
Tower lighting	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Bridge	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Navigation and Aeronautical lighting														
Navigation lighting	0,0	0,90	0,95	x	1,0	0,0	0,0	1,0	0,0	0,0	0,0	0,0	0,0	0,0
Aeronautical lighting	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Mechanical installations														
Buffers	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Dehumidification	0,0	0,80	0,95		0,4	0	0	0,4	0	0	0	0	0	0
Utility water pumps	0,0	0,80	0,95	x	0,2	0	0	0,2	0	0	0	0	0	0
Fire and jockey pumps	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Elevators	0,0	0,80	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cooling and ventilation	0,0	0,80	0,95	x	0,5	0	0	0,5	0	0	0	0	0	0
TMS, Communication & Monitoring														
TMS portals	0,0	0,90	0,95	x	1,0	0	0	0,5	0	0	0	0	0	0
CMS	1,5	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Network switches	2,0	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Heat tracing and fire hydrants	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Health monitoring	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Radio communication	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Other loads														
Socket outlets	0,0	0,90	0,95		0,1	0	0	0,1	0	0	0	0	0	0
Generator related load	2,0	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Switchgear related load	2,0	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Transformer related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Total load busbar BNB10	7,5					8	9		8	9	8	9	8	9

Substation QMT-G-CALABRIA	Busbar BHA20													
Description	**Con-nected Load [kW]**	**Cos(phi) [-]**	**Effi-ciency (η) [-]**	**Essen-tial Load**	**Normal Day**			**Normal Night**			**Generator Day**		**Generator Night**	
					Div. co.	**Load [kW]**	**Load [kVA]**	**Div. co.**	**Load [kW]**	**Load [kVA]**	**Load [kW]**	**Load [kVA]**	**Load [kW]**	**Load [kVA]**
Road lighting														
Main lighting along main bridge	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Service lane lighting														
Service lane lighting	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Internal lighting														
Girder lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross girder lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Ladder lighting tower	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Stair case lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross beam lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Lighting in Subtations on land	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Architectural lighting														
Tower lighting	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Bridge	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Navigation and Aeronautical lighting														
Navigation lighting	0,0	0,90	0,95	x	1,0	0,0	0,0	1,0	0,0	0,0	0,0	0,0	0,0	0,0
Aeronautical lighting	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Mechanical installations														
Buffers	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Dehumidification	0,0	0,80	0,95		0,4	0	0	0,4	0	0	0	0	0	0
Utility water pumps	0,0	0,80	0,95	x	0,2	0	0	0,2	0	0	0	0	0	0
Fire and jockey pumps	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Elevators	0,0	0,80	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cooling and ventilation	3,0	0,80	0,95	x	0,5	2	2	0,5	2	2	2	2	2	2
TMS, Communication & Monitoring														
TMS portals	0,0	0,90	0,95	x	1,0	0	0	0,5	0	0	0	0	0	0
CMS	1,5	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Network switches	2,0	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Heat tracing and fire hydrants	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Health monitoring	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Radio communication	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Other loads														
Socket outlets	0,0	0,90	0,95		0,1	0	0	0,1	0	0	0	0	0	0
Generator related load	2,0	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Switchgear related load	6,3	0,90	0,95	x	1,0	7	7	1,0	7	7	7	7	7	7
Transformer related load	0,3	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Total load busbar BHA20	15,1					14	16		14	16	14	16	14	16

Substation QMT-G-CALABRIA	Busbar BNB20													
Description	Con-nected Load [kW]	Cos(phi) [-]	Effi-ciency (η) [-]	Essen-tial Load	Normal Day			Normal Night			Generator Day		Generator Night	
					Div. co.	Load [kW]	Load [kVA]	Div. co.	Load [kW]	Load [kVA]	Load [kW]	Load [kVA]	Load [kW]	Load [kVA]
Road lighting														
Main lighting along main bridge	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Service lane lighting														
Service lane lighting	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Internal lighting														
Girder lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross girder lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Ladder lighting tower	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Stair case lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross beam lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Lighting in Subtations on land	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Architectural lighting														
Tower lighting	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Bridge	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Navigation and Aeronautical lighting														
Navigation lighting	0,0	0,90	0,95	x	1,0	0,0	0,0	1,0	0,0	0,0	0,0	0,0	0,0	0,0
Aeronautical lighting	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Mechanical installations														
Buffers	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Dehumidification	0,0	0,80	0,95		0,4	0	0	0,4	0	0	0	0	0	0
Utility water pumps	0,0	0,80	0,95	x	0,2	0	0	0,2	0	0	0	0	0	0
Fire and jockey pumps	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Elevators	0,0	0,80	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cooling and ventilation	0,0	0,80	0,95	x	0,5	0	0	0,5	0	0	0	0	0	0
TMS, Communication & Monitoring														
TMS portals	0,0	0,90	0,95	x	1,0	0	0	0,5	0	0	0	0	0	0
CMS	1,5	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Network switches	2,0	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Heat tracing and fire hydrants	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Health monitoring	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Radio communication	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Other loads														
Socket outlets	0,0	0,90	0,95		0,1	0	0	0,1	0	0	0	0	0	0
Generator related load	2,0	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Switchgear related load	1,0	0,90	0,95	x	1,0	1	1	1,0	1	1	1	1	1	1
Transformer related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Total load busbar BNB20	6,5					7	8		7	8	7	8	7	8

Substation QMT-SS-SICILIA	Busbar BHA51													
Description	Con-nected Load [kW]	Cos(phi) [-]	Effi-ciency (η) [-]	Essen-tial Load	Normal Day			Normal Night			Generator Day		Generator Night	
					Div. co.	Load [kW]	Load [kVA]	Div. co.	Load [kW]	Load [kVA]	Load [kW]	Load [kVA]	Load [kW]	Load [kVA]
Road lighting														
Main lighting along main bridge	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Service lane lighting														
Service lane lighting	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Internal lighting														
Girder lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross girder lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Ladder lighting tower	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Stair case lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross beam lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Lighting in Subtations on land	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Architectural lighting														
Tower lighting	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Bridge	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Navigation and Aeronautical lighting														
Navigation lighting	0,0	0,90	0,95	x	1,0	0,0	0,0	1,0	0,0	0,0	0,0	0,0	0,0	0,0
Aeronautical lighting	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Mechanical installations														
Buffers	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Dehumidification	0,0	0,80	0,95		0,4	0	0	0,4	0	0	0	0	0	0
Utility water pumps	0,0	0,80	0,95	x	0,2	0	0	0,2	0	0	0	0	0	0
Fire and jockey pumps	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Elevators	0,0	0,80	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cooling and ventilation	3,0	0,80	0,95	x	0,5	2	2	0,5	2	2	2	2	2	2
TMS, Communication & Monitoring														
TMS portals	0,0	0,90	0,95	x	1,0	0	0	0,5	0	0	0	0	0	0
CMS	1,5	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Network switches	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Heat tracing and fire hydrants	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Health monitoring	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Radio communication	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Other loads														
Socket outlets	0,0	0,90	0,95		0,1	0	0	0,1	0	0	0	0	0	0
Generator related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Switchgear related load	5,0	0,90	0,95	x	1,0	5	6	1,0	5	6	5	6	5	6
Transformer related load	0,3	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Total load busbar BHA51	9,8					9	10		9	10	9	10	9	10

Description	Con-nected Load [kW]	Cos(phi) [-]	Effi-ciency (η) [-]	Essen-tial Load	Normal Day Div. co.	Normal Day Load [kW]	Normal Day Load [kVA]	Normal Night Div. co.	Normal Night Load [kW]	Normal Night Load [kVA]	Generator Day Load [kW]	Generator Day Load [kVA]	Generator Night Load [kW]	Generator Night Load [kVA]
Substation QMT-SS-SICILIA	**Busbar BNB51**													
Road lighting														
Main lighting along main bridge	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Service lane lighting														
Service lane lighting	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Internal lighting														
Girder lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross girder lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Ladder lighting tower	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Stair case lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross beam lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Lighting in Subtations on land	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Architectural lighting														
Tower lighting	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Bridge	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Navigation and Aeronautical lighting														
Navigation lighting	0,0	0,90	0,95	x	1,0	0,0	0,0	1,0	0,0	0,0	0,0	0,0	0,0	0,0
Aeronautical lighting	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Mechanical installations														
Buffers	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Dehumidification	0,0	0,80	0,95		0,4	0	0	0,4	0	0	0	0	0	0
Utility water pumps	0,0	0,80	0,95	x	0,2	0	0	0,2	0	0	0	0	0	0
Fire and jockey pumps	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Elevators	0,0	0,80	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cooling and ventilation	0,0	0,80	0,95	x	0,5	0	0	0,5	0	0	0	0	0	0
TMS, Communication & Monitoring														
TMS portals	0,0	0,90	0,95	x	1,0	0	0	0,5	0	0	0	0	0	0
CMS	1,5	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Network switches	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Heat tracing and fire hydrants	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Health monitoring	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Radio communication	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Other loads														
Socket outlets	0,0	0,90	0,95		0,1	0	0	0,1	0	0	0	0	0	0
Generator related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Switchgear related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Transformer related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Total load busbar BNB51	1,5					2	2		2	2	2	2	2	2

Substation QMT-SS-CALABRIA	Busbar BHA61													
Description	Con-nected Load [kW]	Cos(phi) [-]	Effi-ciency (η) [-]	Essen-tial Load	Normal Day			Normal Night			Generator Day		Generator Night	
					Div. co.	Load [kW]	Load [kVA]	Div. co.	Load [kW]	Load [kVA]	Load [kW]	Load [kVA]	Load [kW]	Load [kVA]
Road lighting														
Main lighting along main bridge	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Service lane lighting														
Service lane lighting	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Internal lighting														
Girder lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross girder lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Ladder lighting tower	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Stair case lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross beam lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Lighting in Subtations on land	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Architectural lighting														
Tower lighting	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Bridge	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Navigation and Aeronautical lighting														
Navigation lighting	0,0	0,90	0,95	x	1,0	0,0	0,0	1,0	0,0	0,0	0,0	0,0	0,0	0,0
Aeronautical lighting	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Mechanical installations														
Buffers	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Dehumidification	0,0	0,80	0,95		0,4	0	0	0,4	0	0	0	0	0	0
Utility water pumps	0,0	0,80	0,95	x	0,2	0	0	0,2	0	0	0	0	0	0
Fire and jockey pumps	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Elevators	0,0	0,80	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cooling and ventilation	3,0	0,80	0,95	x	0,5	2	2	0,5	2	2	2	2	2	2
TMS, Communication & Monitoring														
TMS portals	0,0	0,90	0,95	x	1,0	0	0	0,5	0	0	0	0	0	0
CMS	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Network switches	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Heat tracing and fire hydrants	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Health monitoring	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Radio communication	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Other loads														
Socket outlets	0,0	0,90	0,95		0,1	0	0	0,1	0	0	0	0	0	0
Generator related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Switchgear related load	10,0	0,90	0,95	x	1,0	11	12	1,0	11	12	11	12	11	12
Transformer related load	0,3	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Total load busbar BHA61	13,3					12	14		12	14	12	14	12	14

Substation QMT-SS-CALABRIA	Busbar BNB61														
Description	Con-nected Load [kW]	Cos(phi) [-]	Effi-ciency (η) [-]	Essen-tial Load	Normal Day			Normal Night			Generator Day		Generator Night	
					Div. co.	Load [kW]	Load [kVA]	Div. co.	Load [kW]	Load [kVA]	Load [kW]	Load [kVA]	Load [kW]	Load [kVA]
Road lighting														
Main lighting along main bridge	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Service lane lighting														
Service lane lighting	0,0	0,90	0,95	x	0,0	0	0	1,0	0	0	0	0	0	0
Internal lighting														
Girder lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross girder lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Ladder lighting tower	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Stair case lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cross beam lighting	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Lighting in Subtations on land	0,0	0,90	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Architectural lighting														
Tower lighting	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Bridge	0,0	0,90	0,95		0,0	0	0	1,0	0	0	0	0	0	0
Navigation and Aeronautical lighting														
Navigation lighting	0,0	0,90	0,95	x	1,0	0,0	0,0	1,0	0,0	0,0	0,0	0,0	0,0	0,0
Aeronautical lighting	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Mechanical installations														
Buffers	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Dehumidification	0,0	0,80	0,95		0,4	0	0	0,4	0	0	0	0	0	0
Utility water pumps	0,0	0,80	0,95	x	0,2	0	0	0,2	0	0	0	0	0	0
Fire and jockey pumps	0,0	0,80	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Elevators	0,0	0,80	0,95	x	0,1	0	0	0,1	0	0	0	0	0	0
Cooling and ventilation	0,0	0,80	0,95	x	0,5	0	0	0,5	0	0	0	0	0	0
TMS, Communication & Monitoring														
TMS portals	0,0	0,90	0,95	x	1,0	0	0	0,5	0	0	0	0	0	0
CMS	1,5	0,90	0,95	x	1,0	2	2	1,0	2	2	2	2	2	2
Network switches	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Heat tracing and fire hydrants	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Health monitoring	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Radio communication	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Other loads														
Socket outlets	0,0	0,90	0,95		0,1	0	0	0,1	0	0	0	0	0	0
Generator related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Switchgear related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Transformer related load	0,0	0,90	0,95	x	1,0	0	0	1,0	0	0	0	0	0	0
Total load busbar BNB61	1,5					2	2		2	2	2	2	2	2

Trans-former no.	Con-nected Load [kW]	Cos(phi) [-]	Effi-ciency (η) [-]	Div. co. [%]	Load [kVA]	Trans-former size [kVA]	Capasity use [%]
BLT01	184	0,90	0,95	0,5	108	160	67,3
BLT02	157	0,90	0,95	0,5	92	160	57,4
BLT03	145	0,90	0,95	0,5	85	160	52,8
BLT04	255	0,90	0,95	0,5	149	160	93,2
BLT05	279	0,90	0,95	0,5	156	160	97,8
BLT06	145	0,90	0,95	0,5	85	160	52,8
BLT07	157	0,90	0,95	0,5	92	160	57,4
BLT08	159	0,90	0,95	0,5	93	160	58,2
BLT31	24	0,90	0,95	0,6	17	50	33,1
BHT10	14	0,90	0,95	0,6	10	50	19,8
BLT11	177	0,90	0,95	0,6	124	250	49,6
BLT12	333	0,90	0,95	0,5	195	250	77,9
BLT13	234	0,90	0,95	0,7	192	630	30,4
BLT14	233	0,90	0,95	0,7	191	630	30,3
BLT21	177	0,90	0,95	0,6	124	250	49,6
BLT22	333	0,90	0,95	0,5	195	250	77,9
BLT23	242	0,90	0,95	0,7	198	630	31,4
BLT24	233	0,90	0,95	0,7	191	630	30,3
BHT20	15	0,90	0,95	0,6	11	50	21,2
BLT41	22	0,90	0,95	0,6	16	50	31,0
BHT51	10	0,90	0,95	0,6	7	50	13,8
BHT61	13	0,90	0,95	0,6	9	50	18,7

Table 2 – Load distribution on transformers

2.3.1 UPS load

The calculated UPS sizes are presented in the Table 3. All UPS are single phase and located in the substations. Diversity coefficients and backup time for the equipment is shown in the table below.

Equipment	Backup time [min.]	Diversity coefficients
Emergency lighting	60	0,3
VMS (Variable Message Signs)	15	0,5
Navigation and aeronautical lighting	180	1,0
Communication and data transmission	60	1,0
Other UPS loads	60	1,0

The UPS units will provide power backup for all UPS-loads including emergency lighting in the bridge girders. Emergency light are feed from the UPS system. Internal battery back-up in light fixtures is not used due to the short life span, and high maintenance cost.

UPS No.	Location	Power consump-tion [kW]	UPS size [kWh]
BNA01	QMT-A1	25	13
BNA02	QMT-A2	25	13
BNA03	QMT-A3	25	13
BNA04	QMT-A4	25	13
BNA05	QMT-A5	25	13
BNA06	QMT-A6	25	13
BNA07	QMT-A7	25	13
BNA08	QMT-A8	25	13
BNA10	QMT-G-Sicilia	8	8
BNA11	QMT-A11	15	15
BNA12	QMT-A12	15	8
BNA13	QMT-A13	15	8
BNA20	QMT-G-Calabria	8	4
BNA21	QMT-A21	15	15
BNA22	QMT-A22	15	8
BNA23	QMT-A23	15	8
BNA31	QMT-A31	8	4
BNA41	QMT- A41	8	4
BNA51	QMT-SS-Sicilia	8	4
BNA61	QMT-SS-Calabria	8	4

Table 3 - UPS loads.

2.4 Current carrying capacity and short time withstand currents

The current carrying capacities of the cables are determined in accordance with IEC 60364.

The current carrying capacity depends on cable type, installation configuration and ambient conditions. The followring conditions forms a basis for the calculations:

- A maximum conductor temperature of 90°C.
- An air temperature of 43°C, which equals the the maximum envioronmental temperature at sea level.
- Cables are installed on cable ladders, or perforated cable trays.

- Cables are layed in not more than one layer.

The calculated current carrying capacities of the cables are presented in Table 4.

The highest 1 second short time currents are also listed in Table 4. The short time currents are based on an initial cable conductor temperature of 50°C and a final temperature of 250°C.

Type	Instal-lation voltage	Comments	Current carrying capacity [A]	Max. short time current, 1s [kA]	Examples of Installation
3x1x185Cu	MV	Trefoil formation. Earthing of metallic screens at either end	444	30,5	Between transformer BBT10 and busbar BBB10. Between transformer BBT20 and busbar BBB20.
3x1x95Cu	MV	Trefoil formation. Earthing of metallic screens at either end	285	15,7	Cable systems between substation QMT-G-Sicily and QMT-G-Calabria.
3x1x75Cu	MV	Trefoil formation. Earthing of metallic screens at either end	233	10,9	Between BBB10 and the transformers BLT31, BLT11, BLT12, BLT13, BLT14. Between BBB10 and the transformers BLT31, BLT11, BLT12, BLT13, BLT14
8x1x240	LV		1044	39,5	Secondary side of 630kVA transformers.
4x1x185 & 1x90Cu	LV		444	30,5	Secondary side of 250kVA transformers.
5x120Cu	LV		333	19,7	Secondary side of 160kVA transformers.
5x70Cu	LV		214	11,5	To elevators in towers. Large dehumidification units.
5x50Cu	LV		167	8,2	Secondary side of 50kVA transformers. To FM-switchboards on bridge deck.
5x16Cu	LV		87	2,6	Road lighting circuits.
5x10Cu	LV		65	1,6	To FM-switchboards in towers.
5x2.5Cu	LV		28	0,4	Transformer fan. Socket outlets
5x1.5Cu	LV		20	0,2	Switchboard control, lighting circuits in girders.
3x95Cu	LV		259	15,6	Supply to UPS.
3x70Cu	LV		214	11,5	Supply to UPS.
3x50Cu	LV		167	8,2	Supply from UPS. To UPS busbar in FM panels.
3x16Cu	LV		87	2,6	Supply to UPS.
3x10Cu	LV		65	1,6	Supply from UPS.
3x2.5Cu	LV		28	0,4	Aeronautical lighting.
3x1.5Cu	LV		20	0,2	Emergency lighting circuits in girder.

Table 4 - Current carrying capacity and short time current withstand capacity of cables.

2.5 Power system model

The power system study is made by use of the calculation software Neplan version 5.4.4 developed and maintained by ABB. More information about Neplan can be down loaded on www.neplan.com.

Neplan has a graphical user interface where all electrical components are represented by symbols. The configuration of the network is represented by connecting all the components with lines as in a single line diagram. Electrical characteristics of all components and lines in the network can be defined and calculations can be executed.

The calculation cowers all transformers and switchboards at 20kV and 6kV level. At the low voltage level only a few parts of the network is comprised in the Neplan calculations. These parts are identified to be the most critical (worst case) parts of the LV network. In relation with voltage drop and minimum short circuits critical parts are mainly due to large loads, long cables, small cross section of cables, and small transformers. When calculating maximum voltages and maximum short circuits the most critical parts are at the primary side of the transformers and close to the main supply point or generation unit.

When the most critical parts meet the requirements it can be assumed that the requirements are also fulfilled in the rest of the LV network.

A graphical overview of the Neplan calculation is presented in Figure 4. Main parts of the calculation sheet are indicated on the figure by numbers from 1 to 13. An explanation to each marked part is provided in the item list below.

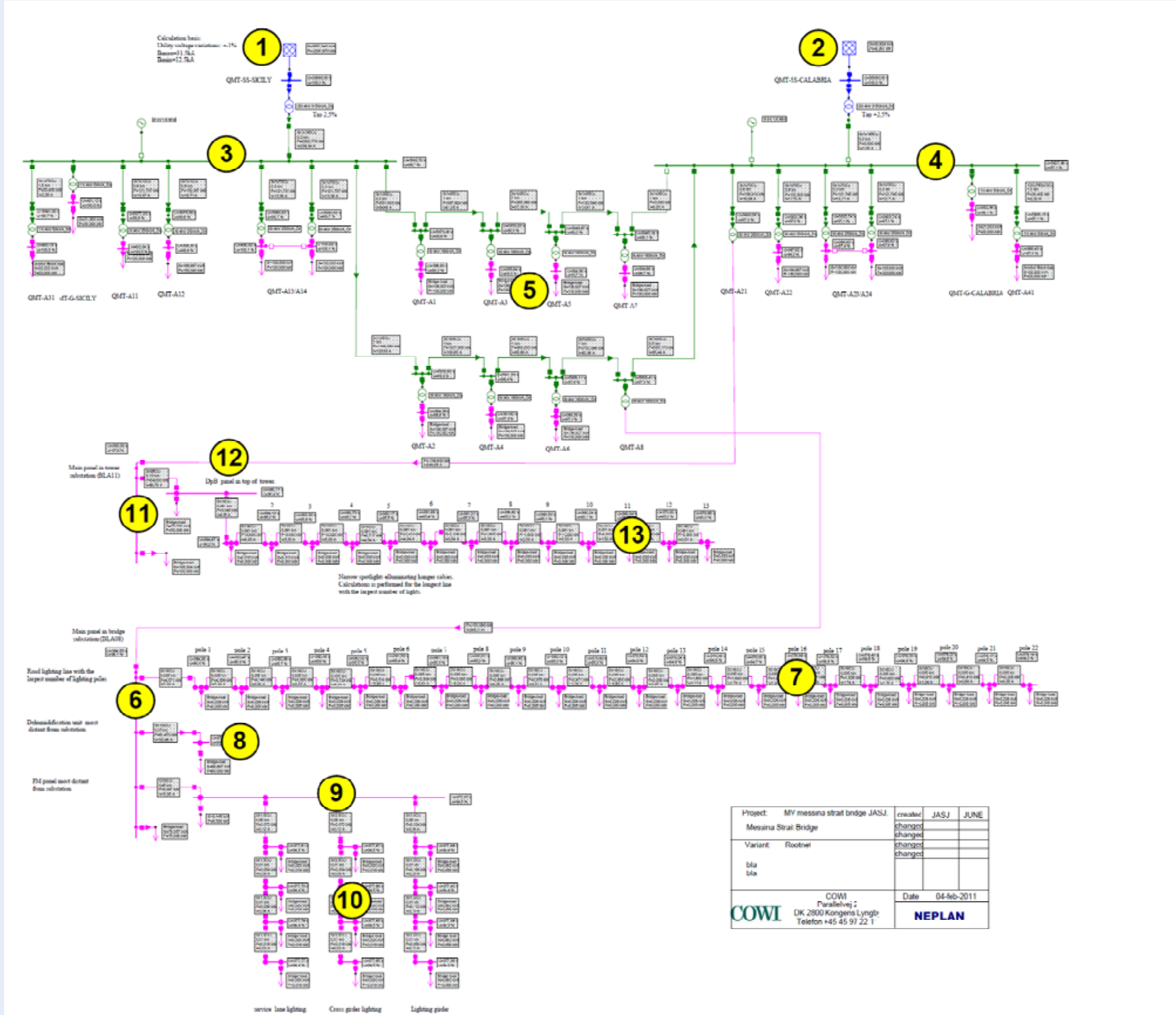


Figure 4 – Screen print of electrical network represented in Neplan.More details are provided in section 2.8.

1. Feeder to network at 20kV level at Sicily side.
2. Feeder to network at 20kV level at Calabria side.
3. Substation QMT-G-Sicily.
4. Substation QMT-G-Calabria.
5. The two cable systems connecting QMT-G-Sicily and QMT-G-Calabria at 6kV level.
6. Low voltage switchboard BLA08. Calculations are performed for BLA08 because substation QMT-A8 with regards to supply distance is the most distant bridge

substation at operation scenario 2 where the network is supplied from the Sicilian side only.

7. Road lighting circuit with the largest number of lighting poles in total 21.

8. Dehumidification unit with a load demand of 60kW. The dehumidification unit is located 270m from a substation which makes it the most distant located dehumidification unit from its supply source.

9. Switchboard FM-29A (bus BLB81) located most distant from BLA08. The length of the cable between BLA08 and FM-29A is 450m.

10. Circuits feeding service lane lighting, cross girder lighting and girder lighting. The circuits are feed from switchboard FM-29A.

11. Low voltage switchboard BLA21 located in tower substation QMT-A21. Calculations are performed for BLA21 because substation QMT-A21 is the most distant tower substation for operation scenario 2 where the network is supplied from the Sicilian side only.

12. Distribution panel DPB-72 located in the top of the Calabria tower. The distribution panel DPB-72 are feeding circuits for architectural lighting.

13. Circuit feeding architectural spotlights on hanger cables. The circuit are feeding 2x13 spotlights. The load consumption of each spot light is 150W. The total length of the supply cable is 800m.

The Network supplied by UPS is studied in a separate NEPLAN sheet, since another calculation module must be used. An overview of the Neplan calculation sheet is presented in Figure 5. Main parts of the calculation sheets are indicated on the figure by numbers from 1 to 5. An explanation to each marked part is provided in the item list below.

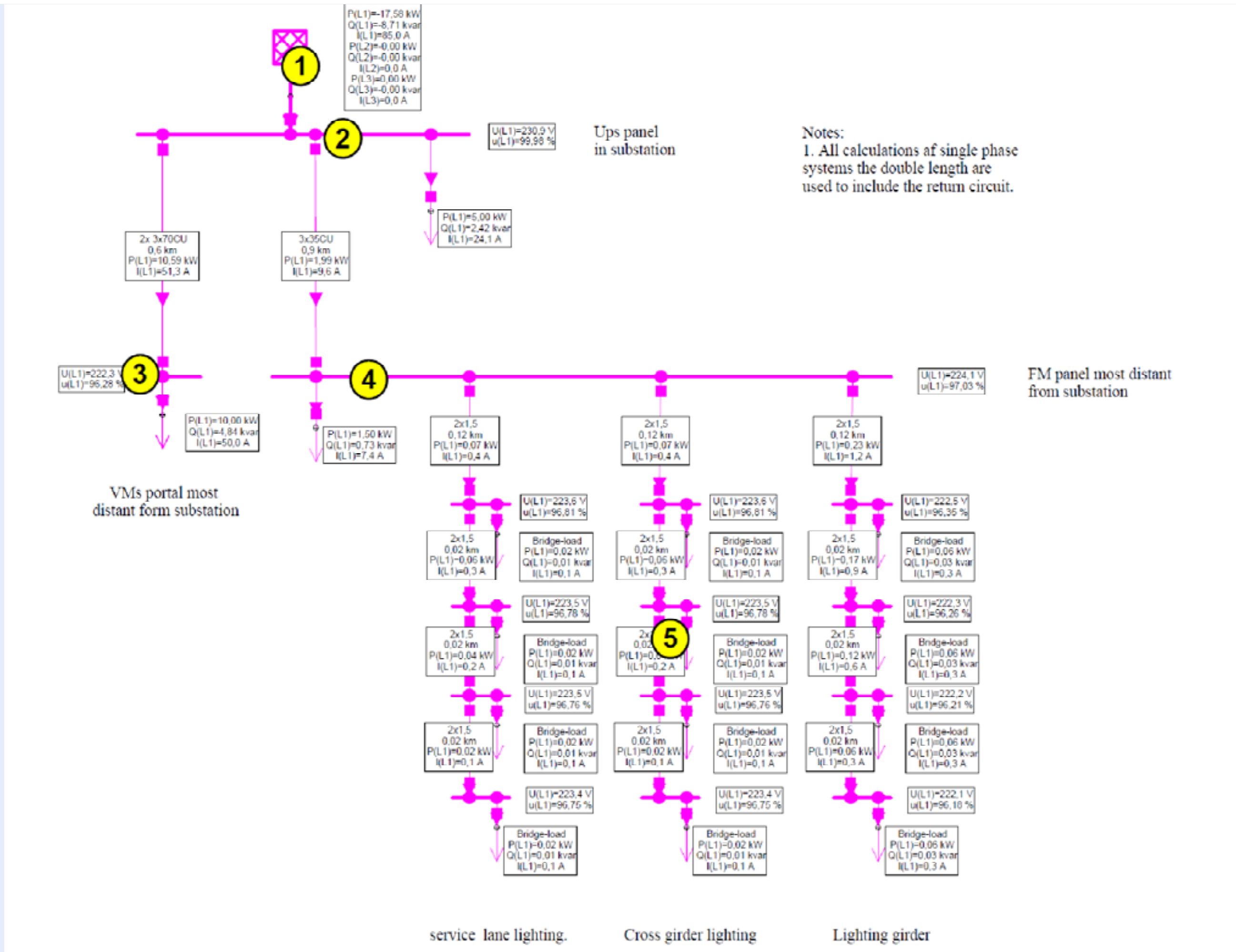


Figure 5 - Screen print of electrical UPS network represented in Neplan.

1. Feeder representing the UPS.
2. UPS switchboard BNB08 in substation QMT-A8.
3. End of circuit feeding a VMS portal located most distant from a substation. The length of the supply cable is 300m. To count in the return circuit of the single phase circuit a conductor length of 600m is used for the calculations.
4. Switchboard FM-29A (bus BNC81) located most distant from BNB08. The electrically length of the cable between BLA08 and FM-29A is 900m.
5. Circuits feeding service lane lighting, cross girder lighting and girder lighting. The circuits are feed from switchboard BNC81.

2.5.1 Network components

Electrical characteristics of all components used for the Neplan calculations are listed for in the tables below.

Feeders:

Type	LF Typle	Sk"min	Sk"max	Ik"min	Ik"max	Z(0)/Z(1) min	Z(0)/Z(1) max	R(1)/R(1) min	R(1)/R(1) max	R(0)/R(0) min	R(0)/R(0) max	C1
		MVA	MVA	kA	kA							uF
20kV Feeder Sicily	SL	1091,19	433,01	12,5	31,5	3	3	0,05	0,05	0,05	0,05	0
20kV Feeder Calabria	SL	1091,19	433,01	12,5	31,5	3	3	0,05	0,05	0,05	0,05	0
UPS Feeder	SL	1,39	2,77	2	4	3	3	0,05	0,05	0,05	0,05	0

Transformers:

Name	Type	Vector group	Size [MVA]	Rated voltage HV-side [kV]	Rated voltage LV-side [kV]	Impedanse voltage [%]	e_r [%]	I0 [%]	Iron losses [kW]	Tap changer				FROM	To
			Sr	Ur1	Ur2	ukr(1)	uRr(1)	I0	Pfe	Tap min	Tap r	Tap max	dU [%]		
BBT10	22/.4kV 3150kVA_Dry	Dyn11	3,15	20	6,15	6	0,63	6	0,63	-2	0	2	2,5	BBA10	At BBA10
BHT10	6/.4kV 50kVA_Dry	Dyn11	0,05	6	0,41	4	2,2	4	2,2	-2	0	2	2,5	BBB10	BHA10
BLT11	6/.4kV 250kVA_Dry	Dyn11	0,25	6	0,41	4	1,24	4	1,24	-2	0	2	2,5	AT BLT11	BLA11
BLT12	6/.4kV 250kVA_Dry	Dyn11	0,25	6	0,41	4	1,24	4	1,24	-2	0	2	2,5	AT BLT12	BLA12
BLT13	6/.4kV 630kVA_Dry	Dyn11	0,63	6	0,4	6	1,02	4	1,02	-2	0	2	2,5	AT BLT13	BLA13
BLT14	6/.4kV 630kVA_Dry	Dyn11	0,63	6	0,4	6	1,02	4	1,02	-2	0	2	2,5	AT BLT14	BLA14
BLT02	6/.4kV 160kVA_Dry	Dyn11	0,16	6	0,41	4	1,48	4	1,48	-2	0	2	2,5	BBB02	BLA02
BLT01	6/.4kV 160kVA_Dry	Dyn11	0,16	6	0,41	4	1,48	4	1,48	-2	0	2	2,5	BBB01	BLA01
BLT04	6/.4kV 160kVA_Dry	Dyn11	0,16	6	0,41	4	1,48	4	1,48	-2	0	2	2,5	BBB04	BLA04
BLT06	6/.4kV 160kVA_Dry	Dyn11	0,16	6	0,41	4	1,48	4	1,48	-2	0	2	2,5	BBB06	BLA06
BLT08	6/.4kV 160kVA_Dry	Dyn11	0,16	6	0,41	4	1,48	4	1,48	-2	0	2	2,5	BBB08	BLA08
BLT03	6/.4kV 160kVA_Dry	Dyn11	0,16	6	0,41	4	1,48	4	1,48	-2	0	2	2,5	BBB03	BLA03
BLT05	6/.4kV 160kVA_Dry	Dyn11	0,16	6	0,41	4	1,48	4	1,48	-2	0	2	2,5	BBB05	BLA05
BLT07	6/.4kV 160kVA_Dry	Dyn11	0,16	6	0,41	4	1,48	4	1,48	-2	0	2	2,5	BBB07	BLA07
BBT20	22/.4kV 3150kVA_Dry	Dyn11	3,15	20	6,15	6	0,63	6	0,63	-2	0	2	2,5	BBA20	BBA20
BLT22	6/.4kV 250kVA_Dry	Dyn11	0,25	6	0,41	4	1,24	4	1,24	-2	0	2	2,5	AT BLT22	BLA22
BLT21	6/.4kV 250kVA_Dry	Dyn11	0,25	6	0,41	4	1,24	4	1,24	-2	0	2	2,5	AT BLT32	BLA21
BHT20	6/.4kV 50kVA_Dry	Dyn11	0,05	6	0,41	4	2,2	4	2,2	-2	0	2	2,5	BBB20	BHA20
BLT24	6/.4kV 630kVA_Dry	Dyn5	0,63	6	0,4	6	1,02	4	1,02	-2	0	2	2,5	AT BLT23	BLA23
BLT23	6/.4kV 630kVA_Dry	Dyn5	0,63	6	0,4	6	1,02	4	1,02	-2	0	2	2,5	AT BLT24	BLA24
BLT31	6/.4kV 50kVA_Dry	Dyn11	0,05	6	0,41	4	2,2	4	2,2	-2	0	2	2,5	AT BLT31	BLA31
BLT41	6/.4kV 50kVA_Dry	Dyn11	0,05	6	0,41	4	2,2	4	2,2	-2	0	2	2,5	AT BLT41	BLA41

Generators:

Name	Type	Size [MVA]	Rated voltage	cosphi	xd sat [%]	xd' sat [%]	xd'' sat [%]	Td' [s]	Td'' [s]	Td0' [s]
		Sr	Ur							
BRV10	Generator Sicily	1,6	6	0,9	290	17,5	12	0,232	0,017	5,07
BRV20	Generator Calabria	1,6	6	0,9	290	17,5	12	0,232	0,017	5,07

Cables:

Type	Nominal operation voltage [kV]	Length [km]	Parallel lines	Positive sequense system R(1) [Ohm/ km]	X(1) [Ohm/ km]	C(1) [muF/ km]	Negative sequense system R(0) [Ohm/ km]	X(0) [Ohm/ km]	C(0) [muF/ km]	Rated Temp. [°C]	Max. Oper Temp. [°C]	Oper Temp. [°C]	From	To
3x1x95Cu	6	1	1	0,154	0,107	0,24	0,46	0,31	0,18	20	90	50	BBB10	BBB02
3x1x95Cu	6	0,5	1	0,154	0,107	0,24	0,46	0,31	0,18	20	90	50	BBB10	BBB01
3x1x95Cu	6	1	1	0,154	0,107	0,24	0,46	0,31	0,18	20	90	50	BBB02	BBB04
3x1x95Cu	6	1	1	0,154	0,107	0,24	0,46	0,31	0,18	20	90	50	BBB06	BBB08
3x1x95Cu	6	1	1	0,154	0,107	0,24	0,46	0,31	0,18	20	90	50	BBB04	BBB06
3x1x95Cu	6	1	1	0,154	0,107	0,24	0,46	0,31	0,18	20	90	50	BBB05	BBB07
3x1x95Cu	6	1	1	0,154	0,107	0,24	0,46	0,31	0,18	20	90	50	BBB03	BBB05
3x1x95Cu	6	1	1	0,154	0,107	0,24	0,46	0,31	0,18	20	90	50	BBB03	BBB01
3x1x185Cu	6	0,2	1	0,101	0,096	0,28	0,36	0,29	0,21	20	90	50	At BBT10	BBB10
3x1x70Cu	6	0,8	1	0,269	0,099	0,29	0,8	0,3	0,18	20	90	50	At BLT11	BBB10
3x1x70Cu	6	0,8	1	0,269	0,099	0,29	0,8	0,3	0,18	20	90	50	At BLT12	BBB10
3x1x70Cu	6	0,3	1	0,269	0,099	0,29	0,8	0,3	0,18	20	90	50	At BLT13	BBB10
3x1x70Cu	6	0,3	1	0,269	0,099	0,29	0,8	0,3	0,18	20	90	50	At BLT14	BBB10
3x1x70Cu	6	0,8	1	0,269	0,099	0,29	0,8	0,3	0,18	20	90	50	At BLT32	BBB20
3x1x185Cu	6	0,2	1	0,101	0,096	0,28	0,36	0,29	0,21	20	90	50	At BBT20	BBB20
3x1x70Cu	6	0,3	1	0,269	0,099	0,29	0,8	0,3	0,18	20	90	50	At BLT24	BBB20
3x1x70Cu	6	0,3	1	0,269	0,099	0,29	0,8	0,3	0,18	20	90	50	At BLT23	BBB20
3x1x70Cu	6	0,8	1	0,269	0,099	0,29	0,8	0,3	0,18	20	90	50	At BLT22	BBB20
3x1x95Cu	6	0,5	1	0,154	0,107	0,24	0,46	0,31	0,18	20	90	50	BBB08	BBB20
3x1x95Cu	6	1	1	0,154	0,107	0,24	0,46	0,31	0,18	20	90	50	BBB07	BBB20
3x1x70Cu	6	1,5	1	0,269	0,099	0,29	0,8	0,3	0,18	20	90	50	At BLT31	BBB10
3x1x70Cu	6	1,5	1	0,269	0,099	0,29	0,8	0,3	0,18	20	90	50	At BLT41	BBB20
5X50CU	0,4	0,45	1	0,389	0,073	0,3	1,55	0,32	0	20	90	50	BLA08	BLB81 (FM-26B)
3X120CU	0,4	0,27	1	0,155	0,07	0,34	0,62	0,38	0	20	90	50	BLA08	At Dehumidification Unit
3X1,5CU	0,4	0,09	1	12,1	0,099	0,22	29,6	0,426	0	20	90	50	BLB81 (FM-26B)	End of Service Lane Lighting Circuit
3X2,5CU	0,4	0,09	1	7,41	0,099	0,22	29,6	0,426	0	20	90	50	BLB81 (FM-26B)	End of Cross Girder Lighting Circuit
3X1,5CU	0,4	0,09	1	12,1	0,099	0,22	29,6	0,426	0	20	90	50	BLB81 (FM-26B)	End of Girder Lighting Circuit
5X16CU	0,4	0,09	1	1,15	0,106	0,25	4,6	0,373	0	20	90	50	BLD15 (DBP-74)	End of Architectural Lighting Circuit
3X95CU	0,4	0,13	1	0,195	0,07	0,33	0,5	0,3	0	20	90	50	BLA21	BLD15 (DBP-74)
3x50CU	0,23 (UPS)	0,45*	1	0,525	0,73	0,21	0	0	0	20	90	50	BNB08	BNC81 (FM-26B)
2x1,5	0,23 (UPS)	0,09*	1	12,1	0,86	0,22	0	0	0	20	90	50	BNC81 (FM-26B)	End of Emg. Service Lane Lighting Circuit
2x1,5	0,23 (UPS)	0,09*	1	12,1	0,86	0,22	0	0	0	20	90	50	BNC81 (FM-26B)	End of Emg. Cross Gider Lighting Circuit
2x1,5	0,23 (UPS)	0,09*	1	12,1	0,86	0,22	0	0	0	20	90	50	BNC81 (FM-26B)	End of Emg. Girder Lighting Circuit
3x70CU	0,23 (UPS)	0,3*	2	0,27	0,72	0,32	0	0	0	20	90	50	BNB08	End Circuit for VMS portal most Distant from UPS

*Double length are used for the calculation to include return circuit.

2.6 Load flow study

The objective of load flow study is to verify that the voltage will be kept within the guidelines of CEI 64\8. The design will aim to have a voltage variation from nominal (100%) limited to 4% at medium voltage level, 5% for lighting circuits, and 4% on other systems.

The load flow study is performed as a system study where voltage variations in the MV system are transferred to the LV system. The system study allow for analysing how voltage variations in the 6kV or 20kV distribution network affect the LV circuits.

It must be noted that it can not directly be evaluated whether the voltage design criteria are fulfilled on basis of the system study because the system study includes variation of the supply voltages. To evaluate whether the voltage design criteria are fulfilled the voltage drop (ΔU) of the low voltage network must be limited to 4% for lighting circuits, and 5% for other systems. The voltage drop (ΔU) of the MV network must be limited to 4%.

2.6.1 Calculation of maximum voltage

Calculation of the maximum voltage is performed for operation scenario 1. The following forms a basis for the calculations:

- The voltage of the ENEL power supply at QMT-SS-Sicily and QMT-SS-Calabria is assumed to be 101% of nominal voltage.

- All transforms are loaded by 5% of their rated size. The UPS units are loaded by 0% of rated size.
- The feed in voltage of the UPS is assumed to be 101% of nominal voltage.

Calculated voltages at all nodes are presented in the tables below.

Node	U	u
Name	kV	%
At Dehumidification Unit	0,40	100,92
End of Architectural Lighting Circuit	0,41	101,56
End of Road Lighting Circuit	0,41	101,47
BLA08	0,41	102,81
BLB81 (FM-26B)	0,41	102,75
BLD15 (DBP-74)	0,41	102,79
End of Cross Girder Lighting Circuit	0,41	102,73
End of Girder Lighting Circuit	0,41	102,63
End of Service Lane Lighting Circuit	0,41	102,71
BLA23	0,41	102,93
BLA24	0,41	102,93
BLA13	0,41	103,23
BLA14	0,41	103,23
BLA21	0,42	103,76
BLA06	0,42	105,36
BLA41	0,42	105,37
BHA20	0,42	105,40
BLA05	0,42	105,39
BLA07	0,42	105,40
BLA22	0,42	105,42
BHA10	0,42	105,72
BLA01	0,42	105,72
BLA02	0,42	105,72
BLA03	0,42	105,72
BLA04	0,42	105,71
BLA11	0,42	105,79
BLA12	0,42	105,73
BLA31	0,42	105,69
At BLT32	6,18	102,94
BBB06	6,18	103,00
BBB08	6,18	103,00
At BLT22	6,18	103,03
At BLT23	6,18	103,04
At BLT24	6,18	103,04
At BLT41	6,18	103,04
BBB05	6,18	103,03
BBB07	6,18	103,03
BBB20	6,18	103,04
At BBT20	6,18	103,07
BBB04	6,20	103,34
At BLT11	6,20	103,35
At BLT12	6,20	103,34
At BLT13	6,20	103,35
At BLT14	6,20	103,35
At BLT31	6,20	103,35
BBB01	6,20	103,35
BBB02	6,20	103,34
BBB03	6,20	103,34
BBB10	6,20	103,35
At BBT10	6,20	103,36
BBA10	20,20	101,00
BBA20	20,20	101,00

Node	U	u
Name	kV	%
BNB08	0,23	101,00
End of Emg. Cross Gider Lighting Circuit	0,23	101,01
End of Emg. Girder Lighting Circuit	0,23	101,01
End Circuit for VMS portal most Distant from UPS	0,23	101,05
BNC81 (FM-26B)	0,23	101,03
End of Emg. Service Lane Lighting Circuit	0,23	101,01

The maximum voltage at 6kV is determined to 103.4% of nominal voltage. At Low voltage level the largest voltage for the lighting circuits are 103% of nominal voltage and for other circuits the largest voltage are 105,7% of nominal voltage.

The maximum voltage increase (ΔU) for the MW and LV network is less than zero thus the voltage at all nodes is within the range of the design criteria.

Neplan calculation sheets are shown in Appendix A.

2.6.2 Calculation of minimum voltage

The minimum voltage is determined for the operation scenario 1, 2 and 3.

Operation scenario 1

For operation scenario 1 (normal coupling configuration) the following operation conditions forms a basis for the calculations:

- The voltage of the ENEL power supply at QMT-SS-Sicily and QMT-SS-Calabria is assumed to be 99% of nominal voltage.
- The feed in voltage of the UPS units are assumed to be 99% of nominal voltage.
- Maximum load demand according to the load study including a spare capacity of 20%.

Calculated voltages at all nodes are presented in the tables below.

Node	U	u
Name	kV	%
At Dehumidification Unit	0,39	97,27
BLB81 (FM-26B)	0,39	97,84
End of Cross Girder Lighting Circuit	0,39	97,81
End of Girder Lighting Circuit	0,39	97,70
End of Service Lane Lighting Circuit	0,39	97,80
End of Architectural Lighting Circuit	0,39	98,12
End of Road Lighting Circuit	0,39	97,88
BLA13	0,40	99,31
BLA14	0,40	99,31
BLA23	0,40	99,25
BLA24	0,40	99,25
BLA08	0,40	99,43
BLD15 (DBP-74)	0,40	99,54
BLA02	0,40	100,09
BLA03	0,40	100,09
BLA04	0,40	100,01
BLA05	0,40	99,94
BLA06	0,40	100,01
BLA07	0,40	100,02
BLA01	0,40	100,17
BLA12	0,40	100,53
BLA22	0,40	100,46
BLA21	0,40	100,65
BLA11	0,40	100,95
BLA31	0,40	100,97
BLA41	0,40	100,90
BHA10	0,41	101,22
BHA20	0,41	101,15
BBB05	5,99	99,84
BBB04	5,99	99,91
BBB06	6,00	99,91
BBB07	6,00	99,92
At BLT22	6,00	99,96
At BLT32	6,00	99,96
BBB02	6,00	99,98
BBB03	6,00	99,98
BBB08	6,00	99,99
At BLT12	6,00	100,02
At BLT23	6,00	100,04
At BLT24	6,00	100,04
At BLT11	6,00	100,04
At BLT41	6,00	100,05
BBB01	6,00	100,06
BBB20	6,00	100,07
At BLT13	6,01	100,10
At BLT14	6,01	100,10
At BLT31	6,01	100,11
BBB10	6,01	100,14
At BBT20	6,01	100,17
At BBT10	6,01	100,23
BBA10	19,80	99,00
BBA20	19,80	99,00

Node	U	u
Name	kV	%
BNB08	0,23	99,08
BNC81 (FM-26B)	0,22	95,88
End Circuit for VMS portal most Distant from UPS	0,22	95,21
End of Emg. Cross Gider Lighting Circuit	0,22	95,59
End of Emg. Girder Lighting Circuit	0,22	94,96
End of Emg. Service Lane Lighting Circuit	0,22	95,59

The calculation of the minimum voltage for the operation scenario 1 verifies that the voltage can be maintained within the range of the design criteria. The minimum voltage is determined to 95% and ΔU=4% (since the UPS supply voltage is 99%) of the nominal voltage for the emergency lighting circuits supplied by UPS.

Neplan calculation sheets are shown in Appendix B.

Operation scenario 2

For operation scenario 2 (ENEL power supply from the Sicilian side only) the following operation conditions forms a basis for the calculations:

- The voltage of the ENEL power supply at QMT-SS-Sicily and QMT-SS-Calabria is assumed to be 100% of nominal voltage.
- Maximum load demand according to the load study including a spare capacity of 20%.

Calculated voltages at all nodes are presented in the table below. Results for the network feed by the UPS systems are not shown since the calculation is similar to the calculation of the minimum voltage of operation scenario 1.

Node	U	u
Name	kV	%
At BBT20	0,00	0,00
BBA20	0,00	0,00
At Dehumidification Unit	0,38	94,36
End of Girder Lighting Circuit	0,38	94,87
BLB81 (FM-26B)	0,38	95,02
End of Architectural Lighting Circuit	0,38	94,94
End of Cross Girder Lighting Circuit	0,38	94,99
End of Road Lighting Circuit	0,38	94,99
End of Service Lane Lighting Circuit	0,38	94,98
BLA23	0,39	96,26
BLA24	0,39	96,26
BLA08	0,39	96,59
BLD15 (DBP-74)	0,39	96,40
BLA22	0,39	97,36
BLA21	0,39	97,55
BLA06	0,39	97,78
BLA41	0,39	97,81
BHA20	0,39	98,07
BLA04	0,39	98,37
BLA13	0,40	98,87
BLA14	0,40	98,87
BLA02	0,40	99,04
BLA05	0,40	99,21
BLA07	0,40	99,13
BLA03	0,40	99,38
BLA01	0,40	99,63
BLA12	0,40	100,07
BLA11	0,40	100,49
BLA31	0,40	100,51
BHA10	0,40	100,76
At BLT22	5,82	96,99
At BLT32	5,82	96,99
At BLT23	5,82	97,07
At BLT24	5,82	97,07
At BLT41	5,83	97,08
BBB20	5,83	97,11
BBB08	5,84	97,30
BBB06	5,87	97,78
BBB04	5,90	98,34
BBB02	5,94	98,98
BBB07	5,94	99,07
BBB05	5,95	99,15
BBB03	5,96	99,31
BBB01	5,97	99,54
At BLT12	5,98	99,58
At BLT11	5,98	99,60
At BLT13	5,98	99,66
At BLT14	5,98	99,66
At BLT31	5,98	99,67
BBB10	5,98	99,70
At BBT10	5,99	99,89
BBA10	20,00	100,00

The minimum voltage calculated for operation scenario 1 verifies that the voltage can be maintained within the range of the design criteria. The minimum voltage at 6kV is 97% of nominal voltage. At Low voltage level the minimum voltage for the lighting circuits and other circuits are 95% of the nominal voltage. The minimum voltage drop of the LV network is ΔU=2%.

The Neplan calculation sheets are shown in section 2.8 and Appendix C. Information about current flow and power consumption is available form the sheets.

Operation scenario 3

For the operation scenario 3 with generators feeding the network the following operation conditions forms a basis for the calculations:

- The feed in voltage from the generators are 100% of nominal voltage.
- Maximum load demand according to the load study including a spare capacity of 20%.

Calculated voltages at all nodes are presented in the table below. Results for the network feed by the UPS systems are not shown since the calculation is similar to the calculation of the minimum voltage of operation scenario 3.

Node	U	u
Name	kV	%
At BBT10	0	0
At BBT20	0	0
BBA10	0	0
BBA20	0	0
At Dehumidification Unit	0,39	97,4
End of Girder Lighting Circuit	0,391	97,8
BLB81 (FM-26B)	0,392	97,94
End of Cross Girder Lighting Circuit	0,392	97,91
End of Road Lighting Circuit	0,392	97,97
End of Service Lane Lighting Circuit	0,392	97,89
End of Architectural Lighting Circuit	0,393	98,31
BLA08	0,397	99,36
BLA13	0,397	99,18
BLA14	0,397	99,18
BLA23	0,397	99,18
BLA24	0,397	99,18
BLD15 (DBP-74)	0,398	99,58
BLA01	0,4	100,03
BLA02	0,4	99,96
BLA03	0,4	99,96
BLA04	0,4	99,88
BLA05	0,4	99,88
BLA06	0,4	99,95
BLA07	0,4	99,96
BLA12	0,402	100,39
BLA21	0,402	100,58
BLA22	0,402	100,39
BLA11	0,403	100,82
BLA31	0,403	100,82
BLA41	0,403	100,82
BHA10	0,404	101,07
BHA20	0,404	101,07
BBB04	5,987	99,79
BBB05	5,987	99,79
BBB02	5,991	99,86
BBB03	5,991	99,86
BBB06	5,991	99,85
BBB07	5,991	99,86
At BLT12	5,993	99,89
At BLT22	5,993	99,89
At BLT32	5,993	99,89
At BLT11	5,995	99,91
BBB08	5,995	99,92
BBB01	5,996	99,93
At BLT13	5,998	99,97
At BLT14	5,998	99,97
At BLT23	5,998	99,97
At BLT24	5,998	99,97
At BLT31	5,998	99,97
At BLT41	5,998	99,97
BBB10	6	100
BBB20	6	100

The minimum voltage calculation verifies that the voltage can be maintained within the range of the design criteria for operation scenario 3.

Neplan calculation sheets are shown in Appendix D.

2.6.3 Voltage drop at motor start

Motors are used for dehumidification, fire fighting, pumping and drainage systems. When a motor is starting up it need more current than during continuous operation. This temporary large current stresses the electricity network and results in voltage drop.

The voltage drop at start up has been calculated for two different motor start-up scenarios. A scenario with two 74kW motors located in the pump and drainage house and one scenario with a 60kW motor used in a dehumidification unit on the bridge deck. At start up cosphi is set to 0.35. The motor on the bridge deck is located at the maximum distance from a substation.

The calculation is performed for a coupling configuration similar to operation scenario 1. Moreover the following forms a basis for the calculations:

- The voltage of the ENEL power supply at QMT-SS-Sicily and QMT-SS-Calabria is assumed to be 99% of nominal voltage.
- Maximum load demand according to the load study including a spare capacity of 20%.

Results of Neplan calculations are shown in Figure 6 and Figure 7. Figure 6 shows motors in the pump and drainage house and Figure 7 shows the motor on the bridge deck. The voltages at the motors are 95.9% and 91.2% of the nominal voltages. A voltage drop not more than 10% at motor start is acceptable.
In appendix E the entire Neplan calculation is shown.

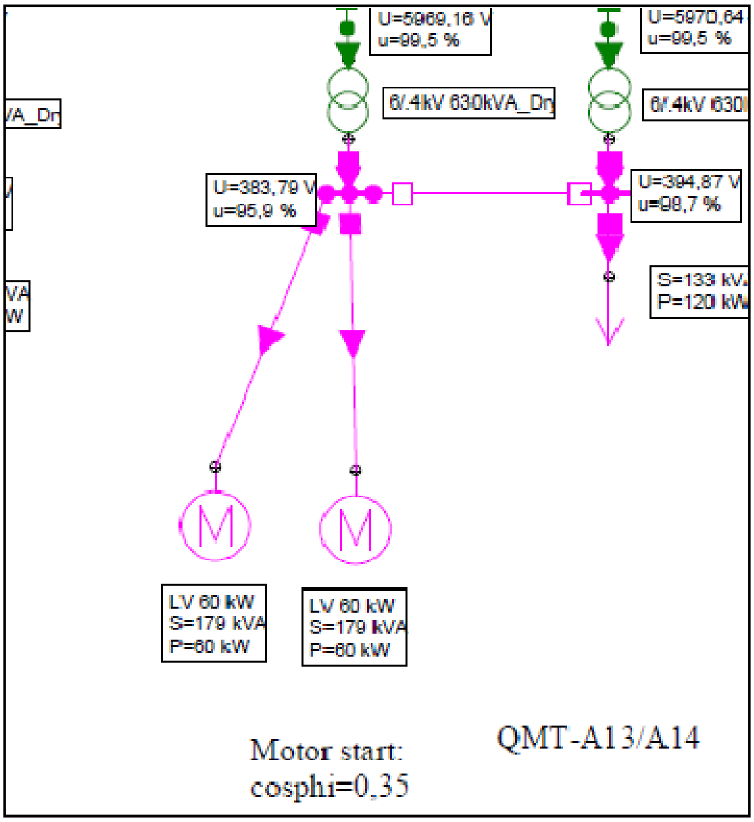


Figure 6 – Neplan calculation sheet of motor in pump and drainage house.

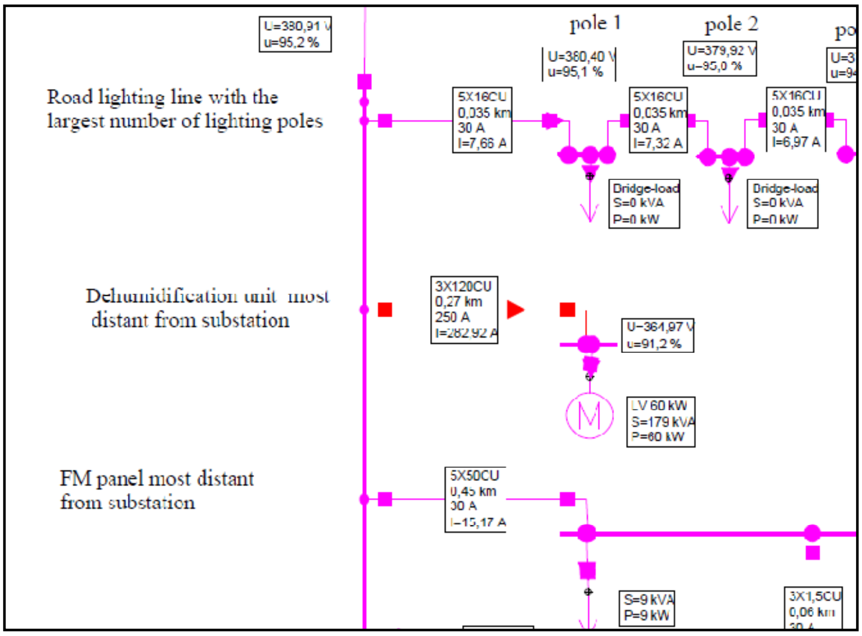


Figure 7 - Neplan calculation sheet of motor on bridge deck.

2.7 Short circuit study

Fault current that flows as a result of short-circuit is calculated for three phase and phase-to-earth fault conditions. The calculations are in accordance with CEI/EN/IEC 60909

The short circuit study shall verify that the short circuit currents are within acceptable values that ensure that the power supply system can be build of standard equipment.

2.7.1 Calculation of maximum short circuit

Maximum short circuit calculations are performed for operation scenario 1. The following operation conditions forms a basis for the calculation:

- Ik´´max. at QMT-SS-Sicilia and QMT-SS-Calabria 31.5kA.
- Ik´´max feed by the UPS units are 4kA.
- Short circuit contributions from motors are not included in the calculations.

The maximum short circuit currents are presented in the tables below:

Node	Un	Ik" 1s	Ip	Fault Type
Name	kV	kA	kA	
At BBT10	6,00	4,98	12,26	3phase fault
At BBT20	6,00	4,98	12,26	3phase fault
At BLT11	6,00	4,17	7,94	3phase fault
At BLT12	6,00	4,17	7,94	3phase fault
At BLT13	6,00	4,60	9,91	3phase fault
At BLT14	6,00	4,60	9,91	3phase fault
At BLT22	6,00	4,17	7,94	3phase fault
At BLT23	6,00	4,60	9,91	3phase fault
At BLT24	6,00	4,60	9,91	3phase fault
At BLT31	6,00	3,61	6,20	3phase fault
At BLT32	6,00	4,17	7,94	3phase fault
At BLT41	6,00	3,61	6,20	3phase fault
At Dehumidification Unit	0,40	2,96	4,52	3phase fault
BBA10	20,00	31,50	83,01	3phase fault
BBA20	20,00	31,50	83,01	3phase fault
BBB01	6,00	4,47	9,75	3phase fault
BBB02	6,00	4,13	8,40	3phase fault
BBB03	6,00	3,82	7,37	3phase fault
BBB04	6,00	3,55	6,56	3phase fault
BBB05	6,00	3,55	6,56	3phase fault
BBB06	6,00	3,82	7,37	3phase fault
BBB07	6,00	4,13	8,40	3phase fault
BBB08	6,00	4,47	9,75	3phase fault
BBB10	6,00	4,85	11,59	3phase fault
BBB20	6,00	4,85	11,59	3phase fault
BHA10	0,40	1,80	2,96	3phase fault
BHA20	0,40	1,80	2,96	3phase fault
BLA01	0,40	5,42	10,21	3phase fault
BLA02	0,40	5,38	10,09	3phase fault
BLA03	0,40	5,34	9,97	3phase fault
BLA04	0,40	5,30	9,85	3phase fault
BLA05	0,40	5,30	9,85	3phase fault
BLA06	0,40	5,34	9,97	3phase fault
BLA07	0,40	5,38	10,09	3phase fault
BLA08	0,40	5,42	10,21	3phase fault
BLA11	0,40	8,00	15,65	3phase fault
BLA12	0,40	8,00	15,65	3phase fault
BLA13	0,40	13,33	29,93	3phase fault
BLA14	0,40	13,33	29,93	3phase fault
BLA21	0,40	8,00	15,65	3phase fault
BLA22	0,40	8,00	15,65	3phase fault
BLA23	0,40	13,33	29,93	3phase fault
BLA24	0,40	13,33	29,93	3phase fault
BLA31	0,40	1,78	2,92	3phase fault
BLA41	0,40	1,78	2,92	3phase fault
BLB81 (FM-26B)	0,40	0,96	1,39	3phase fault
BLD15 (DBP-74)	0,40	4,81	7,39	3phase fault
End of Architectural Lighting Circuit	0,40	0,27	0,38	3phase fault
End of Cross Girder Lighting Circuit	0,40	0,28	0,40	3phase fault
End of Girder Lighting Circuit	0,40	0,19	0,27	3phase fault
End of Road Lighting Circuit	0,40	0,28	0,40	3phase fault
End of Service Lane Lighting Circuit	0,40	0,19	0,27	3phase fault

Node	Un	Ik'' 1s	Ip	Fault Type
Name	kV	kA	kA	
End of Emg. Cross Gider Lighting Circuit	0,40	0,09	-	1phase ground fault
End of Emg. Service Lane Lighting Circuit	0,40	0,09	-	1phase ground fault
End of Emg. Girder Lighting Circuit	0,40	0,10	-	1phase ground fault
BNC81 (FM-26B)	0,40	0,38	-	1phase ground fault
End Circuit for VMS portal most Distant from UPS	0,40	0,80	-	1phase ground fault
BNB08	0,40	5,85	-	1phase ground fault

The maximum short circuit level at both 6kV and 400V allows for installation of standard electrical equipment. The calculated short circuit levels are within the short circuit withstand capability of the MV and LV switchbords specified in the Design Specifications report no. CG1000-P2SDPITM4C3000000-06.

Neplan calculation sheets are shown in Appendix F.

2.7.2 Calculation of minimum short circuit

Calculation of the minimum short circuits is performed for operation scenario 2. The following operation conditions forms a basis for the calculations:

- Ik´´min at QMT-SS-Sicilia and QMT-SS-Calabria is 12.5kA.
- Ik´´min feed by the UPS units are 2kA.
- Contributions from motors are not included in the calculations.

The minimum short circuit currents are presented in the tables below:

Node	Un	Ik" 1s	Ip	Fault Type
Name	kV	kA	kA	
End of Service Lane Lighting Circuit	0,40	0,08	0,12	1phase ground fault
End of Road Lighting Circuit	0,40	0,10	0,14	1phase ground fault
End of Girder Lighting Circuit	0,40	0,08	0,12	1phase ground fault
End of Cross Girder Lighting Circuit	0,40	0,09	0,14	1phase ground fault
End of Architectural Lighting Circuit	0,40	0,09	0,13	1phase ground fault
BLD15 (DBP-74)	0,40	2,77	4,13	1phase ground fault
BLB81 (FM-26B)	0,40	0,35	0,50	1phase ground fault
BLA41	0,40	1,52	2,47	1phase ground fault
BLA31	0,40	1,55	2,54	1phase ground fault
BLA24	0,40	10,97	21,06	1phase ground fault
BLA23	0,40	10,97	21,06	1phase ground fault
BLA22	0,40	6,67	12,07	1phase ground fault
BLA21	0,40	6,67	12,07	1phase ground fault
BLA14	0,40	12,19	27,23	1phase ground fault
BLA13	0,40	12,19	27,23	1phase ground fault
BLA12	0,40	7,18	13,96	1phase ground fault
BLA11	0,40	7,18	13,96	1phase ground fault
BLA08	0,40	4,61	8,36	1phase ground fault
BLA07	0,40	4,63	8,44	1phase ground fault
BLA06	0,40	4,66	8,54	1phase ground fault
BLA05	0,40	4,69	8,63	1phase ground fault
BLA04	0,40	4,71	8,72	1phase ground fault
BLA03	0,40	4,74	8,82	1phase ground fault
BLA02	0,40	4,77	8,92	1phase ground fault
BLA01	0,40	4,80	9,03	1phase ground fault
BHA20	0,40	1,54	2,51	1phase ground fault
BHA10	0,40	1,57	2,58	1phase ground fault
BBB20	6,00	1,53	2,43	1phase ground fault
BBB10	6,00	4,21	10,04	1phase ground fault
BBB08	6,00	1,66	2,67	1phase ground fault
BBB07	6,00	1,81	2,96	1phase ground fault
BBB06	6,00	1,99	3,32	1phase ground fault
BBB05	6,00	2,21	3,78	1phase ground fault
BBB04	6,00	2,47	4,38	1phase ground fault
BBB03	6,00	2,79	5,17	1phase ground fault
BBB02	6,00	3,19	6,26	1phase ground fault
BBB01	6,00	3,66	7,81	1phase ground fault
BBA20	20,00	7,50	19,77	1phase ground fault
BBA10	20,00	7,50	19,77	1phase ground fault
At Dehumidification Unit	0,40	1,42	2,11	1phase ground fault
At BLT41	6,00	1,13	1,69	1phase ground fault
At BLT32	6,00	1,29	1,97	1phase ground fault
At BLT31	6,00	2,39	3,94	1phase ground fault
At BLT24	6,00	1,43	2,23	1phase ground fault
At BLT23	6,00	1,43	2,23	1phase ground fault
At BLT22	6,00	1,29	1,97	1phase ground fault
At BLT14	6,00	3,79	8,00	1phase ground fault
At BLT13	6,00	3,79	8,00	1phase ground fault
At BLT12	6,00	3,12	5,72	1phase ground fault
At BLT11	6,00	3,12	5,72	1phase ground fault
At BBT20	6,00	4,41	10,90	1phase ground fault
At BBT10	6,00	4,41	10,90	1phase ground fault

Node	Un	Ik" 1s	Ip	Fault Type
Name	kV	kA	kA	
BNB08	0,40	3,08	-	1phase ground fault
End of Emg. Cross Gider Lighting Circuit	0,40	0,07	-	1phase ground fault
End of Emg. Girder Lighting Circuit	0,40	0,07	-	1phase ground fault
BNC81 (FM-26B)	0,40	0,38	-	1phase ground fault
End Circuit for VMS portal most Distant from UPS	0,40	0,74	-	1phase ground fault
End of Emg. Service Lane Lighting Circuit	0,40	0,07	-	1phase ground fault

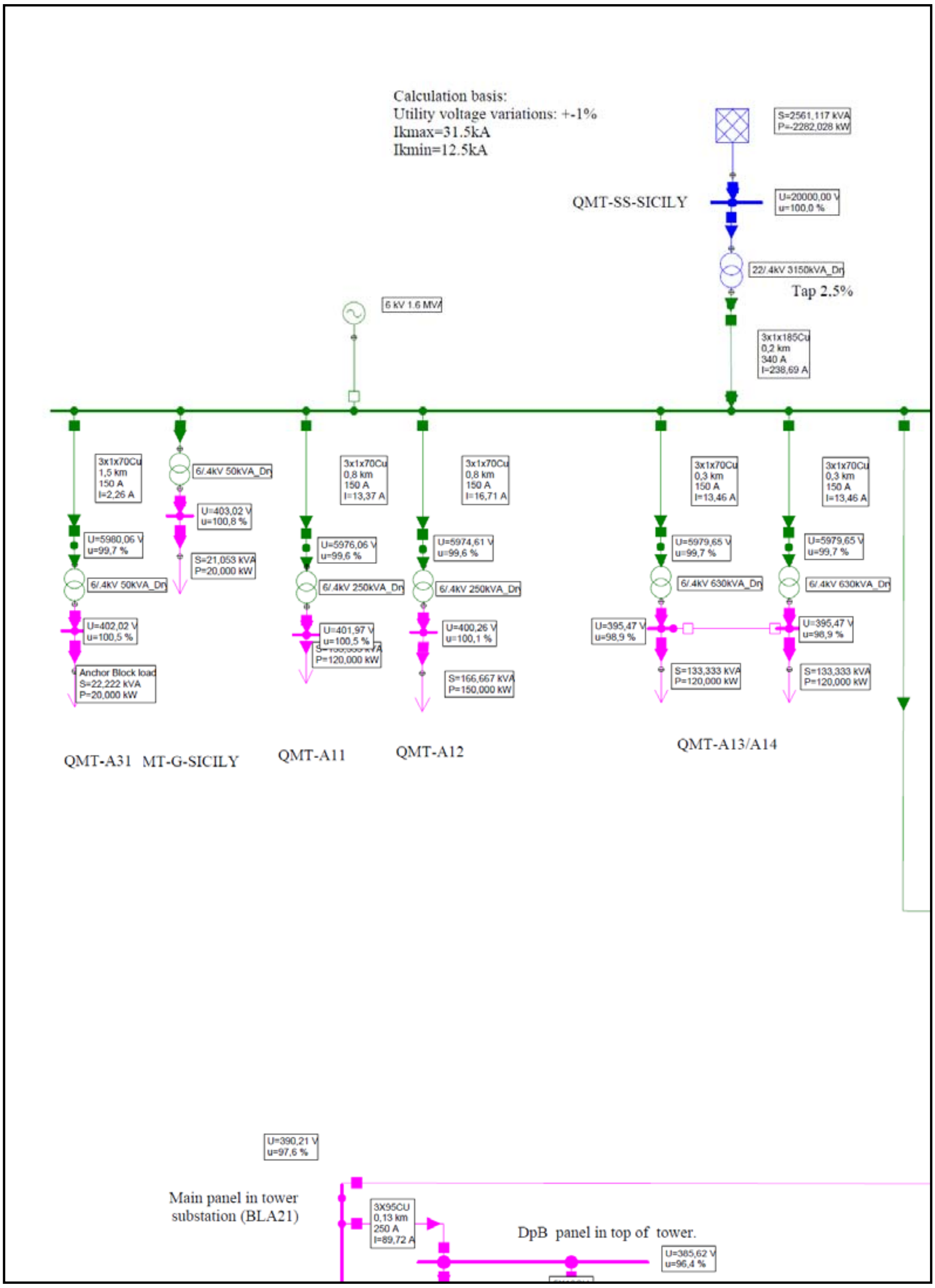
The minimum short circuit level at 6kV level is 1.5kA which is more than 5 times the maximum nominal current of the 6kV network thus short circuits can easily be detected and the network protected.

The smallest short circuit current in the low voltage network is found at the end of the emergency light circuit feed by the UPS system. The short circuit current is calculated to 70A which can be detected and beaked by a 10A breaker (tripping curve L, 6 x I_n).

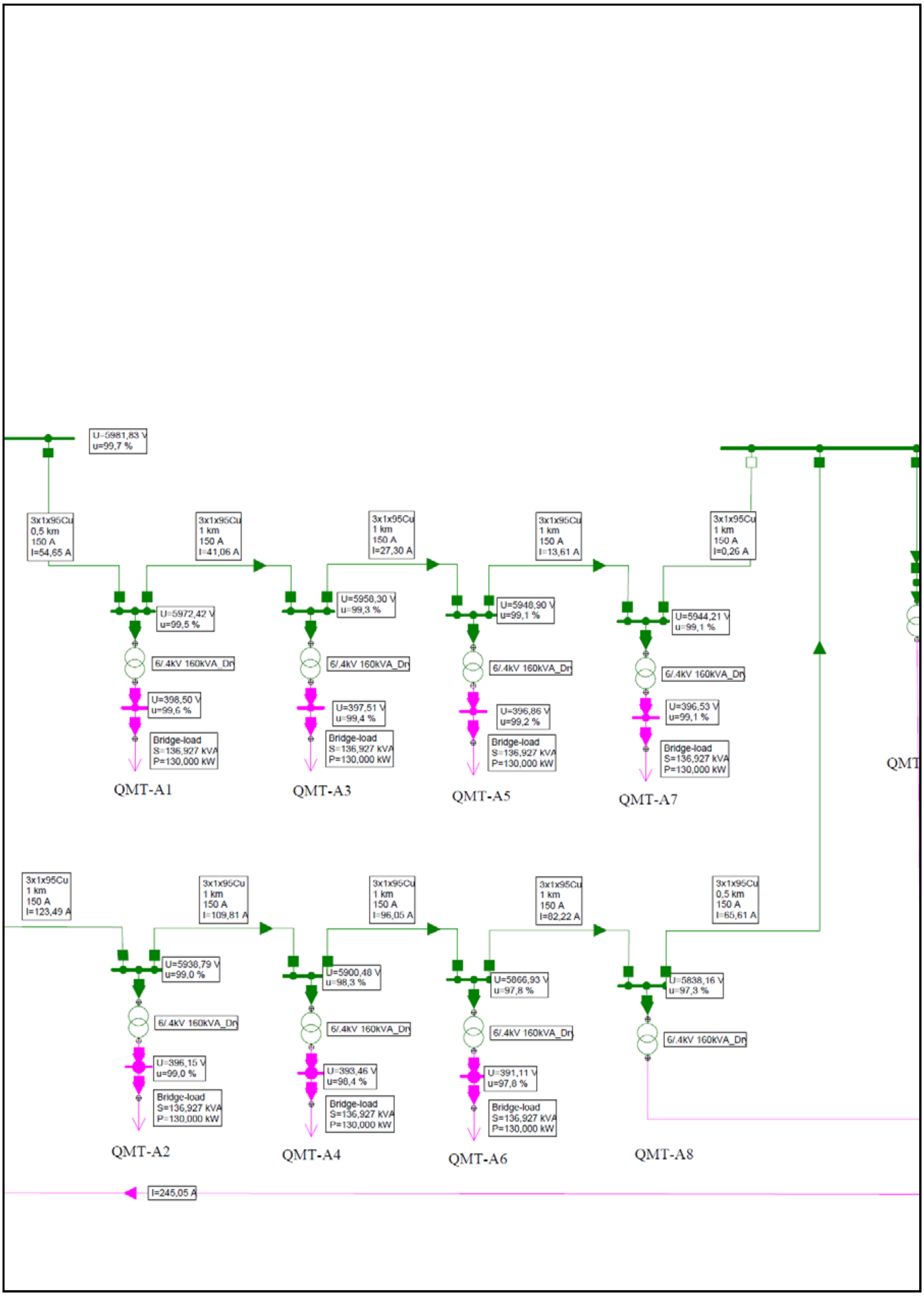
Neplan calculation sheets are shown in Appendix G.

2.8 Calculation sheets

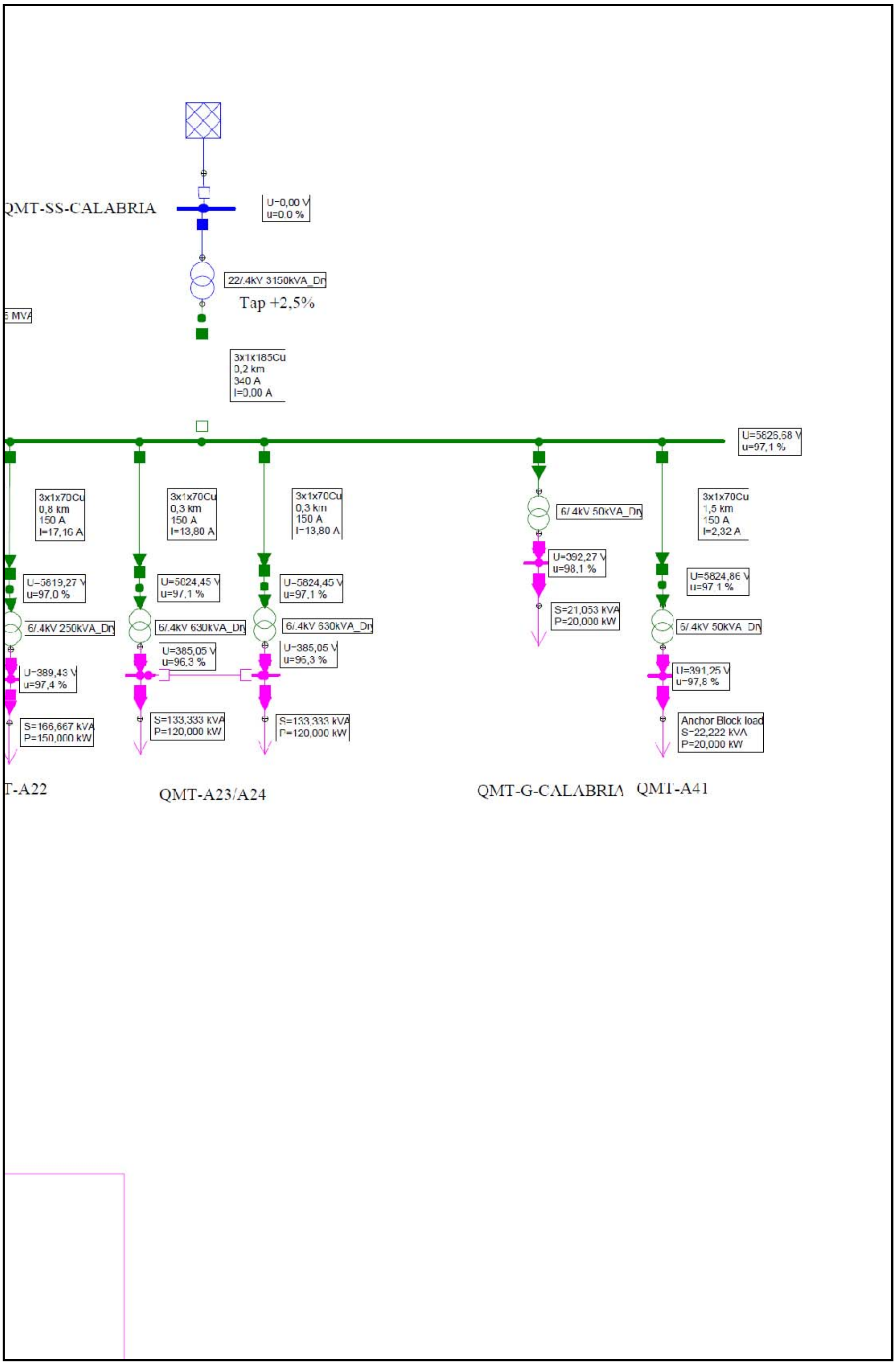
Neplan calculation sheets of the minimum voltage calculation are shown on the following pages. The calculation is performed for the operation scenario 2.

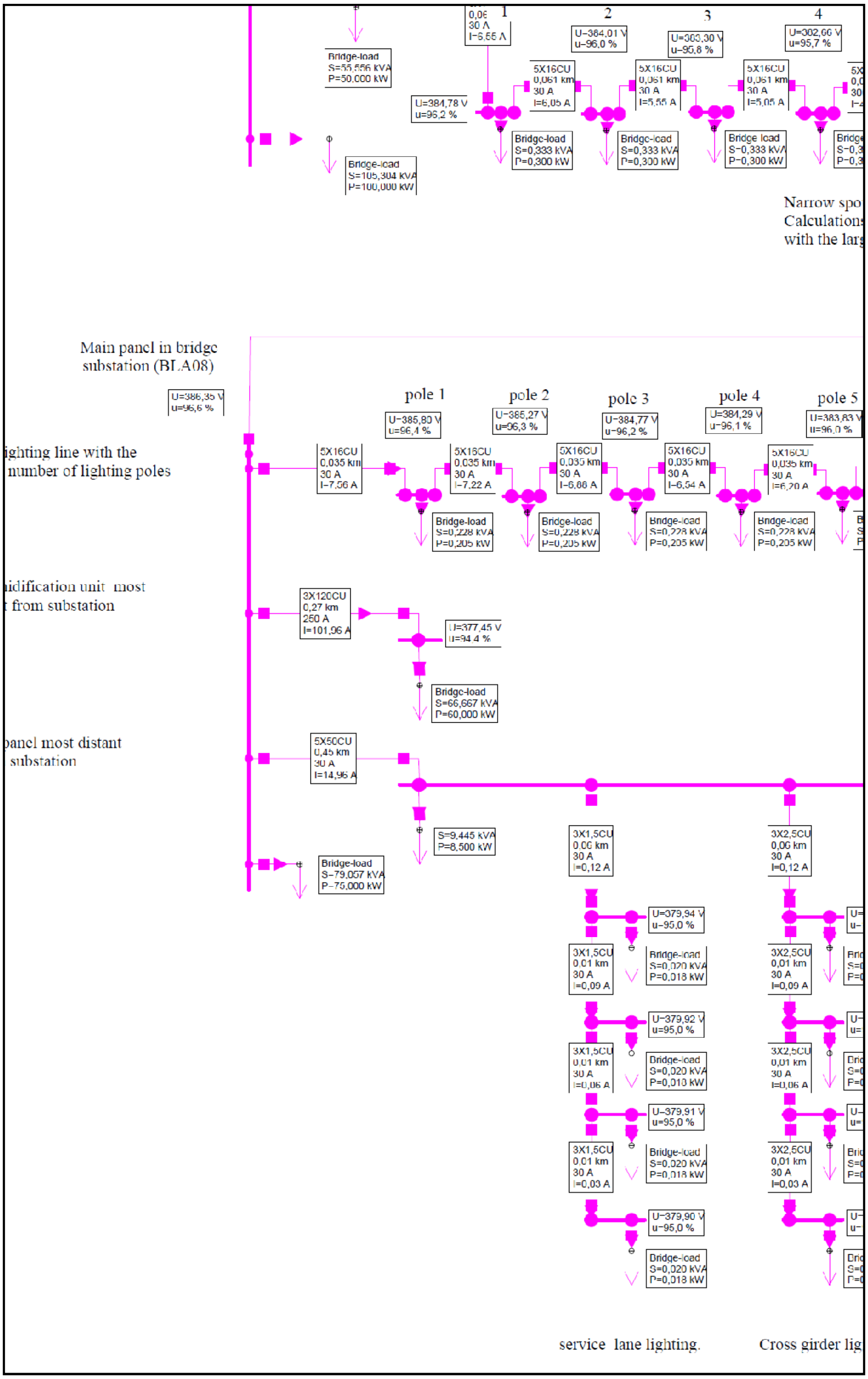


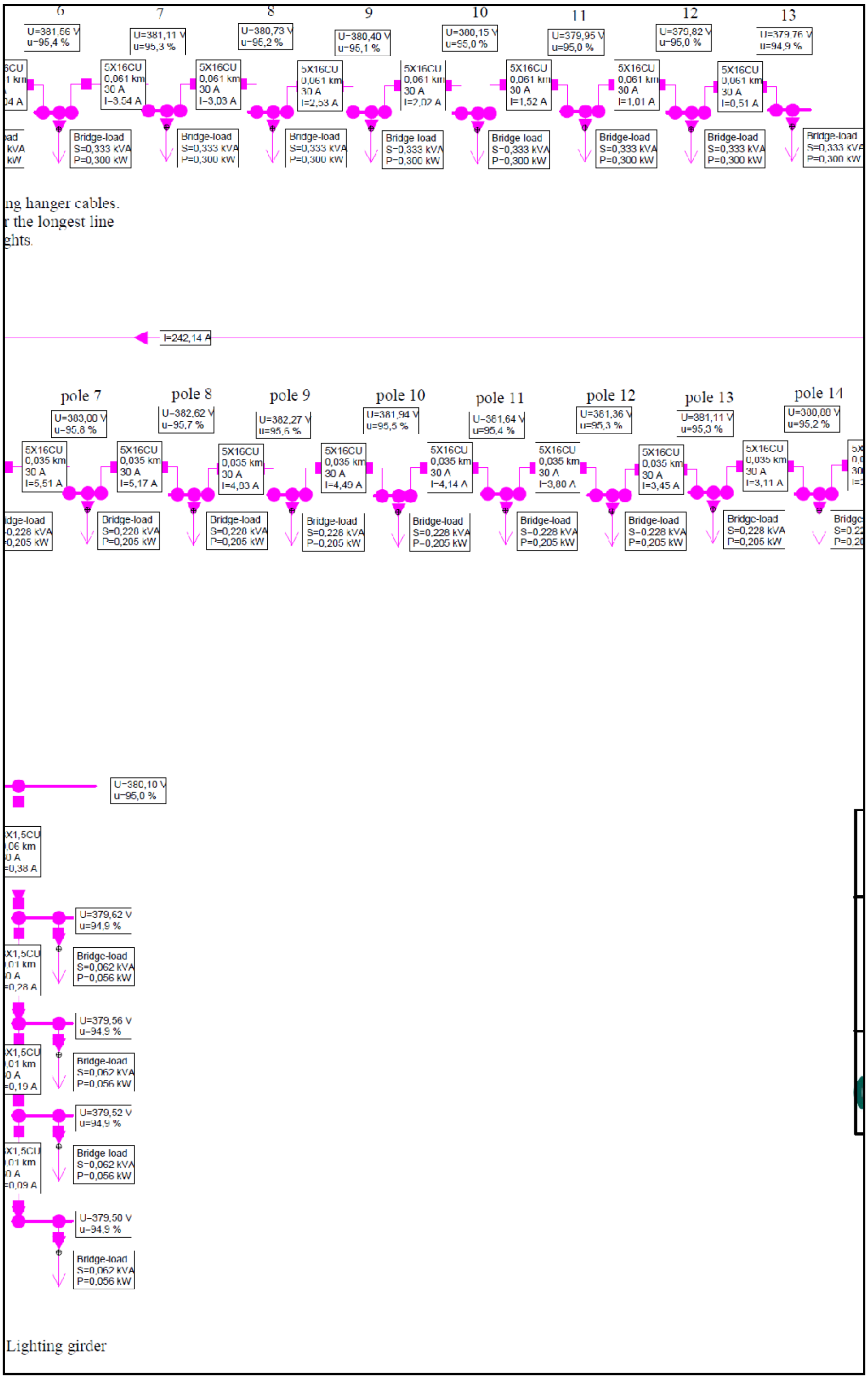
Calculation basis:
Utility voltage variations: +-1%
Ikmax=31.5kA
Ikmin=12.5kA
S=2561,117 kVA
P=-2282,028 kW
QMT-SS-SICILY
U=20000,00 V
u=100,0 %
22/.4kV 3150kVA_Dn
Tap 2.5%
6 kV 1.6 MVA
3x1x185Cu
0,2 km
340 A
I=238,69 A
3x1x70Cu
1,5 km
150 A
I=2,26 A
6/.4kV 50kVA_Dn
U=403,02 V
u=100,8 %
S=21,053 kVA
P=20,000 kW
U=5980,06 V
u=99,7 %
6/.4kV 50kVA_Dn
U=402,02 V
u=100,5 %
Anchor Block load
S=22,222 kVA
P=20,000 kW
3x1x70Cu
0,8 km
150 A
I=13,37 A
U=5976,06 V
u=99,6 %
6/.4kV 250kVA_Dn
U=401,97 V
u=100,5 %
P=120,000 kW
3x1x70Cu
0,8 km
150 A
I=16,71 A
U=5974,61 V
u=99,6 %
6/.4kV 250kVA_Dn
U=400,26 V
u=100,1 %
S=166,667 kVA
P=150,000 kW
3x1x70Cu
0,3 km
150 A
I=13,46 A
U=5979,65 V
u=99,7 %
6/.4kV 630kVA_Dn
U=395,47 V
u=98,9 %
S=133,333 kVA
P=120,000 kW
3x1x70Cu
0,3 km
150 A
I=13,46 A
U=5979,65 V
u=99,7 %
6/.4kV 630kVA_Dn
U=395,47 V
u=98,9 %
S=133,333 kVA
P=120,000 kW
QMT-A31
MT-G-SICILY
QMT-A11
QMT-A12
QMT-A13/A14
U=390,21 V
u=97,6 %
Main panel in tower
substation (BLA21)
3X95CU
0,13 km
250 A
I=89,72 A
DpB panel in top of tower.
U=385,62 V
u=96,4 %



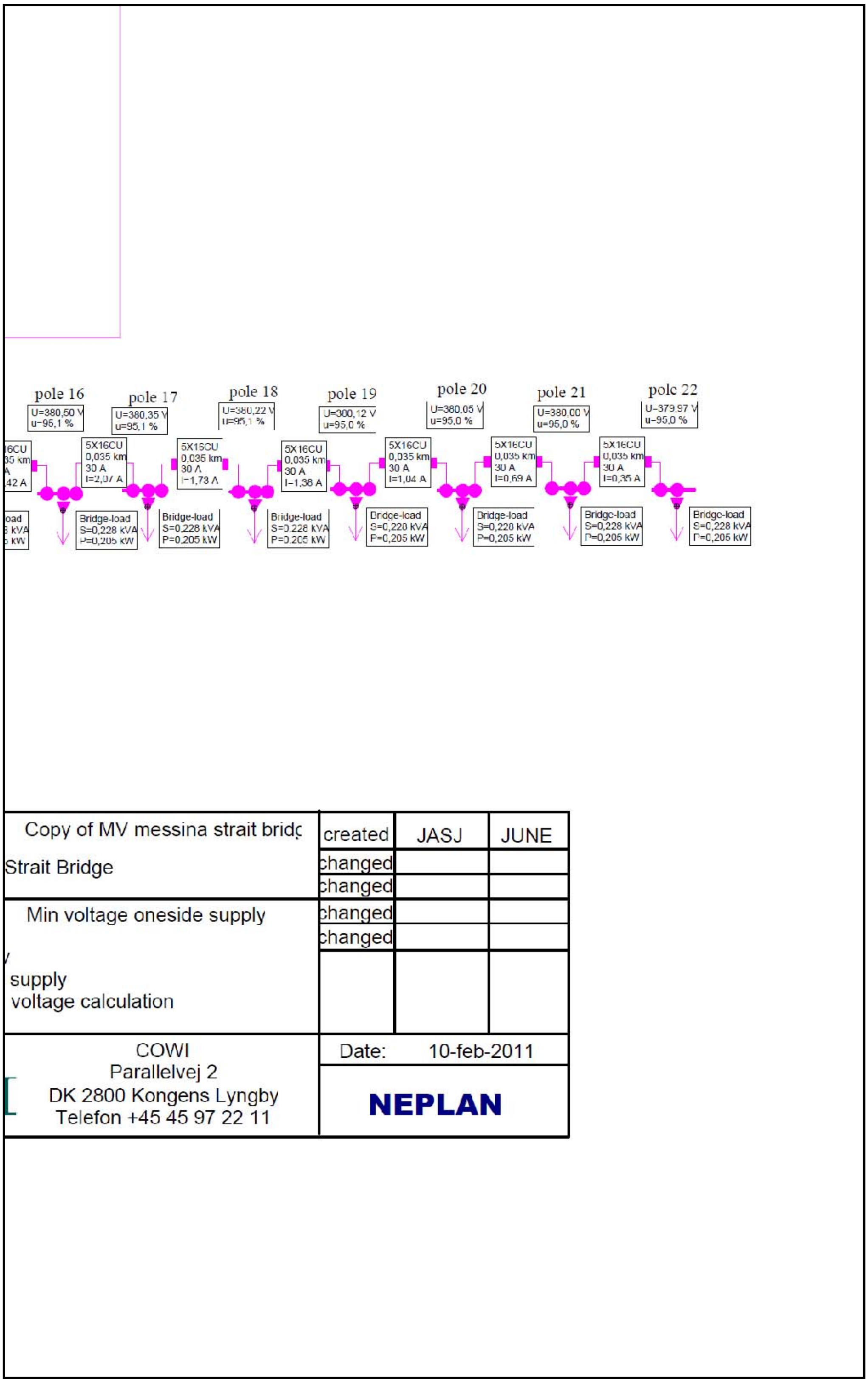
U=5981,83 V
u=99,7 %
3x1x95Cu
0,5 km
150 A
I=54,65 A
3x1x95Cu
1 km
150 A
I=41,06 A
3x1x95Cu
1 km
150 A
I=27,30 A
3x1x95Cu
1 km
150 A
I=13,61 A
3x1x95Cu
1 km
150 A
I=0,26 A
U=5972,42 V
u=99,5 %
U=5958,30 V
u=99,3 %
U=5948,90 V
u=99,1 %
U=5944,21 V
u=99,1 %
6/.4kV 160kVA_Dn
U=398,50 V
u=99,6 %
U=397,51 V
u=99,4 %
U=396,86 V
u=99,2 %
U=396,53 V
u=99,1 %
Bridge-load
S=136,927 kVA
P=130,000 kW
QMT-A1
QMT-A3
QMT-A5
QMT-A7
QMT
3x1x95Cu
1 km
150 A
I=123,49 A
3x1x95Cu
1 km
150 A
I=109,81 A
3x1x95Cu
1 km
150 A
I=96,05 A
3x1x95Cu
1 km
150 A
I=82,22 A
3x1x95Cu
0,5 km
150 A
I=65,61 A
U=5938,79 V
u=99,0 %
U=5900,48 V
u=98,3 %
U=5866,93 V
u=97,8 %
U=5838,16 V
u=97,3 %
U=396,15 V
u=99,0 %
U=393,46 V
u=98,4 %
U=391,11 V
u=97,8 %
QMT-A2
QMT-A4
QMT-A6
QMT-A8
I=245,05 A


QMT-SS-CALABRIA
U=0,00 V
u=0,0 %
22/.4kV 3150kVA_Dn
Tap +2,5%
3x1x185Cu
0,2 km
340 A
I=0,00 A
U=5826,68 V
u=97,1 %
3x1x70Cu
0,8 km
150 A
I=17,16 A
3x1x70Cu
0,3 km
150 A
I=13,80 A
3x1x70Cu
0,3 km
150 A
I=13,80 A
6/.4kV 50kVA_Dn
3x1x70Cu
1,5 km
150 A
I=2,32 A
U=5819,27 V
u=97,0 %
U=5824,45 V
u=97,1 %
U=5824,45 V
u=97,1 %
U=392,27 V
u=98,1 %
U=5824,86 V
u=97,1 %
6/.4kV 250kVA_Dn
6/.4kV 630kVA_Dn
6/.4kV 630kVA_Dn
S=21,053 kVA
P=20,000 kW
6/.4kV 50kVA_Dn
U=389,43 V
u=97,4 %
U=385,05 V
u=96,3 %
U=385,05 V
u=96,3 %
U=391,25 V
u=97,8 %
S=166,667 kVA
P=150,000 kW
S=133,333 kVA
P=120,000 kW
S=133,333 kVA
P=120,000 kW
Anchor Block load
S=22,222 kVA
P=20,000 kW
T-A22
QMT-A23/A24
QMT-G-CALABRIA
QMT-A41


Bridge-load
S=55,556 kVA
P=50,000 kW
Bridge-load
S=105,304 kVA
P=100,000 kW
U=384,78 V
u=96,2 %
1
2
3
4
U=384,01 V
u=96,0 %
U=383,30 V
u=95,8 %
U=382,66 V
u=95,7 %
5X16CU
0,061 km
30 A
I=6,05 A
5X16CU
0,061 km
30 A
I=5,55 A
5X16CU
0,061 km
30 A
I=5,05 A
Bridge-load
S=0,333 kVA
P=0,300 kW
Narrow spo
Calculation
with the larg
Main panel in bridge
substation (BLA08)
U=386,35 V
u=96,6 %
pole 1
pole 2
pole 3
pole 4
pole 5
U=385,80 V
u=96,4 %
U=385,27 V
u=96,3 %
U=384,77 V
u=96,2 %
U=384,29 V
u=96,1 %
U=383,83 V
u=96,0 %
ighting line with the
number of lighting poles
5X16CU
0,035 km
30 A
I=7,56 A
5X16CU
0,035 km
30 A
I=7,22 A
5X16CU
0,035 km
30 A
I=6,88 A
5X16CU
0,035 km
30 A
I=6,54 A
5X16CU
0,035 km
30 A
I=6,20 A
Bridge-load
S=0,228 kVA
P=0,205 kW
idification unit most
from substation
3X120CU
0,27 km
250 A
I=101,96 A
U=377,45 V
u=94,4 %
Bridge-load
S=66,667 kVA
P=60,000 kW
panel most distant
substation
5X50CU
0,45 km
30 A
I=14,96 A
S=9,445 kVA
P=8,500 kW
Bridge-load
S=79,057 kVA
P=75,000 kW
3X1,5CU
0,06 km
30 A
I=0,12 A
3X2,5CU
0,06 km
30 A
I=0,12 A
U=379,94 V
u=95,0 %
Bridge-load
S=0,020 kVA
P=0,018 kW
3X1,5CU
0,01 km
30 A
I=0,09 A
U=379,92 V
u=95,0 %
3X1,5CU
0,01 km
30 A
I=0,06 A
U=379,91 V
u=95,0 %
3X1,5CU
0,01 km
30 A
I=0,03 A
U=379,90 V
u=95,0 %
service lane lighting.
Cross girder lig



ng hanger cables.
r the longest line
ghts.
I=242,14 A
pole 7
pole 8
pole 9
pole 10
pole 11
pole 12
pole 13
pole 14
5X16CU
Bridge-load
S=0,333 kVA
P=0,300 kW
S=0,228 kVA
P=0,205 kW
S=0,062 kVA
P=0,056 kW
Lighting girder



pole 16
U=380,50 V
u−95,1 %
5X16CU
0,035 km
30 A
I=2,07 A
Bridge-load
S=0,228 kVA
P=0,205 kW
pole 17
U=380,35 V
u=95,1 %
5X16CU
0,035 km
30 A
I−1,73 A
Bridge-load
S=0.228 kVA
P=0.205 kW
pole 18
U=380,22 V
u=95,1 %
5X16CU
0,035 km
30 A
I−1,38 A
Bridge-load
S=0.228 kVA
P=0.205 kW
pole 19
U=300,12 V
u=95,0 %
5X16CU
0,035 km
30 A
I=1,04 A
Bridge-load
S=0,220 kVA
P=0,205 kW
pole 20
U=380,05 V
u=95,0 %
5X16CU
0,035 km
30 A
I=0,69 A
Bridge-load
S=0,220 kVA
P=0,205 kW
pole 21
U=380,00 V
u=95,0 %
5X16CU
0,035 km
30 A
I=0,35 A
Bridge-load
S=0,228 kVA
P=0,205 kW
pole 22
U−379,97 V
u−95,0 %
Bridge-load
S=0,228 kVA
P=0,205 kW
Copy of MV messina strait bridg
Strait Bridge
Min voltage oneside supply
supply
voltage calculation
created
JASJ
JUNE
changed
changed
changed
changed
COWI
Parallelvej 2
DK 2800 Kongens Lyngby
Telefon +45 45 97 22 11
Date:
10-feb-2011
NEPLAN

3 Fire fighting system

3.1 Introduction

Current section presents the results from hydraulic simulations of the fire-fighting systems in the tower (high beam and low beam) and on the bridge.

The simulations cover both *steady-state* and transient simulations. The steady-state simulations are intended to suggest pipe dimensions and verify the characteristics of the selected pumps.

The objective of the *transient* analyses is to reveal any possible hydraulic problems in the fire-fighting system. This includes e.g. pump trip, start of pumps, opening and closing of valves.

The software used for the hydraulic calculations is Aquis version 1.50 from 7T (www.7t.dk).

3.2 Conclusion

The current document presents simulation results for the three hydraulically separated networks in the fire-fighting system for the Messina Strait Bridge. Four types of scenarios have been analysed for each network: steady-state, pump trip, valve closing and pump start.

The following subsections include a summary of the conclusions made.

3.2.1 Bridge

- Suggested pipe dimension: DN150.
- Pipe pressure class: PN25.
- Suitable surge vessel volume: 1 m^3. Operation in start/stop mode at low flow may change the size of the surge vessel, see comments in section 3.3.1.
- Vacuum breakers should be installed on the middle of the bridge (at the highest elevation).
- Design flow: 2000 l/min.
- Required pump head at design flow: 18.9 bar.

3.2.2 Tower - High Beam

- Suggested pipe dimension: DN80.
- Pipe pressure class: PN63.
- Suitable surge vessel volume: 0.1 m^3. Operation in start/stop mode at low flow may change the size of the surge vessel, see comments in section 3.3.1.
- Vacuum breakers should be installed at the highest elevation.
- Design flow: 300 l/min.
- Required pump head at design flow: 44.2 bar.

3.2.3 Tower - Low Beam

- Suggested pipe dimension: DN80.
- Pipe pressure class: Depends on pump selection.
  - Current pump selection: PN40 in elevation from 0 to ~50 metres (bridge elevation), PN25 is sufficient above 50 metres.
  - Pressure rating can be reduced to PN25 in case pumps with reduced head can be applied.
- Suitable surge vessel volume: 0.1 m^3. Operation in start/stop mode at low flow may change the size of the surge vessel, see comments in section 3.3.1.
- Vacuum breakers should be installed at the highest elevation.
- Design flow: 300 l/min.
- Required pump head at design flow: 19.0 bar.

3.3 Assumptions

- Young's modulus for steel pipes is assumed to be $2.05 \cdot 10^5$ N/mm^2.
- Young's modulus for fibre filament wound epoxy pipes, according to Wavistrong engineering guide (ω=63º), is assumed to be 24515 N/mm^2.
- Bridge: Pipes used are glass fibre reinforced epoxy (GRE) pipes with spigot and socket end.

- High tower: Pipes used are steel pipes.
- Lower tower: Pipes used are steel pipes.
- The maximum acceptable pressure in transient analyses is the maximum operating pressure in accordance to the pressure class, multiplied by 1.5. This is under the assumption that pipes and components are subject to a test pressure at 1.5 x design pressure.
- The minimum acceptable pressure in the transient analyses is 0 bar(g).
- Operational parameters are as shown in Table 3.1.

Table 3.1 Operation parameters

	Towers	Bridge
Required volumetric flow [l/min]	300	2000
Number of open hydrants in simulation	1	2
Required supply pressure at hydrant exit [bar(g)]	4.0	6.9
Supply pressure safety [bar]	0.5	0.5
Hydrant pressure drop at max flow [bar]	1.5	1.5
Minimum supply pressure upstream hydrant [bar(g)]	6.0	8.9

- Pipe type catalogue used is as shown in Table 3.2 and Table 3.3. See attachments D and E.

Table 3.2 Pipe type catalogue for steel pipes.

Pipe Type, steel	Internal diameter [mm]	Roughness [mm]	Wall thickness [mm]
DN80	82.5	0.1	3.2
DN100	107.1	0.1	3.6
DN150	160.3	0.1	4.0
DN200	210.1	0.1	4.5

Table 3.3 Pipe type catalogue for GRE pipes.

Pipe Type, GRE	Internal diameter [mm]	Roughness [mm]	Wall thickness [mm]
DN100	100	0.1	3.2
DN150	150	0.1	3.9
DN200	200	0.1	4.9

- Polytrophic exponent for air in surge vessels is assumed to be n = 1.3 ($p_1V_1^n = p_2V_2^n$).
- Bridge, one of two parallel supply pipes across the bridge is in operation, the other is assumed to be closed.
- Towers (high and low), one of two parallel supply pipes in the tower is in operation, the other is assumed to be closed.
- Water level in supply tanks is assumed to be 1-4 metre above elevation of pumps. This implies that pressure upstream fire pumps is 0.1-0.4 bar(g).
- Bridge fire pump is KSB Multitec A 100/ 3-7.1 10.67. Pump curve is attached in attachment A.
- Tower high fire pump is KSB Multitec A 50/ 13C-3.1 20.61. Pump curve is attached in attachment B.
- Tower low fire pump is KSB Multitec A 50/ 6C-3.1 20.61. Pump curve is attached in attachment C.
- The singular losses such as pipe fittings and non-return valves are not specifically included in the pressure loss calculations, but is assumed to be covered within the pressure safety margin of 0.5 bar.
- The maximum pressure losses in fire hydrant is 1.5 bar, see attachment F.

- The operating pressure range of fire hydrants is not discussed in the current memo. The hydrants should deliver water at constant pressure to the fire hoses, but is subjected to varying pressure range. It is suggested that this issue will be investigated.

3.3.1 Note on start/stop operation of pumps

The start and stop operation of the pumps has not been analysed in the current memo. This matter is of importance and is related to the operational parameters of the pumps, e.g. a well defined stop/start strategy is defined and is suitable for all load cases, e.g. low load cases.

The concern is to define start/stop pressure range of both the jockey pumps and fire pumps. Too many start/stop of the pumps can result in overheating of the pump motor.

Investigation of this issue is relevant in the discussion of surge vessel volume and motor selection. It is suggested that this analyse will be performed and documented.

3.4 Conceptual Layout

3.4.1 Network Layout

The network layout is as indicated in document "CG1000-P1L-DP-IT-M2-DI-00-00-00-01A", see attachment H.

Elevation op pipes (metres above mean sea level):

- Pumps: 0.0 m
- Terminal structure end, Sicilia: 52.6 m
- Bridge at tower, Sicilia: 55.4 m
- Tower, lower cross beam: 130.0 m
- Tower, high cross beam: 382.6 m
- Terminal structure end, Calabria: 63.1 m
- Bridge at tower, Calabria: 54.7 m
- Highest point on bridge (middle): 81.1 m

3.4.2 Pressure profile and hydraulic model

Figure 3-1and Figure 3-2 present the pressure profiles and hydraulic model of the fire fighting system.

Under normal operation situation both DN150 pipes are in service and water is supplied from one pump station, on either Sicilia or Calabria end of the bridge.

In case one DN150 pipe is out of service, water can not be supplied from one pump station. In this case both pump stations are in operation.

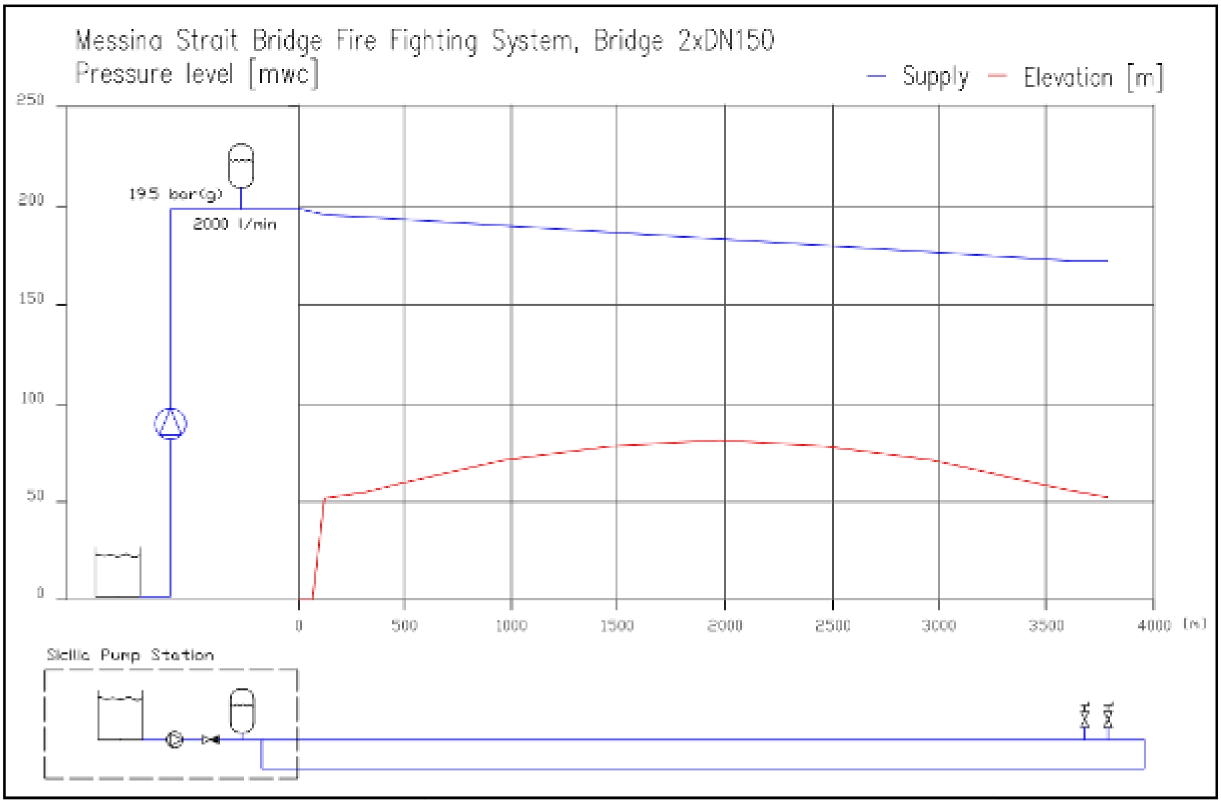


Figure 3-1 Pressure profile and hydraulic model, 2 DN150 in service, 1 pump station in operation

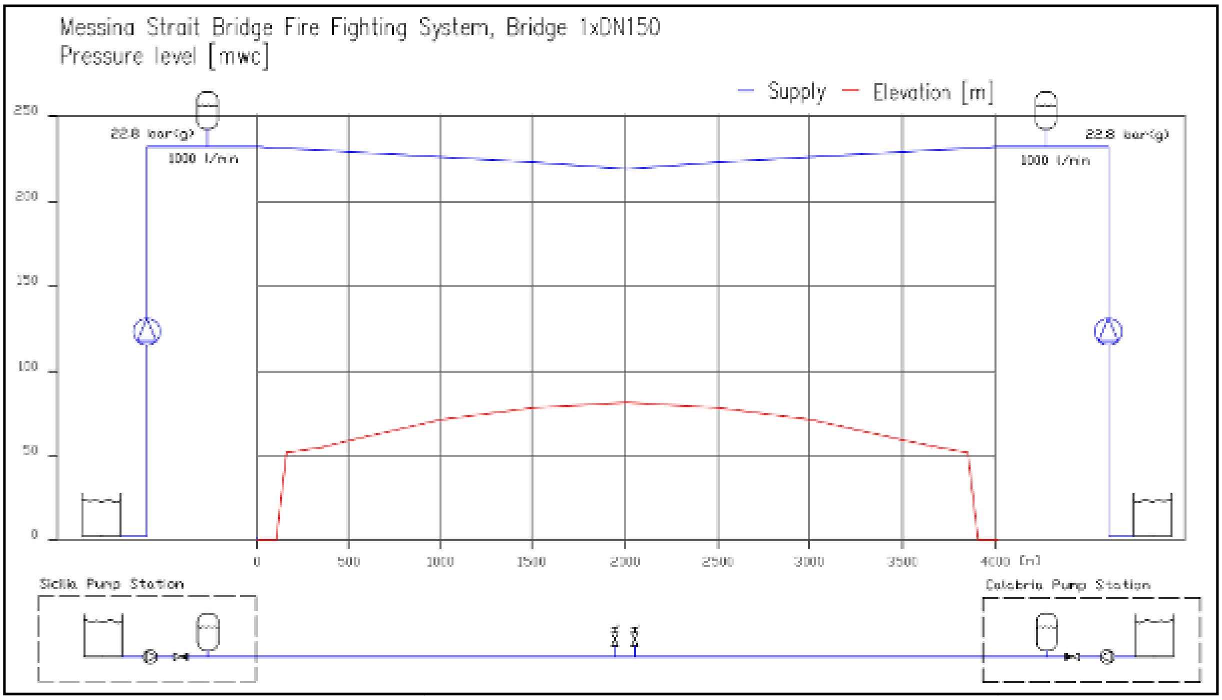


Figure 3-2 Pressure profile and hydraulic model, 1 DN150 in service, 2 pump stations in operation

3.5 Scenario Enumeration

The model scenarios have a number indicated by X.Y.Z. The numbering system is as follows:

X: A - Bridge, B: High Beam, C: Low Beam

Y: 1 - Pump trip, 2 - Valves Closing, 3 - Pump start

Z: Model variants and sensitivity analysis, non-consistent numbering, explanation showed in header of result graphs. 1 - This is the reference scenario with operational parameters and network layout as described in Sections 3.3 and 3.4.

3.6 Results, Bridge

3.6.1 Steady State

The required mass flow is 2000 l/min, which is to be delivered at minimum 8.9 bar(g) upstream the fire hydrants arrangement.

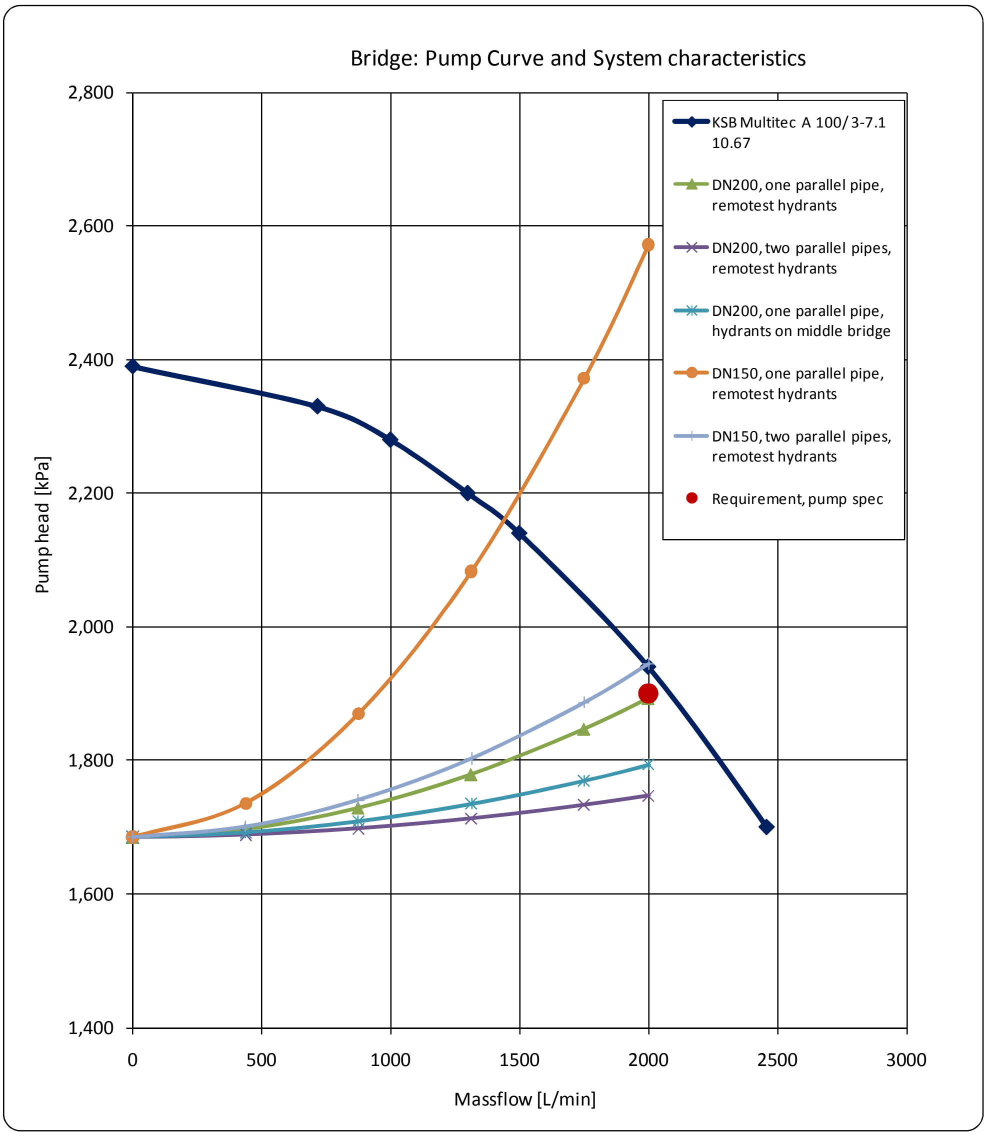


Figure 3-3 Bridge Pump curve and system characteristics.

Figure 3-3 illustrates the pump and system characteristics. A larger format can be viewed in attachment A. The assumption for this diagram is water is supplied from one pump station only.

At first the supply criteria was water supply of 2000 l/min from one pump station and at minimum pressure of 8.9 bar(g) upstream fire hydrants and one parallel pipe on the bridge in service.

It has now been accepted through risk assessment, that in case one parallel pipe on the bridge is out of service the second pump station (on the opposite end of the bridge) will be taken into operation.

A pipe dimension of DN150 is sufficient in both cases. With DN150 and 2 pipes in service, 1 pump station in operation, the required pump head is 17.25 bar and the delivered pump head is 19.4 bar. With 1 pipe in service and 2 pump station in operation the required pump head is 18.11 bar and the delivered pump head is 22.79 bar.

The pump head at zero flow is 23.9 bar. The pressure class should minimum be the maximum observed pressure under normal operation. The recommended pressure class is PN25.

The simulations have been performed with the assumed lowest possible water level in the supply tanks, 1 metre above the pump elevation. When the tanks are full the pressure at zero flow is higher than 23.9 bar(g).

The minimum pressure at 2000 l/min is 10.1 bar(g) and 13.6 bar(g) for 2 and 1 pipes in service, respectively.

3.6.2 Transient

3.6.2.1 Pump Trip

The system is initially in full operation, the water flow is 2000 l/min, and the pumps are at full speed. At time t=10 seconds, the fire pump trips.

Figure 3-4 presents the simulation results for Scenario A.1.3. This scenario presents the system under normal operation with 2 DN150 pipes in service and one pump station in operation. The 2 remotest fire hydrants are open.

The system is equipped with vacuum breaker at the highest elevation (middle of the bridge). There are no surge vessels nor surge relief valves included.

The results show an instantaneous pressure drop downstream the fire pump. The pressure wave reaches the open fire hydrants after 5 seconds.

The results indicate that the vacuum breaker is activated at time t=21 second, at the moment when the pressure at the middle of the bridge drops to 0 bar(g). The pressure at this location remains 0 bar(g), indicating that the vacuum breaker remains activated throughout the simulation period.

The introduction of vacuum breaker has the consequence that air will be sucked into the system at pump stop. The system must be furnished with (automatic) vents to ensure that air is vented.

Scenario A.1.3 is acceptable from a hydraulic point of view.

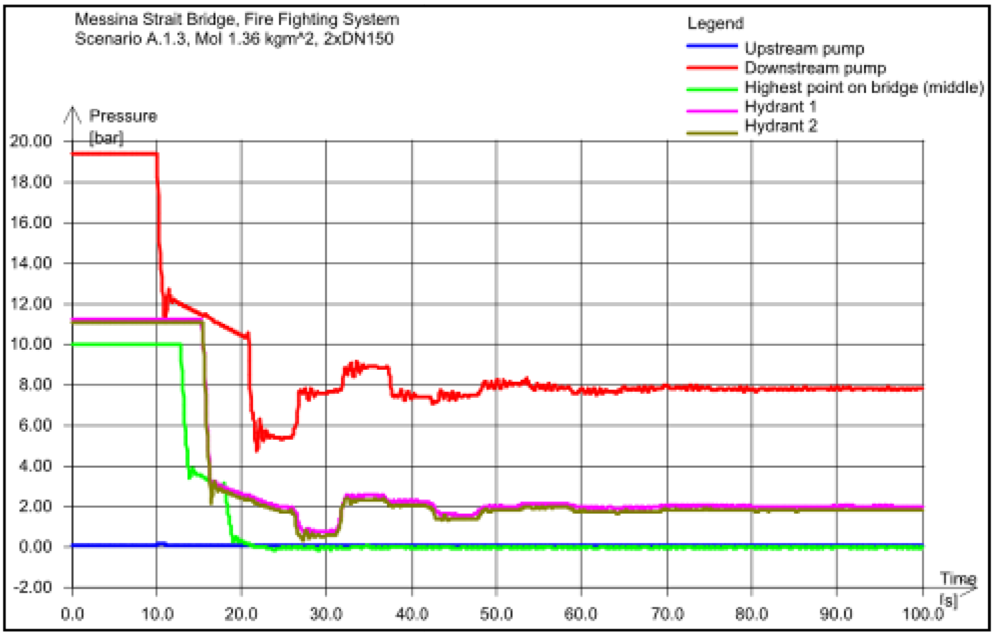


Figure 3-4 Scenario A.1.3 Pressure development as a function of time.

Scenario A.1.4 corresponds to scenario A.1.3 but now with one DN150 pipe in service and water is supplied from both pump stations. The 2 remotes hydrants are open. In this case the 2 remotest hydrants are on the middle of the bridge.

The results indicate that the vacuum breaker is activated at time t=19 seconds, at the moment when the pressure at the middle of the bridge drops to 0 bar(g). The pressure at this location remains 0 bar(g), indicating that the vacuum breaker remains activated throughout the simulation period.

Scenario A.1.4 is acceptable from a hydraulic point of view.

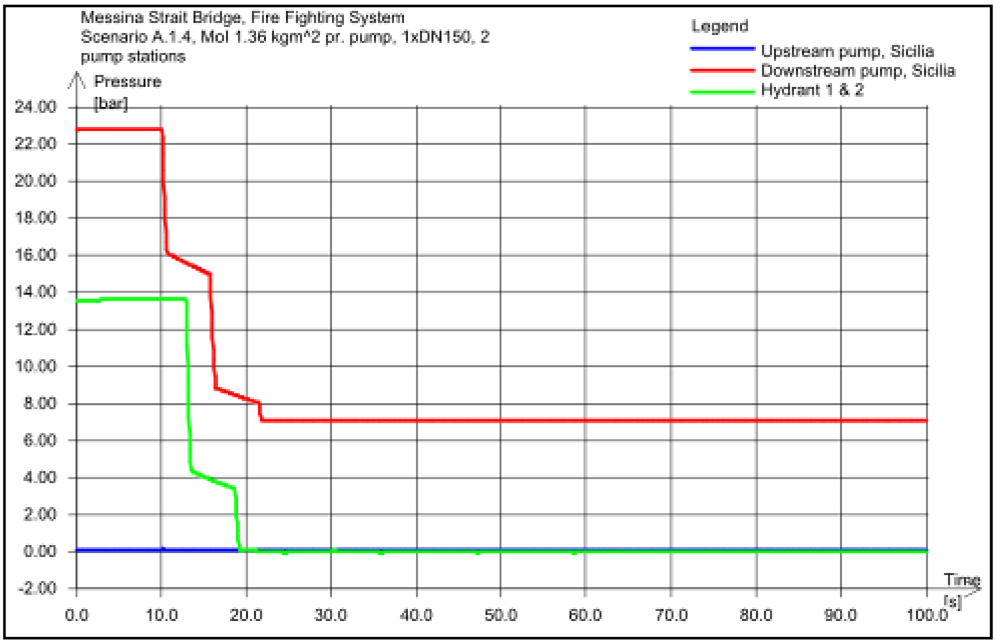


Figure 3-5 **Scenario A.1.4 Pressure development as a function of time.**

3.6.2.2 Valves Closing

The system is initially in full operation, the water flow is 2000 l/min, and the pumps are at full speed. At time t=10 seconds, the fire hydrants are closed simultaneously. To illustrate the worst-case scenario with regard to closing of the fire hydrants, a short closing time is chosen. The closing time of the hydrants is 0.1 second.

Figure 3-6 presents the simulation results for Scenario A.2.2. This scenario presents the system under normal operation with 2 DN150 pipes in service and one pump station in operation. The 2 remotest fire hydrants are open.

The results show a sudden rise in pressure at the fire hydrant at the time when the hydrants are closed. The maximum observed pressure is 30 bar(g) downstream the fire pump. The minimum observed pressure is 0.1 bar(g) upstream the fire pump.

Scenario A.2.2 is acceptable from a hydraulic point of view.

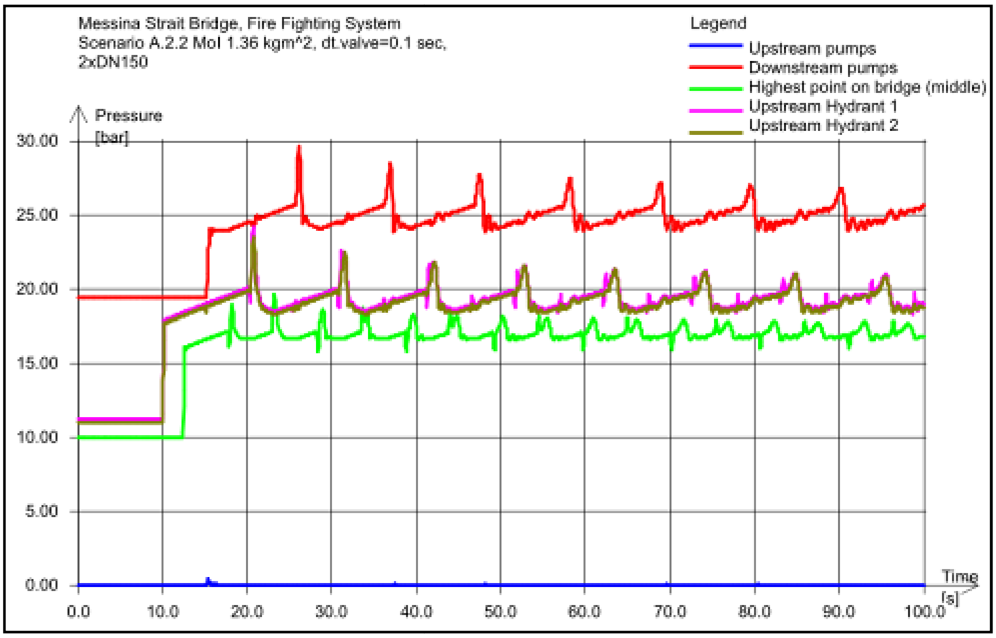


Figure 3-6 Scenario A.2.2 Pressure development as a function of time.

Scenario A.2.3 corresponds to scenario A.2.2 but now with one DN150 pipe in service and water is supplied from both pump stations. The 2 remotes hydrants are open. In this case the 2 remotest hydrants are on the middle of the bridge. Simulation results for scenario A.2.3 are presented in Figure 3-7.

The maximum observed pressure is 25 bar(g) downstream the fire pump. The minimum observed pressure is 0.1 bar(g) upstream the fire pump.

Scenario A.2.3 is acceptable from a hydraulic point of view.

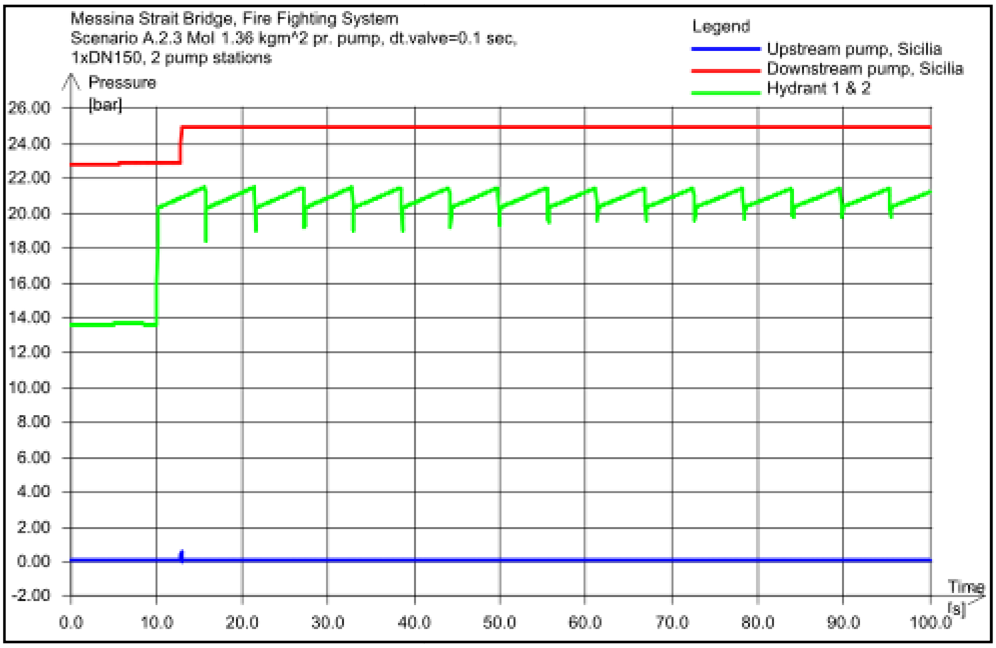


Figure 3-7 Scenario A.2.3 Pressure development as a function of time.

3.6.2.3 Pump Start

The system is initially in standby mode. At time t=10 seconds, the fire pump is started. The initial pressure conditions correspond to a minimum pressure of 8.9 bar(g) in the system (at the highest location, middle of the bridge).

The initial pump speed of the fire pump is 2442 rpm, to maintain the above mentioned 8.9 bar(g) at the middle of the bridge. This model configuration is equivalent to a scenario where the jockey pump is initially in operation to maintain a minimum pressure of 8.9 bar(g), and then the fire pump is started when the pressure drops (due to open hydrants).

At time t=10 seconds. two fire hydrants are opened. The opening time is assumed to be 0.1 second. At the same moment (t=10 seconds), the fire pump is started. The ramp-up time of the fire pump is assumed to be 0.1 seconds.

Figure 3-8 presents the simulation results for Scenario A.3.6. This scenario presents the system under normal operation with 2 DN150 pipes in service and one pump station in operation. The 2 remotest fire hydrants are open. The system includes one surge vessel, installed downstream fire pump with total water volume of 1 m^3. The initial air volume is 0.2 m^3.

The maximum observed pressure is 22 bar(g) and the minimum pressure is 0.1 bar(g). Scenario

A.3.6 is acceptable from hydraulic point of view.

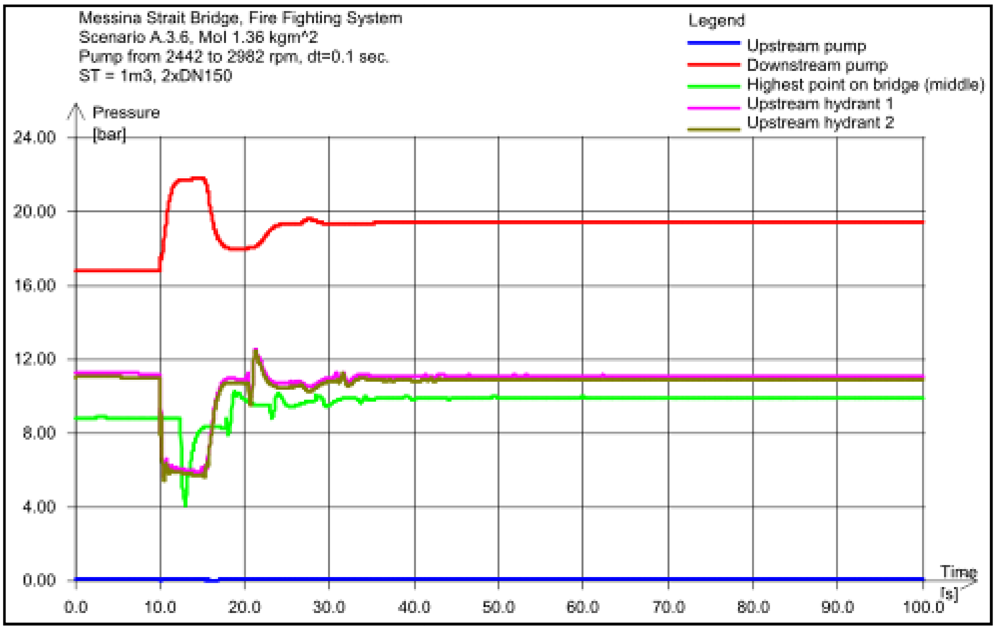


Figure 3-8 Scenario A.3.6 Pressure development as a function of time.

Scenario A.3.7 corresponds to scenario A.3.6 but now with one DN150 pipe in service and water is supplied from both pump stations. The 2 remotes hydrants are open. In this case the 2 remotest hydrants are on the middle of the bridge. The system includes one surge vessel in each pump station, installed downstream the fire pump with total water volume of 1 m^3 each. The initial air volume is 0.2 m^3. Simulation results for scenario A.3.7 are presented in Figure 3-9.

The maximum observed pressure is 21.5 bar(g) and the minimum pressure is 0.1 bar(g). Scenario A.3.6 is acceptable from a hydraulic point of view.

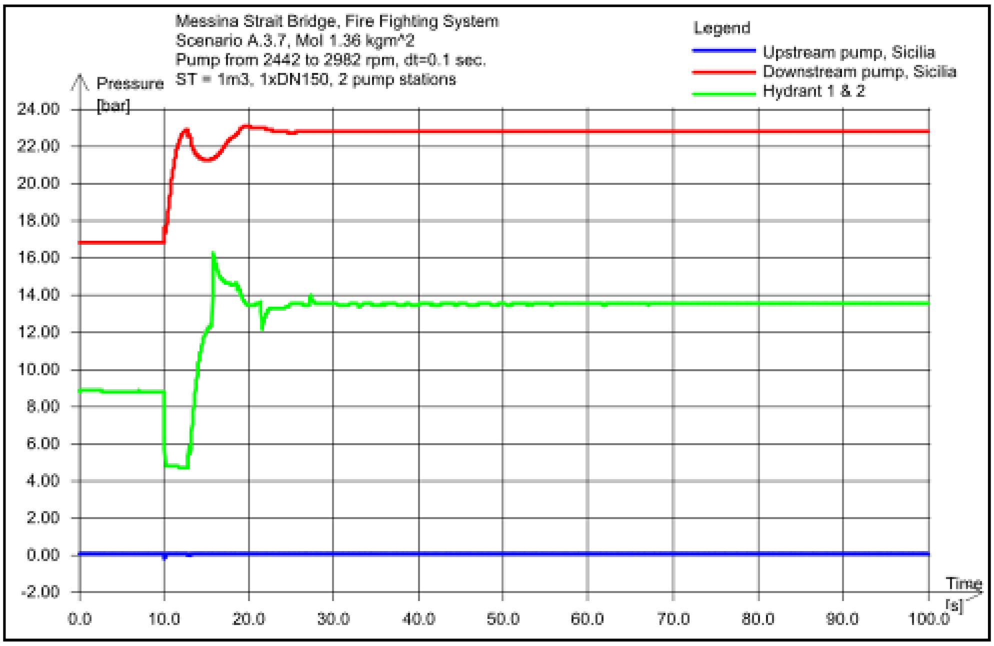


Figure 3-9 Scenario A.3.7 Pressure development as a function of time.

The volume of the surge vessel is 1.0 m^3. Sensitivity analyses indicate that this is a suitable volume for the surge vessel. A larger surge vessel will result in smoother pressure development but only by a small margin compared to the surge vessel volume.

With regards to the suitable size of the surge vessel, please note the comments in section 3.3.1.

3.7 Results, Tower - High Beam

3.7.1 Steady state

The required water flow is 300 l/min, which is to be delivered at minimum 6.0 bar(g).

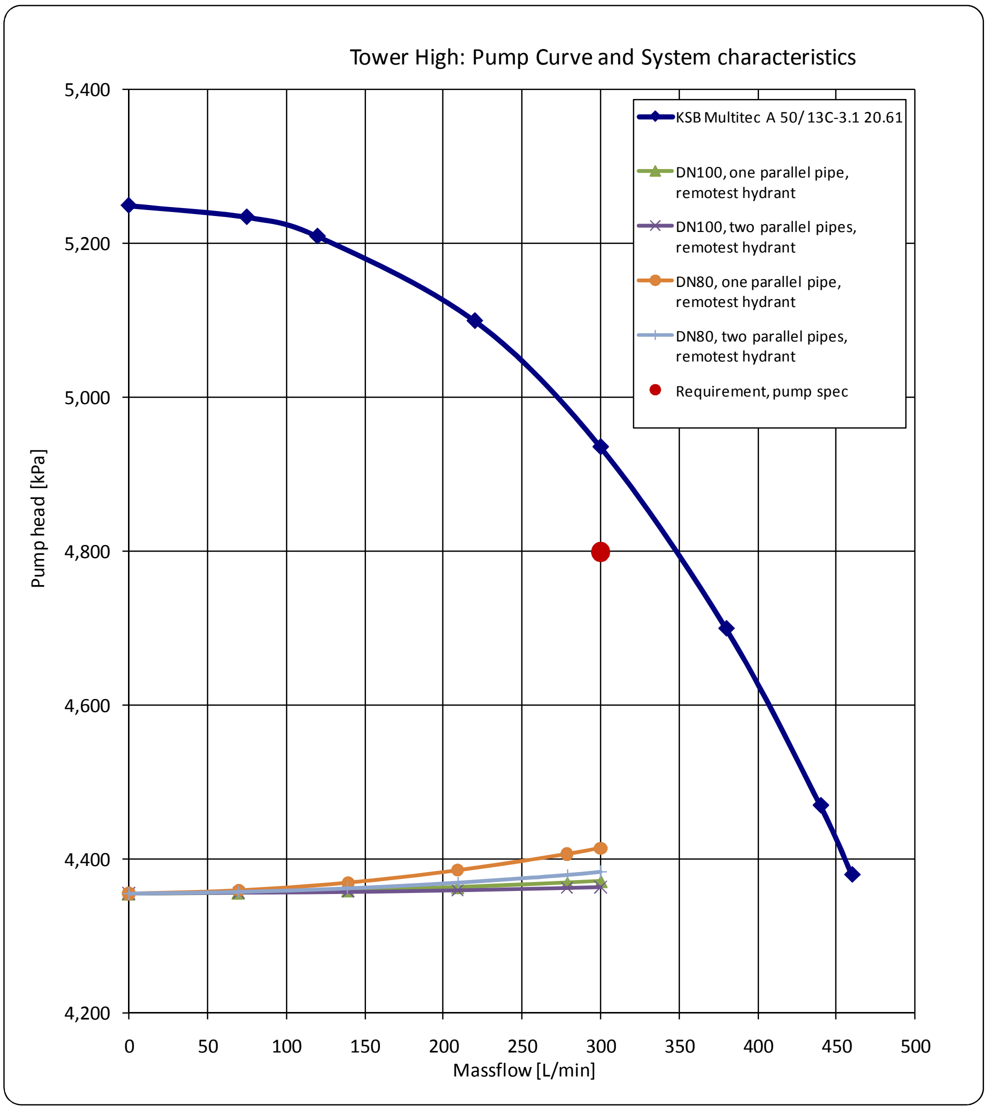


Figure 3-10 Tower High, Pump curve and system characteristics.

Figure 3-10 illustrates the pump curve and system characteristics. A larger format can be viewed in attachment B. The figure reveals marginal difference between DN80 and DN100 in required pump head. The selected pipe dimension is DN80.

At flow rate 300 l/min and with pipe dimension DN80 the necessary pump head is 44.2 bar, and the maximum velocity is 0.94 m/s. The necessary pump head is defined as the pump head required to maintain the pressure at minimum 6.0 bar(g) at all locations in the network.

The delivered pump head at flow 300 l/min is 49.6 bar. The reason for this is that the pumps are not speed regulated. The minimum pressure in the system is 11.5 bar(g) upstream the open fire hydrant.

The maximum pressure upstream fire hydrants at design flow is 24.6 bar(g).

The pump head at zero flow is 59.6 bar. The pressure class should minimum be the maximum observed pressure under normal operation. The recommended pressure class is therefore PN63.

3.7.2 Transient

3.7.2.1 Pump Trip

The system is initially in full operation, the water flow is 300 l/min, and the pumps are at full speed, 2950 rpm. At time t=10 seconds, the fire pump trips.

Figure 3-11, Figure 3-12 and Figure 3-13 present the simulation results for scenario B.1.1. This is the reference scenario. The reference scenario does not include surge vessel, vacuum breakers or surge relief valves.

The results show an instantaneous pressure drop downstream the fire pump. The pressure drops from 50 bar(g) down to around 38 bar(g). Pressure of 38 bar(g) corresponds to the elevation difference between the fire pump and the hydrant. It is assumed that no backflow is allowed in the fire pump, this is illustrated in Figure 3-13.

The maximum observed pressure is 49.7 bar(g) downstream the fire pump. The minimum pressure is -0.2 bar(g).

Figure 3-12 is a close-up look of the pressure development at the fire hydrant. The figure illustrates a negative pressure of -0.2 bar(g). There is a spike in the pressure graph down to -0.4 bar(g), which is considered to be simulation noise and therefore is disregarded.

The simulation results depend strongly on the backflow assumption. It is assumed that no backflow is allowed, not through the fire pump or e.g. a non-return valve. In case of any backflow at the fire pump, the pressure at the fire hydrant will be lower than simulated.

Scenario B.1.1 is not acceptable from a hydraulic point of view.

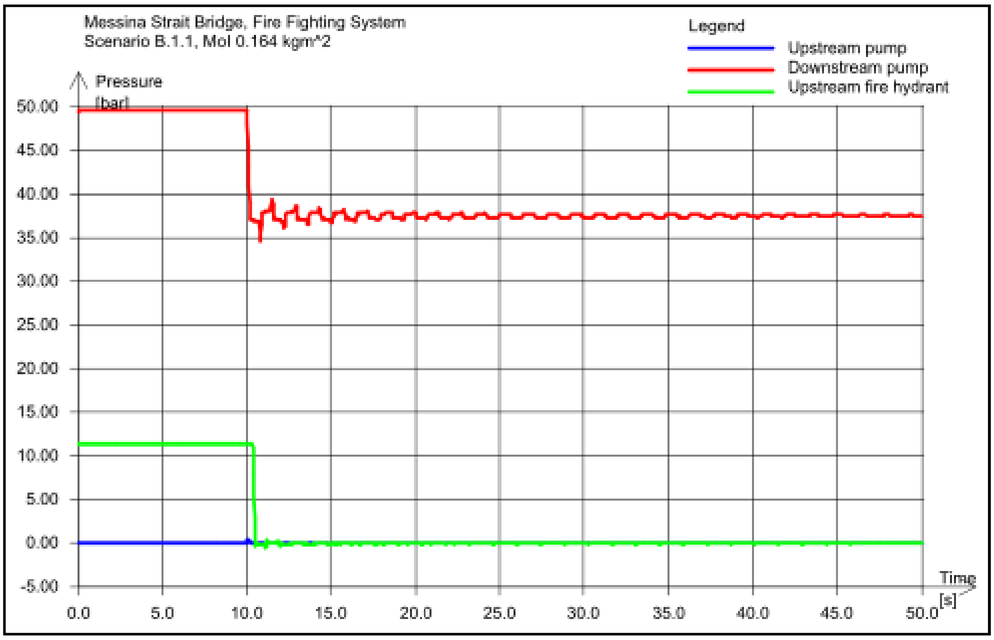


Figure 3-11 Scenario B.1.1 Pressure development as a function of time.

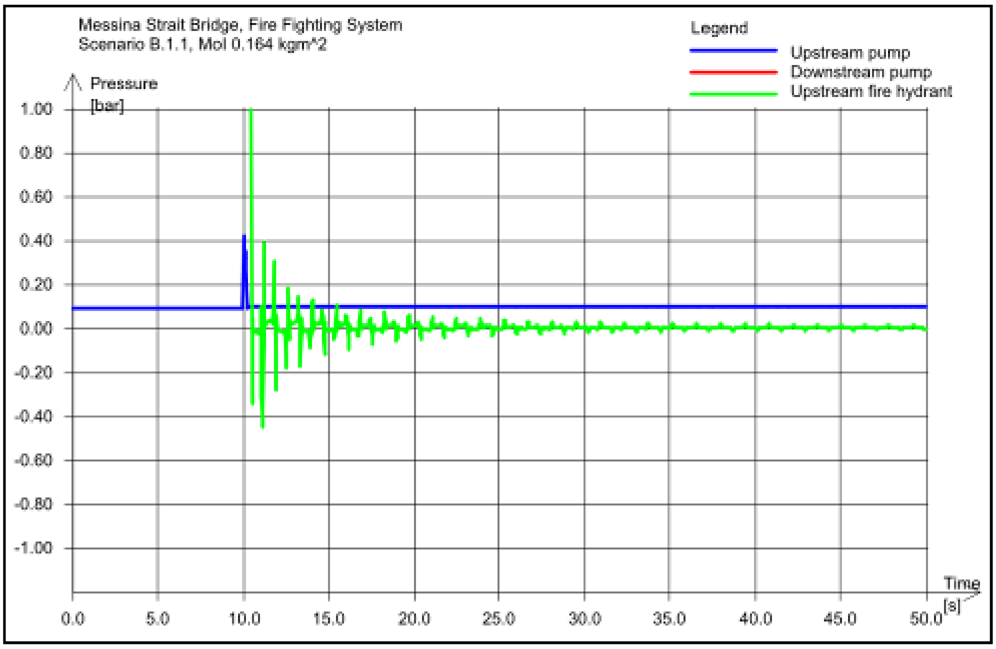


Figure 3-12 Scenario B.1.1 Pressure development as a function of time.

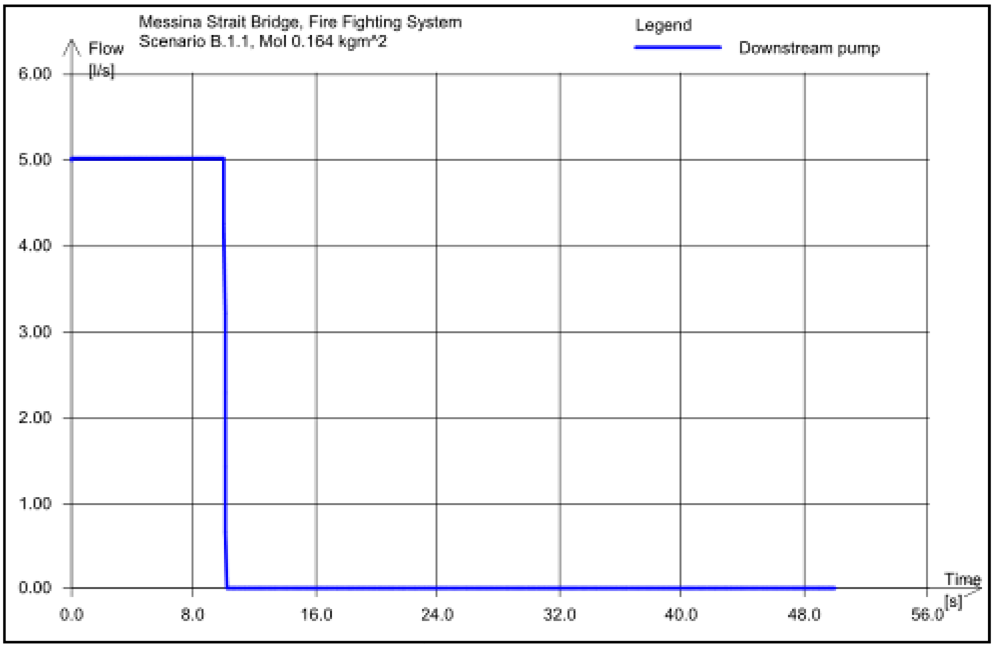


Figure 3-13 Scenario B.1.1 Flow development as a function of time.

In scenario B.1.2, a vacuum breaker has been inserted at the highest elevation near the fire hydrant (and at same elevation as the fire hydrant). The simulation results are presented in Figure 3-14 and Figure 3-15. It is assumed that the size and capacity of the vacuum breaker are sufficient.

The results indicate that the vacuum breaker is activated at time t=11.3 seconds, when the pressure at the fire hydrant drops to 0 bar(g). The pressure at this location remains 0 bar(g), indicating that the vacuum breaker remains activated throughout the simulation period. The water flow drops from 300 l/min down to 0 l/min immediately after the pump trip.

The maximum observed pressure is 49.7 bar(g) downstream the fire pump. The minimum pressure is 0 bar(g).

The presence of a vacuum breaker of sufficient size and capacity at the highest elevation in the system can solve the issue of pressure below 0 bar(g).

Scenario B.1.2 is acceptable from a hydraulic point of view.

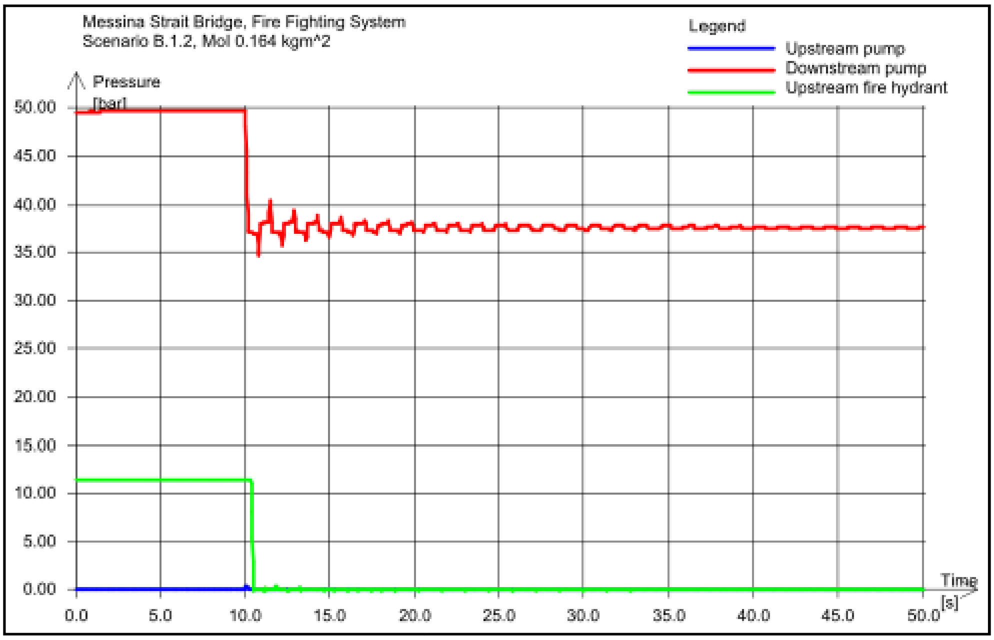


Figure 3-14 Scenario B.1.2 Pressure development as a function of time.

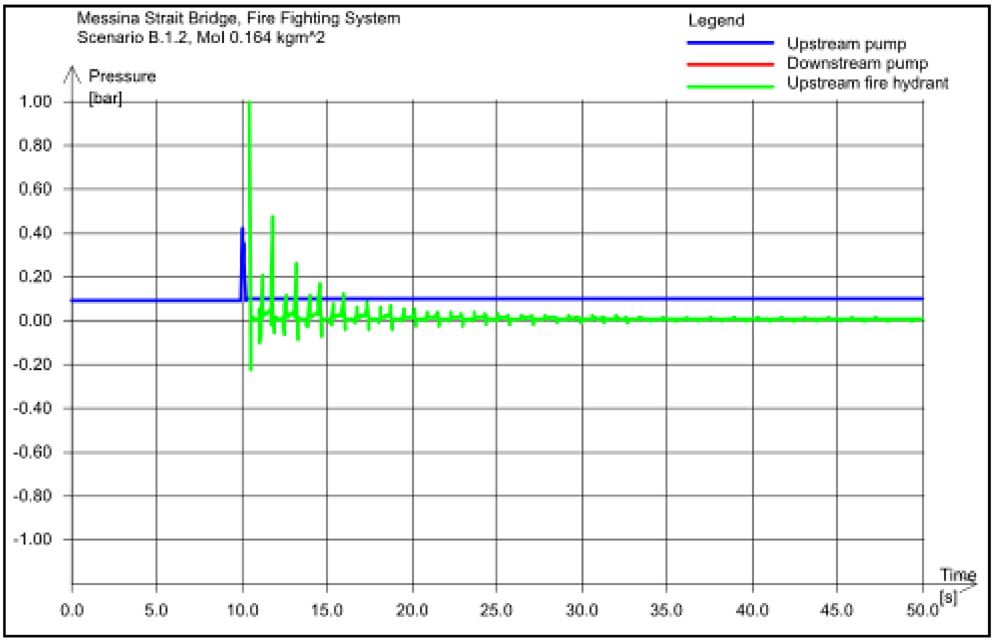


Figure 3-15 Scenario B.1.2 Pressure development as a function of time.

3.7.2.2 Valves Closing

The system is initially in full operation, the water flow is 300 l/min, and the pump is at full speed, 2950 rpm. At time t=10 seconds, the fire hydrant is closed. To illustrate the worst-case scenario with regard to closing of the fire hydrant, a short closing time is chosen. The closing time of the hydrant is 0.1 second.

Figure 3-16 and Figure 3-17 present the simulation results for scenario B.2.1. This is the reference scenario. The reference scenario does not include any surge vessel, vacuum breakers or surge relief valves.

The results show are sudden rise in pressure at the fire hydrant at the time when the hydrant is closed. The maximum observed pressure is 65 bar(g) downstream the fire pump. The minimum observed pressure is 0 bar(g) upstream the fire pump.

Scenario B.2.1 is acceptable from a hydraulic point of view.

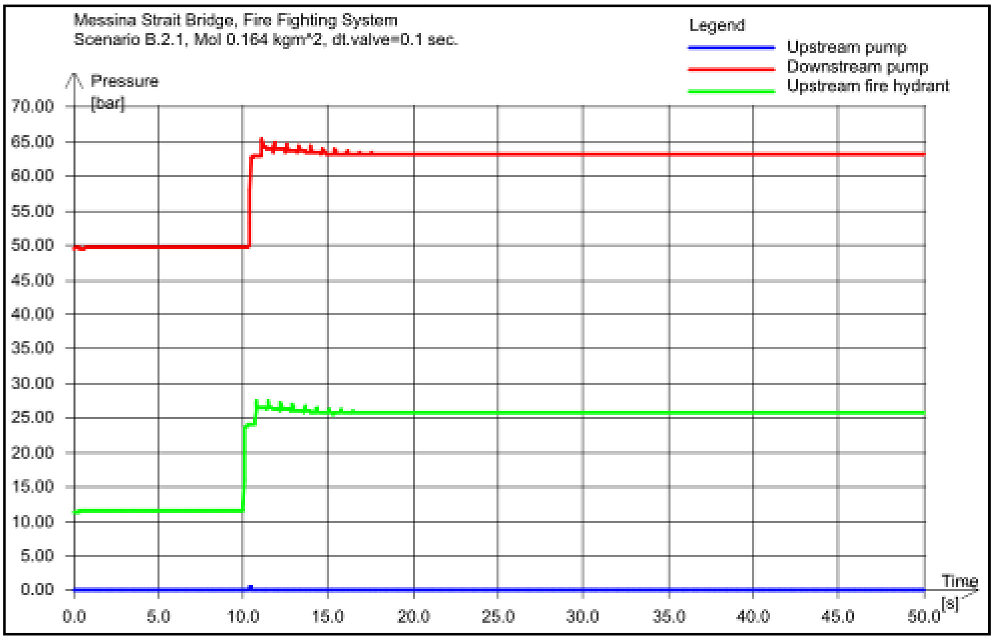


Figure 3-16 Scenario B.2.1 Pressure development as a function of time.

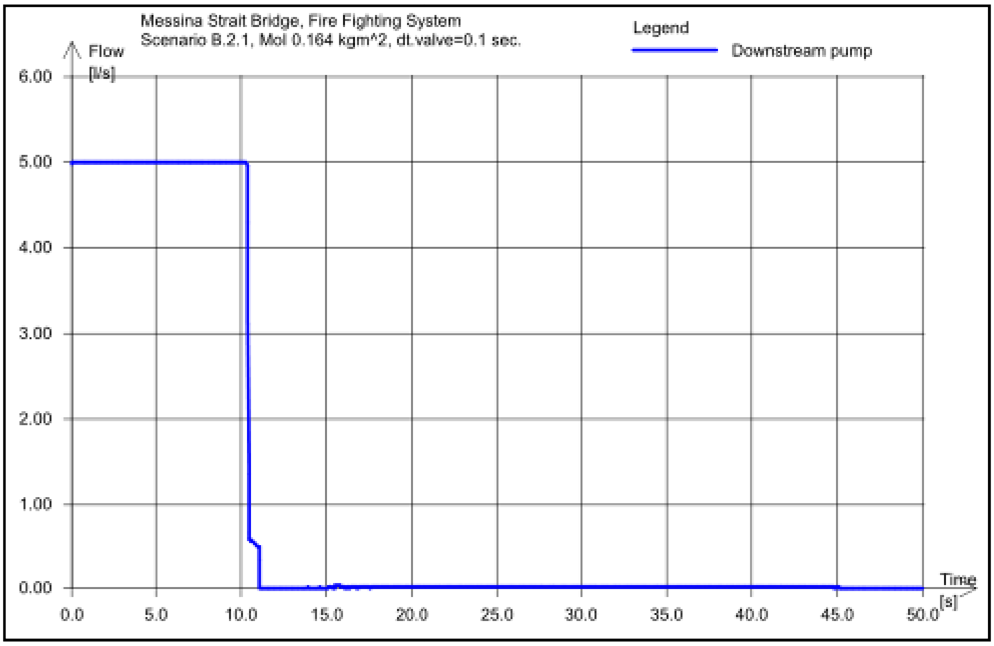


Figure 3-17 Scenario B.2.1 Flow development as a function of time.

3.7.2.3 Pump Start

The system is initially in standby mode, and then the fire pump is started. The initial pressure conditions correspond to at minimum pressure of 6.0 bar(g) in the system at the highest location (383 metres), upstream the hydrant).

The initial pump speed of the fire pump is 2404 rpm, to maintain the above mentioned 6.0 bar(g) upstream the hydrant. This model configuration is equivalent to a scenario where the jockey pump is initially in operation to maintain a minimum pressure of 6.0 bar(g), and the fire pump is started when the pressure drops (due to an open hydrant).

The reference scenario B.3.1 does not include a surge vessel.

The other presented scenario B.3.4 includes a surge vessel with a volume of 0.1 m^3. The initial air volume at pressure 42 bar(g) is 0.02 m^3.

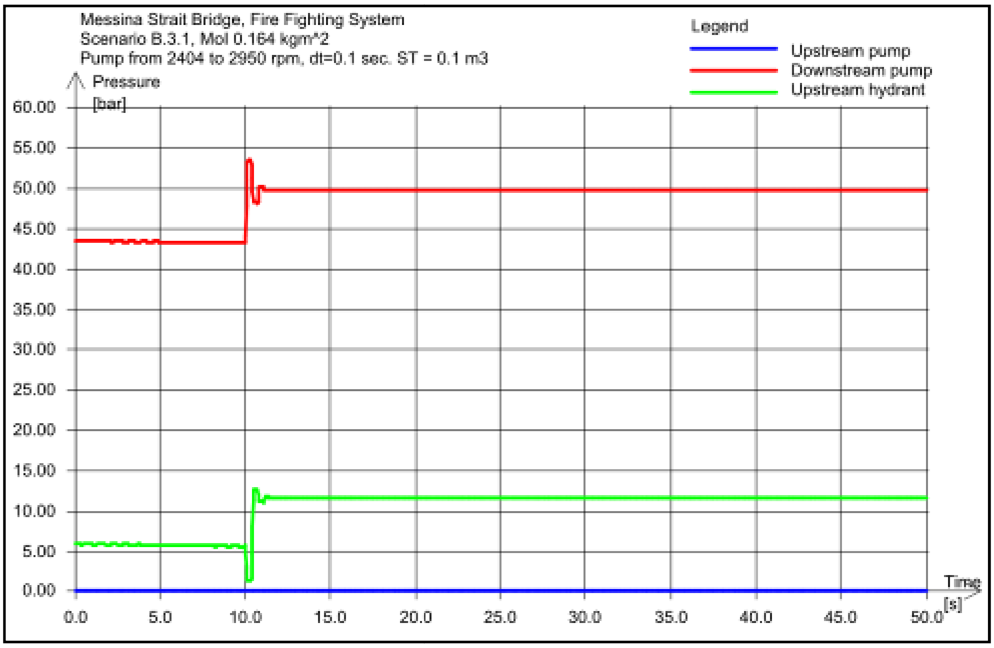


Figure 3-18 Scenario B.3.1 Pressure development as a function of time.

Figure 3-18 presents the simulation results for Scenario B.3.1. This scenario is the reference scenario, with no surge vessel installed.

The system is in standby-mode from time t=0 to t=10 seconds. In standby-mode, the minimum pressure in the system is maintained at 6.0 bar(g) (4.0 bar(g) + 0.5 bar in safety + 1.5 in pressure drop in fire hydrant). The minimum pressure is upstream the fire hydrant at the highest elevation.

At time t=10 seconds, the fire hydrant is opened. The opening time is assumed to be within 1 second. At the same moment (t=10 seconds), the fire pump is started. The ramp-up time of the pump is assumed to be 0.1 seconds.

The results show that the resulting pressure in the system has a maximum of 54 bar(g) downstream the fire pump and minimum of 1.5 bar(g) upstream the fire hydrant. The pressure development is very rapid, almost instantaneous.

Figure 3-19 presents the simulation result for scenario B.3.4. This scenario corresponds to the reference scenario, but with surge vessel installed downstream the fire pump.

The resulting maximum and minimum pressure are 50 bar(g) and 1.5 bar(g) and the pressure development is more smooth compared to scenario B.3.1. The volume of the surge vessel is 0.1 m^3. Sensitivity analyses indicate that this is a suitable volume for the surge vessel. A larger surge vessel will result in smoother pressure development, but only by a small margin compared to the surge vessel volume.

Please note comments in section 3.3.1 on start/stop operation.

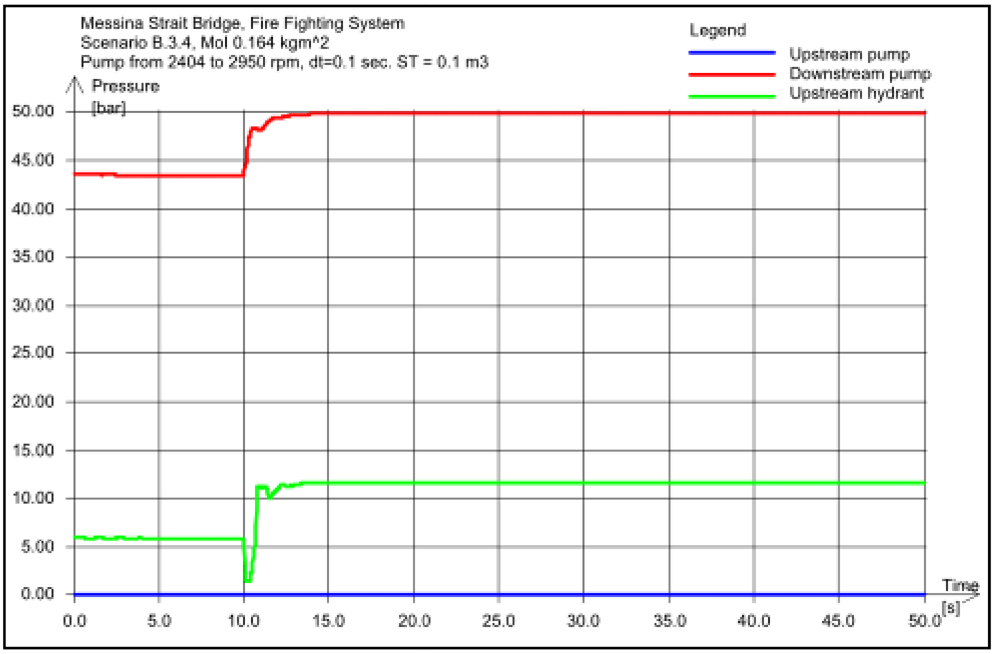


Figure 3-19 Scenario B.3.4 Pressure development as a function of time.

3.8 Results, Tower - Low Beam

3.8.1 Steady state

The required water flow is 300 l/min, which is to be delivered at minimum 6.0 bar(g).

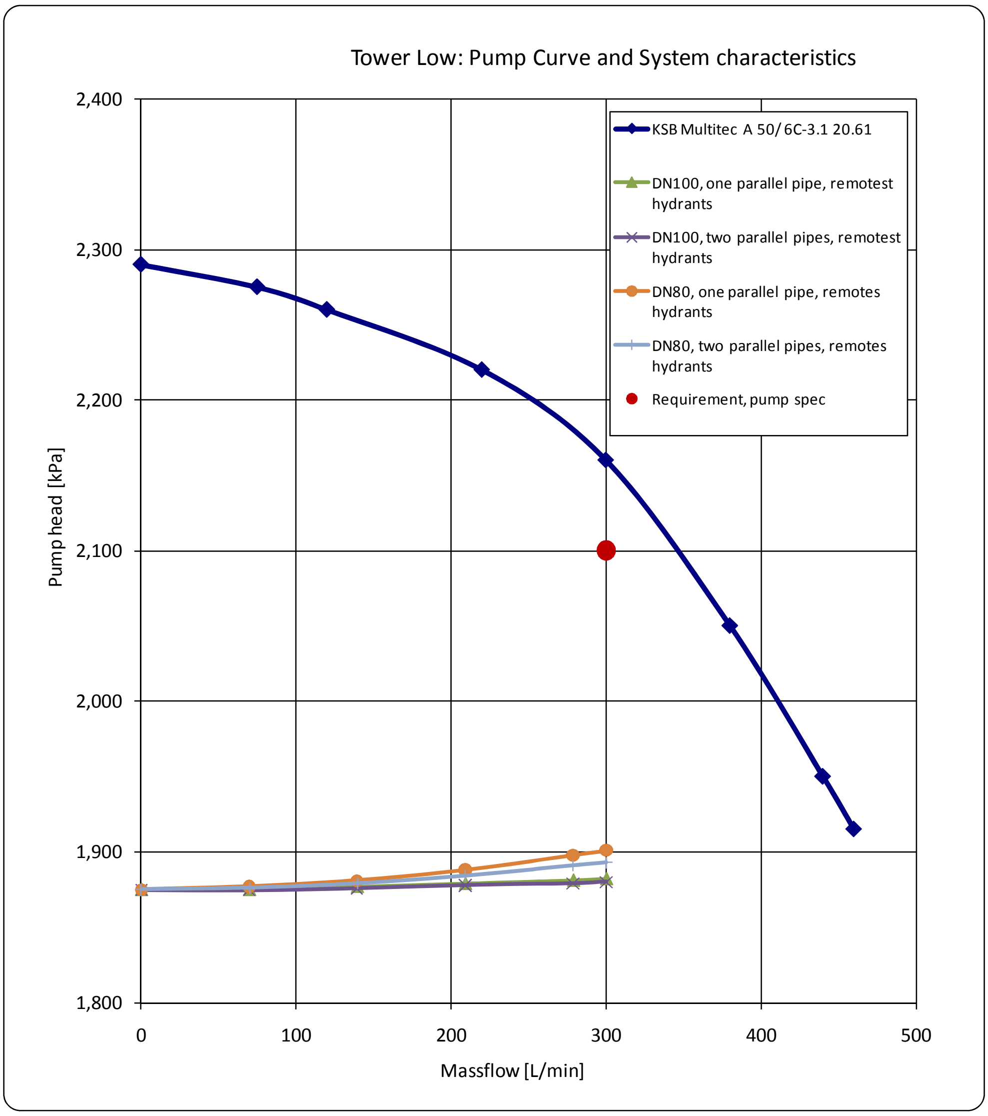


Figure 3-20 Tower Low, Pump curve and system characteristics.

Figure 3-20 illustrates the pump curve and system characteristics. A larger format can be viewed in attachment C. The figure reveals marginal difference between DN80 and DN100 in required pump head. The selected pipe dimension is DN80.

At flow rate 300 l/min and with pipe dimension DN80, the necessary pump head is 19.0 bar, and the maximum velocity is 0.94 m/s. The necessary pump head is defined as the pump head required to maintain the pressure at minimum 6.0 bar(g) at all locations in the network.

The delivered pump head at flow 300 l/min is 21.7 bar. The reason for this is that the pumps are not speed regulated. The minimum pressure in the system is 8.7 bar(g) upstream the open fire hydrant, which is 2.7 bar above the requirements.

The maximum pressure upstream fire hydrants at design flow is 8.7 bar(g).

The pump head at zero flow is 25.9 bar. The pressure class should minimum be the maximum observed pressure under normal operation. For this reason, the recommended pressure class is PN40.

The simulations have been performed with the assumed lowest possible water level in the supply tanks, 1 metre above the pump elevation. When the tanks are full the pressure at zero flow is higher than 25.9 bar(g). If the water level in the tanks is, e.g. 5 metres above the pump level the resulting maximum pressure in the system is 26.4 bar(g).

The pump curve can be adjusted so that the fire pump does not exceed the 25 bar(g) limit and maintain a minimum 6.0 bar(g). The delivered pump head at zero flow should be lowered by 1.4 bar from 26.4 bar to 25, but the pump should be able to deliver a pump head of 19 bar at flow rate of 300 l/min. The maximum water level of the supply tanks should also be taken into consideration in this matter. If this is done then the suggested pressure class can be brought down to PN25.

Another solution could be to construct the pipe section from pump to bridge elevation in a pressure class PN40 and the rest of the system in PN25.

3.8.2 Transient

3.8.2.1 Pump Trip

The system is initially in full operation, the water flow is 300 l/min, and the pumps are at full speed, 2950 rpm. At time t=10 seconds, the fire pump trips.

Figure 3-21, Figure 3-22 and Figure 3-23 present the simulation results for Scenario C.1.1. This is the reference scenario. The reference scenario does not include surge vessel, vacuum breakers or surge relief valves.

The results show an instantaneous pressure drop downstream the fire pump. The pressure drops from 21.7 bar(g) down to around 13 bar(g), which corresponds to the elevation difference between the fire pump and the hydrant. It is assumed that fire pump allows no backflow, this is illustrated in Figure 3-23.

Figure 3-22 is a close-up look of the pressure development at the fire hydrant. The figure illustrates a negative pressure of -0.2 bar(g).

The simulation results depend strongly on the backflow assumption. It is assumed that no backflow is allowed, not through the fire pump or e.g. a non-return valve. In case of any backflow at the fire pump, the pressure at the fire hydrant will be lower than simulated.

The maximum observed pressure is 21.7 bar(g) downstream the fire pump. The minimum observed pressure is -0.2 bar(g) upstream the fire hydrant.

Scenario C.1.1 is not acceptable from a hydraulic point of view.

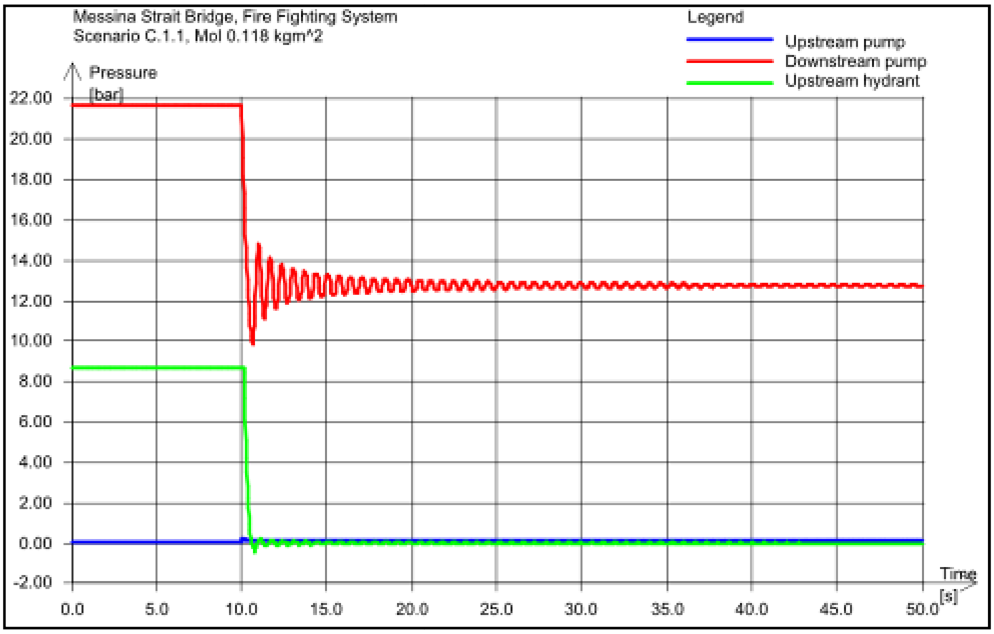


Figure 3-21 Scenario C.1.1 Pressure development as a function of time.

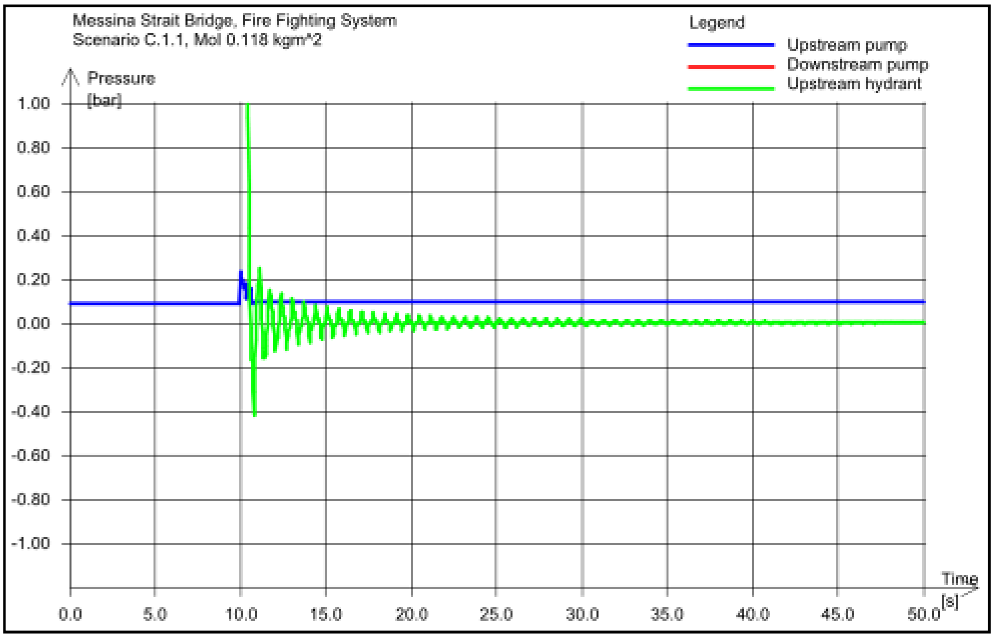


Figure 3-22 Scenario C.1.1 Pressure development as a function of time.

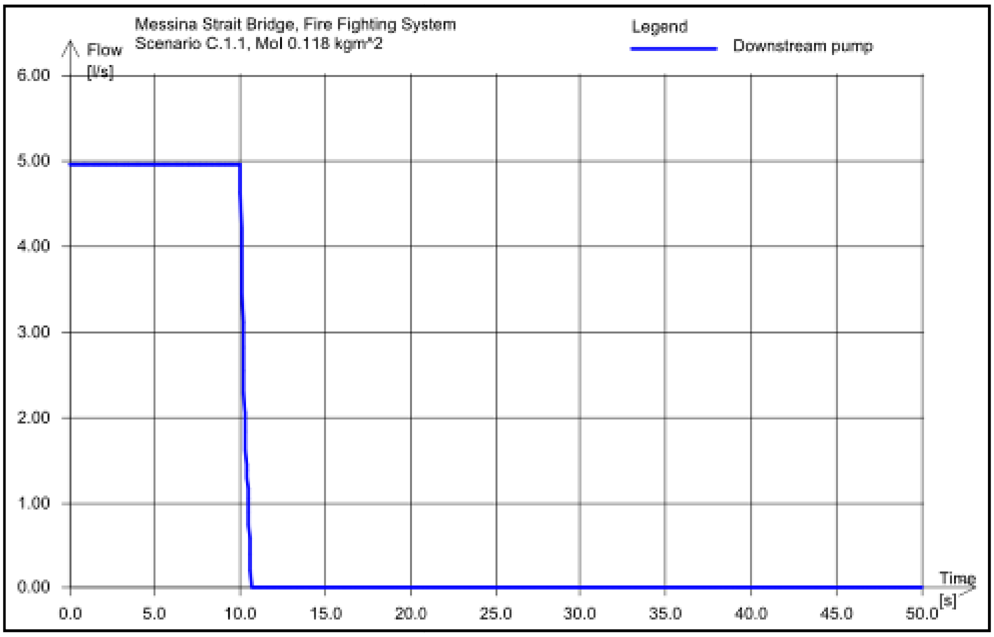


Figure 3-23 Scenario C.1.1 Flow development as a function of time.

In Scenario C.1.2, a vacuum breaker has been inserted at the highest elevation near the fire hydrant (and at same elevation as the fire hydrant). The simulation results are presented in Figure 3-24 and Figure 3-25 . It is assumed that the size and capacity of the vacuum breaker is sufficient.

The results indicate that the vacuum breaker is activated at time t=11 seconds, when the pressure at the fire hydrant drops to 0 bar(g). The pressure at this location remains 0 bar(g), indicating that the vacuum breaker remains activated. The water flow drops from 300 l/min down to 0 l/min immediately after the pump trip.

The presence of a vacuum breaker of sufficient size and capacity at the highest elevation in the system can solve the issue of pressure below 0 bar(g).

The maximum observed pressure is 21.7 bar(g) downstream the fire pump. The minimum observed pressure is 0 bar(g) upstream the fire hydrant.

Scenario C.1.2 is acceptable from a hydraulic point of view.

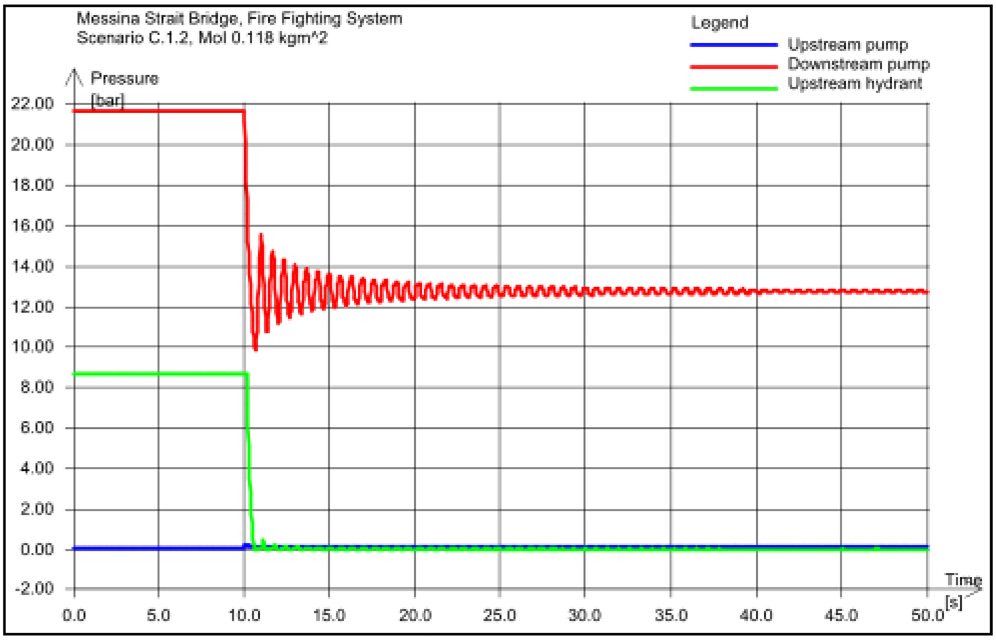


Figure 3-24 Scenario C.1.2 Pressure development as a function of time.

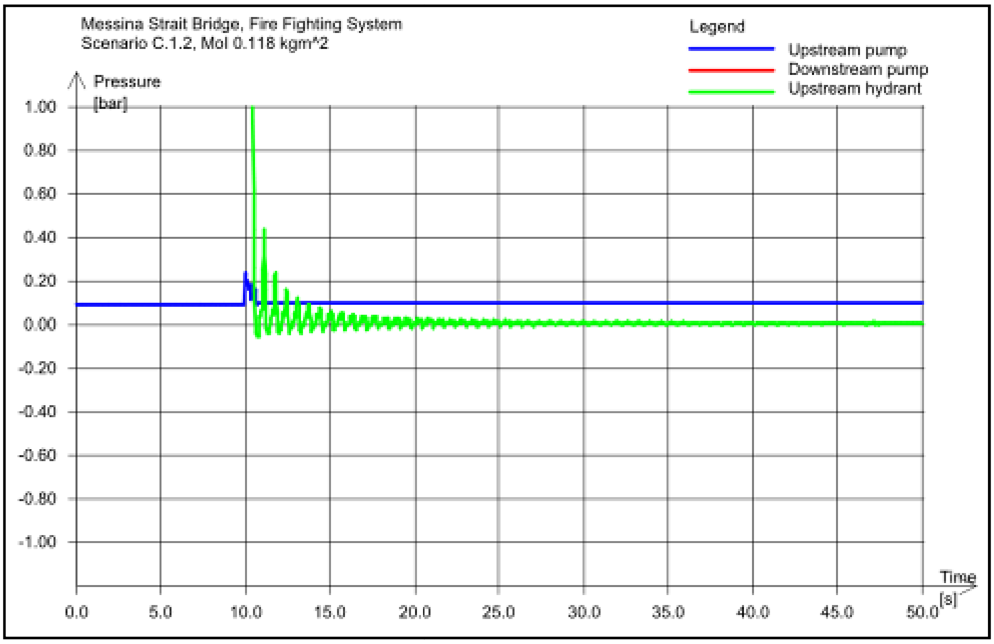


Figure 3-25 Scenario C.1.2 Pressure development as a function of time.

3.8.2.2 Valves Closing

The system is initially in full operation, the water flow is 300 l/min, and the pumps are at full speed, 2950 rpm. At time t=10 seconds, the fire hydrant is closed. To illustrate the worst-case scenario with regard to closing of fire hydrant, a short closing time is chosen. The closing time of the hydrant is 0.1 seconds.

Figure 3-26 and Figure 3-27 present the simulation results for Scenario C.2.1. This is the reference scenario. The reference scenario does not include any surge vessel, vacuum breakers or surge relief valves.

The results show a sudden rise in pressure upstream the fire hydrant at the time when the hydrant is closed. The maximum observed pressure is 34 bar(g) downstream the fire pump. The minimum observed pressure is 0 bar(g) upstream the fire pump.

Scenario C.2.1 is acceptable from a hydraulic point of view.

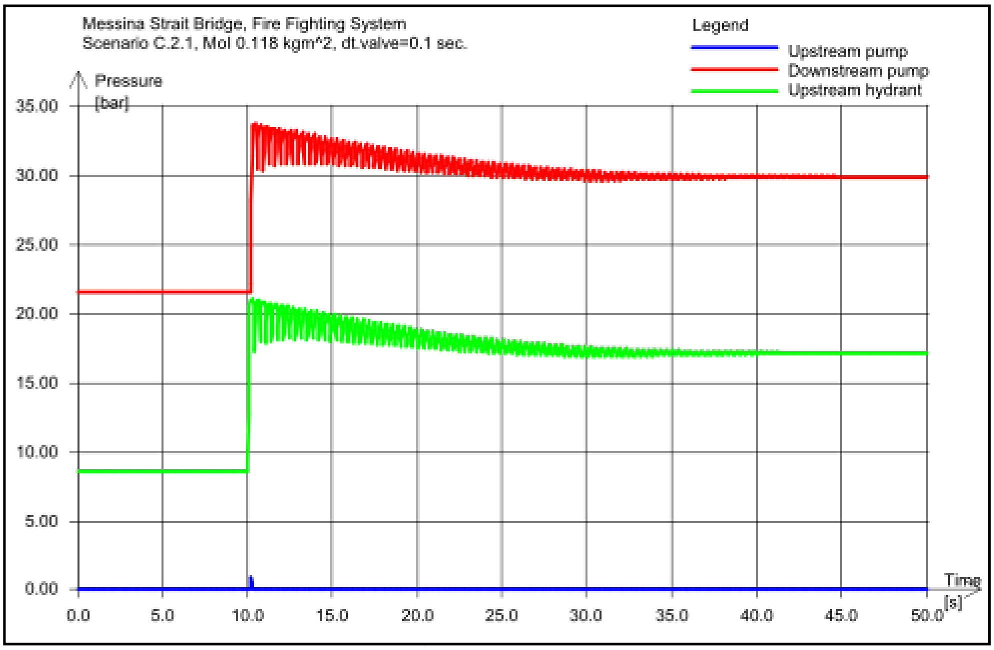


Figure 3-26 Scenario C.2.1 Pressure development as a function of time.

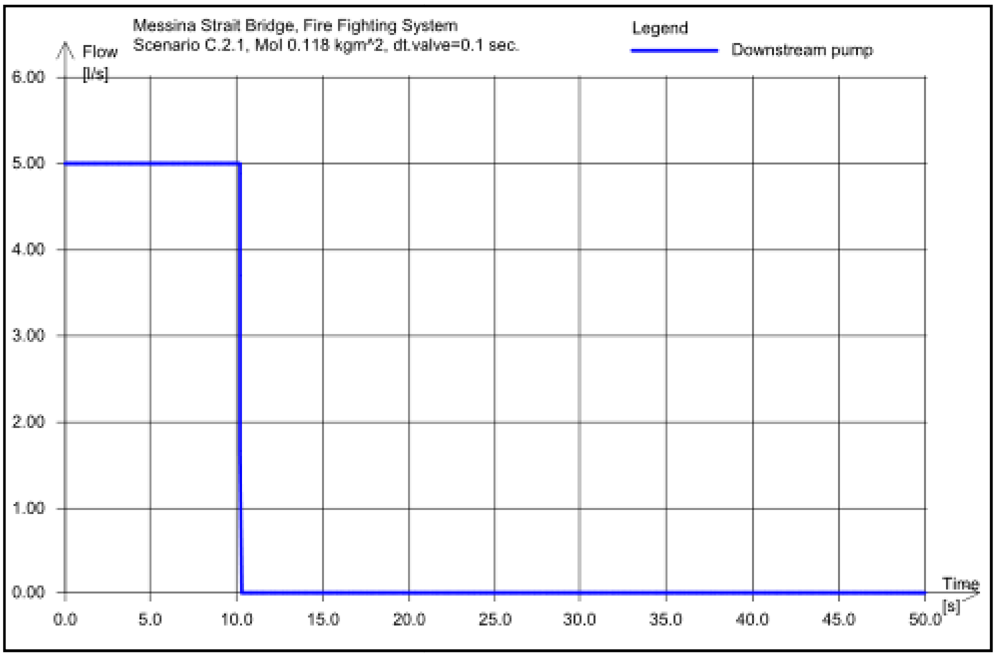


Figure 3-27 Scenario C.2.1 Flow development as a function of time.

3.8.2.3 Pump Start

The system is initially in standby mode, and then the fire pumps are started. The initial pressure conditions correspond to at minimum pressure of 6.0 bar(g) in the system at the highest location (130 metres), upstream the hydrant.

The initial pump speed of the fire pump is 2385 rpm, to maintain the above mentioned 6.0 bar(g) upstream the hydrant. This model configuration is equivalent to a scenario where the jockey pumps are initially in operation to maintain a minimum pressure of 6.0 bar(g), and then fire pump is started when the pressure begins to drop (due to the open hydrant).

The reference Scenario C.3.1 does not include a surge vessel.

The other presented scenario, C.3.3, includes a surge vessel with a volume of 0.1 m^3. The initial air volume at pressure 17.3 bar(g) is 0.02 m^3.

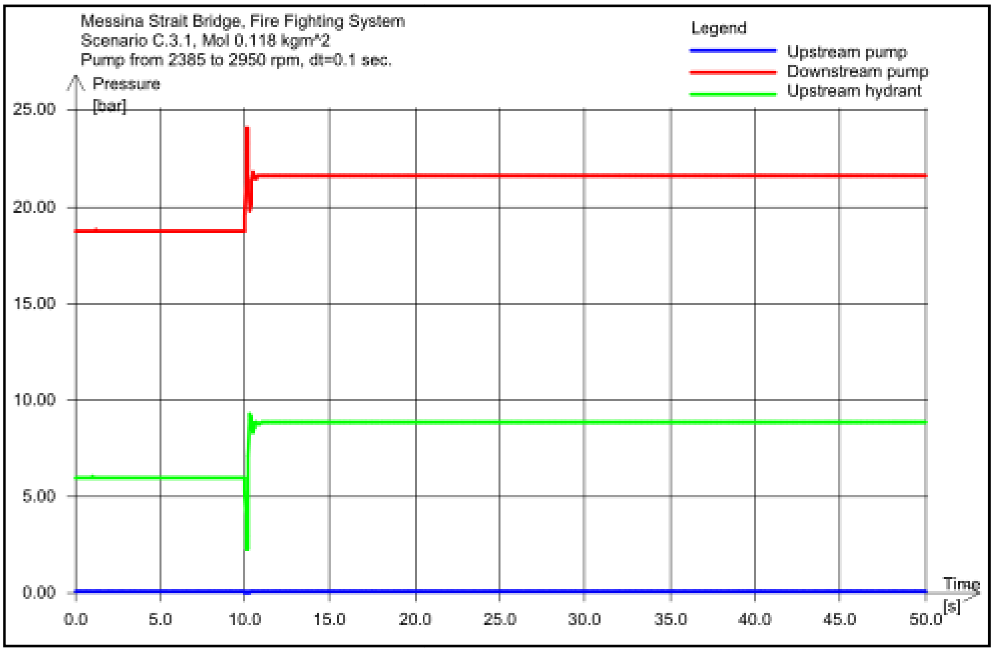


Figure 3-28 Scenario C.3.1 Pressure development as a function of time.

Figure 3-28 presents the simulation results for Scenario C.3.1. This scenario is the reference scenario, with no surge vessel installed.

The system is in standby-mode from time t=0 to t=10 seconds. In standby-mode, the minimum pressure in the system is maintained at 6.0 bar(g) (4.0 bar(g) + 0.5 bar in safety + 1.5 bar in pressure drop in fire hydrant). The minimum pressure is upstream the fire hydrant at the highest elevation.

At time t=10 seconds, the fire hydrant is opened. The opening time is assumed to be within 1 second. At the same moment (t=10 seconds), the fire pump is started. The ramp-up time of the fire pump is assumed to be 0.1 seconds.

The results show that the resulting pressure in the system has a maximum of 24 bar(g) downstream the fire pump and minimum of 2 bar(g) upstream the fire hydrant. The pressure development is very rapid, almost instantaneous.

Figure 3-29 presents the simulation result for scenario C.3.3. This scenario corresponds to the reference scenario, but with are surge vessel installed downstream the fire pump.

The resulting maximum pressure is 22 bar(g) and the minimum pressure is 2 bar(g). The pressure development is more smooth compared to scenario C.3.1. The volume of the surge vessel is 0.1 m^3. From sensitivity analysis it has been concluded that this is a suitable volume for the surge vessel. A larger surge vessel will result in smoother pressure development but only by a small margin compared to the surge vessel volume.

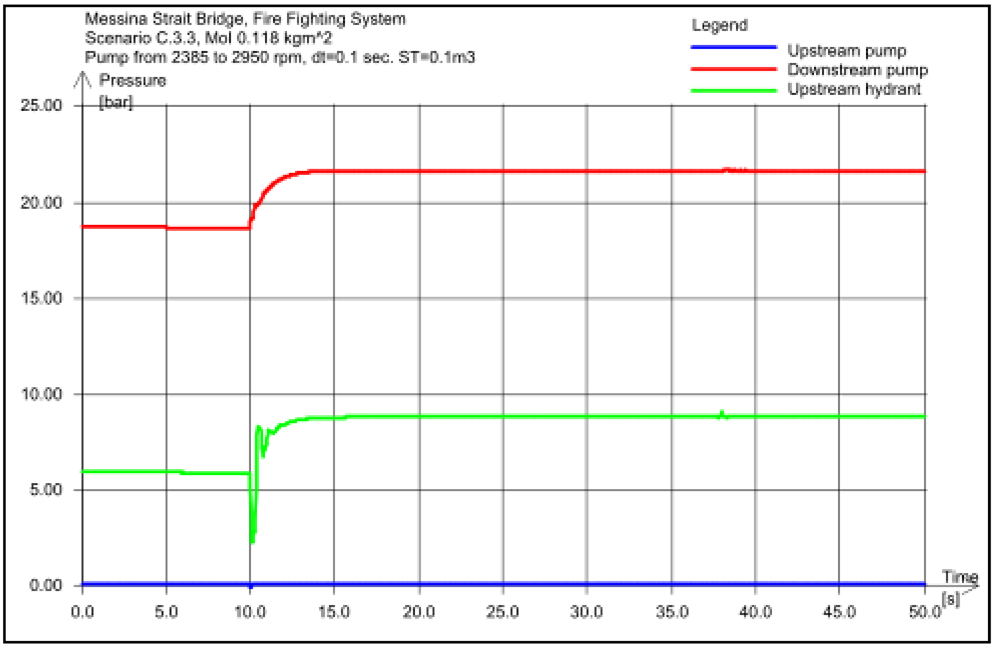
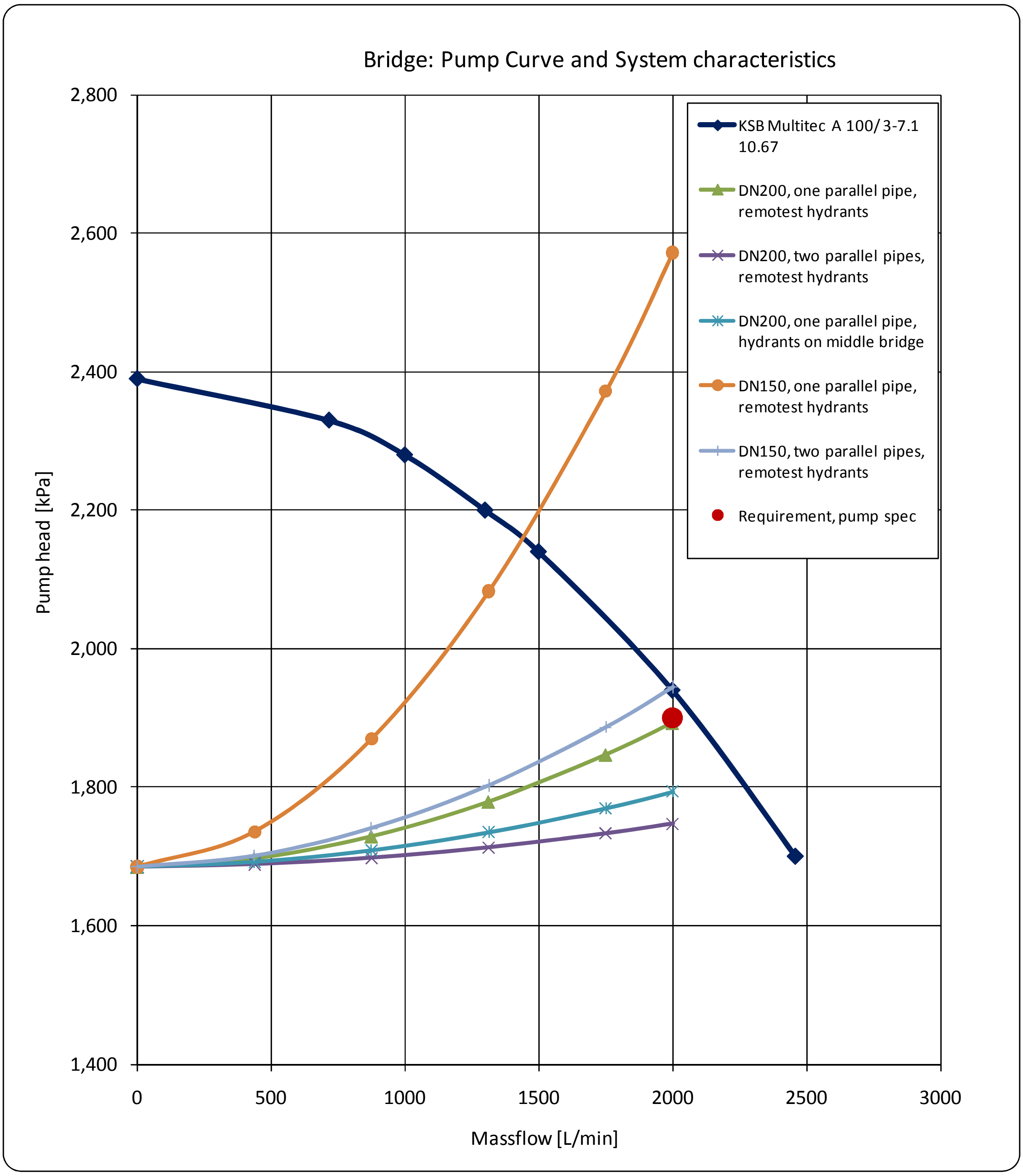


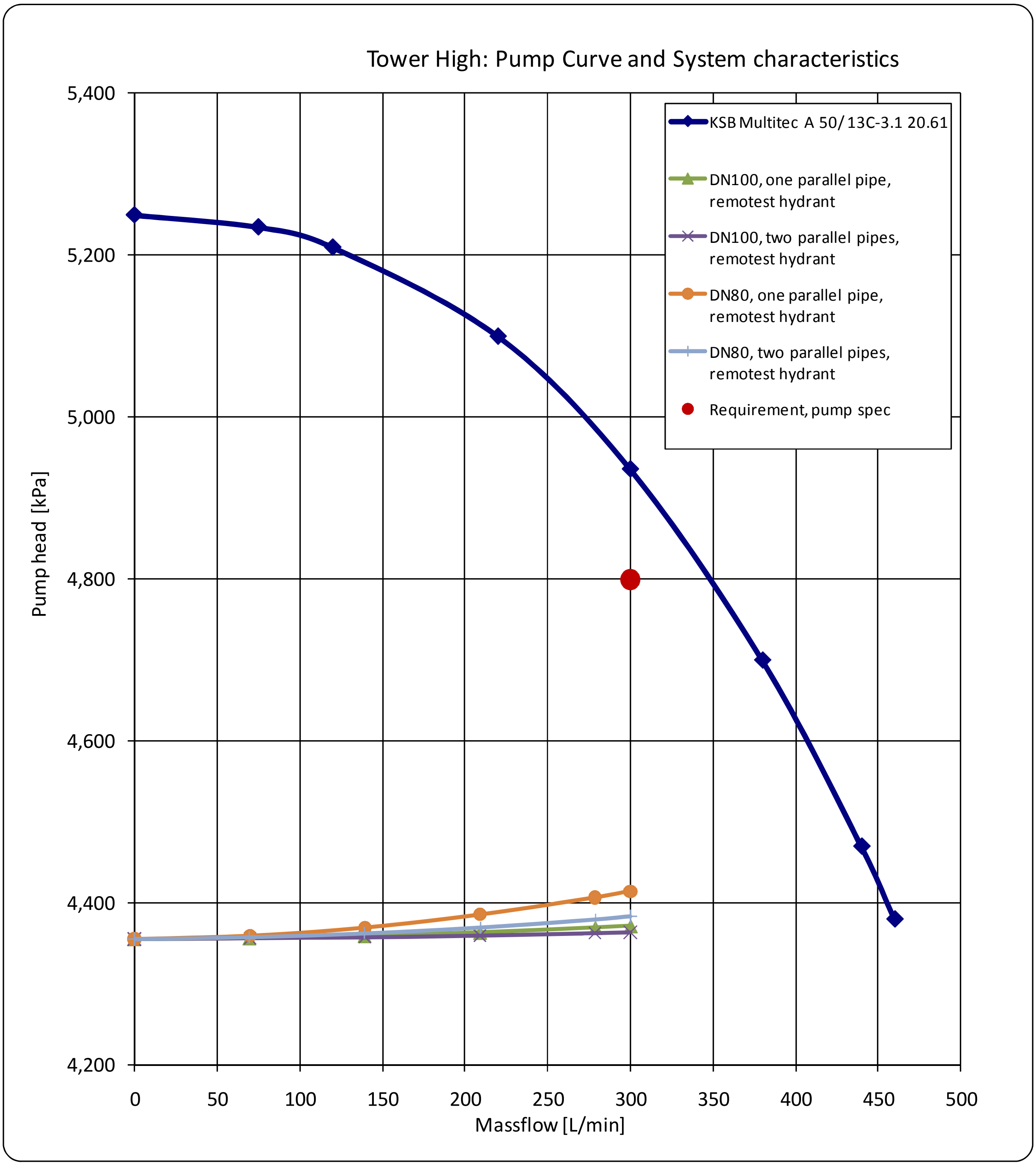
Figure 3-29 Scenario C.3.3 Pressure development as a function of time.

3.9 Miscellaneous

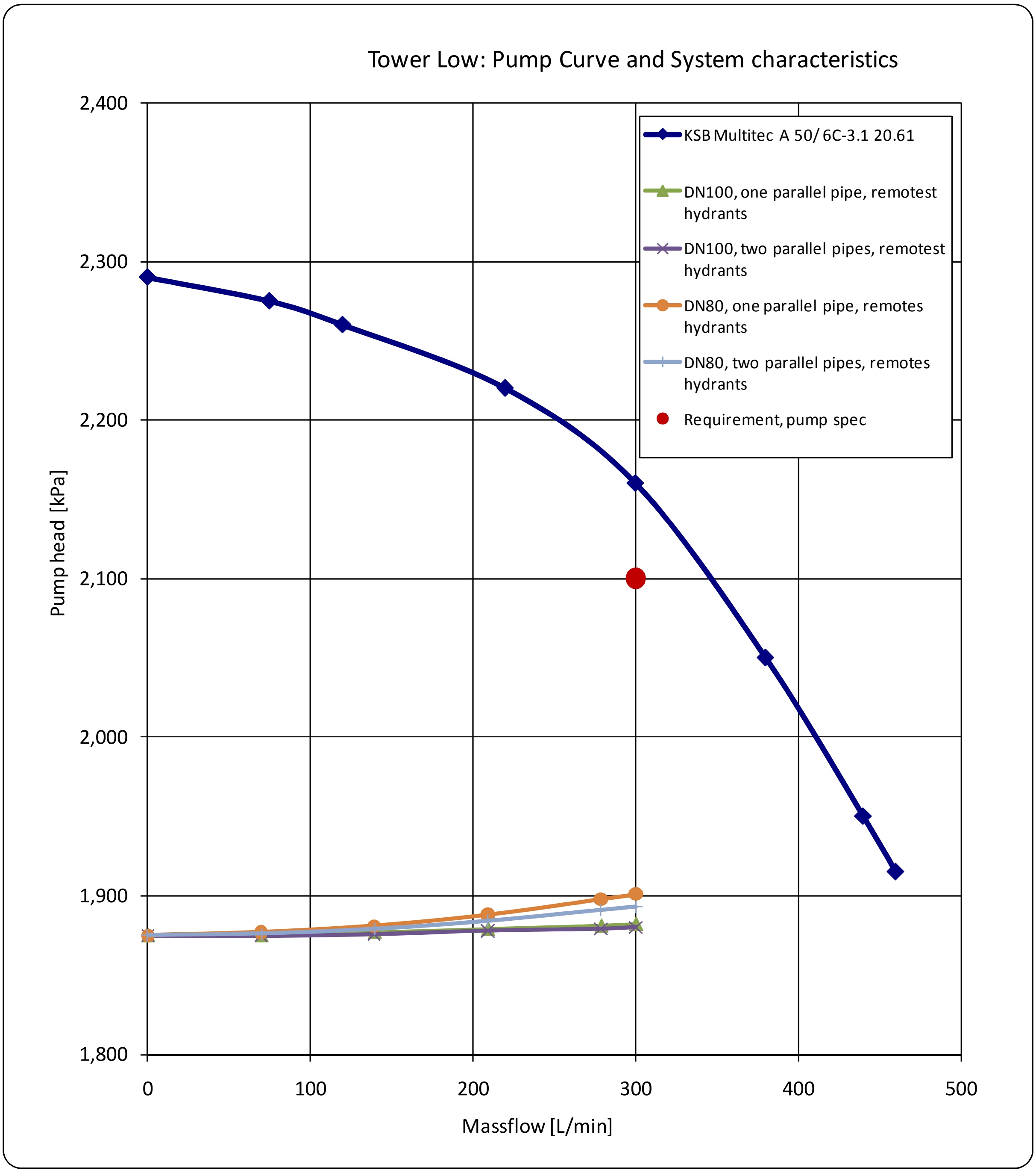
3.9.1 Bridge pump curve



3.9.2 Tower High pump



3.9.3 Tower Low pumps



3.9.4 Logstor Pipe Type Catalogue

LOGSTOR 2.0.2.2

The bonded pipe system

District heating pipes - Insulation series 1

Component overview/data

Component No. 2000

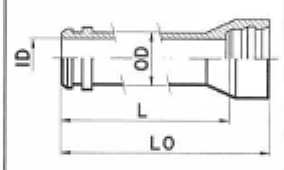
Steel pipe ø nom. mm	Steel pipe ø out. mm	Steel pipe Wall thick. mm	Outer casing ø out. mm	Outer casing Wall thick. mm	6 m pipe	12 m pipe	16 m pipe	Pipe Weight kg/m	Water content l/m
20	26.9	2.6	90	3.0	x	x		2.9	0.4
25	33.7	2.6	90	3.0	x	x		3.3	0.6
32	42.4	2.6	110	3.0	x	x		4.2	1.1
40	48.3	2.6	110	3.0	x	x		4.6	1.5
50	60.3	2.9	125	3.0	x	x		6.1	2.3
65	76.1	2.9	140	3.0	x	x		7.5	3.9
80	88.9	3.2	160	3.0	x	x		9.4	5.3
100	114.3	3.6	200	3.2	x	x	x	14	9.0
125	139.7	3.6	225	3.4	x	x	x	16	14
150	168.3	4.0	250	3.6	x	x	x	21	20
200	219.1	4.5	315	4.1	x	x	x	31	35
250	273	5.0	400	4.8	x	x	x	45	54
300	323.9	5.6	450	5.2		x	x	58	77
350	355.6	5.6	500	5.6		x	x	66	93
400	406.4	6.3	520*	5.7		x	x	79	120
450	457	6.3	560	6.0		x	x	88	160
500	508	6.3	630	6.6		x	x	100	190
600	610	7.1	780*	7.8		x	x	140	280
700	711	8.0	900	8.7		x	x	180	380
800	813	8.8	1000	9.4		x	x	230	500
900	914	10.0	1100	10.2		x	x	280	630
1000	1016	11.0	1200	11.0		x	x	340	780
1100	1118	11.0	1300	11.8		x	x	378	943
1200	1219	12.5	1400	12.5		x	x	460	1120

3.9.5 Wavistrong Pipe Type Catalogue

FPI

Pipe with spigot and socket end
Buis met spie- en mofeind
Rohr mit Spitzende und Muffende
Tuyau à embouts mâle et femelle

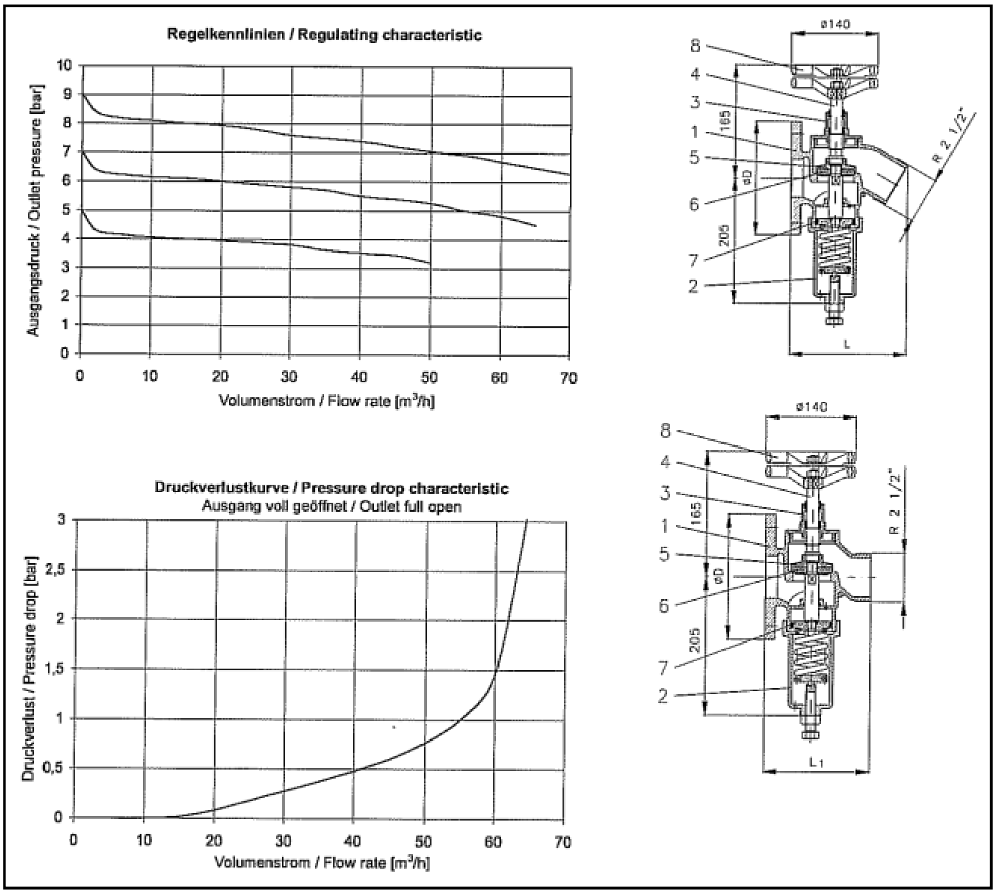
PN bar	ID mm	OD mm	L mm	Lo mm	Weight kg/m	Art.nr. EST : 11.3.. CST : 13.3.. EWT : 17.3..
20	150**	156.4	10000	10118	4.5	...16.40
	200**	208.2	10000	10126	7.5	...21.40
	250**	259.8	10000	10175	11.5	...26.40
	300	311.4	10000	10180	15.0	...31.40
	350	363.0	10000	10229	22.0	...36.40
	400	414.6	10000	10255	29.5	...41.40
	450	466.2	10000	10265	33.0	...46.40
	500	517.8	10000	10348	42.0	...51.40
	600	621.2	10000	10369	57.5	...61.40
25	100**	106.4	10000	10092	3.0	...11.50
	150**	157.8	10000	10118	5.0	...16.50
	200**	209.8	10000	10156	9.0	...21.50
	250**	261.8	10000	10220	14.5	...26.50
	300	313.8	10000	10234	19.0	...31.50
	350	365.8	10000	10229	25.0	...36.50
	400	418.0	10000	10255	35.0	...41.50
	450	470.0	10000	10265	38.5	...46.50
	500	522.0	10000	10348	48.0	...51.50
	600	626.0	10000	10369	67.0	...61.50
32	80**	86.4	10000	10093	2.5	...08.14
	100**	106.8	10000	10092	3.0	...11.60
	150**	159.2	10000	10118	6.0	...16.60
	200**	211.8	10000	10156	10.5	...21.60
	250**	264.4	10000	10220	16.5	...26.60
	300	317.0	10000	10234	22.5	...31.60



FS / FB

Note:
L = assembly dimension
L = montage afmeting
L = Montageabmessung
L = cote de montage

3.9.6 Fire hydrant characteristics



3.9.7 Surge vessel calculations

Bridge:

	Init. air procent		20%	80%
	bar(g)	bar(a)	Surge Vessel Volume [m3]	Water volume
Initial state				
p1	**16.5**	17.5	**1**	**0.80**
V1		0.20		
Final state				
p2	**2**	3	1	**0.22**
V2		0.78		

	Init. air procent		20%	80%
	bar(g)	bar(a)	Surge Vessel Volume [m3]	Water volume
Initial state				
p1	**16.5**	17.5	**1**	**0.80**
V1		0.20		
Final state				
p2	**25**	26	1	**0.85**
V2		0.15		

Tower High:

	Init. air procent		20%	80%
	bar(g)	bar(a)	Surge Vessel Volume [m3]	Water volume
Initial state				
p1	**42**	43	**0.1**	**0.080**
V1		0.02		
Final state				
p2	**5**	6	0.1	**0.009**
V2		0.09		

	Init. air procent		20%	80%
	bar(g)	bar(a)	Surge Vessel Volume [m3]	Water volume
Initial state				
p1	**42**	43	**0.1**	**0.080**
V1		0.02		
Final state				
p2	**55**	56	0.1	**0.084**
V2		0.02		

Tower Low:

	Init. air procent		20%	80%
	bar(g)	bar(a)	Surge Vessel Volume [m3]	Water volume
Initial state				
p1	**17.3**	18.3	**0.1**	**0.080**
V1		0.02		
Final state				
p2	**2**	3	0.1	**0.020**
V2		0.08		

	Init. air procent		20%	80%
	bar(g)	bar(a)	Surge Vessel Volume [m3]	Water volume
Initial state				
p1	**17.3**	18.3	**0.1**	**0.080**
V1		0.02		
Final state				
p2	**25**	26	0.1	**0.085**
V2		0.02		

3.9.8 Applied equations for pressure drop calculation

The software (Aquis) applied for analyses of the hydraulics in the fire fighting system offers the option to calculate the frictional pressure drop based on two alternative sets of equations i.e. a calculation of frictional pressure drop by calculation of a friction factor (f) by application of Colebrook-White equations or calculation of frictional pressure drop based on Hazen-Williams equations and a specification of a roughness coefficient (C).

Pressure drop is calculated according to Colebrook-White equations as

dp = (2·rho·f·v^2)/D [Pa/m],

where rho is the fluid density [kg/m3], f is the friction factor, v is the velocity [m/s] and D is the pipes inside diameter [m].

For Reynolds number (Re) smaller than 2300 the friction factor f is calculated as:

f = 16/Re

and for large Reynolds numbers as:

$1/\text{sqrt}(f) = -4\cdot\log_{10}[k/(3.7\cdot D) + 1.413/(Re\cdot\text{sqrt}(f))]$

k is the pipe roughness [m]

The Hazen-Williams equation is as follows:

$dp = 1.1101\cdot 10^{10}\cdot(Q/C)^{1.85}\cdot 1/D^{4.8655}$ [kPa/m]

where Q is the volumetric flow [m3/h], D is the pipes inside diameter [mm] and C is the roughness coefficient.

In the hydraulic analyses that have been carried out, the frictional pressure loss in the pipes has been calculated based on Colebrook-White set of equations (C-W).

The equations based on C-W provides the best estimate of the frictional loss (compared to the frictional pressure loss experienced in the actual system) and that the C-W equations are applicable in a much wider range.

As mentioned above another set of equations that can be used are the Hazen-Williams (H-W) equations.

The reason for applying H-W and not C-W is that the determination of the friction factor (f) in C-W equation can not be made explicitly. In case the H-W equation is used a roughness coefficient (C) has to be applied based on experiences and indications in the literature.

Determining the friction factor in the C-W equation requires iteration. An iterative calculation procedure does not represent any difficulties when using state of the art software and suitable hardware and can be calculated with great accuracy.

The C-W pipe roughness (k) applied in the analyses is 0.1 mm. To obtain identical frictional pressure drop by the H-W method a roughness coefficient (C) of 133 shall be applied. Using these values identical frictional pressure losses are calculated with the two alternative sets of equations.

The literature indicates a typical interval for the H-W roughness coefficient (C) of 130-150 for the type of pipes and pipe dimensions in question for the fire fighting system on the Messina Strait Bridge.

Applying a roughness coefficient (C) of 133 and using the H-W equations provides identical frictional pressure drops as the pressure drops calculated in the present report by application of pipe roughness (k) of 0.1 mm and using the C-W equations. It is noted that the H-W roughness coefficient (C) of 133 is within the interval indicated in the literature.

3.10 Utility Water System

3.10.1 Calculation of utility water pumps

There are different pumps for utility water supply to the towers and to the bridge girder.

3.10.2 Supply to the towers :

Wash valve specifications: Flow = 125 l/min. = 7.5 m^3/h

Outlet pressure = min. 4 bar.

Pipe material is Stainless steel.

3.10.2.1 Pumps for low level: (up to level 130 m)

Static pressure = 130m - 5 m = 125 mWc = 12.5 bar.

Pressure at valves = 4 bar.

Pressure loss = appr. 250 m[1)] ø50mm ⇒ 0.032 mWc/m x 205 m = 8 mWc = 0.8 bar.

Min. pump head = 12.5 + 4 + 0.8 = 17.3 bar.

<u>Pump requirement including safety margin : Flow = 150 l/min at head = 21 bar</u>

3.10.2.2 Pumps for high level: (level 130 m to level 380 m)

Static pressure = 380m- 5 m = 375 mWc = 37.5 bar.

Pressure at valves = 4 bar.

Pressure loss = appr. 500 m[1)] ø50mm ⇒ 0.032 mWc/m x 500 m = 16 mWc = 1.6 bar.

Min pump head = 37.5 + 4 + 1.6 = 43.1 bar.

<u>Pump requirement including safety margin : Flow = 150 l/min at head = 45 bar</u>

1) The length includes pipes and fittings inside the pump station and between pump station and tower.

3.10.3 Supply to bridge girder:

Valve specifications as for towers.

3.10.3.1 Evaluation of utility water main dimension

In order to keep the pressure range for the equipment on the gantry at PN10 the utility water main dimension DN65 has first been chosen.

It will be possible to reduce the pipe dimension to DN50. This will cause a higher pump head and require a higher pressure range for the equipment on the gantry.

The rough calculations are stated in the following:

<u>Design conditions:</u>

Wash valve specifications:

Flow = 125 l/min = 7.5m3/h.

Outlet pressure = min. 4 bar.

Level in the one end of the bridge = 55 meter.

Level in the middle of the bridge = 75meter.

Calculation of pressure variations at the wash valves at different positions with DN65 and DN50:

One pump station is supplying the half of the bridge length = 1625 meter.

The pipe material is GRE. See head loss flow chart from Wavistrong below

In the calculations the pump pressure PX is used.

DN65:

Pressure at valves in the ends of the bridge:

Pressure loss in 1625 m DN65: ΔP_{DN65} = 0.008 mVs/m x 1625 m = 13 mVs = 1.3 bar.

P_{end} = PX - 55/10 = PX - 5.5 bar

P_{middle} = PX - 75/10 - ΔP_{DN65} = PX - 7.5 - 1.3 bar = PX - 8.8bar.

Pressure variations at the wash valves = P_{end} - P_{middle} = -5.5 -(-8.8) bar = 3.3 bar

With pressure at valve = 4 bar the variation of the pressure will be from **4 bar** to 4+3.3 = **7.3 bar**

DN50:

Pressure at valves at the middle of the bridge:

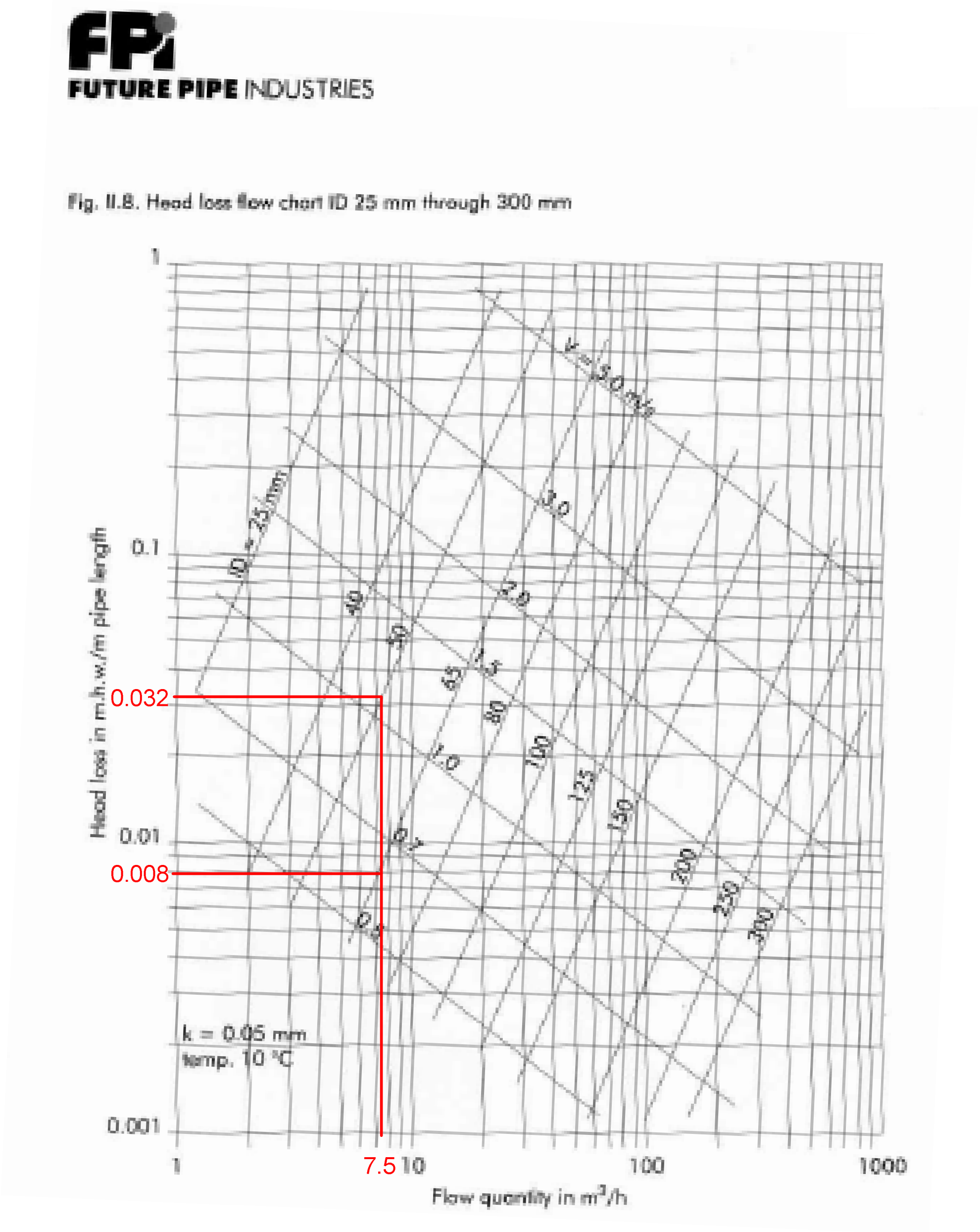
Pressure loss in 1625 m DN50: ΔP_{DN65} = 0.032 mVs/m x 1625 m = 52 mVs = 5.2 bar.

P_{end} = PX 55/10 = PX - 5.5 bar

P_{middle} = PX - 75/10 - ΔP_{DN65} = PX - 7.5 - 5.2 bar = PX -12.7bar.

Pressure variations at the wash valves = P_{end} - P_{middle} = -5.5 -(-12.7) bar = 7.2 bar

With pressure at valve = 4 bar the variation of the pressure will be from **4 bar** to 4+7.2 = **11.2 bar**



Head loss flow chart for GRE pipes

3.10.3.2 Evaluation of pump capacities

Pressure drop in wash water main along the bridge.

Total length 3250 /2 m = 1625 m

Flow = 125 l/min = 7,5 m3/h

Pipe diameter = ø50 mm:

ΔP = 0,032 mVs/m = 52 mVs = 5,2 bar

Pump pressure = 17 bar

Static high at the end of the bridge girder (first wash valve) = 55 m

Static high at the middle the bridge girder (the highest wash valve) = 75 m

Pressure at the first wash valve: 17 bar - 5.5 bar = 11,5 bar

Pressure at the wash valve at the middle of the bridge girder: 17 bar - 7.5bar - 5.2 bar = 4,3 bar

Diff. = 7,2 bar

Pipe diameter = ø65 mm:

ΔP = 0,008 mVs/m = 13 mVs = 1,3 bar

Pump pressure = 17 bar

Static high at the end of the bridge girder (first wash valve) = 55 m

Static high at the middle the bridge girder (the highest wash valve) = 75 m

Pressure at the first wash valve: 17 bar - 5.5 bar = 11,5 bar

Pressure at the wash valve at the middle of the bridge girder: 17 bar - 7.5bar - 1.3 bar = 8,2 bar

Diff. = 3,3 bar

If the pump pressure is reduced from 17 bar to 12,8 bar the wash valve pressures will be 7,3

Diff. = 3,3 bar 4

3.10.3.3 Pumps for bridge girder:

The water main dimension DN50 has been chosen and the pump requirements are as stated in item 2.2: Flow 125 l/min at head 17 bar.

Pump requirements including safety margin: Flow = 150 l/min at head = 17 bar.

3.11 Pipeline design

3.11.1 Purpose

This section is prepared in order to evaluate design and installation methods for utility water, fire fighting and drainage pipelines in GRE (Glass Fibre Reinforced Epoxy) depending on design conditions and constraints stipulated by the main bridge structure.

3.11.2 Conclusion

It is recommend using GRE pipelines due to several advantages in compare with other plastic, carbon steel and ductile iron pipeline materials:

- Lightweight saving pipeline material.
- High corrosion resistance.
- High pipe joint flexibility.
- Easy and fast installation methods.
- Reduced cost of installation compared to metals.
- Low health impact during installation.
- Fire resistance level 3, acc. to IMO Resolution A.753 can be achieved by fire barrier integrated in the outer surface (Wavistrong FR).
- Wavistrong FR has low flame spread, smoke and toxicity.
- Static electricity can be avoided by a conductive liner and a structural wall with integrated carbon fibres (Wavistrong CST).

The utility water, fire fighting and drainage pipelines are recommended to be designed and installed according to the following principles:

- The pipelines shall be established by using glass fibre reinforced epoxy (GRE) standard pipes in length of 7.5 m which are jointed by standard tensile resistant joints similar to epoxy standard tensile resistant pipes (EST) with rubber seal lock joints (RSLJ) and with adhesive bonded conical joints (CJ) for DN<80 from Future Pipe Industries (FPI).

- The drainage pipelines shall be supported and guided at each diaphragm (cc 3750 mm) in the bridge girders and intermediate anchor pipe supported (cc 30 m) in order to diminish pipeline movements at pipe branches and to assure the pipeline column stability.

- The fire pipelines shall be supported and guided at every second walkway bracket at railway bridge girder (cc 3750 mm) and intermediate anchor pipe supported (cc 30 m) in order to diminish pipeline movements at pipe branches and to assure the pipeline column stability.

- The utility water pipelines shall be supported and guided at every walkway bracket at railway bridge girder (cc 1875 mm) and intermediate anchor pipe supported (cc 30 m) in order to diminish pipeline movements at pipe branches and to assure the pipeline column stability.

- The RSLJ- joints for drainage and fire pipelines shall be capable of accommodating a certain amount of temperature expansion and to transfer the full pressure resultant in the elongated position.

- The CJ- joints for utility water pipelines shall be capable of transferring tension and compression forces due to pressure and temperature expansion with sufficient column stability.

- The pipe joints are not able to transfer the pressure resultant at temperature expansions where as the pipelines shall be installed with primary anchor supports at pipeline ends to the roadway and railway girders where pipelines are provided with loops at first terminal structure pier to the ground.

- At the ends of the bridge girders the pipelines shall be installed with primary anchor pipe supports which are capable of transferring the full design pressure resultant.

- The pipeline loops between bridge girders and terminal structures/piers shall be installed with angular expansion bellows in order to accumulate the large longitudinal (± 2000 mm; ULS) movements of the bridge girders to which pipelines are anchored.

- At the drop-in span interconnections the pipelines shall be installed with axial bellows in order to accumulate the large longitudinal bridge deck movements (±100 to ± 700 mm; ULS) and minor transverse movements (± 20 mm; ULS).

Implementing of the above described pipeline design principle has the following consequences for the design of the bridge girders:

- Minimum pipe whole diameter in the bridge girder diaphragms shall be 610 mm in roadway girders and 480 mm in railway girder.
- Minimum pipe whole diameter in bottom of girders at bridge ends shall be 610 mm in roadway girders and 480 mm in railway girder.
- Pipeline support design loadings acc. to principle layout drawings and 4.10.4 calculations.
- Intermediate anchor design loadings acc. to principle layout drawings and 4.10.4 calculations.
- Primary anchor design loadings acc. to principle layout drawings and 4.10.4 calculations.

3.11.3 Design basis

3.11.3.1 Design Lifetime

The design lifetime for the pipeline facilities will be minimum 50 years.

3.11.3.2 Principle process diagrams

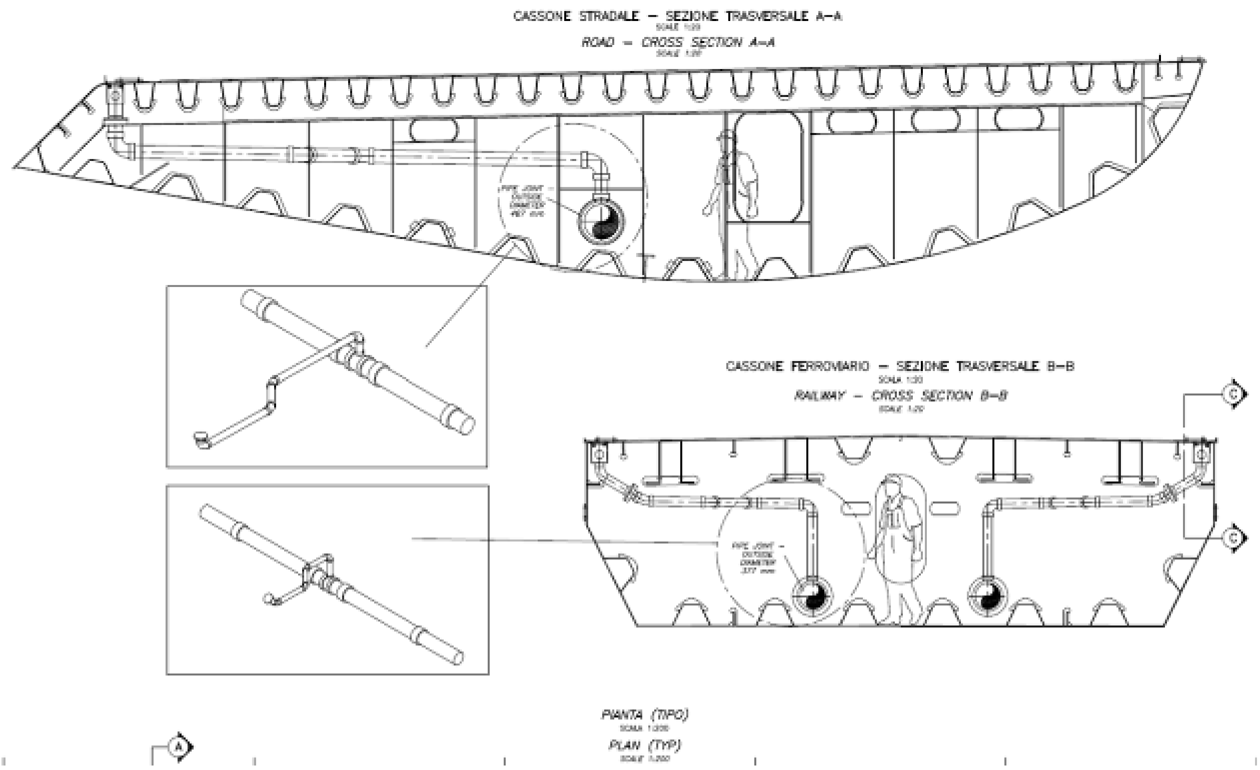
The following drawings describe the principle process systems and typical layout for the drainage and fire fighting pipeline systems:

- Drainage system, Girders and towers, Principle diagram.
- Drainage system, Birders and towers, Principle plan and section layout.
- Utility water and fire fighting, Pumping station and distribution, Principle diagram.
- Utility water and fire fighting, Water main locations, Typical section in girders and towers.

3.11.3.3 Pipeline system description

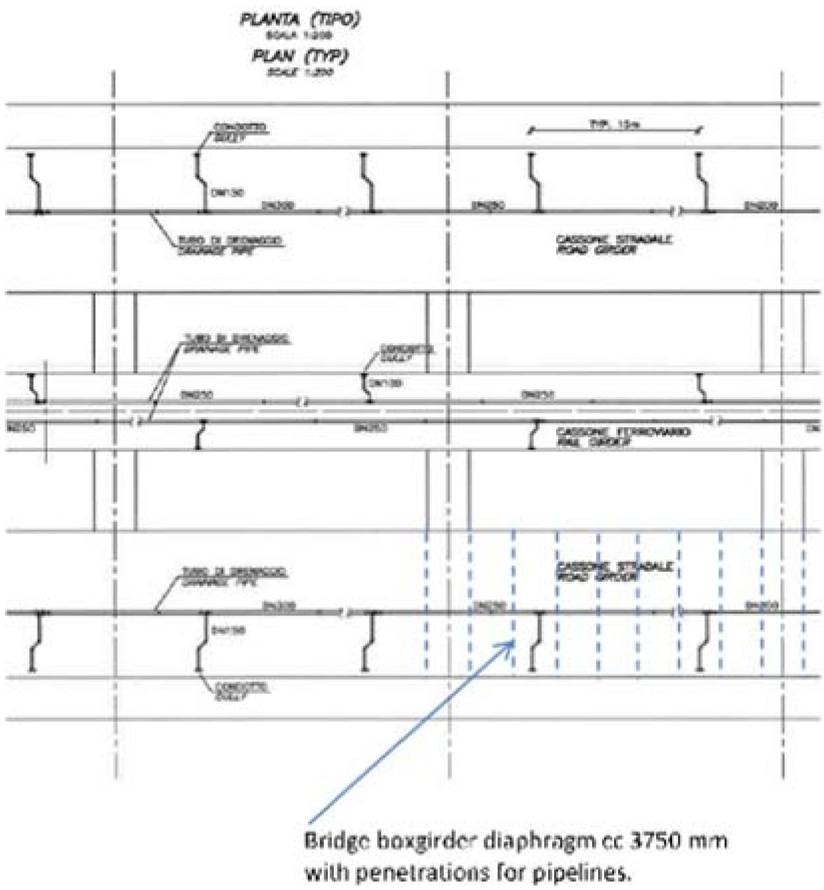
DRAINAGE SYSTEM

The drainage pipelines with branches spaced every 15 m to gullies are installed inside the roadway and railway bridged girder and along the whole length of the suspended bridge i.e. approximately 3666 m, see drawings below. The pipelines pass the diaphragms which are stiffening the box girders within a spacing of 3750 mm.



The drainage pipeline varies in pipe diameter from DN200 at middle of bridge to DN300/400 at ends of the bridge where the pipeline is installed with pipe loops to the ground and connected to the reception chamber/sand trap. The branches to gullies are DN150 at roadway deck and DN100 at railway deck.

The drainage pipeline elements shall be installed with restrained joints along the bridge girders and stabilized by pipe supports. The probably most feasible jointing method for the main GRE pipeline elements is to use restrained joints like "Rubber Seal Lock Joints" (RSLJ) from Future Pipe Industries (FPI). This solution requires rest, guides and intermediate anchoring of the GRE pipeline along the bridge girders and can be placed at penetrations of the bridge box girder diaphragms cc 3750 mm. This support distance comply with the maximum pipe support distance of 3.6 - 5.6 m for the main drainage pipes (see pipeline calculations).



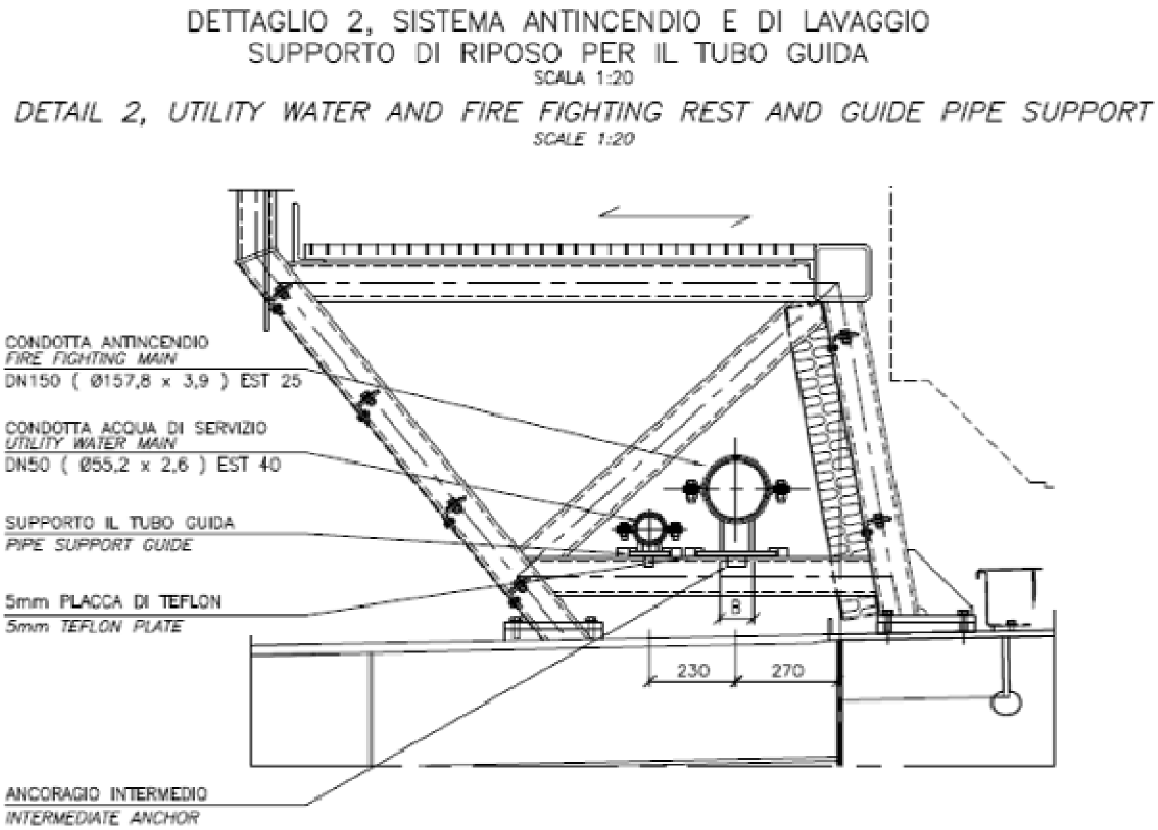
The distance between the intermediate anchors depends mainly on the spacing of branches to gullies, length of main GRE pipeline elements and the maximum allowable movement in the couplings.

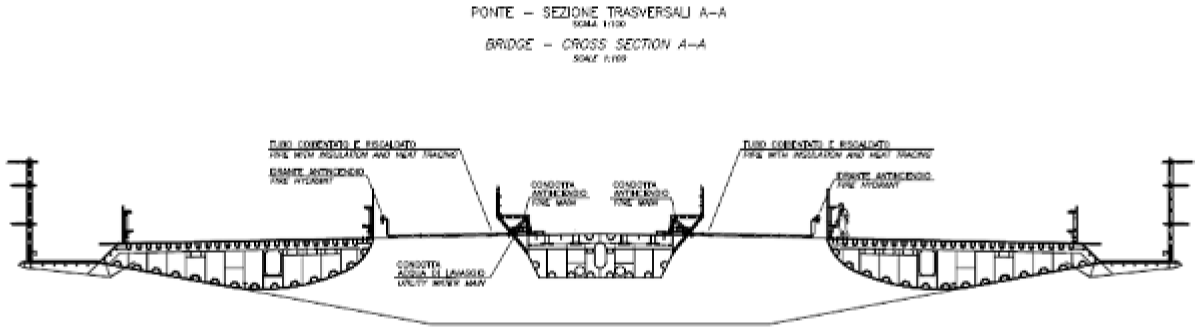
At bridge deck ends the GRE pipelines have to be anchored to the bridge deck in order to eliminate the relative movements between pipelines and bridge deck. The pipeline loop between bridge deck and the terminal structure shall be designed to withstand longitudinal bridge deck movements of maximum ± 2000 mm.

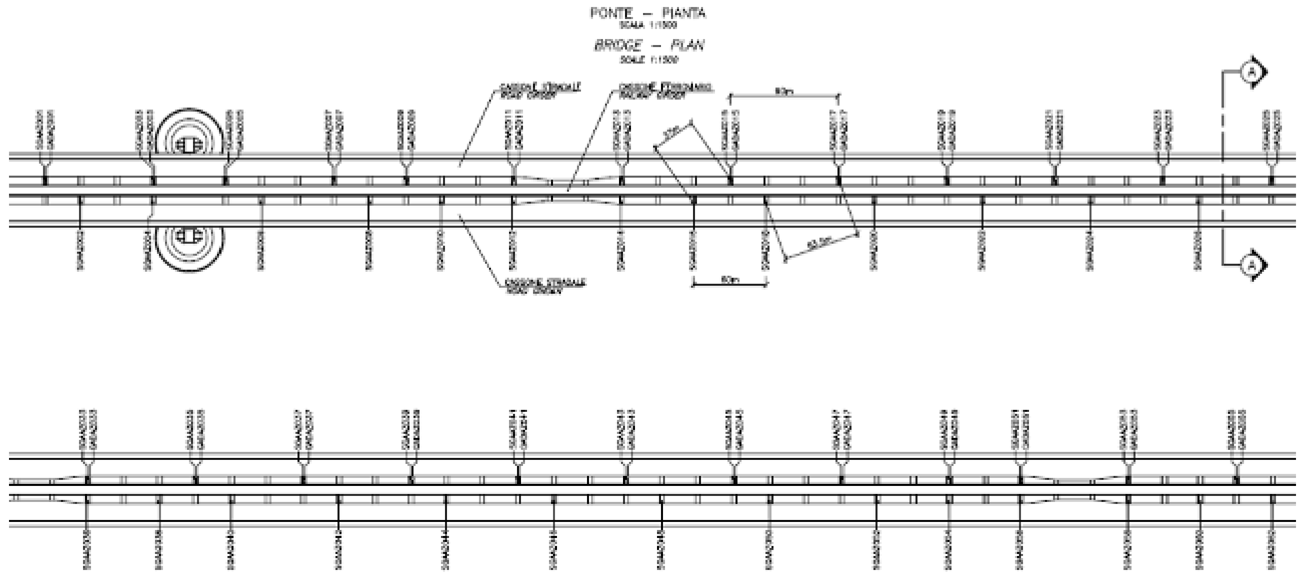
FIRE FIGHTING SYSTEM

The fire fighting pipeline DN150 with branches for fire hydrants DN65 spaced every 90 m is installed all along the outside edges of the railway bridge girder (below the walkway) as shown on the bridge cross section and plan drawing below.

The pipelines shall be provided with rest and guide supports approximately cc 3750 mm on the RHS- profiles which is supporting the walkway at the edges of the railway bridge deck.







UTILITY WATER SYSTEM

The utility water pipeline DN50 with branches for service valves spaced every 90 m is installed all along one edge of the railway bridge girder (below the walkway) as shown on the bridge cross section and plan drawing.

The pipelines will be provided with rest and guide supports approximately cc 1875 mm on the RHS- profiles which is supporting the walkway at the edges of the railway bridge deck.

3.11.3.4 Codes and standards

- ISO 14692 Glass-reinforced plastics (GRP) piping.
- BS 7159 Design and construction of glass reinforced plastics (GRP) piping systems for individual plants or sites.
- WAVISTRONG Engineering Guide
- WAVISTRONG Product List (pipes & fittings)
- EN 1092 Part 1: Steel Flanges
- ANSI/ASME B31.3 Chemical plant and petroleum refinery piping
- ANSI/ASME B36.10 Dimensions of steel pipes
- ANSI/ASME B16.9 Steel butt welding fittings
- ANSI/ASME B16.5 Flanges

3.11.3.5 Procedures

Future Pipe Industries Engineering Guide

3.11.3.6 Computer programs

Piping stress analyses:

- TRIFLEX Windows version 3.3.1 developed by Piping Solutions Inc.

3.11.3.7 Symbols and indices

$c = c_1 + c_2$	allowance on theoretical wall thickness in mm
c_1	allowance to compensate for permissible undersize on wall thickness in %
c_2	allowance for corrosion and wear
d	inside diameter of pipe
D	outside diameter of pipe
N	number of stress cycles
f	stress range reduction factor
p	design pressure (i.e. maximum possible internal overpressure for a length of line with allowance made for all conceivable operating conditions including surges etc.)
R	radius of curvature of the centre line of a pipe bend
t_m	minimum required thickness, including mechanical, corrosion and erosion allowances

E	basic quality factor
Y	material/temperature factor
E_m	modulus of elasticity
S	0.2 % minimum specified tensile strength (SMYS)
S_c	basic allowable stress at minimum metal temperature
S_h	basic allowable stress at maximum metal temperature
S_A	allowable displacement stress range
S_L	longitudinal stress
S_E	displacement stress range

3.11.3.8 Geometry parameters

GRE PIPE AND FITTINGS:

Drainage, mains — EST 16 (PN16); 300 ≤ D ≤ 400 acc. to Wavistrong

Drainage, branches — EST 25 (PN25); 150 ≤ D ≤ 200 acc. to Wavistrong

Fire fighting — EST 25 (PN25); DN150main and EST 40; DN65 branch

Utility — EST 40 (PN40); DN50 main and branch

DN [ID] [mm]	OD Lock (RSLJ)	OD adhesive (CJ)
200	251	215
250	321	269
300	377	322
350	431	376
400	487	429

Liner/Topcoat — 0,5 mm inner liner + 0,3 mm outer topcoat

Fire resistance — 5 mm outer phenol coating (Optional)

Bends — R = 1,5xD

Tees — $t = 1{,}5xt_{ESTxx}$, moulded $D \leq 400$

Reducer — $t = t_{ESTxx,}$ moulded, PN20; $150 \leq D \leq 400$

Joints

- restrained — Rubber seal lock joint type (RSLJ).
Adhesive bonded conical/cylindrical joint type (CJ).

-flanged — PN 40; Drainage
PN 40; Fire fighting
PN 40; Utility water

3.11.3.9 Material characteristics

GRE MATERIALS (Ω=55°, EST SERIES) ACC. TO WAVISTRONG

Axial design stress — Sa = 40 MPa, ref. Futurepipe

Hoop design stress — Sh = 63 MPa (HDS=HydrostaticDesignStress)

Allowable stresses for combined longitudinal and circumferential loading:

Seq = 19.3 MPa; pressure + weight
Seq = 24.5 MPa; pressure + weight + Q

Allowable stress curves for combined axial, hoop and shear are given in Wavistrong "Engineering Guide".

Axial tensile modulus Ex = 10500 MPa

Hoop tensile modulus Eh = 20500 MPa

Shear modulus Es = 11500 MPa

Temperature correction factor $R_{E1\text{-}axial}$ = 0,87 and $R_{E4\text{-}hoop}$ = 0,90 for T=60ºC

Poisson ratio Nxy = 0,65 (axial/hoop)

Poisson ratio Nyx = 0,38 (hoop/axial)

Coefficient of exp. $\gamma_L = 2.0 \times 10^{-5}$ mm/mm ºC

3.11.3.10 Operation and design loads

DEAD WEIGHT

GRE pipe density δ_{gre} = 1850 kg/m^3

PRESSURE AND TEMPERATURE

Media	Drainage	Fire fighting	Utility water
Design press (Barg)	16	25	25
Test pressure (Barg)			
Design temp (ºC)	0/50	0/50	0/50

Installation temperature T_{inst} = 20 ºC

PIPE SUPPORTS RESTRAINTS

Coefficient of friction μ_{ss} = 0.3 (steel on steel)
μ_{tt} = 0.1 (steel on PTFE)

BRIDGE GIRDER MOVEMENTS

The bridge girder is able to move at both ends where expansion elements are located. The maximum bridge girder movements are:

dL_{Long} = ± 2000 mm; ULS (Ultimate Limit State)

dL_{Trans} = ± 0 mm; ULS

The maximum relative bridge girder movements at drop-in span at towers are:

dL_{Long} = ± 100 - ± 800 mm; ULS

dL_{Trans} = ± 20 mm; ULS

BRIDGE DECK SLOPES

The design slope towards Calabria is 0.85 %.

The design slope towards Sicily is 1.5 %.

3.11.3.11 Environmental loads

AMBIENT AIR TEMPERATURES

Min. air temperature $T_{A\ min}$ = -2 °C

Max. air temperature $T_{A\ max}$ = +43 °C

Sun radiation increase T_{rad} = 10 °C; average value for un-insulated lines

WIND LOAD

Design wind velocity V~ 50 m/s

Velocity pressure Qz ~ 1600 N/m^2

Force coefficient Cf ~ 0,75

Design wind load Fw = Qz x Cf x D

EARTHQUAKE LOAD

Seismic load ≤ 6.3 m/s^2

Design base shear V = W x (Cv x I)/(R x T)

Horizontal effect E^H = NA

3.11.3.12 Load combinations

Design and testing load cases:

- Case C1: T +P + W
- Case C2: Tinst +P + W + Fw
- Case C3: Tinst +P + W + E^H
- Case C4: Tinst +Ptest + W

Symbols:

P = Pd = design pressure
W = dead weight
$T = T_{min} \rightarrow T_{max}$
T_{inst} = installation temperature
T_{min} = min design temperature
T_{max} = maximum design temperature
F_w = horizontal wind load
E^H = horizontal earthquake load

3.11.3.13 Technical analysis methods

GENERAL

All GRE pipelines including branches and expansion loops shall be detailed stress analysed by use of a recognised pipe stress analysis program.

PIPING STRESS ANALYSES

General GRE pipeline stress design.
The pipe stress calculations are performed by use of TRIFLEX Windows version 3.3.1, with stress code check according to BS 7159:

CIRCUMFERENTIAL STRESS

$S_N = S_{Np} + S_{Nb}$

CIRCUMFERENTIAL PRESSURE STRESS

$S_{Np} = mp(D_i+t_d)/2t_d$

CIRCUMFERENTIAL BENDING STRESS

$S_{Nb} = \{(D_i+2t_d)/2I\}\{(M_iSIF_{Ni})^2 + (M_oSIF_{No})2\}^{0.5}$

LONGITUDINAL STRESS

$S_x = S_{xp} + S_{xb}$

LONGITUDINAL PRESSURE STRESS

$S_{xp} = p(D_i + t_d)/4t_d$

LONGITUDINAL BENDING STRESS

$S_{xb} = \{(D + 2t\ )/2I\}(M_i^2 + M^O{}_2)^{0.5}$

TORSIONAL STRESS

$S_s = M(D_i + 2t_d)/4I$

MAXIMUM COMBINED STRESS:

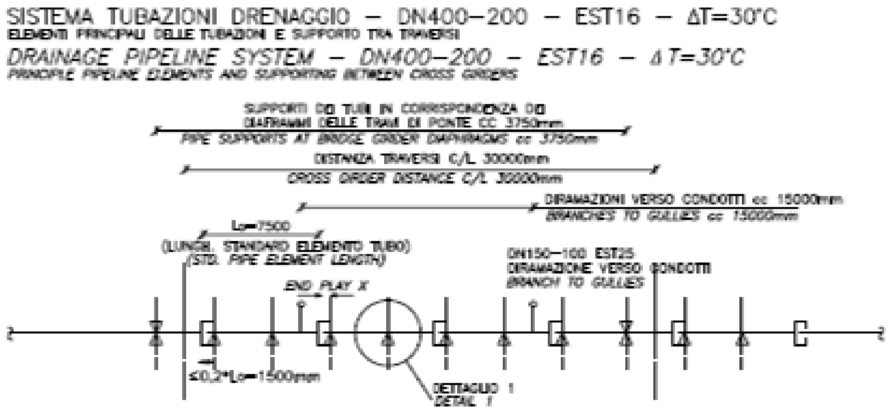
$S_{cB} = \{(S_{Sp\,+}\,S_{bB})^2 + 4S_{sB}{}^2\}^{0.5} \leq S_{design}$

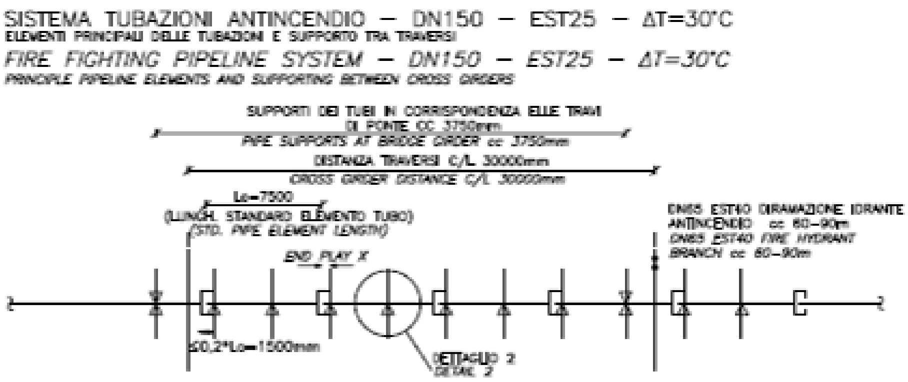
THERMAL EXPANSION DESIGN

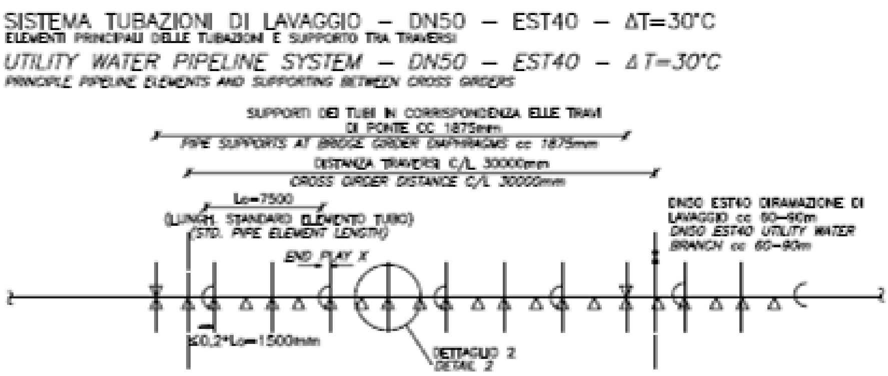
Thermal end loads: According to FPI "Engineering Guide".

GUIDE SPACING

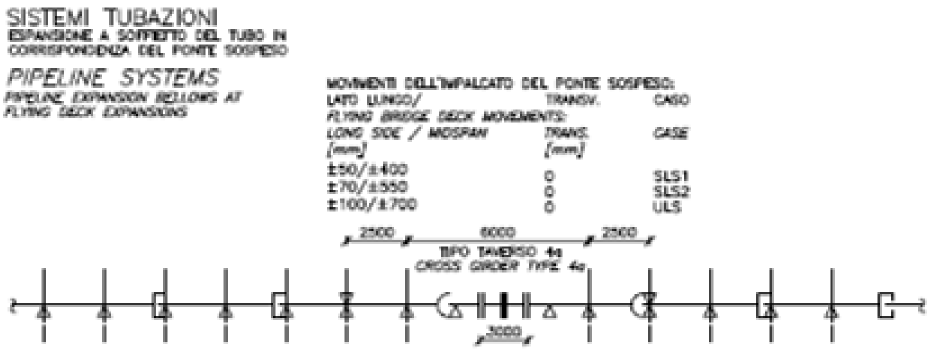
According to FPI "Engineering Guide".



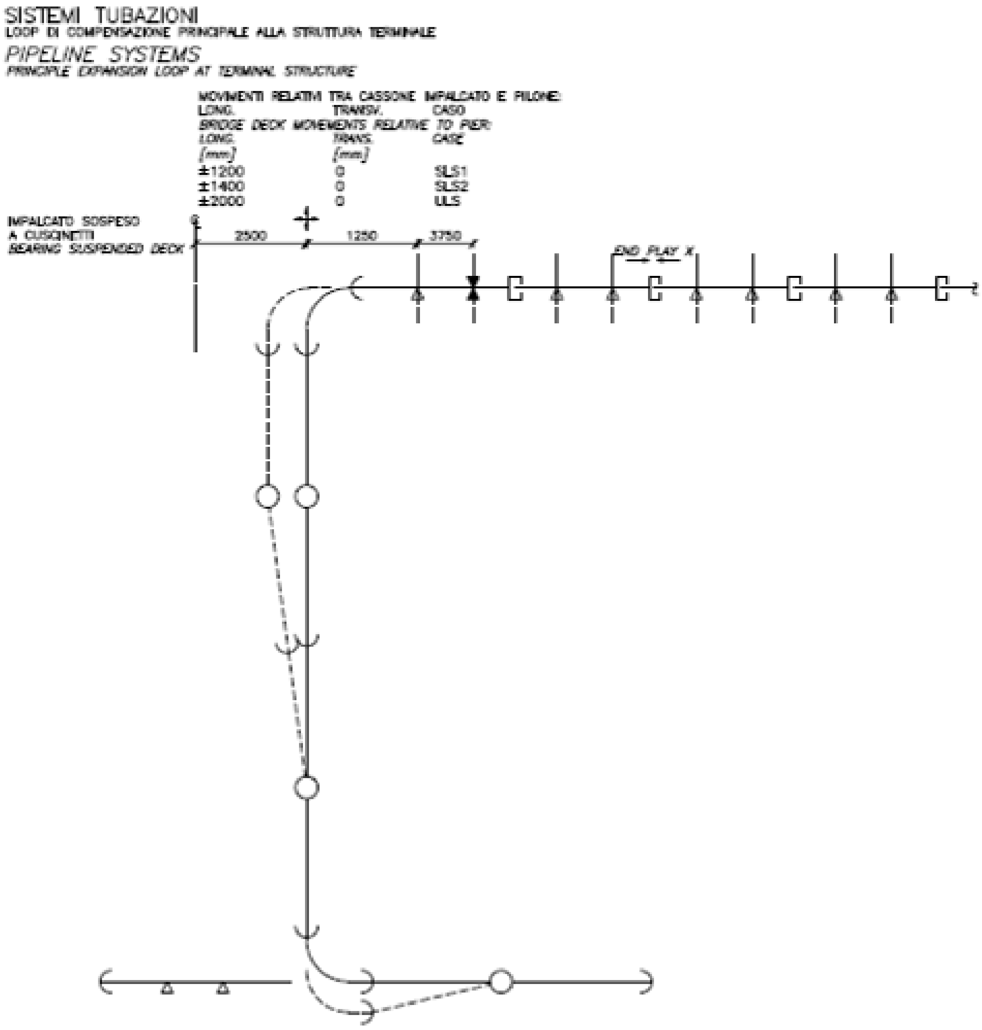




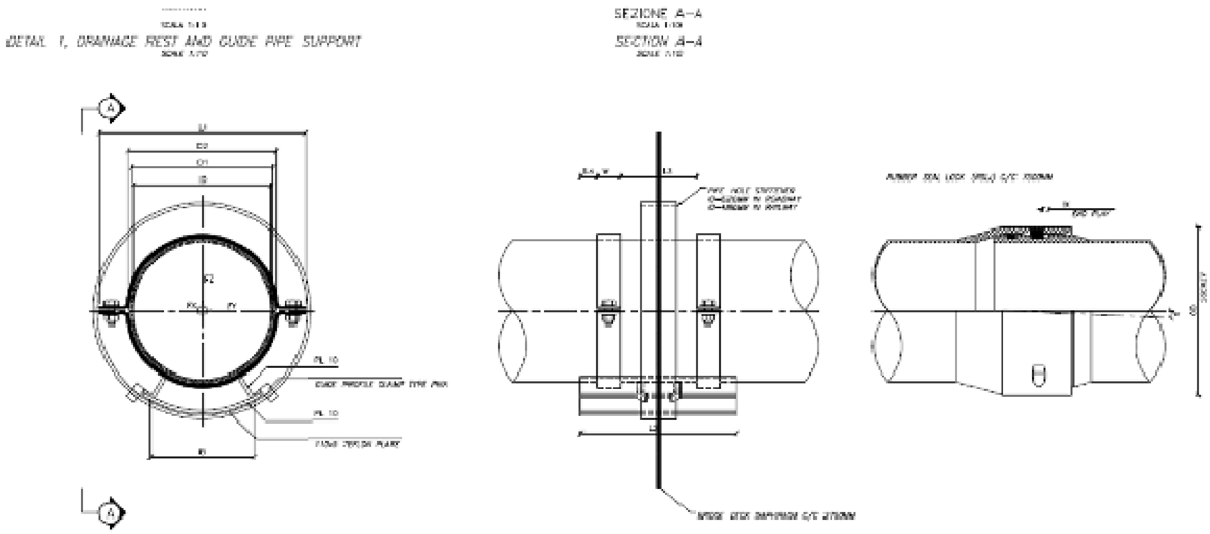
Expansion joint design



Expansion loops



Rest, guide and anchor supports for drainage main pipes



ACQUA DI LAVAGGIO TUBI EPOSSIDICI EST 40 / *UTILITY WATER EPOXY PIPES EST 40* ID [mm]	OD [mm]	OD SOCKET [mm]	X [mm]	α[deg]	STAFFA IN ACCIAIO / *STEEL BRACKET* D2 [mm]	L1 [mm]	SUPPORTO TUBI / *PIPE SUPPORT* WxS [mm]	B [mm]	L2 [mm]	L3 [mm]	L4 [mm]	BULLONE / *BOLT* [mm]	STRATO DI GOMMA / *RUBBER INLAY* D1 [mm]	WxT [mm]	CARICHI DI PROGETTO / *DESIGN LOADS* FX 2) [kN]	FY=0,3*FZ [kN]	FZ [kN]
50	55,2				66	156	40x8	50	130		45	M12x40	58	40x4		0,1	0,2
65	71,4				85	173	40x8	60	130		45	M12x40	77	40x4		0,1	0,3
SISTEMA DI ANTINCENDIO TUBI EPOSSIDICI EST 25 / *FIRE FIGHTING EPOXY PIPES EST 25* ID [mm]	OD [mm]	OD SOCKET [mm]	X [mm]	α[deg]	STAFFA IN ACCIAIO / *STEEL BRACKET* D2 [mm]	L1 [mm]	SUPPORTO TUBI / *PIPE SUPPORT* WxS [mm]	B [mm]	L2 [mm]	L3 [mm]	L4 [mm]	BULLONE / *BOLT* [mm]	STRATO DI GOMMA / *RUBBER INLAY* D1 [mm]	WxT [mm]	CARICHI DI PROGETTO / *DESIGN LOADS* FX 2) [kN]	FY=0,3*FZ [kN]	FZ [kN]
100	106,4		6	1,5	119	232	50x8	70	300	110	45	M16x50	109	50x5	5,7	0,2	0,5
150	157,8		6	1,5	170	282	50x8	70	325	135	45	M16x50	160	50x5	10,4	0,4	1,2
200	209,8		6	1,5	222	344	50x8	70	325	135	45	M16x50	212	50x5	17,3	0,6	2,1
TUBI EPOSSIDICI EST 16 1) / *EPOXY PIPES EST 16 1)* ID [mm]	OD [mm]	OD SOCKET [mm]	X [mm]	α[deg]	STAFFA IN ACCIAIO / *STEEL BRACKET* D2 [mm]	L1 [mm]	SUPPORTO TUBI / *PIPE SUPPORT* WxS [mm]	B [mm]	L2 [mm]	L3 [mm]	L4 [mm]	BULLONE / *BOLT* [mm]	STRATO DI GOMMA / *RUBBER INLAY* D1 [mm]	WxT [mm]	CARICHI DI PROGETTO / *DESIGN LOADS* FX 2) [kN]	FY=0,3*FZ [kN]	FZ [kN]
200	206,7	251	6	1,5	222	344	50x8	140	350	160	45	M16x50	212	50x5	11,5	0,8	2,0
250	257,9	321	8	1,5	277	390	60x8	140	375	165	45	M20X55	285	60X6	17,5	0,9	3,1
300	309,2	377	8	1,5	329	466	60x8	200	400	190	45	M20X55	317	60X6	24,0	1,3	4,4
350	360,5	431	12	1,5	381	518	60x8	200	425	215	45	M20X55	369	60X6	31,8	1,8	6,0
400	411,8	487	12	1,5	433	568	70x10	240	450	220	45	M24x70	421	70x6	41,2	2,3	7,8

Bending

NA

Thermal conductivity

NA

Heat tracing

NA

Vacuum or external pressure

NA

3.11.4 Calculations

3.11.4.1 GRE Pipeline calculations

Estimated GRE nominal pipe wall thicknesses and maximum pipe support distances (Lf) according to Future Pipe Industries:

Epoxy pipes type EST (Epoxy Standard Tensile)								
		DRAINAGE						
	Unit	Main					Branches	
DI		400	350	300	250	200	150	100
HDB	[Mpa]							
HDS=HDB/1,5	[Mpa]	63	63	63	63	63	60,5	52,5
p	[Mpa]	**1,6**	**1,6**	**1,6**	**1,6**	**1,6**	**2,5**	**2,5**
Te=pDI/2HDS	[mm]	5,1	4,4	3,8	3,2	2,5	3,1	2,4
Tl inner liner	[mm]	0,5	0,5	0,5	0,5	0,5	0,5	0,5
Tc topcoat	[mm]	0,3	0,3	0,3	0,3	0,3	0,3	0,3
Tw=Te+Tl+Tc	[mm]	5,9	5,2	4,6	4,0	3,3	3,9	3,2
OD	[mm]	411,8	360,5	309,2	257,9	206,7	157,8	106,4
L' (PN, 60C)	[m]	6,1	5,7	5,3	4,8	4,3	3,8	3,0
Rs		1,0	1,0	1,0	1,0	1,0	1,0	1,0
Rt (dT=30C)		0,92	0,91	0,89	0,87	0,84	0,80	0,79
Lf =L'RsRt (single span)	[m]	5,6	5,2	4,7	4,2	3,6	3,0	2,4
Gb pipe mass	[kg(m]	13,9	10,8	8,2	5,9	3,9	3,5	1,9
Gv pipe content	[kg(m]	125,6	96,2	70,7	49,1	31,4	17,7	7,9
G = Gb+Gv	[kg(m]	**139,5**	**107,0**	**78,8**	**54,9**	**35,3**	**21,1**	**9,8**
Dead loads								
Fz = Lf*G	[kN]	7,8	5,5	3,7	2,3	1,3	0,6	0,2
Fz design=G*3,75*1,5		7,8	6,0	4,4	3,1	2,0	1,2	0,5
Anchor loads (Intermediate)								
Pa		15,8	12,2	9,2	6,7	4,4	4,0	2,2
Re (60C)		0,87	0,87	0,87	0,87	0,87	0,87	0,87
dT ©		30,0	30,0	30,0	30,0	30,0	30,0	30,0
FX.=Pat = Pa*dT*Re/10		41,2	31,8	24,0	17,5	11,5	10,4	5,7
Anchor loads (Primary)								
FX.		112,0						

Epoxy pipes type EST (Epoxy Standard Tensile)							
	FIRE FIGHTING				UTILITY WATER		
	Main		Hydrant		Main		Valve
DI	200	150	65		65	50	25
HDB							
HDS=HDB/1,5	61,3	60,5	54,5		54,5	55,0	35
p	**2,5**	**2,5**	**4,0**		**4,0**	**4,0**	**5,0**
Te=pDI/2HDS	4,1	3,1	2,4		2,4	1,8	1,8
Tl inner liner	0,5	0,5	0,5		0,5	0,5	0,5
Tc topcoat	0,3	0,3	0,3		0,3	0,3	0,3
Tw=Te+Tl+Tc	4,9	3,9	3,2		3,2	2,6	2,6
OD	209,8	157,8	71,4		71,4	55,2	30,2
L' (PN, 60C)	5,1	3,8	2,9		2,9	2,9	1,8
Rs	1,0	1,0	1,0		1,0	1,0	1,0
Rt (dT=30C)	0,84	0,80	0,70		0,70	0,7	0,49
Lf =L'RsRt (single span)	4,3	3,0	2,0		2,0	2,0	0,9
Gb pipe mass	5,8	3,5	1,3		1,3	0,8	0,4
Gv pipe content	31,4	17,7	3,3		3,3	2,0	0,5
G = Gb+Gv	**37,2**	**21,1**	**4,6**		**4,6**	**2,8**	**0,9**
Dead loads							
Fz = Lf*G	1,6	0,6	0,1		0,1	0,1	0,0
Fz design=G*3,75*1,5	2,1	1,2	0,3		0,3	0,2	0,1
Anchor loads (Intermediate)							
Pa	6,6	4,0	1,4		1,4	0,9	0,5
Re (60C)	0,87	0,87	0,87		0,87	0,87	0,87
dT ©	30,0	30,0	30,0		30,0	30,0	30,0
FX.=Pat = Pa*dT*Re/10	17,3	10,4	3,8		3,8	2,3	1,2
Anchor loads (Primary)							
FX.	44,6						

4 Drainage system

4.1 Pupose

Calculations are carried out to sizes the the drainage systems in order to collect and treath first flush of rainwater from the bridge.

First flush rain is 5 mm evenly distributed rain water supplied to the bridge surface during 15 minutes (Rain intensity 20 mm/hr.).

First flush principle is argued that the first flush water will be the most polluted as regard content of oil spillage from roads. Second flush of rain (rain after five millimetres) is assessed to be more clean rain assuming that oil film on road pavement is being washed away during the first five millimetres of rain (first flush).

The "first flush" rain water are to be treated in oil separator on shore before outlet to the Messina Strait.

4.2 Design basis

4.2.1 Catchment area

The bridge is sloping from the middle towards each shore sides. The middle of the bridge is therefore the start of the catchment areas.

The total catchment area for each road girder section is 2.2 ha (~ 1,833 metres in length x 12m of width).

The total catchment area for the rail girder is 1.4 ha (~ 1,833 metres in length x 7.5m of width).

4.2.2 Slopes

The design slope towards Calabria is 0.85 %.

The design slope towards Sicily is 1.5 %.

4.2.3 Spacing of gullies

For calculations the gullies are assumed spaced every 15 meters. However, this is only used for the assumption that an increase in pipe dimension can occur every 15 meters.

4.2.4 Drain pipe material

GRE (Glassfiber Reinforced Epoxy) pipes are proposed as drain pipe material.

The pipe roughness used for GRE is 1.5 mm. This is on the conservative side of what that can be expected during normal condition, but allows for some internal sedimentation.

4.3 Design peak flows ~ First flush principle 20 mm/hr

				Bridge drainage		
	Length	Width	Area	*Rain Intensity*	*Q_{dim}*	*Q_{full}*
	[m]	[m]	[ha]	*[l/s/ha]*	*[l/s]*	*[l/s]*
Bridge - Road (N)	1833	12	2,2	*56*	*122*	*202*
Bridge - Rail	1833	7,5	1,4	*56*	*76*	*188*
Bridge - Road (S)	1833	12	2,2	*56*	*122*	*202*
Terminal- Road (N)	32	12	0,04	*56*	*2*	*32*
Terminal- Rail	32	7,5	0,024	*56*	*1*	*32*
Terminal- Road (S)	32	12	0,038	*56*	*2*	*32*
			5,9		*326*	*688*

4.4 Carrier pipes

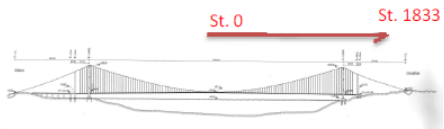
The drainage of each road girder will be facilitated by one carrier drain pipe in the entire length of the bridge starting from the middle.

The drainage of the railway will be facilitated by two carrier drain pipes in the entire length of the bridge starting from the middle.

4.4.1 Overview of pipes sections

Stretto di Messina
P-072889-C-7.51, Stormwater drainage

1 / 1



Preparer	LJN
Checker	KPL
Approver	KPL
Rev	B
Date	11-10-2010

Drainge of bridge - From centre of bridge and towards Calabria
Design intensity 20 mm/hr

GRE Pipe inner dimensionens [mm] for no. of sections						
Station	Road Girder (S)		Rail girder			Road Girder (N)
0	200		200	200		200
180	200		200	200		200
195	250		200	200		250
300	250		200	200		250
315	300		200	200		300
570	300		200	200		300
585	350		200	200		350
630	350		200	200		350
645	350		250	250		350
885	350		250	250		350
900	400		250	250		400
1155	400		250	250		400
1170	400		300	300		400
1830	400		300	300		400

	Road Girder (S)		Rail girder			Road Girder (N)	
Q_{dim} [l/s]	123		38	38		123	*Design peak flow*
Q_{full} [l/s]	202		94	94		202	*Capacity at full*
Pipe [ton]	25		13	13		25	*Weight of pipe*
Water [ton]	205		96	96		205	*Weight of water*

4.4.2 Calculation of road girder

Stretto di Messina
P-072889-C-7.51, Stormwater drainage

1 / 5

Drainage of road Girder - Towards Calabria (One GRP pipe with maximum 65% filling)

Pipe rougness	k [mm]	1,5			
Spacing of gullies	[m]	15		Number of gullies	123
Total length of bridge	[m]	1845	OBS: only 1833	Total drain area [ha]	2,214
Width of girder	[m]	12			
Slope of bridge	[-]	0,0085			

	Section					Rain intensity				Hydraulics in gravity pipe					
	Length	Width	Slope	Area	Σ A	Time of concentration	Rain duration	Intensity	Flow	Pipe dim	Qf	Depth	I (hyd gradient)	Velocity	Filling
Station	[m]	[m]	[-]	[ha]	[ha]	[min]	[min]	[l/s/ha]	[l/s]	[mm]	[l/s]	[m]	[-]	[m/s]	[%]
0	15	12	0,0085	0,018	0,018	7,9		55,55556	1	200	32	0,03	0,0	0,03	14%
15	15	12	0,0085	0,018	0,036	11,8		55,55556	2	200	32	0,04	0,0	0,06	19%
30	15	12	0,0085	0,018	0,054	14,4		55,55556	3	200	32	0,05	0,1	0,10	23%
45	15	12	0,0085	0,018	0,072	16,4		55,55556	4	200	32	0,05	0,1	0,13	27%
60	15	12	0,0085	0,018	0,09	17,9		55,55556	5	200	32	0,06	0,2	0,16	30%
75	15	12	0,0085	0,018	0,108	19,2		55,55556	6	200	32	0,07	0,3	0,19	33%
90	15	12	0,0085	0,018	0,126	20,4		55,55556	7	200	32	0,07	0,4	0,22	36%
105	15	12	0,0085	0,018	0,144	21,3		55,55556	8	200	32	0,08	0,5	0,25	38%
120	15	12	0,0085	0,018	0,162	22,2		55,55556	9	200	32	0,08	0,7	0,29	40%
135	15	12	0,0085	0,018	0,18	23,0		55,55556	10	200	32	0,09	0,8	0,32	43%
150	15	12	0,0085	0,018	0,198	23,7		55,55556	11	200	32	0,09	1,0	0,35	45%
165	15	12	0,0085	0,018	0,216	24,4		55,55556	12	200	32	0,09	1,2	0,38	47%

⇩ ⇩

1635	15	12	0,0085	0,018	1,98	70,6		55,55556	110	400	202	0,23	2,5	0,88	58%
1650	15	12	0,0085	0,018	1,998	70,9		55,55556	111	400	202	0,23	2,6	0,88	58%
1665	15	12	0,0085	0,018	2,016	71,2		55,55556	112	400	202	0,23	2,6	0,89	58%
1680	15	12	0,0085	0,018	2,034	71,5		55,55556	113	400	202	0,23	2,7	0,90	59%
1695	15	12	0,0085	0,018	2,052	71,7		55,55556	114	400	202	0,24	2,7	0,91	59%
1710	15	12	0,0085	0,018	2,07	72,0		55,55556	115	400	202	0,24	2,8	0,92	59%
1725	15	12	0,0085	0,018	2,088	72,3		55,55556	116	400	202	0,24	2,8	0,92	60%
1740	15	12	0,0085	0,018	2,106	72,5		55,55556	117	400	202	0,24	2,9	0,93	60%
1755	15	12	0,0085	0,018	2,124	72,8		55,55556	118	400	202	0,24	2,9	0,94	60%
1770	15	12	0,0085	0,018	2,142	73,1		55,55556	119	400	202	0,24	3,0	0,95	61%
1785	15	12	0,0085	0,018	2,16	73,3		55,55556	120	400	202	0,24	3,0	0,95	61%
1800	15	12	0,0085	0,018	2,178	73,6		55,55556	121	400	202	0,24	3,1	0,96	61%
1815	15	12	0,0085	0,018	2,196	73,9		55,55556	122	400	202	0,25	3,1	0,97	61%
1830	15	12	0,0085	0,018	2,214	74,1		55,55556	123	400	202	0,25	3,2	0,98	62%

4.4.3 Calculation of rail girder

Stretto di Messina 1 / 3
P-072009-C-7.51, Stormwater drainage

Drainage of rail Girder - Towards Calabria (Two GRP pipe with maximum 55% filling)

Pipe rougness	k [mm]	1,5			
Spacing of gullies	[m]	15		Number of gullies	123
Total length of bridge	[m]	1845	OBS: only 1833	Total drain area [ha]	0,691875
Width of girder	[m]	3,75			
Slope of bridge	[-]	0,0085			

	Section					Rain intensity				Hydraulics in gravity pipe					
	Length	Width	Slope	Area	Σ A	Time of concentration	Rain duration	Intensity	Flow	Pipe dim	Qf	Depth	I (hyd gradient)	Velocity	Filling
Station	[m]	[m]	[-]	[ha]	[ha]	[min]	[min]	[l/s/ha]	[l/s]	[mm]	[l/s]	[m]	[-]	[m/s]	[%]
0	15	3,75	0,0085	0,005625	0,005625	25,1		55,55556	0,3125	200	32	0,02	0,0	0,01	8%
15	15	3,75	0,0085	0,005625	0,01125	37,7		55,55556	0,625	200	32	0,02	0,0	0,02	11%
30	15	3,75	0,0085	0,005625	0,016875	46,1		55,55556	0,9375	200	32	0,03	0,0	0,03	13%
45	15	3,75	0,0085	0,005625	0,0225	52,4		55,55556	1,25	200	32	0,03	0,0	0,04	15%
60	15	3,75	0,0085	0,005625	0,028125	57,4		55,55556	1,5625	200	32	0,03	0,0	0,05	17%
75	15	3,75	0,0085	0,005625	0,03375	61,6		55,55556	1,875	200	32	0,04	0,0	0,06	18%
90	15	3,75	0,0085	0,005625	0,039375	65,2		55,55556	2,1875	200	32	0,04	0,0	0,07	20%
105	15	3,75	0,0085	0,005625	0,045	68,3		55,55556	2,5	200	32	0,04	0,1	0,08	21%
120	15	3,75	0,0085	0,005625	0,050625	71,1		55,55556	2,8125	200	32	0,05	0,1	0,09	23%
135	15	3,75	0,0085	0,005625	0,05625	73,6		55,55556	3,125	200	32	0,05	0,1	0,10	24%
150	15	3,75	0,0085	0,005625	0,061875	75,9		55,55556	3,4375	200	32	0,05	0,1	0,11	25%
165	15	3,75	0,0085	0,005625	0,0675	78,0		55,55556	3,75	200	32	0,05	0,1	0,12	26%
1635	15	3,75	0,0085	0,005625	0,61875	151,8		55,55556	34,375	300	94	0,14	1,1	0,49	46%
1650	15	3,75	0,0085	0,005625	0,624375	152,4		55,55556	34,6875	300	94	0,14	1,1	0,49	47%
1665	15	3,75	0,0085	0,005625	0,63	152,9		55,55556	35	300	94	0,14	1,2	0,50	47%
1680	15	3,75	0,0085	0,005625	0,635625	153,4		55,55556	35,3125	300	94	0,14	1,2	0,50	47%
1695	15	3,75	0,0085	0,005625	0,64125	153,9		55,55556	35,625	300	94	0,14	1,2	0,50	47%
1710	15	3,75	0,0085	0,005625	0,646875	154,3		55,55556	35,9375	300	94	0,14	1,2	0,51	47%
1725	15	3,75	0,0085	0,005625	0,6525	154,8		55,55556	36,25	300	94	0,14	1,3	0,51	48%
1740	15	3,75	0,0085	0,005625	0,658125	155,3		55,55556	36,5625	300	94	0,14	1,3	0,52	48%
1755	15	3,75	0,0085	0,005625	0,66375	155,8		55,55556	36,875	300	94	0,14	1,3	0,52	48%
1770	15	3,75	0,0085	0,005625	0,669375	156,3		55,55556	37,1875	300	94	0,14	1,3	0,53	48%
1785	15	3,75	0,0085	0,005625	0,675	156,7		55,55556	37,5	300	94	0,15	1,3	0,53	49%
1800	15	3,75	0,0085	0,005625	0,680625	157,2		55,55556	37,8125	300	94	0,15	1,4	0,53	49%
1815	15	3,75	0,0085	0,005625	0,68625	157,7		55,55556	38,125	300	94	0,15	1,4	0,54	49%
1830	15	3,75	0,0085	0,005625	0,691875	158,1		55,55556	38,4375	300	94	0,15	1,4	0,54	49%

4.5 Sand trap

4.5.1 Dimensions

	Design flow [l/s]	Width [m]	Length [m]	Depth [m]	Pit for sand collection [m]
Sand trap dimensions	326	5	2.5	2	0.5

4.5.2 Calculations of sand trap

Sand trap design literature references

i) BS EN 858-1:2002 and BS EN 858-2:2008, Separator systems for light liquids (e.g. oil and petrol)
ii) Winther, Leif et all, Spildevandsteknik, 1978, Figur 6.8 (inserted to the right)
iii) Huisman, L., Sedimentation and flotation, October 1986, Chapter 2 Principles of discrete settling
iv) Qasim, Syed R., Waste treatment plants, Planning, design and operation, 2. ed. 1999, Section 11-3 Gravity settling
v) Vejdirektoratet (Danish Road Directorate), Afvandingskonstruktioner, September 2005, Section 4.4.4 Opdeling
vi) Bollaert, Erik, Standardization of civil engineering works of small hydropower plants, 19.10.2004. Article from Internet, Section Sand trap design

Assumptions

Sand trap general design criteria

5mm, 15 minutes duration, intensity, i (l/s/ha)		56		
Minimum sand grain size to be settled, ds (mm)		0,5		
Maximum horizontal velocity of flow, Vh (m/s)		0,3		
Length/width proportion, L/W (-)		8	(BS EN 858-1:2002, Clause 6.5.6.2, b says between 5 and 1.5 (for oil separators), other says 6 - 10))	
Length extension factor to compensate for turbulence, C (-)		1,2	($L_3 = L*C$)	
Minimum surface area of sand trap sedimentation section, A_{min} (m^2/ha)		20	(Ref. v))	
Volume factor for volume, V_p, of sand collection chamber, K (-)		100	($V_p = K*Q$, V_p in m^3 and Q in m^3/s). C.f. BS EN 858-2:2003, Table 5 and Equation (1). Small sand load assumed)	
Minimum depth of pit for sediment collection, Hp (m)		0,35	(BS EN 858-1:2002, Clause 6.5.6.2, b says minimum 0.35 m))	
Maximum depth of water, exclusive pit for sediment collection, H (m)		2,5	(BS EN 858-1:2002, Clause 6.5.6.2, b indirectly says minimum 2.0 m)	
Specific mass of sand (kg/m^3)		2650		
Specific mass of water (kg/m^3)		1000		
Kinematic viscosity of water (m^2/s)		8,010E-07	(30 °C)	
Gravitational constant, g (m/s^2)		9,80665		

Calculations

Full catchment area (m^2)		58747,5		
Other (m^2)		0		
Runoff coefficient (-)		1,0		
Length of sand trap sedimentation section available, L_3 (m)		6	($L_3 = L*C$)	
Efficient area Ared (m^2)		58747,5		
Design flow rate, Q (m^3/s)		0,329		
Settling velocity of sand in quiescent water, V''s (m/s)	Transition region 2	0,09450869	($50 \le NR < 1620$)	340,2 (m/h)
Reynold number for settling, N_R (-)		59		
Critical mean flow velocity, Vm (m/s)		0,31112698	(Equation not verified)	
Settling velocity of sand in flowing water, V's (m/s)		0,08206381	(Equation not verified)	295,4 (m/h)
Settling velocity of sand in flowing water chosen, Vs (m/s)		0,02222222	(Ref. ii), Figure 6.8)	80,0 (m/h)
Surface area required of sand trap sedimentation section, A' = Q/Vs (m^2)		14,8		
Efficient length of sand trap sedimentation section calculated, L' (m)		5,0		
Efficient length of sand trap sedimentation section chosen, L (m)		5,0	($L \le L'$)	
Width of sand trap calculated, W'm)		2,96	(W' = A/L)	
Width of sand trap chosen, W (m)		2,50	($W \ge W'$)	
Length/width proportion (-)		2,00		
Surface area of sand trap efficient sedimentation section, A = L*W (m^2)		12,5	**Surface area < 20 m2/ha. Consider enlarging surface area**	
Minimum depth of water, exclusive pit for sediment collection, H' (m)		0,44		
Depth of water, exclusive pit for sediment collection, chosen, H (m)		2,00		
Horizontal velocity of flow, Vh (m/s)		0,066	**Check that settling velocity of sand in flowing water chosen (Vs) corresponds to the horizontal velocity of flow (Vh) - if not, change Vs**	
Minimum volume of pit for sediment collection, V_p (m^3)		32,8986		
Depth of sandpit calculated, H_p (m)		2,19	**Not realistic!**	32,5
Depth of sandpit chosen, H_p (m)		0,5		
Volume of pit for sediment collection, V_p (m^3)		7,5		
Outlet weir length = width of sand trap choosen, W (m)		2,50		
Outlet weir overflow heigth, h (m)		0,169	($Q = 1.89*W*h^{3/2}$)	

4.6 Retention reservoir

The reservoir is designed to even out the flow to the oil and petrol separator thus maximizing the amount of drain water being treated before discharge to the sea.

The reservoirs will be designed for a higher return period than the gravity system on the bridge. This is to treat more drain water before discharge to the sea - without additional provisions of drain system on the bridge.

The storage volume of the retention chamber will therefore exceed the theoretically needed in order to even out the peak flows and be based on an estimated "first flush volume". - A 2,000 m3 retention reservoir is selected.

4.6.1 Calculation of retention reservoir

				Bridge drainage		
	Length	**Width**	**Area**	***Rain Intensity***	***Q_{dim}***	***Q_{full}***
	[m]	**[m]**	**[ha]**	***[l/s/ha]***	***[l/s]***	***[l/s]***
Bridge - Road (N)	1833	12	2,2	*56*	*122*	*202*
Bridge - Rail	1833	7,5	1,4	*56*	*76*	*188*
Bridge - Road (S)	1833	12	2,2	*56*	*122*	*202*
Terminal- Road (N)	32	12	0,04	*56*	*2*	*32*
Terminal- Rail	32	7,5	0,024	*56*	*1*	*32*
Terminal- Road (S)	32	12	0,038	*56*	*2*	*32*
			5,9		*326*	*688*

Q_{full} = full running capacity of drainage pipes

Event	**$Q_{outfall}$**	***Rain Intensity***	**Duration**	**Retention Volume**
	[l/s]	***[l/s/ha]***	**[min]**	**[m^3]**
First flush of 5mm	20	56	15	278
First flush of 5mm	20	56	60	1112
First flush of 5mm	20	56	75	1390
First flush of 5mm	20	56	120	2225
Full running pipes (*1)	20	117	15	601
Full running pipes (*1)	20	117	30	1202
Full running pipes (*1)	20	117	45	1804
Full running pipes (*1)	20	117	50	2004
Full running pipes (*1)	20	117	60	2405

(*1) Full running pipes gives a total discharge of 326 l/s (~117 l/s/ha x 5.9 ha)

4.7 Oil and fuel separator

Oil/petrol separation shall comply with EN 858-1:2002 and EN 858-2:2003, Class I separators.

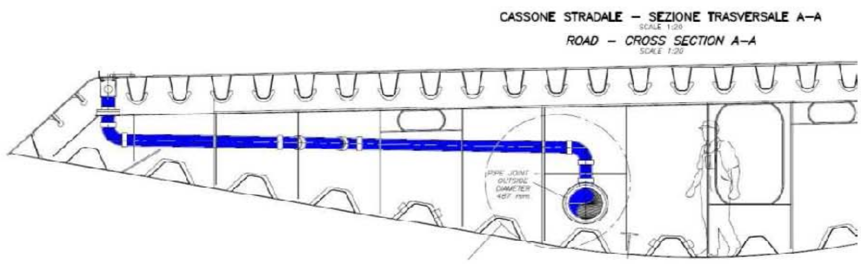
The capacity of the oil and petrol separator will have a capacity of 20 l/s.

This capacity is within the range of available prefabricated separators and one standard separator is therefore sufficient.

4.8 Down pipes

Since the bridge deck and the carrier pipe has the same slope it is assumed that the design peak flow towards the down pipes is the full running capacity of the carrier pipe (DN400)

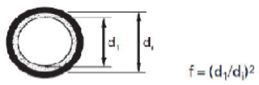
Design peak flow (DN400)	222,2	l/s	(202 + 10% safety)

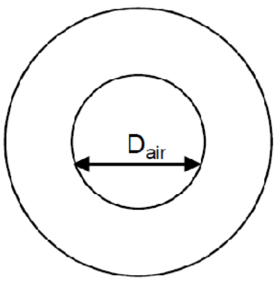


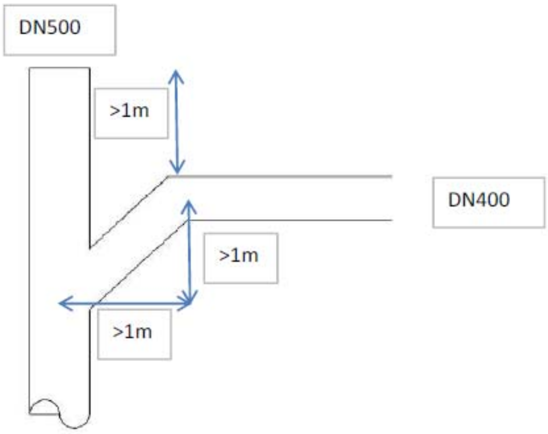
Vertical pipe - Wyly-Eatons formula

$$q = 7{,}9 \cdot k^{-\frac{1}{6}} \cdot d_i^{\frac{8}{3}} \cdot f^{\frac{5}{3}}$$

k	0,0025	m	
di	0,50	m	
f	0,2	m2/m2	Pipe filling
q	0,23	m3/s	Flow capacity in down pipe
A_{pipe}	0,20	m^2	
A_{wet}	0,04	m^2	
V	5,9	m/s	Velocity in downpipe
D_{air}	0,22	m	





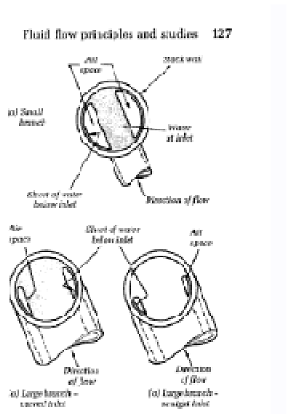


Branch section with 45 deg bend

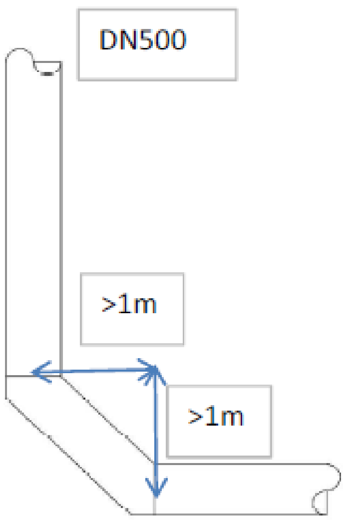
Pipe roughness	k [mm]	1,5	
Slope	I [prom.]	1000	
Dim.	Di [mm]	400	
Flow (full)	Qf [l/s]	2186	
Flow (actual)		222,2	l/s
% filling		24%	
depth		0,10	m
I - gradient		10,3	prom.
Velocity		1,77	m/s

Calculation of air space at junction

Air space at each side	0,019112	m2	Measured in AutoCAD
Total air	0,038224	m2	
Wet area	0,158124	m2	Measured in AutoCAD
Total	0,20	m2	
Filling	0,81		

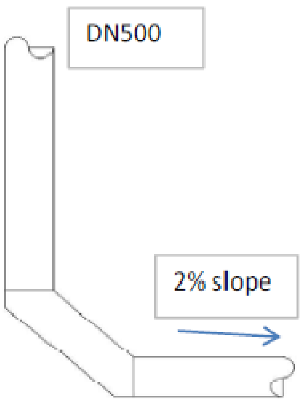


Foot bend at ground level (45 deg)



Pipe roughness	k [mm]	1,5	
Slope	I [prom.]	1000	
Dim.	Di [mm]	500	
Flow (full)	Qf [l/s]	3936	
Flow (actual)		222,2	l/s
% filling		18%	
depth		0,09	m
I - gradient		3,2	prom.
Velocity		1,13	m/s

Foot bend at ground level (discharge pipe)



Pipe roughness	k [mm]	1,5	
Slope	I [prom.]	20	
Dim.	Di [mm]	500	
Flow (full)	Qf [l/s]	557	
Flow (actual)		222,2	l/s
% filling		49%	
depth		0,24	m
I - gradient		3,2	prom.
Velocity		1,13	m/s

VERY IMPORTANT: The discharge pipe shall at all circumstance be able to discharge freely (water level shall be kept below the Invert level)

OBS: The discharge velocity may be up to 5,9 m/s

5 Lightning protection and earthing

5.1 Need for lightning protection of the Messina Bridge

There are no devices nor methods preventing lightning discharges. Lightning flashes to, or nearby, structures (or services connected to the structures) are hazardous to people, to the structures themselves, their contents and installations as well as to services.

In accordance with lightning statistics the Calabria area is located in geographic area with low number of lightning per year. The statistic lightning frequency is shown shown in Fig. 6.1.

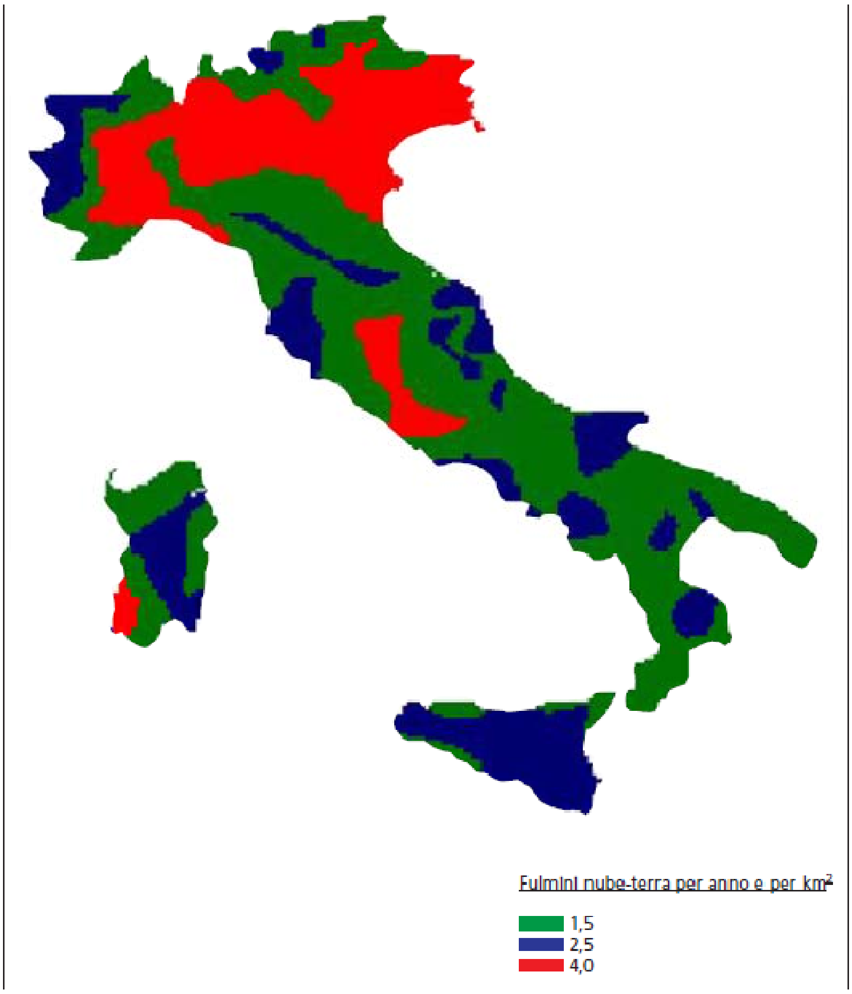


Fig.6.1 Densitá di fulmini al suolo in Italia (Guida CEI-81-3-1999)

The bridge over strait of Messina will be one of the significant structures in the World and it was in early phase of the project decided that this object shall be equipped with installations prowiding very high level of availability even in case of single failure in essential systems e.g. power supply system, ligting system, bridge marking etc. These reasons have led to a decision that the bridge shall be equipped with the highest class of lightning protection system LPS class 1.

With reference to EN 62305 the following types of losses shall be considered:

- L1: loss of human life;
- L2: loss of service to the public;

- L3: loss of cultural heritage;
- L4: loss of economical value (structure and its content, service and loss of activity).

Loss of type L1, L2 and L3 may be considered as loss of social values, whereas loss of type L4 may be considered as purely economical loss.

Losses which may appear in a structure are as follows:

- L1: loss of human life;
- L2: loss of service to the public;
- L3: loss of cultural heritage
- L4: loss of economic value (structure and its content).

Losses which may appear in a service are as follows:

- L2: loss of service to the public;
- L4: loss of economic value (service and loss of activity).

The bridge is a tall structure over sea and will be exposed to lightning strokes. These lightning strokes will result in flow of lightning current along towers, cables and bridge deck and create potential danger to maintenance personnel (loss type L1) and loss of service to the trafficants (loss type L2).

The standard EN 62305-2 opens for possibility to reduce requirements to the LPS classification by means of an assessment of risks in form of a risk analysis. If agreed between the General Contractor and the Employer, such analysis may be carried out during the Projetto Esecutivo phase of the Works.

Overvoltages produced by lightning current will also cause danger for loss of service in case of missing overvoltage protection within mechanical and electrical installations installed on the deck, tower surface, anchor blocks etc. (loss type 2).

Lightning strokes may cause damage to electrical equipment installed on the bridge structures, if not protected (loss type L3).

The above standard operates with tolerability of losses of human life and services for the public. However, the requirements for very high availability of services, as well as need for protection of important bridge construction elements do not allow for other choice than installation of highest class LPS and installation of LPMS protection measures for all essential electrical systems.

The following measures will be implemented:

- Protection measures to reduce physical damage - lightning protection system (LPS) class 1
- Protection measures to reduce failure of electrical and electronic systems LEMP protection measures system (LPMS) consisting of earthing and bonding measures; magnetic shielding; line routing; coordinated SPD protection" .

Furthermore, in order to reduce loss of service the M&E installations are designed with route redundancy, redundant equipment, autonomous power generating sets, uninterruptible power systems, fluid storage systems, and automatic failure detection system are effective protection measures to reduce the loss of activity of the service.

5.2 Design of LPS

5.2.1 General

The LPS is intended to intercept direct lightning strikes to the structure and conduct the lightning current to the ground without causing thermal or mechanical damage.

The following standard is used for design of the LPS: EN 62305 Protection against lightning (Protezione contro i fulmini):

CEI EN 62305-1 **(CEI 81-10/1)** - Part 1: General principles (parte 1 : principi generali)

CEI EN 62305-2 **(CEI 81-10/2)** – Part 2: Risk management (parte 2 : valutazione del rischio)

CEI EN 62305-3 **(CEI 81-10/3)** – Part 3 Physical damage to structures and life hazard (parte 3 : danni materiali alla struttura e pericolo per le persone)

CEI EN 62305-4 **(CEI 81-10/4)** : Electrical and electronic systems within structures (parte 4 : impianti elettrici ed elettronici all'interno delle strutture)

5.2.2 Design basis

The design is based on EN 62305 standard. This standard defines a number of values which are relevant for the design of the LPS system.

Table 5 – Maximum values of lightning parameters according to LPL

First short stroke			LPL			
Current parameters	**Symbol**	**Unit**	**I**	**II**	**III**	**IV**
Peak current	I	kA	200	150	100	
Short stroke charge	Q_{short}	C	100	75	50	
Specific energy	W/R	MJ/Ω	10	5,6	2,5	
Time parameters	T_1/T_2	μs/μs	10 / 350			
Subsequent short stroke			**LPL**			
Current parameters	**Symbol**	**Unit**	**I**	**II**	**III**	**IV**
Peak current	I	kA	50	37,5	25	
Average steepness	di/dt	kA/μs	200	150	100	
Time parameters	T_1/T_2	μs/μs	0,25 / 100			
Long stroke			**LPL**			
Current parameters	**Symbol**	**Unit**	**I**	**II**	**III**	**IV**
Long stroke charge	Q_{long}	C	200	150	100	
Time parameter	T_{long}	s	0,5			
Flash			**LPL**			
Current parameters	**Symbol**	**Unit**	**I**	**II**	**III**	**IV**
Flash charge	Q_{flash}	C	300	225	150	

Table 6 – Minimum values of lightning parameters and related rolling sphere radius corresponding to LPL

Interception criteria			LPL			
	Symbol	**Unit**	**I**	**II**	**III**	**IV**
Minimum peak current	I	kA	3	5	10	16
Rolling sphere radius	r	m	20	30	45	60

With respect to the threat of lightning, the following LPZs are defined:

LEMP protection for electrical and electronic installations CEI EN 62305-4	
Lightning protection zone	**Description**
LPZ 0_A	zone where the threat is due to the direct lightning flash and the full lightning electromagnetic field. The internal systems may be subjected to full or partial lightning surge current;
LPZ 0_B	zone protected against direct lightning flashes but where the threat is the full lightning electromagnetic field. The internal systems may be subjected to partial lightning surge currents;.
LPZ 1	zone where the surge current is limited by current sharing and by SPDs at the boundary. Spatial shielding may attenuate the lightning electromagnetic field;

LPZ 2	zone where the surge current may be further limited by current sharing and by additional SPDs at the boundary. Additional spatial shielding may be used to further attenuate the lightning electromagnetic field.

Protezione LEMP degli impianti degli edifici contenenti sistemi elettrici ed elettronici secondo CEI EN 62305-4	
Zona di protezione da fulminazione	**Descrizione**
LPZ 0_A	Esposta al pericolo di fulminazione diretta, di correnti impulsive di valore max pari a quello della corrente da fulmine e ai rischi determinati dall'intero campo elettromagnetico del fulmine.
LPZ 0_B	Protetta dalla fulminazione diretta. Esposta al pericolo di correnti impulsive di valore max pari a quello delle correnti parziali da fulmine e ai rischi determinati dall'intero campo elettromagnetico del fulmine.
LPZ 1	Correnti impulsive ulteriormente attenuate dalla ripartizione delle correnti e da SPD installati nei punti di passaggio da una zona all'altra. Il campo elettromagnetico del fulmine è per lo più attenuato dalla schermatura delle stanze.
LPZ 2	Correnti impulsive ulteriormente attenuate dalla ripartizione delle correnti e da SPD installati nei punti di passaggio da una zona all'altra. Il campo elettromagnetico del fulmine è per lo più attenuato dalla schermatura delle stanze.

An evaluation of the bridge construction has resulted in definition of zones on the bridge as shown in Fig. 6.2.2-1.

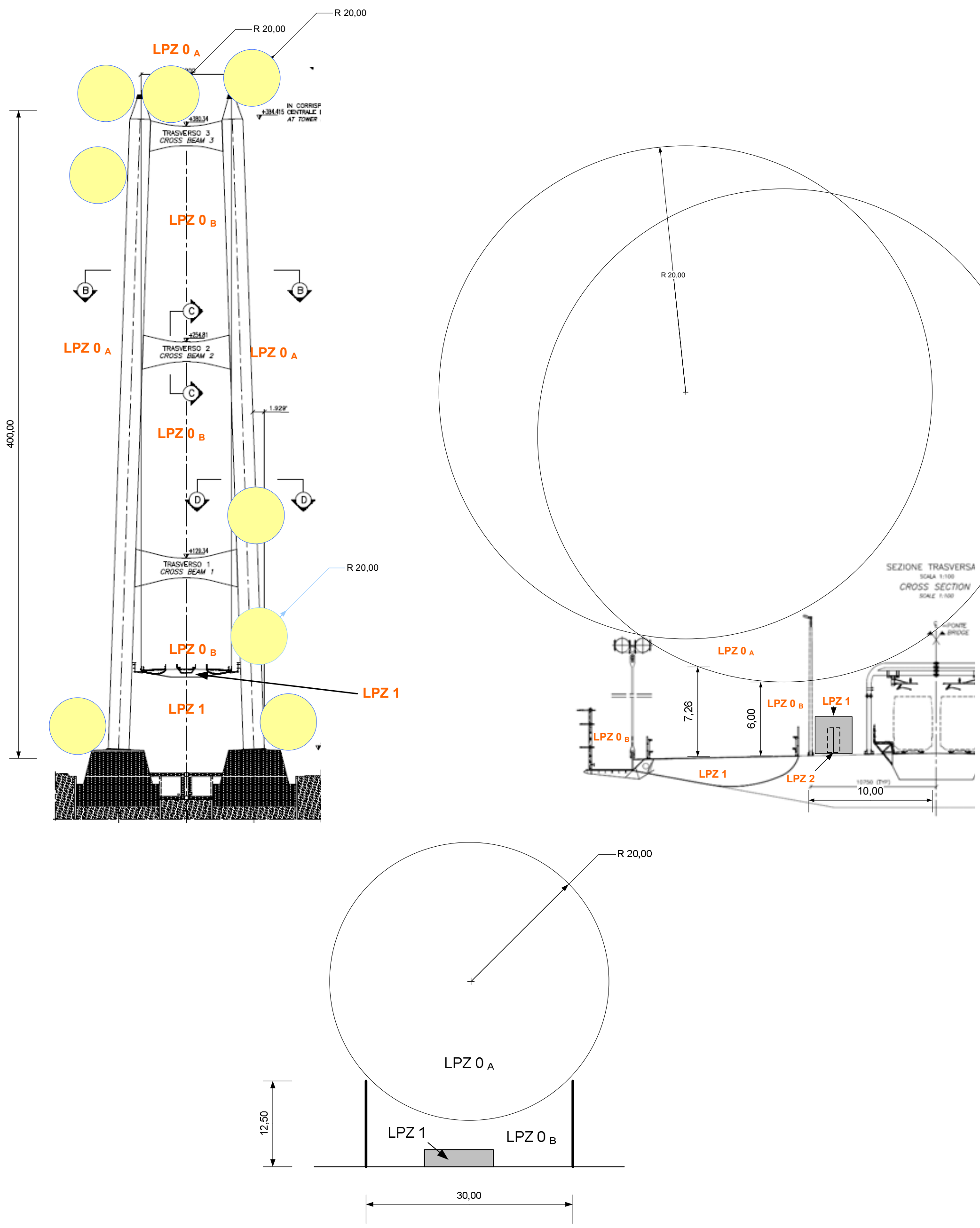


Fig. 6.2.2 Definition of lightning protection zones (LPZ)

In accordance to EN 62305-3 section 5.1.3 the external LPS can be constructed by means of use of natural components of the structure which will always be a part of the structure and will not be modified (e.g. interconnected reinforcement steel, metal framework of the structure etc.).

The LPS consist of:

1. Air termination system
2. Down conductor system
3. Earth termination system

The external LPS is intended to intercept direct strikes to the structure (air termination system, including the sides of the structure), to conduct the lightning current to the earth (down-conductor system) and to disperse it into the earth (effective earth termination system).

The LPS system is designed as LPS class I in accordance with EN 62305-3.

5.2.3 Air termination system

The probability of structure penetration by lightning current is considerably decreased by the presence of a properly designed air termination system.

In case of a steel bridge the air termination system can best be composed of metal structure of the bridge.

In accordance to EN 62305 section 5.2.5 natural air-termination components should be considered.

The bridge structure consists of the following components which will be used as natural parts of the air-termination:

1. Steel towers
2. Towing wire along the walkway on the main cables
3. Steel cores of the main cables
4. Steel cores of the hangers
5. Steel deck and barriers along the deck
6. Lighting poles
7. Traffic sign portals

8. Catenary system portals

The above metal components have thickness greater than 0.5 mm and comply with the minimum requirements in table 3 in EN 62305-3.

The steel structure of towers and the bridge deck is welded or bolted together and provide solid electrical connection of its parts.

It is assumed that corrosion protection of the steel surface is not providing significant resistance to the lightning currents.

The other parts like lighting poles, metal barriers, steel cores in the cables and hangers will be electrically interconnected with other parts of LPS by means of stainless steel wires as bonding conductors.

The size of bonding conductors will comply with minimum requirements stated in EN 62305.

5.2.4 Down conductor system

The steel construction of the towers will be used as down conductor for the towers.

The cable hangers will be used as down conductors for the main cables, the steel wires along the walkway along the cables and the steel wire for the inspection vehicle along the cables.

The ends of the main cables at the towers will be electrically bonded with the steel structure of the towers. This bonding will be made by means of stainless steel wires with cross section of 95mm² which is greater than 50 mm² specified in Table 1 CEI/IEC 62305-4.

The cable ends in anchor blocks will be electrically interconnected with steel cable holders by means of bonding. This bonding will be made by means of stainless steel wires with cross section of 95mm² which is greater than 50 mm² specified in Table 1 CEI/IEC 62305-4.

In the terminal structures the down conductors will be constructed of electrically-continuous reinforced concrete framework of the structure as recommended in EN 62305-3, section 5.3.5. b) and c). As an additional security for good and reliable earth termination system in the bottom part of the foundation the terminal structure will be provided with a ring connection at the top of the terminal structure and electrically connected down conductors made of selected reinforcement bars in each four corners of the terminal structure. This construction will result that the whole terminal construction will work as both down conductors and earth termination system with reinforcement bars connected by binding and a number of reinforcement bars connected solidly by clamps.

The electrical connection between the selected reinforcement bars will be made by means of clamping with factory manufactured clamps e.g. Dehn no.308 046, or similar.

All mentioned down conductors will provide several parallel connections for the lightning current.

In accordance with EN 62305 section 5.3.6 no test joints are required. However, the test can be carried out between terminal for bonding of the deck structure to the terminal earthing system and located at the top of the terminal structure (next to the bridge bearings) and the earthing busbar located inside the terminal bottom rum.

5.2.5 Earth termination system

All earth termination systems will be constructed in accordance to EN 62305-3 section 5.4.4, which recommends natural earth electrodes made of interconnected reinforcing steel in the foundation. This method will be used for tower foundations, terminal foundations and anchor blocks.

The earth terminations are conductive metal parts embedded in the concrete of the bottom part of the foundation structure. Concrete embedded directly in the ground has natural moisture content and can be considered as conductive matter, with conductivity similar to that of the earth. Because of the large area of this type of electrode, low resistance can be achieved. Furthermore, the concrete protects the metal parts against corrosion and steel electrode elements embedded in the concrete do not need any additional corrosive protection. Foundation earth electrodes are nowadays recommended as a very practical solution to external earthing electrodes.

Tests measurements of this type of earthing systems have shown that the resulting earthing resistance is far below 0,1 ohm and often lower than 0,01 ohm.

Principle of foundation earthing system is shown in Fig. 6.2.5.

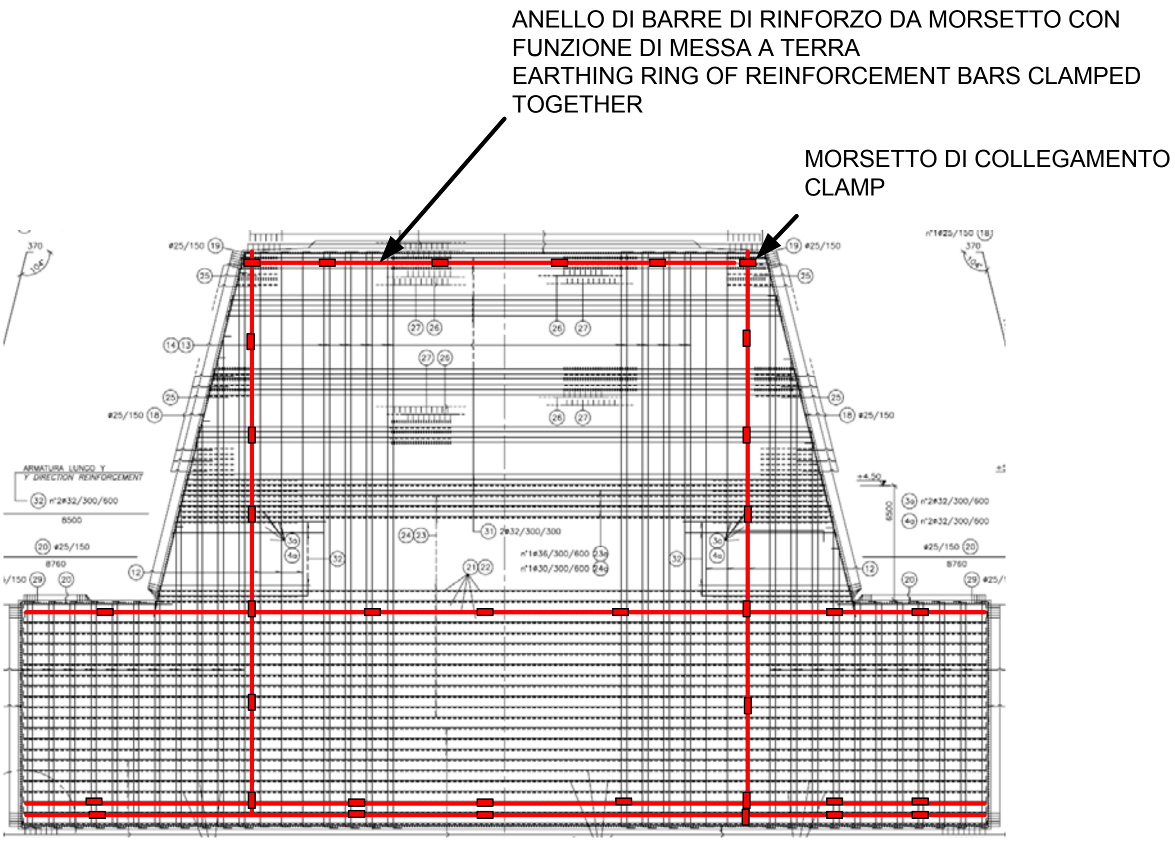


Fig.6.2.5 Foudation earthing system principle for tower foundation

The foundation earth termination earth resistance can be calculated using the following simplified equation:

Dispersore a semisfera/di fondazione	$R_A = \frac{\rho_E}{\pi \cdot d}$	$d = 1,57 \cdot \sqrt[3]{V}$

Where:

R_A is earthing resistance in ohms (Resistenza di terra)

ρ_E is the specific resistivity of the soil ohm/m (Resistivita del terreno (Ωm))

d is the effective diameter of the foundation in m (Diametro del dispersore ad anello, dell'area equivalente o di un dispersore a semisfera (m))

The earthing resistances are calculated to be as shown in table 1.

Table 1 Earthing resistance calculations

ID	Foundation	Volume m^3	$\sqrt[3]{V}$ m	ρ Ω m	d m	R Ω
1	Tower Calabria (estimated)	90.776	44,94	20	70,56	0,09027
2	Tower Messina (estimated)	105.290	47,22	20	74,14	0,08592
3	Anchor block Calabria	230.780	61,34	20	96,30	0,06614
4	Anchor block Messina	291.660	66,32	20	104,12	0,06118
5	Terminal Calabria	26.584	29,85	20	46,86	0,13593
6	Terminal Messina	29.716	30,97	20	48,63	0,13098

The down-conductor system is arranged in such a way that from the point of strike to earth several parallel currentpaths exist, the length of the current paths is kept to a minimum and an effective equipotential bonding to conducting parts of the structure is performed.

For structures utilizing steel reinforced concrete (including pre-cast, pre-stressed reinforced units), the electrical continuity of the reinforcing bars shall be determined by electrical testing between the uppermost part and ground level. The overall electrical resistance is not be greater than 0,2 Ω and the reinforcing steel may be used as a natural down-conductor as discussed in EN 62305-3 sections 4.3 and 5.3.5.

Earthing plates (punto fisso di terra) for bonding/earthing connection to the foundation earthing system will be as Dehn type M, or similar.

5.3 Internal lightning protection

The purpose of construction of an internal LPS is to avoid the occurrence of dangerous sparking within the structure to metal constructions and electrical installation due to lightning current flowing in the external LPS or in other conductive parts of the structure.

A low impedance bonding network will be used to avoid dangerous potential differences between all equipment inside the inner LPZ.

All metallic constructions and installations in towers will bonded to the steel tower construction.

All metallic constructions and installations in terminals and anchor blocks will bonded to the earthing system in the concrete construction. The bonding will be carried out to earthing plates installed in the surface of the concrete structure. The earthing plates will be connected electrically to the down conductors/reinforcement bars inside the structure. The bonding cables will be either copper wires or stailless steel wires in areas with corrosive atmosphere.

It shall be mentioned that majority of cable trays/ladders will be made of fibreglass selfextinguishing plastic.

Equipotentialization will be achieved by interconnecting the LPS with:

- structural metal parts,
- metal installations,
- internal systems,
- external conductive parts and lines connected to the structure.

Since part of the lightning current may flow into electrical systems the installations will be equipped with surge protection devices (SPD).

Railway track is installed on the bridge as insulated from the steel structure of the bridge. In order to keep this principle bonding of the railway track will be carried out through rare-gas filled surge protectors, as shown in section 6.6.

5.4 Design and installation of a LEMP protection measures system (LPMS)

Electrical and electronic systems are subject to damage from the lightning electromagnetic impulse (LEMP). Therefore LEMP protection measures need to be provided to avoid failure of internal systems.

Protection against LEMP is based on the lightning protection zone (LPZ) concept: the volume containing systems to be protected shall be divided into LPZ. These zones are theoretically assigned volumes of space where the LEMP severity is compatible with the withstand level of the internal systems enclosed (see Figure 6.2.2). Successive zones are characterized by significant changes in the LEMP severity. The boundary of an LPZ is defined by the protection measures employed.

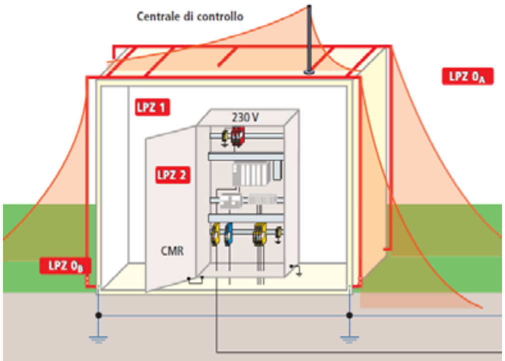


Fig. 6.4-1 Definition of protection zones for a switchgear - suddivizione della centrale di controllo in zone di protezione da fulminazione LPZ

5.4.1 Medium voltage switchgear

The medium voltage switchboards will be equipped with lightning arresters in the feeder compartment.

The lightning aresters will be zinc-oxide (ZnO) varistorbased surge arresters.

Protection of medium voltage AC networks against both, multiple atmospheric and switching overvoltages as well as Very Fast Transients (VFT). Suitable for the protection of motors and cable sheaths. They will be of a type which is optimised for the use in link boxes of cable installations.

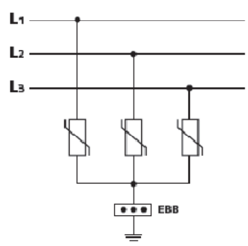


Fig. 6.4.1 Principle diagram - Schema di pricipio

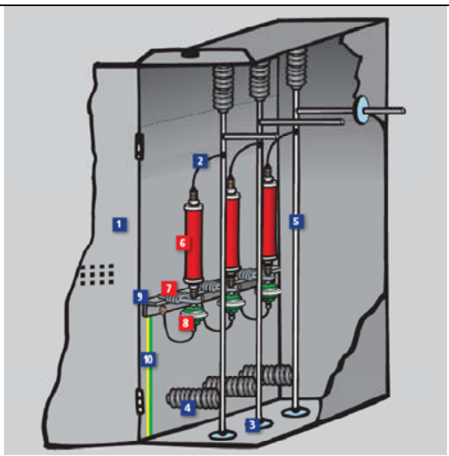
	Descrizione 1 Sportello apribile 2 Scomparto di arrivo e risalita conduttori 3 Passante 4 Isolatore portante 5 Risalita conduttore 6 Scaricatore di media tensione 7 Supporto isolato 8 Unitá di sezionamento 9 Staffa di fissagio metallica 10Verso l'impianto di terra della cabina

Fig. 6 3.1 Principle for SPD for medium voltage switchgear

Recommended values for MO arresters according to the continuous operating voltage U_c and the associated rated voltage U_r

Nominal system voltage kV	Phase arrester at $C_E = 1.4$ U_c kV	Phase arrester at $C_E = 1.4$ U_r kV	Phase arrester at $C_E = \sqrt{3}$ U_c kV	Phase arrester at $C_E = \sqrt{3}$ U_r kV	Neutral-point arrester at $C_E = 1.4$ U_c kV	Neutral-point arrester at $C_E = 1.4$ U_r kV	Neutral-point arrester at $C_E = \sqrt{3}$ U_c kV	Neutral-point arrester at $C_E = \sqrt{3}$ U_r kV
6	–	–	7,2	9	–	–	> 4,7	> 5,9
10	–	–	12	15	–	–	> 7,8	> 9,75
20	–	–	24	30	–	–	> 15,6	> 12,5
30	–	–	36	45	–	–	> 23,4	> 29,3
110	75	126	123[1)]	144[1)]	50	78	72	84
220	160	216[2)]	–	–	60	108	–	–
380	260	360[2)]	–	–	110	168	–	–

[1)] Lower values are possible if the duration of the earth fault is accurately known.
[2)] Higher values are set for generator transformers.

The nominal discharge current serves to classify MO arrester. According to IEC 60099-4 lightning arresters can have classes: 2.5 kA, 5 kA, 10 kA and 20 kA.

For MV distribution systems commonly used classes are 5 kA and 10 kA. For lightning protection of the installations on a steel bridge with possibility for high induced current it is appropriate to use 10 kA class of lighting arresters.

<u>Configuring MO arresters for 20kV network with solidly earthed neutral (minimum values, as check for recommendations in the table above)</u>

Rated voltage level $U_m = U_S$ = 24kV

Standard lightning withstand voltage (BIL) of equipment = 125kV

Maximum short circuit current = 12.5kA (in future 20kA)

Maximum duration of temporary overvoltage: 10 s

Required nominal discharge current I_N=10kA

Determining the minimally required continuous operating and rated voltage

$U_{C,\ min} = 1.05 \times U_S / 1.73 = 14.6$ kV

$U_{r1,\ min} = 1.25 \times U_{C,\ min} = 18.2$ kV

$U_{r2,\ min} = 1.4 \times (U_S / 1.73)/k_{10s} = 1.4 \times (24/1.73)/1 = 19.4$ kV

Chosen values: $U_r > U_{r2min}$ = 21 kV; $U_C = U_r / 1.25$ = 16.8 kV

Creepage distance = 20 mm/kV x 24 kV = 480 mm

Short circuit withstand capacity: 10 kA (typical value)

<u>For 20 kV switchgear the surge arresters will comply with the following minimum requirements:</u>

- Rated current: 10kA
- Operating duty impulse withstand current (4/10μs): 100 kA
- Continuous operating voltage U_c: 20kV
- Rated voltage: 22kV
- Residual voltage at 20 kA (8/20 μs): 68kV
- Residual voltage at 40 kA (8/20 μs): 79kV
- Energy high current impulse: 5,3 kJ/kV Uc

For 6 kV switchgear the surge arresters will comply with the following minimum requirements:

- Rated current: 10kA
- Operating duty impulse withstand current (4/10μs): 100 kA
- Continuous operating voltage U_c: 6kV

- Rated voltage: 7.5kV
- Residual voltage at 20 kA (8/20 µs): 20kV
- Residual voltage at 40 kA (8/20 µs): 22.5kV
- Energy high current impulse: 5,3 kJ/kV Uc

5.4.2 Low voltage switchgear

The low voltage switchgear will be equipped with overvoltage protection units.

In accordance to standards the lightning protection levels shall comply with the values given in Table 6.4.2-1.

Table 6.4.2 -1 – Expected surge overcurrents due to lightning flashes

LPL	Low voltage systems		
	Flash to the service	Flash near the service	Near to, or on the structure
	Source of damage S3 (direct flash) Waveform: 10/350 µs (kA)	Source of damage S4 (indirect flash) Waveform: 8/20 µs (kA)	Source of damage S1 or S2 (induced current only for S1) Waveform: 8/20 µs (kA)
III - IV	5	2,5	0,1
I - II	10	5	0,2

In accordance with EN 62305 - 1 SPDs to be used according to their installation position are as follows:

1) At the line entrance into the structure (at the boundary of LPZ 1, e.g. at the main distribution board MB):

- SPD tested with *I*imp (typical waveform 10/350, e.g. SPD tested according to Class I);
- SPD tested with *I*n (typical waveform 8/20, e.g. SPD tested according to Class II).

2) Close to the apparatus to be protected (at the boundary of LPZ 2 and higher, e.g. at secondary distribution board SB, or at a socket outlet SA):

- SPD tested with *I*n (typical waveform 8/20, e.g. SPD tested according to Class II);

- SPD tested with a combination wave (typical current waveform 8/20, e.g. SPD tested according to Class III).

The surge protection devices will be from manufacturer Dehn, or similar.

	Definition acc. to IEC 61643	Definition acc. to EN 61643
SPDs which withstand the partial lightning current with a typical waveform 10/350 µs require a corresponding impulse test current I_{imp} The suitable test current I_{imp} is defined in the Class I test procedure of IEC 61643-1	SPD class I	SPD Type 1
SPDs which withstand induced surge currents with a typical waveform 8/20 µs require a corresponding impulse test current I_n The suitable test current I_n is defined in the Class II test procedure of IEC 61643-1	SPD class II	SPD Type 2
SPDs that withstand induced surge currents with a typical waveform 8/20 µs and require a corresponding impulse test current I_{sc} The suitable combination wave test is defined in the Class III test procedure of IEC 61643-1	SPD class III	SPD Type 3

Equivalents for SPD classification

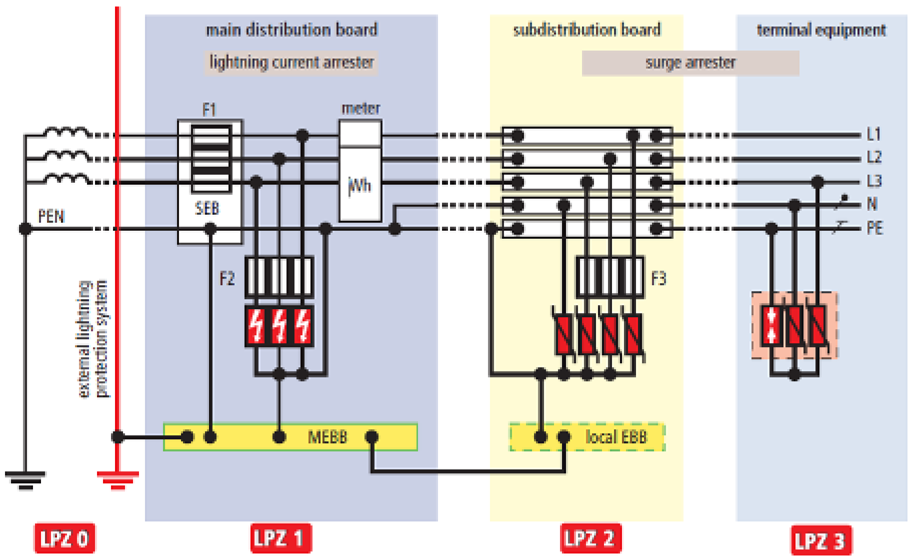


Table 6.4.2-2 Installation of SPD in zones - principle

Tipo/Denominazione \ Norma	CEI 81-8/4:2002 (già abrogata)	IEC 61643-1:2005	EN 61643-11:2002
Scaricatore di corrente da fulmine Scaricatore combinato	SPD di Classe di Prova I	SPD class I	SPD Tipo 1
Limitatore di sovratensione per distribuzione, distribuzione secondaria	SPD di Classe di Prova II	SPD class II	SPD Tipo 2
Limitatore di sovratensione per prese/apparecchi utilizzatori	SPD di Classe di Prova III	SPD class III	SPD Tipo 3

Fig. 6.4.2-3 Classificazione dei dispositivi di protezione secondo CEI, IEC und EN

The SPDs shall be installed in all main switchboards. The SPDs shall comply with the following minimum specifications:

SPD according to EN 61643-11	Type 1
Nominal ac voltage U_N	230 / 400 V
Max. continuous ac voltage U_C	255 V
Lightning impulse current (10/350) [L1+L2+L3+N-PE] I_{imp}	100 kA
Nominal ac voltage U_N	230 / 400 V
Lightning impulse current (10/350) [L,N-PE] I_{imp}	25 kA
Nominal discharge current (8/20) I_n	25 / 100 kA
Voltage protection level [L-PE] U_P	≤ 1.5 kV
Follow current extinguishing capability ac I_{fi}	50 kArms
Response time t_A	≤ 100 ns
Max. backup fuse (L) up to I_K = 50 kArms	315 A gL/gG
Max. backup fuse (L) at I_K > 50 kArms	200 A gL/gG
Max. backup fuse (L-L´)	125 A gL/gG
TOV voltage [L-N] UT	335 V / 5 sec.

The SPD devices to be installed in sub-distribution switchboards shall comply with the following specifications:

SPD according to EN 61643-11	Type 2
Nominal voltage ac U_N	230/400 V
Max. continuous ac voltage U_C	275 V
Nominal discharge current (8/20) In	20 kA
Max. discharge current (8/20) Imax	40 kA
Voltage protection level UP	≤ 1.25 kV
Voltage protection level at 5 kA UP	≤ 1 kV

Response time tA	≤ 25 ns
Max. mains-side overcurrent protection	125 A
Short circuit withstand capability at max. mains-side overcurrent protection	50 kArms
TOV voltage UT	335 V / 5 sec.
Enclosure material	plastic
Degree of protection	IP 20
Type of remote signalling contact	changeover contact
Switching capacity ac	250 V/0.5 A

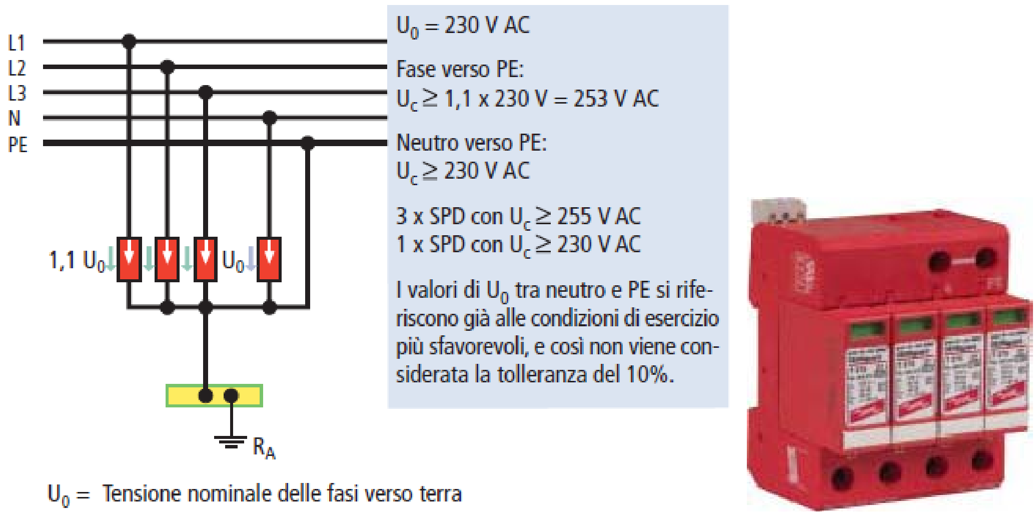


Fig.6.4.2-4 Protection diagram "4-0" for TNS system - Circuito di protezione “4-0” nel sistema TN-S

5.5 Railway

Railway power supply system shall be isolated from the bridge steel structure.

In order to provide potential equlisation of the railway track in case of lightning the steel track will be connected to the bridge earthing system through spark gaps based SDPs.

The protection level U_P of the SPD will be defined when the railway traction voltage has been agreed.

Installation principle for the SPD on the railway track is shown in Fig. 6.5-1.

SDS — **EQUIPOTENZIALIZZAZIONE ANTIFULMINE**

Dispositivo di limitazione tensione — **SPINTEROMETRI DI SEZIONAMENTO**

- Separazione galvanica tra sezioni di binari isolati e parti d'impianto collegati a terra
- Equipotenzialità sicura in caso di un corto circuito/ corto verso terra della linea di trazione, tramite la saldatura ad elevate correnti degli elettrodi
- Anche in caso di scariche diretta da fulmini, non si verifica alcun corto circuito
- Tenuta alla corrente di corto circuito fino a 25 kA_{eff} / 100 ms; 36 kA_{eff} / 75 ms

SDS ...: inserto spinterometrico SDS in esecuzione cilindrica, per l'inserimento nell'adattatore Siemens per binari, cod. 431.34

Nella norma CEI EN 50122-1 viene descritto l'utilizzo di dispositivi di limitazione nei sistemi ferroviari in corrente continua e corrente alternata, per la cosiddetta "messa a terra aperta di sistemi ferroviari" di parti conduttori nella zona della linea di trazione e del pantografo.
Per poter evitare, nei sistemi ferroviari a trazione elettrica, la formazione di sovratensioni pericolose tra i binari oppure sezioni di binari isolati verso parti d'impianto collegati a terra, vengono impiegati dispositivi di limitazione tensione (SDS ...).

Essi hanno lo scopo di collegare in modo permanente le parti d'impianto nella zona della linea di trazione e del pantografo con la linea di ritorno, nel caso in cui venga superata la tensione d'intervento.

In caso di sovratensioni causate da eventi atmosferici, il dispositivo di limitazione tensione SDS ... possiede la capacità di ritornare nello stato iniziale, dopo aver scaricato una corrente impulsiva. Solamente con il superamento della sollecitazione con corrente di fulmine indicata, avviene un corto circuito permanente tramite la saldatura ad elevata corrente degli elettrodi e la conseguente necessità di sostituzione dell'inserto di protezione.

Il dispositivo di limitazione tensione SDS ... è composto dall'inserto spinterometrico ed il relativo set di connessione, adatto per il collegamento direttamente al binario oppure al palo della linea di trazione.

L'inserto di protezione spinterometrico, sviluppato da DEHN + SÖHNE, tipo SDS 1, Art. 923 110, è stato omologato dall'Ente Ferroviaria Tedesca (EBA - Eisenbahn-Bundesamt).

Inserto spinterometrico tipo SDS, per l'inserimento nell'adattore Siemens per binari, cod. 431.34

Fig. 6.5-1 Principle for railway track potential equalisation

The traction current will return back to traction substations via the continous rail system. In such a direct current traction system where the negative of the traction supply is connected to the continous rail system, the bridge grounding system will through the foundation concrete reinforcement bars and soil provide an additional return path, in parallel with the track, for stray leakage current flowing back to the traction supply source. Particularly in the *case* of extensive structures such the bridge structure and the concrete reinforcement bars in the foundation, part of the stray current flowing into the soil through the concrete reinforcement bars may be picked up in one area and discharge in another and finally leading to stray current corrosion. Although this in general will be mitigated by the isolation provided by the embedded rail system from Edilon to be installed, stray current driven corrosion will still be a risk. This have been further analysed in the document "*Stray currents, analysis and monitoring*" CG-1000- P-2S-D-P-IT-M3-SM-00-00-00-02.

5.6 Earthing system

5.6.1 General

The earthing and bonding shall comply with the Low Voltage Directive 2006/95/EEC, CEI EN IEC 60364 and IEC 61892.

5.6.2 MV Installations

The neutral point of the transformers will be directly connected to the system earth.

All metallic construction in the medium voltage rooms will be earthed to the earthing bar installation in these rooms.

The main earth reference points shall be earth bars. The earth bar for protective earth (PE) will be located in the switchgear and transformer rooms and the earth bar for instrument earth (IE) shall be located in the Instrumentation equipment room.

On the bridge deck earthing bar system will be established by means of earthing bars connected by welding to the bridge deck.

In towers the earthing bar system will be electrically connected to earthing bar welded to the tower surface.

If necessary earthing conductor system in the electrical room will be constructed of copper 24x4 mm fixed to steel walls in distance holders and finally connected to the earthing bars in both its ends.

Earth cables for earthing connections between the MV equipment and earthing bars will be 95mm^2 Cu.

Earth bars will be fabricated from copper and will be prepared with suitable drilled holes for the required size and number of connections.

The main PE bar shall act as the main connection point for the following equipment:

- 6/0,4kV transformers neutral point
- UPS systems neutral point
- Earth bars in MV and LV switchgear
- PE earth bars in instrument panels

5.6.3 LV Installations

The earthing system will be TN-S system in accordance with IEC 60364.

Earthing of the LV switchgear will follw the same principle as for MV installations.

The earthing and equipotentila bondig bars will be installed in all electrical rooms. The equipotential bonding bars will be installed in all technical rooms.

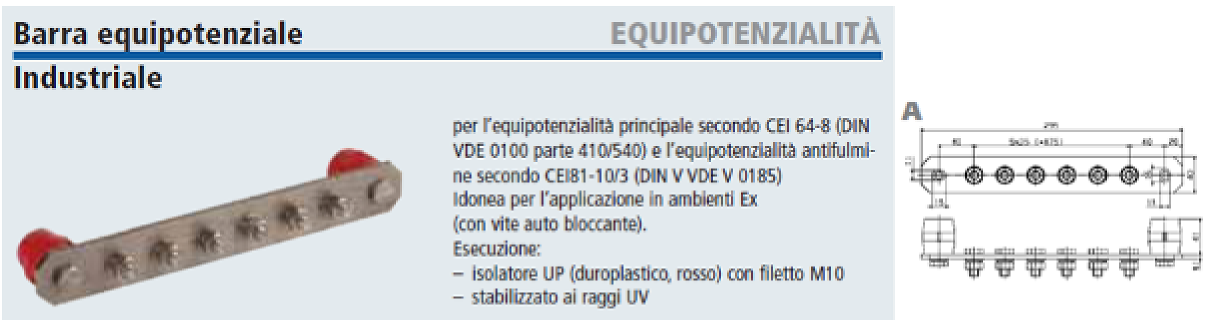


Fig. 6.6.3 - 1 Equipotential bonding bar

The equipotential bonding bars will be used for direct connection of metallic mechanical and electrical installations.

All equipotential connections will not be less than 10 mm² copper in order to provide sufficient mechanical strength of the connection.

Equipment and items to be bonded shall include:

- All metallic components of the structure which is not welded to the main structure
- Metallic enclosures of electrical equipment

- Metallic doors
- Stairs, ladders and railings
- Steel cable ladders and trays
- Piping systems
- Packaged units

In concrete structures the equipotential and earthing bars will be arranged on concrete wall and connected to the foundation earthing system via earthing plates with direct connection to the reinforcement bars, as shown in Fig. Fig. 6.6.3 - 2.

Fig. 6.6.3 - 2 Equipotential bonding bar

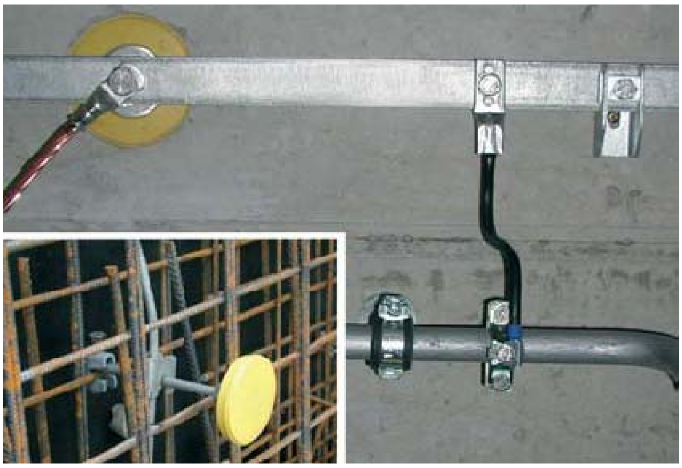


Fig. 6.6.3-3 Earthing plate point - Punto fisso di messa a terra

6 Radio Communication System

The purpose of the calculations in this section is to verify that the requirements of the Mechanical and Electrical Design Specification, doc.no. CG1000-P-2S-D-P-IT-M4-C3-00-00-00-06 are fulfilled.

The section contains the following calculations:

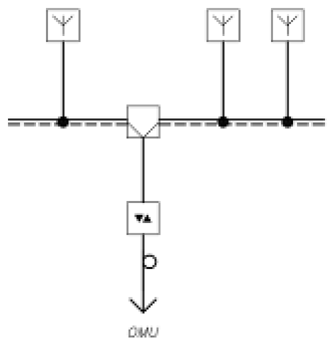
- Indicative calculations of link budgets, i.e. the RF-receiving levels and margins inside the bridge girders towers and anchor blocks;
- Indicative calculations of the availability of the radio communication system.

6.1 Link budgets

Calculations of the receiving levels inside the bridge girders, the towers and the anchor blocks are shown in the tables below together with simplified block diagrams.

6.1.1 Bridge girders

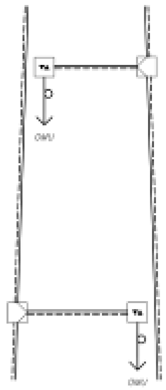
There are four TETRA repeaters at each side of the bridge. The repeaters are installed in the substations located between the road girder and the railway girder. Each repeater provides radio coverage of a section of approximately 960 m, viz. 480 m on each side of the repeater. Radio coverage in the girders is provided by leaky coaxial cable (radiating cable). RF-Taps are inserted in the cable for tapping out a small portion of the RF signal which feeds a discrete antenna for coverage of a cross beam. The block diagram below shows a part of one radio section. The table shows the receiving level at the end of a 480 m long section.



TETRA - 450 MHz	Att	Unit	Length (m)	
Repeater output		dBm		33.0
½" coax cable	4.5	dB/100m	60	2.7
3 dB splitter		dB		3.0
½" leaky coax longitudial loss	5.7	dB/100m	480	27.4
Tapping losses				2.0
Connector losses		dB		1.0
Coupling loss (2m) 95%		dB		79.0
Addition to coupling loss (10m)		dB		6.0
Receiving level		dBm		-88.1
Threshold		dBm		-100.0
Margin 95 %		db		11.9

6.1.2 Towers

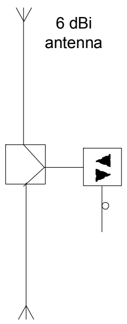
There are two TETRA repeaters installed in each tower. Radio coverage is provided by leaky coax as shown on the figure below. An antenna is foreseen to cover the top cross beam (not shown). Calculation of the receiving level for the longest run in one of the legs is shown in the table below.



TETRA - 450 MHz	Att	Unit	Length (m)	
Repeater output		dBm		30.0
½" leaky coax longitudial loss	5.7	dB/100m	70	4.0
3 dB splitter		dB		3.0
½" leaky coax longitudial loss	5.7	dB/100m	240	13.7
Connector losses		dB		0.5
Coupling loss (2m)		dB		79.0
Addition to coupling loss (10m)		dB		6.0
Receiving level		dBm		-75.7
Threshold		dBm		-100.0
Margin 95 %		db		24.3

6.1.3 Anchor blocks

The two rooms in the anchor blocks are covered by discrete antennas being fed from a repeater installed in the substation next to the anchor blocks.

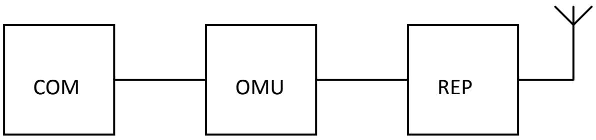


TETRA - 450 MHz	Att	Unit	Length (m)	
Repeater output		dBm		20.0
½" coax	4.5	dB/100m	10	0.5
3 dB splitter		dB		3.0
½" coax	4.5	dB/100m	70	3.2
Connector losses		dB		0.2
Antenna gain		dBi		6.0
Free space attenuation		dB	100	65.5
Addition for no free space		dB		6.0
Receiving level		dBm		-52.3
Threshold		dBm		-100.0
Margin 95 %		db		47.7

6.2 Availability

The availability of a section of the radio communication system caused by equipment failures can be calculated as shown below.

The figure below shows the radio equipment used in the calculation;



COM/BS: Communication switch / Base station

OMU: Optical Master Unit

REP: Optical fed RF repeater

The table below shows the required Mean Time Between Failures (MTBF) values for each unit. It is assumed that a failure can be rectified within 4 hours, i.e. the Mean Time To Repair (MTTR).

The availability A is calculated for each unit from the formula: A = MTBF / (MTBF + MTTR).

Since the equipment is connected in series the resulting availability can be calculated as shown in table below:

Equipment	MTBF hrs	MTTR hrs	Availability		
Com/BS	50,000	4	A1=	0.99992	
OMU	50,000	4	A2=	0.99992	
Repeater	100,000	4	A3=	0.99996	
Resulting availability: A1*A2*A3=				0.99980	

The resulting availability for this radio section is 0.9998 or 99.98 % corresponding to an unavailability of 0.02 % or 1.75 hours per year.

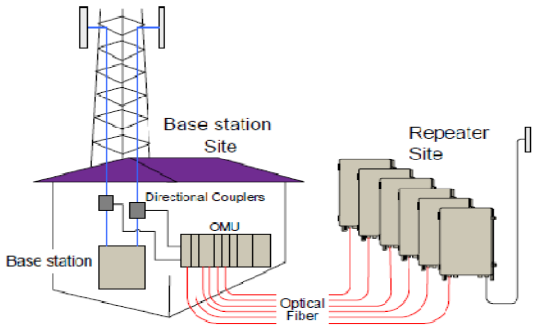
6.3 Equipment for the radio communications system

The following paragraphs describe typical equipment to be installed for the radio communications system. All radio equipment will be for the 450 MHz frequency range.

Optical Master Unit

The Optical Master Unit converts the RF-signals to light for feeding of the fibre fed repeaters.

Some typical characteristics are shown below:



SPECIFICATIONS

RF Parameters

Frequency bands	380-960/1710-2170 MHz
Gain Flatness	2 dB (p-p)
Nominal RF input power	+10 dBm composite power
Maximum Absolute RF input powe	+23 dBm composite power
Number of optical modules	1-6
Laser class	Class 1

Optical Module Electrical Specification

Optical Wavelength	Two color system	Three color system	Four color system
Master1	310 ± 10 nm	1310 ± 10 nm	1310 ± 10 nm
Slave 1	1550 ± 3 nm	1550 ± 3 nm	1530 ± 3 nm
Slave 2	N/A	1510 ± 3 nm	1510 ± 3 nm
Slave 3	N/A	N/A	1550 ± 3 nm

Optical output power	
Master	+3 ± 2 dBm
Slave	+3 ± 2 dBm
Maximum Optical Input Power	+2 dBm
Output Power (Tx) max	+5 dBm
Operating Temperature	+5 ~ +45°C
Automatic fibre optic loss compensation	Yes
Power Requirements	
Power Requirements	230/115 VAC, 50/60 Hz, 24/-48 VDC
Power Consumption	Typical 50 W (fully equipped)
External Electrical Interfaces	
Local Maintenance Terminal	RS232
RF Ports	N-type Connector Female
Optical Ports	SC/APC
AC/DC Mains Input	Plinth
External alarms	Plinth
Modem connector	RJ45 or RJ11
Modem antenna connector	SMA
Ethernet connector	RJ45
Mechanical Specifications	
Dimensions (w x h x d)	17.5 x 5.2 x 11.4 in (444 x 132.5 x 291 mm) 19" rack
Weight	TBD kg (fully equipped)
IP rating	IP20
Reliability Specification	
Lifetime (MTBF)	>70 000 hrs

Fibre Fed Repeater – Typical characteristics:

SPECIFICATIONS

Frequency bands available (MHz):

UL	DL
380-385	390-395
385-390	395-400
410-415	420-425
415-420	425-430
450-455	460-465
455-460	465-470

Operator bandwidth	5 MHz
Duplex distance	10 MHz
Output power/carrier (DL)	1 carrier: +36 dBm, 2 carriers: +33 dBm, 3-4 carriers: +30 dBm 8 carriers: +27 dBm

Optical Module Electrical Specification

Optical Wavelength	Two color system	Three color system	Four color system
Master	1310 ± 10 nm	1310 ± 10 nm	1310 ± 10 nm
Slave 1	1550 ± 3 nm	1550 ± 3 nm	1550 ± 3 nm
Slave 2	N/A	1510 ± 3 nm	1510 ± 3 nm
Slave 3	N/A	N/A	1550 ± 3 nm

Power Requirements	230 VAC 50Hz, 115 VAC 60Hz, –48 VDC
Power Consumption	<100 W, typical
External connection	
Local Maintenance Terminal	RS232
Server Port	7/16 female
Optical Ports	1 x SC/APC female
Modem antenna connector	SMA
Remote connection	Via OMU or (optional) GSM, GSM-R PSTN modem or Ethernet
Mechanical Specification	
Dimensions	540 x 350 x 150 mm
Enclosure	Aluminium (IP65)
Weight	28 kg
Cooling	Convection
Environmental Specification	
EMC	See compliance below
Operating Temperature	- 25°C to + 55°C
Storage	- 30°C to + 70°C
Humidity	ETSI EN 300 019-2-4 (see compliance below)
MTBF	> 100 000 hrs
Complies with	R&TTE Directive including, EN 301 489-18 ETSI TS 101 789-1, EN 60 950

The leaky feeder cable for the 450 MHz frequency range will be as Radiflex or similar:

1/2" RADIAFLEX® RCF Cable

RCF12 SERIES	
Cable Type	RCF/RSF
Size	1/2"
Slot Design	Milled (Two-Row)
Maximum Frequency, MHz	6000
STRUCTURE	
Inner Conductor Material	Copper Clad Aluminum Wire
Diameter Inner Conductor, mm (in)	4.8 (0.19)
Outer Conductor Material	Corrugated Copper Tube
Diameter Outer Conductor, mm (in)	13.8 (0.54)
Diameter over Jacket, mm (in)	16.2 (0.64)
MECHANICAL SPECIFICATIONS	
Minimum Bending Radius, Single Bend, mm (in)	125 (4.9)
Tensile Force, N (lb)	1000 (225)
Storage Temperature, °C (°F)	-70 to +85 (-94 to +185)
Operation Temperature, °C (°F)	-40 to +85 (-40 to +185)
Installation Temperature, °C (°F)	-25 to +60 (-13 to +140)
Recommended Clamp Spacing, m (ft)	0.6 (2.0)
Minimum Distance to Wall, mm (in)	50 (2)
Indication of Slot Alignment	None
ELECTRICAL SPECIFICATIONS	
Impedance, ohm	50 +/-2
Velocity, %	88
Inner Conductor dc Resistance, ohm/1000 m (1000 ft)	1.57 (0.48)
Outer Conductor dc Resistance, ohm/1000 m (1000 ft)	2.23 (0.68)
Stop bands, MHz	None

RCF12-50JFN/JFL

PERFORMANCE		
Frequency, MHz	Longitudinal Loss, dB/100 m (dB/100 ft)	Coupling Loss 50%/95%, dB
75	2.20 (0.67)	50/62
150	3.15 (0.96)	59/71
450	5.70 (1.74)	67/79
800	7.83 (2.39)	67/79
870	8.25 (2.51)	66/78
900	8.40 (2.56)	66/78
960	8.65 (2.64)	66/78
1800	13.1 (3.99)	68/80
1900	13.6 (4.15)	69/81
2000	14.0 (4.27)	72/84
2200	14.7 (4.48)	70/82
2400	15.3 (4.66)	70/82
2600	15.9 (4.85)	70/82
5000	24.8 (7.56)	75/87
5200	25.7 (7.83)	75/87

RF splitters/tappers are used to distribute the RF signals to the various areas in the bridge girders. Typical characteristics are shown below:

- Split ratios from 1000:1 to 2:1
- Tetra, PMR, Cellular, UMTS, WiFi & WiMAX
- Low specified PIM
- 500 W Avg Power Rating
- Minimal RF Insertion Loss
- RoHS compliant
- High Reliability, IP67
- N connectors

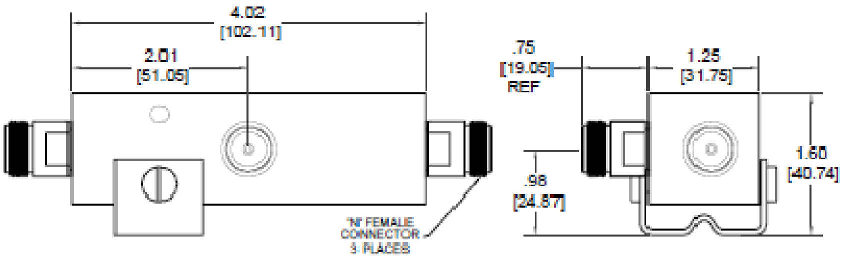
Microlab DN-x4FN series of Tappers unevenly split high power cellular signals in fixed ratios from 1000:1 to 2:1 with minimal reflections or loss over the wireless bands in the range 350 - 2,700 MHz, (there is no coupling 1550 to 1650 MHz). The innovative asymmetric design ensures an excellent input VSWR and coupling flatness across the band, even down to a 2:1 split. If DC Continuity/AISG to the branch line is a requirement, see the DK-x4FN series.

The lightweight design allows easy attachment to a wall using the supplied bracket. Designed with only a few solder joints and an air dielectric, loss is minimized and reliability enhanced. (01/10)

Model Number	Output Split Ratio, nom. (dB inequality between Outputs)	Outputs ref. to Input Level, incl Loss, dB Main/Branch dB	Branch Flatness	Input VSWR max. 700-2500 MHz	350-2700 MHz
DN-34FN	2:1/3.0dB	-1.8/-4.8	+0.5/-0.8*	1.3:1	1.4:1
DN-44FN	3:1/4.8dB	-1.3/-6.1	± 0.7*	1.3:1	1.3:1
DN-54FN	4:1/6.0dB	-1.0/-7.0	± 0.7*	1.2:1	1.3:1
DN-64FN	6:1/8.0dB	-0.7/-8.6	± 0.8*	1.2:1	1.2:1
DN-74FN	10:1/10dB	-0.4/-10.4	± 1.0	1.2:1	1.2:1
DN-84FN	20:1/13dB	-0.2/-13.2	± 1.0	1.2:1	1.2:1
DN-94FN	30:1/15dB	-0.1/-15.1	± 1.25	1.2:1	1.2:1
DN-04FN	100:1/20dB	-0.1/-20.1	± 1.00	1.25:1	1.25:1
DN-14FN	1000:1/30dB	-0.1/-30.1	± 1.25	1.2:1	1.2:1

*In range 350 - 380 MHz Branch Flatness is ±1.0

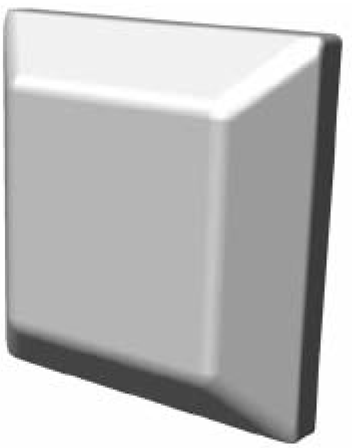
Frequency Bands:	350 - 960 & 1,710 – 2,700 MHz.
Dissipative Loss:	0.1 dB max. (main line)
Power Rating:	500W avg, 3 kW peak
Impedance:	50Ω nominal
Intermod. (PIM):	<-150 dBc (test with 2 x 20W tones)
Environment:	IP67, -35°C to +75°C
Connectors:	N(f) trimetal
Housing Finish:	Passivated Aluminum
Weight, nom:	14 oz (380 g)
Mounting:	Bracket supplied



Typical characteristics for Indoor antennas:

The 752.01.05.00 antenna is a broadband panel antenna suitable for indoor or outdoor coverage with TETRA and other UHF repeater systems. The dual-patch design gives the antenna stable radiation characteristics over a broad band of frequencies making the antenna ideal for a large range of indoor multichannel UHF repeater networks. The antenna is available with a snap-fit wall mounting bracket or pole mounting kit for easy installation, and can be supplied with connector and cabling options to suit application requirements.

Electrical & mechanical specifications



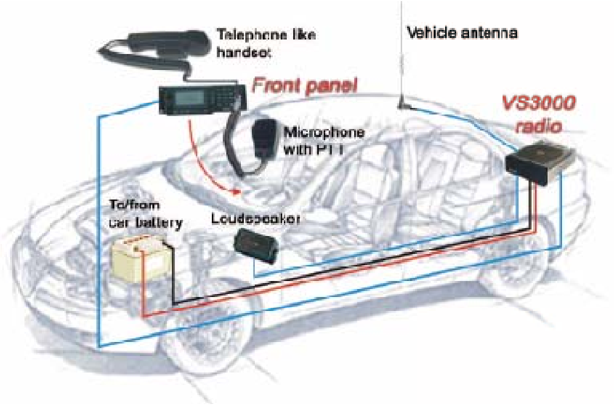
Frequency range	380-470MHz
Input impedance	50Ω
VSWR	<2.0:1
Front to back ratio	9 dB
Input power	50 W
Polarisation	Vertical & horizontal
Forward gain	6 dBd
Beamwidth	**E-Plane** 80° **H-Plane** 70°
Standard connection	'N' Socket on 150mm pigtail or antenna back
Materials	Aluminium, PTFE
Radome	Polyurethane white RAL 6014
Fasteners	Stainless Steel A2-70
Weight	0.4 kg
Dimensions	292 x 292 x 76mm

Handhelds and mobile TETRA radio terminals.

The operations and maintenance staff will be equipped with handhelds/mobile terminals as required.

The equipment will be as Selex, Sepura or similar. A selection of some of the options are show below:

Mobile terminal:



TECHNICAL DATA

Equipment type:	TETRA (TErrestrial Trunked RAdio) mobile radio with TEDS capabilities
Frequency bands: (other on request)	• 380 to 430 MHz • 410 to 470 MHz
Functional Modes:	Trunked Mode, Direct Mode, Direct Mode Repeater, Direct Mode Gateway
RF Power class:	• class 2 (10W 40dBm) ETSI EN 300 392-2 • class 3 (3W 35dBm) ETSI EN 300 392-2 • Adaptive Power control supported
RX Class:	Compliant ETSI ETS 300 392-2 / 396-2 Class A + B
Power supply:	+10.8 to 15.6 Vdc nominal, typical 13.2 Vdc
AF Power:	8 W @1 kHz into a 4 Ohm load
Dimensions:	48 x 172 x 188 mm (transceiver); 210 x 70.3 x 66.5 mm (front panel)
Weight:	1850 g (transceiver); 650 g (front panel)

Environmental specifications

Climatic condition:	ETSI EN 300 019-1-5 Class 5.1 (-25 ° to +70 °C)
Operation temperature: Water and Dust protection:	ETSI EN 300 394-1 (-20° to +55° C) • VS radio body: IEC 60529 class IP65 and IP67 • Control panel: IEC 60529 class IP54
Mechanical conditions:	• ETSI EN 300 019-1-5/6 classes 5/6 M3 & IEC 721 3-7 • MIL STD 810 D/E - Methods 516.4/5 procedures I/V • MIL STD 810 D/E - Methods 514.4/5 procedure I category 20
EMC	ETSI EN 300 489-18
Storage temperature:	-40 °C to +70° C
Transportation temperature:	ETSI EN 300 019-1-2 class 2.3

STP8000 Hand-Portable:

- Rugged
- High Power RF and Audio
- Fully integrated, ultra-sensitive, GPS option
- Fully integrated Bluetooth™ wireless interface option
- Automatic Man-Down reporting option
- Memory card, up to 32GB. eg. for document storage and applications
- Supported by Sepura's market-leading software tools, including Radio Manager.
- A wide range of market leading accessories
- End-to-End encryption requires only a software upgrade for activation[2]
- DMO Repeater ready (frequency efficient Type 1A option) with Call Participation

The STP8000 Hand-Portable is the most rugged TETRA hand-portable radio.

Designed and built to meet industry standard IEC529 IP55, it withstands day to day use in some of the harshest environments in the public safety, military, transport, and utilities markets.

DIMENSIONS

Height: 133mm
Width: 61mm (54mm)
Depth: 32mm (Standard Battery)
Depth: 37.5mm (High Capacity Battery)

WEIGHT

With Standard Battery <250g
With High Capacity Battery <275g

FREQUENCY BANDS

300-344MHz – STP8030
344-400MHz – STP8035
380-430MHz – STP8038
407-473MHz – STP8040
806-870MHz – STP8080

POWER SUPPLY

7.4V (nominal) Lithium Polymer Battery Packs
Intelligent Reporting Batteries
1260mAh Standard Battery
1400mAh Mid Capacity Battery
1880mAh High Capacity Battery

RF PERFORMANCE

RF Power – MS Power Class 3L (1.8 Watts)
RF Power – customisable for TMO/DMO/REP
Adaptive Power Control Supported
Receiver Class – A and B
Receiver Static Sensitivity -112dBm
Receiver Dynamic Sensitivity -103dBm

PRODUCT PERFORMANCE

Audio Power - >1 Watt
Operational Temperature -20°C to +60°C
Storage Temperature -40° to +85°C
Dust & Water Protection IP55
Shock, Drop & Vibration ETS 300 019

PRODUCT OPTIONS

GPS
Bluetooth
Micro SD Card
Man-Down Alarm[3]
DMO Repeater Type 1A
Air Interface Encryption Options
End to End Encryption Options
Wide Range of Languages & Keymats

DISPLAY AND USER INTERFACE

Large 30x38mm Active LCD Area
176 x 220 pixels
Transflective TFT Display, 262K colours
Normal, Large & Very Large Mode Text
18 Configurable Soft Keys
Vibrate Call/message
Call History
Phone Book (2000 entries)
3000 Talkgroups in TMO/DMO
255 Talkgroup Folders
Quick Groups
Transmit Inhibit with on/off Status messaging
Fixed & definable Scan Lists
Remaining Charge Time Indication

VOICE SERVICES

Full Duplex Calls (to MS and PABX/PSTN)
Half Duplex Calls (Individual and Group)
Priority Call
Emergency Call (Pre-emptive Priority)
Talking Party Identity
Calling Line Identity Presentation
DTMF Dialling
MSISDN Dialling
Abbreviated Dialling
Dynamic Group Number Assignment
Background (hidden) Groups
DMO Individual Call
DMO Group Call
DMO Emergency Call
DMO Intelligent Emergency Call

DATA SERVICES AND APPLICATIONS

Status Messaging (in TMO & DMO)
SDS Messaging (in TMO & DMO)
Multi-slot Packet Data
Circuit Mode Data[1]
TETRA Pager and Call Out[1]
WAP Browsing
Short Data Applications
Image & Map Storage on Memory Card
Lone Worker Feature
Missed Event Application

LOCATION BASED SERVICES

GPS Integrated Option
-190dBw (-160dBm) Tracking Sensitivity
Bluetooth Location System
GPS Based Compass
Over The Air GPS reporting using the following protocols:

- ETSI Location Standard Reporting (LIP)
- NMEA
- Sepura Compact Messaging

SECURITY SERVICES

Authentication
Class 1, 2 and 3 TETRA Security
Air Interface Encryption
TEA1/2/3/4 Supported[2]
SMART Card E2E Encryption Support[2]
Embedded E2E Encryption Support[2]
Indigenous E2E Encryption Algorithm Support[2]

DMO REPEATER SERVICES (LICENCE REQUIRED)

DMO Voice Repeated
DMO Tone Signalling Repeated
Group Status & SDS Repeated
Type 1A Efficient Operation over one Frequency Channel
Presence Signal Support
Emergency Call
Monitoring & Participation in Calls

CONNECTIVITY

TETRA V+D
Bluetooth Support for Voice and Data (PEI)
PEI Data via RS232 and USB Data Cables
Audio Connections via Rugged Accessory Connector
High Speed Interface for Feature-rich Audio Accessories
Audio and Data Connection via Facility Connector

ACCESSORIES

Personal Charger
Vehicle DC Charger
1+1 Desktop Charger
6+6 Desktop Charger
12 and 24 Way Battery only Chargers
Wide Range of Antennas
Stud and Belt Attachments
Rugged Belt Clip
Rugged and Soft Leather Cases
Basic IP55 Remote Speaker Microphone
Advanced Remote Speaker Microphone with Integral Antenna
Hands-Free Kit
Personal Ear Pieces
Feature-rich Car Kit
Serial and USB Data Leads

7 Switchgear

7.1 MV Switchgear

Medium voltage switchgear shall comply with the technical minimum requirements stated in the document CG1000-P-2S-D-P-IT-M4-C3-00-00-00-02 General Specifications M&E Works. This requirements have been based on load flow and short circuit calculations presented in section 2.5 of this document.

The switchgear will be supplied by well renamed manufacturers having as minimum their service facilities in Italy. The switchgear to be installed inside land located substations will be withdrawable type standard metal-clad construction from e.g. Schneider (type SM6), or ABB Unigear Zs1, or similar. The switchgear to be installed in bridge substations will be fixed compact design substations as e.g ABB Safe Plus, or similar

Some data for these switchgear are presented below.

SM6 range

Operating conditions

In addition to its technical characteristics, SM6 meets requirements concerning protection of life and property as well as ease of installation, operation and protecting the environment.

SM6 units are designed for indoor installations (IP2XC).
Their compact dimensions are:
- 375 mm to 750 mm wide;
- 1600 mm high;
- 840 mm deep…

… this makes for easy installation in small rooms or prefabricated substations.
Cables are connected via the front.
All control functions are centralised on a front plate, thus simplifying operation.
The units may be equipped with a number of accessories (relays, toroids, instrument transformers, surge arrestor, telecontrol, etc.).

Standards

SM6 units meet all the following recommendations, standards and specifications:
- recommendations IEC:

60694: Common specifications for high-voltage switchgear and controlgear standards.
60271-200: A.C. metal-enclosed switchgear and controlgear for rated voltage above 1 kV and up to including 52 kV.
60265: High voltage switches for rated voltages of 52 kV and above.
60420: High voltage alternating current switch-fuse combinations.
60255: Electrical relays.
62271-100: High-voltage alternating current circuit breakers.
62271-102: High-voltage alternating current disconnectors and earthing switches.
- UTE standards:

NFC 13.100: Consumer substation installed inside a building and fed by a second category voltage public distribution system.
NFC 13.200: High voltage electrical installations requirements.
NFC 64.130: High voltage switches for rated voltage above 1 kV and less than 52 kV.
NFC 64.160: Alternating current disconnectors and earthing switches.
- EDF specifications:

HN 64-S-41: A.C. metal-enclosed swichgear and controlgear for rated voltages above 1 kV and up to and including 24 kV.
HN 64 S 43: Electrical independent operating mechanism for switch 24 kV 400 A.

Designation

SM6 units are identified by a code including:
- **an indication of the function, i.e. the electrical diagram code: IM, QM, DM1, CM, DM2, etc.**
- the rated current: 400 - 630 - 1250 A;
- the rated voltage: 7.2 - 12 - 17.5 - 24 kV;
- the maximum short-time withstand current values: 12.5 - 16 - 20 - 25 kA.1 s;
- the colour is of RAL 9002 type (frosted satin white).

Example for a unit designated: **IM 400 - 24 - 12.5**
- IM indicates an “incoming” or “outgoing” unit;
- 400 indicates the rated current is 400 A;
- 24 indicates the rated voltage is 24 kV;
- 12.5 indicates the short-time withstand current is 12.5 kA.1 s.

SM6 range

Main characteristics

The hereunder values are for working temperatures from -5°C up to +40°C and for a setting up at an altitude below 1000 m.

Internal arc withstand:
- standard:12.5 kA. 0.7 s;
- enhanced:16 kA. 1 s.

Protection index:
- units: IP2XC (IP3X consult us);
- between compartments: IP2x.

		7.2	12	17.5	24
Rated voltage (kV)		7.2	12	17.5	24
Insulation level					
50 Hz, 1 mn (kV rms)	insulation	20	28	38	50
	isolation	23	32	45	60
1.2/50 µs (kV peak)	insulation	60	75*	95	125
	isolation	70	85	110	145
Breaking capacity					
transformer off load (A)		16			
cables off load (A)		31.5			
short-time withstand current (kA. 1 s)	25	630 - 1250 A			
	20	630 - 1250 A			
	16	630 - 1250 A			
	12.5	400 - 630 - 1250 A			

The making capacity is equal to 2.5 times the short-time withstand current.
* 60 kV peak for the CRM unit.

General characteristics

Maximum breaking capacity

	7.2	12	17.5	24
Rated voltage (kV)	7.2	12	17.5	24
Units				
IM, IMC, IMB, NSM-cables, NSM-busbars	630 A - 800 A*			
PM, QM, QMC, QMB	25 kA		20 kA	
CRM	10 kA	8 kA		
CRM with fuses	25 kA			
SF6 circuit breaker range:				
DM1-A, DM1-D, DM1-W, DM1-Z, DM1-S, DM2	25 kA		20 kA	
vacuum circuit breaker range:				
DMV-A, DMV-D, DMV-S	25 kA		20 kA	

Electro-magnetic compatibility:
- relays: 4 kV withstand capacity, as per recommendation IEC 60801.4;
- compartments:
  - electrical field:
    - 40 dB attenuation at 100 MHz,
    - 20 dB attenuation at 200 MHz;
  - magnetic field: 20 dB attenuation below 30 MHz.

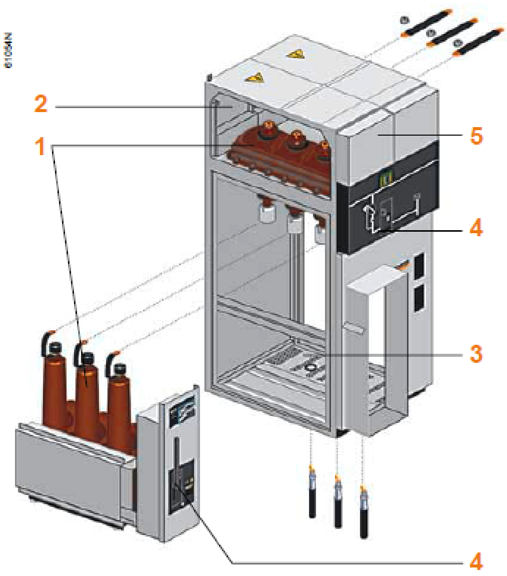
Temperatures:
The cubicles must be stored in a dry area free from dust and with limited temperature variations.

- for stocking: from –40°C to +70°C,
- for working: from –5°C to +40°C,
- other temperatures, consult us.

Endurance

Units		mechanical endurance	electrical endurance
IM, IMC, IMB, PM, QM*, QMC*, QMB*, NSM-cables, NSM-busbars		IEC 60265 1000 operations class M1	IEC 60265 100 breaks at In, p.f. = 0.7 class E3
CRM	Disconnector	IEC 62271-102 1000 operations	
	Rollarc 400	IEC 62470 300 000 operations	IEC 62470 100 000 breaks at 320 A 300 000 breaks at 250 A
	Rollarc 400D	100 000 operations	100 000 breaks at 200 A
SF6 circuit breaker range:			
DM1-A, DM1-D, DM1-W, DM1-Z, DM1-S, DM2	Disconnector	IEC 62271-102 1000 operations	
	Circuit breaker SF	IEC 62271-100 10 000 operations	IEC 62271-100 40 breaks at 12.5 kA 10 000 breaks at In, p.f. = 0.7
vacuum circuit breaker range:			
DMV-A, DMV-D, DMV-S	Disconnector	IEC 62271-102	
	Circuit breaker Evolis	IEC 62271-100 10 000 operations	IEC 62271-100 10 000 breaks at In, p.f. = 0.7

* as per recommendation IEC 60420, three breakings at p.f. = 0.2
- 1730 A under 12 kV,
- 1400 A under 24 kV,
- 2600 A under 5.5 kV.



SF6 circuit breaker cubicles

1 **switchgear:** disconnector(s) and earthing switch(es), in enclosures filled with SF6 and satisfying "sealed pressure system" requirements.

2 **busbars:** all in the same horizontal plane, thus enabling later switchboard extensions and connection to existing equipment.

3 **connection and switchgear:** accessible through front, connection to the downstream terminals of the circuit breaker.
Two circuit breaker offers are possible:
- SF1: combined with an electronic relay and standard sensors (with or without an auxiliary power supply;
- SFset: autonomous set equipped with an electronic protection system and special sensors (requiring no auxiliary power supply).

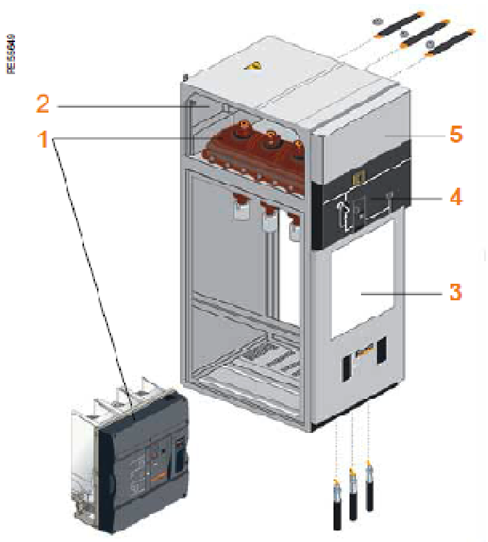
4 **operating mechanism:** contains the elements used to operate the disconnector(s), the circuit breaker and the earthing switch and actuate the corresponding indications.

5 **low voltage:** installation of compact relay devices (Statimax) and test terminal boxes. If more space is required, an additional enclosure may be added on top of the cubicle.

Optional, cubicles may be fitted with:
- current and voltage transformers;
- circuit breaker control motorisation;
- surge arrestors.

SM6 range

Factory-built cubicles description



Vacuum type circuit breaker cubicles

1 **switchgear**: disconnector(s) and earthing switch(es), in enclosure filled with SF6 and satisfying and one vacuum circuit breaker, "sealed pressure system" requirements.

2 **busbars:** all in the same horizontal plane, thus enabling later switchboard extensions and connection to existing equipment

3 **connection and switchgear:** accessible through front, connecion to the downstream terminals of the circuit breaker.
- Evolis: device associated with an electronic relay and standard sensors (with or without auxiliary source);

4 **operating mechanism:** contains the elements used to operate the disconnector(s), the circuit breaker and the earthing switch and actuate the corresponding indications.

5 **low voltage:** installation of compact relay devices (VIP) and test terminal boxes. If more space is required, an additional enclosure may be added on top of the cubicle.

Optional, cubicles may be fitted with:
- current and voltage transformers;
- circuit breaker control motorisation;
- surge arrestors.

SM6 range

Telecontrol of power distribution networks

SM6: an integrated range for telecontrol of MV networks.

SM6 switchgear is perfectly suited to a telecontrol environment due to options such as:
- Easergy T200 S telecontrol interface;
- independent power supply of electrical controls;
- auxiliary contacts for position and fault signalling;
- current sensors for fault detection.

T200 S

Easergy T200 S: an interface designed for the telecontrol of MV networks

Easergy T200 S is an interface that is both "plug and play" and multifunctional. It integrates all the functional features required for the remote monitoring and controlling of SM6:
- acquisition of various types of data: switch position, fault detectors, current values, etc.
- transmission of switch opening and closing orders.
- exchange with the control centre.

Particularly called on during network incidents, Easergy T200 S has proven reliability and dependability in order to operate the switchgear whenever required.
It is simple to install and to operate.

T200 I

A functional unit dedicated to medium voltage networks
- Easergy T200 S is installed inside the low voltage control cabinet of an IM and NSM SM6 for the telecontrol of one or two switches.
- For switchboards up to 16 switches, the wall mounted version Easergy T200 I could be installed in the substation, and it is directly connected to the switches without any interface and converters.
- It has a simple facia layout for local operation, allowing local control (local/remote) and enables visualisation of switchgear status.
- It integrates a fault current detector (overcurrent and zero sequence) with detection thresholds that are configurable per channel (threshold and fault duration).

Ready to connect and secure
- Integrated into SM6 low voltage control cabinet, it is provided ready to connect to the transmission system.
- The version in cabinet for installation in the substation Easergy T200 I is provided with kits for switch interface and CTs. The connectors are foolproof to avoid any error during installation and maintenance.
- Easergy T200 S has been subjected to severe testing in terms of MV electrical constraints.
- A backup power supply guarantees continuity of service for several hours for the electronic devices, the motorisation and the transmission system.
- Current transformers are of split core type for easier installation.

Compatible with all telecontrol system (SCADA)
Easergy T200 S provides as standard the protocols: Modbus, DNP3.0 level 2 and IEC 870-5-101.
Numerous other protocols are also available (WISP+, HNZ, PUR, TG800, ...).
- The standard transmission system are: RS232, RS485, PSTN, FSK.

Other transmissions are available on special request. Radio emitter/receiver is not supplied.

SM6 range

Description of the control/monitoring and protection functions

The Sepam range of protection and metering is designed for the operation of machines and electrical distribution networks of industrial installations and utility substations for all levels of voltage.
It consists of complete, simple and reliable solutions, suited to following 3 families:
■ Sepam series 20,
■ Sepam series 40,
■ Sepam series 80.

Sepam protection relay

A range adapted at your application
■ Protection of substation (incoming, outgoing line and busbars).
■ Protection of transformers.
■ Protection of motors, and generators.

Accurate measurement and detailed diagnosis
■ Measuring all necessary electrical values.
■ Monitoring switchgear status: sensors and trip circuit, mechanical switchgear status
■ Disturbance recording.
■ Sepam self-diagnosis and watchdog.

Simplicity
Easy to install
■ Light, compact base unit.
■ Optional modules fitted on a DIN rail, connected using prefabricated cords.
■ User friendly and powerful PC parameter and protection setting software to utilize all of Sepam's possibilities.

User-friendly
■ Intuitive User Machine Interface, with direct data access.
■ Local operating data in the user's language.

Flexibility and evolutivity
■ Enhanced by optional modules to evolve in step with your installation.
■ Possible to add optional modules at any time.
■ Simple to connect and commission via a parameter setting procedure.

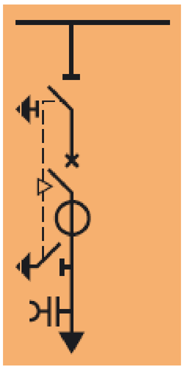
Sepam	Characteristics	Protections: Basic	Specific	Applications: Substation	Transformer	Rotation	generator	Busbars
Sepam series 20 For common applications	■ 10 logic inputs and 8 relay outputs ■ 1 Modbus communication port	Current protection		**S20**	T20	**M20**		
		Voltage and frequency protection						**B21**
			Loss of mains (ROCOF)					**B22**
Sepam series 40 For demanding applications	■ 10 logic inputs ■ 8 relay outputs ■ 1 Modbus communication port ■ Logic equations editor	Current voltage and frequency protection		**S40**	T40		G40	
			Directional earth fault	**S41**		**M41**		
			Directional earth fault and phase overcurrent	**S42**	T42			
Sepam series 80 For complete applications	■ 42 logic inputs and 23 relay outputs ■ 2 Modbus communication port ■ Logic equations editor ■ Removal memory cartridge ■ Battery to save event logging data	Current voltage and frequency protection		**S80**				
			Directional earth fault	**S81**	T81	**M81**		
			Directional earth fault and phase overcurrent	**S82**	T82		G82	

Characteristics of the functional units

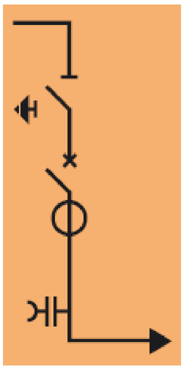
Functional units selection

SF6 type circuit breaker protection

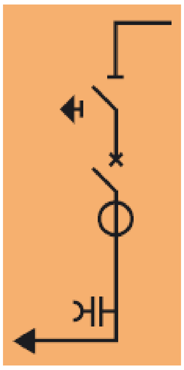
DM1-A (750 mm)
Single-isolation
circuit breaker



DM1-D (750 mm)
Single-isolation
circuit breaker
Outgoing line on right



DM1-D (750 mm)
Single-isolation
circuit breaker
Outgoing line on left



Basic equipment:

- SF1or SFset circuit breaker (only for the 400-630 A performances)
- disconnector and earthing switch
- three-phase busbars
- circuit breaker operating mechanism RI
- disconnector operating mechanism CS
- voltage indicators
- three CTs for SF1 circuit breaker
- auxiliary contacts on circuit breaker

- connection pads for dry-type cables
- downstream earthing switch

- three-phase bottom busbars

.

- **cubicle:**
- auxiliary contacts on the disconnector
- additional enclosure or connection enclosure for cabling from above
- protection using Statimax relays, or Sepam programable electronic unit for SF1 circuit breaker
- three voltage transformers for SF1 circuit breaker
- key-type interlocks
- 50 W heating element
- stands footing
- surge arrestors
- **circuit breaker:**
- motor for operating mechanism
- release units
- operation counter on manual operating mechanism

Characteristics of the functional units

Current transformers

For unit QMC

Transformer ARJP1/N2F
- single primary winding;
- double secondary winding for measurement and protection.

Short-time withstand current Ith (kA)

I1n (A)		10	20	30	50	75	100	150	200
Ith (kA)		1.2	2.4	3.6	6	10	10	10	10
t (s)		1							
measurement	5 A	15 VA - class 0.5							
and protection	5 A	2.5 VA - 5P20							

For unit CRM

Transformer ARJP1/N2F
- single primary winding;
- double secondary winding for measurement and protection.

Short-time withstand current Ith (kA)

I1n (A)		50	100	150	200
Ith (kA)		6	10		
t (s)		1			
measurement	5 A	15 VA - class 0.5			
and protection	5 A	2.5 VA - 5P20			

***Note:** please consult us for other characteristics.*

For 400 - 630 A units
DM1-A, DM1-D, DM1-W, DM2, GBC-A, GBC-B

Transformer ARM3/N2F
- double primary winding;
- single secondary winding for measurement and protection.

Short-time withstand current Ith (kA)

I1n (A)		10/20	20/40	50/100	100/200	200/400	300/600
Ith (kA)		5	12.5	12.5/21*	12.5/25*	12.5/25*	25
t (s)		1	0.8	1			
measurement	5 A	7.5 VA - class 0.5					
and protection	1 A	1 VA - 10P30					
	5 A	5 VA - 5P10		5 VA - 5P15			

** for 5 A protection*

- double primary winding;
- double secondary winding for measurement and protection.

Short-time withstand current Ith (kA)

I1n (A)		50/100	100/200	200/400	300/600
Ith (kA)		14.5	25	25	25
t (s)		1			
measurement	5 A	30 VA - class 0.5			
and protection	5 A	5 VA - 5P15	7.5 VA - 5P15		
	5 A	7.5 VA - 5P10	15 VA - 5P10		

Characteristics of the functional units

Voltage transformers

For units CM, DM1-A, DM1-D, DM2, GBC-A, GBC-B

Transformers VRQ2-n/S1 (phase-to-earth) 50 or 60 Hz

rated voltage (kV)	24			
primary voltage (kV)	10/√3	15/√3	15-20/√3	20/√3
secondary voltage (V)	100/√3			
thermal power (VA)	250			
accuracy class	0.5			
rated output for single primary winding (VA)	30	30		30
rated output for double primary winding (VA)			30-50	

For units CM2, GBC-A, GBC-B

Transformers VRC2/S1 (phase-to-phase) 50 or 60 Hz

rated voltage (kV)	24		
primary voltage (kV)	10	15	20
secondary voltage (V)	100		
thermal power (VA)	500		
accuracy class	0.5		
rated output for single primary winding (VA)	50		

Surge arrestor

For units IM500, DM1-A, DM1-W, GAM, DMV-A*, DMV-S*

In (A) (unit)	400/630				
Un (kV) (unit)	7.2	10	12	17.5	24

Note: *the rated voltage of the surge arrestor is according to unit's rated voltage.*
(*) limited up to 17.5 kV for DMV-A and DMV-S circuit breaker cubicles.

Switch units

■ **the switch can be closed** only if the earthing switch is open and the access panel is in position.
■ **the earthing switch can be closed** only if the switch is open.
■ **the access panel for connections can be opened** only if the earthing switch is closed.
■ **the switch is locked** in the open position when the access panel is removed. The earthing switch may be operated for tests.

Circuit-breaker units

■ **the disconnector(s) can be closed** only if the circuit breaker is open and the access panel is in position interlock type 50.
■ **the earth switch(es) can be closed** only if the disconnector(s) is/are open.
■ **the access panel for connections can be opened** only if:
□ the circuit breaker is locked open,
□ the disconnector(s) is/are open,
□ the earth switch(es) is/are closed.

Note: it is possible to lock the disconnector(s) in the open position for no-load operations with the circuit breaker.

Functional interlocks

These comply with IEC recommendation 60271-200 and EDF specification HN 64-S-41.
In addition to the functional interlocks, each disconnector and switch include:
■ **built-in padlocking** capacities (padlocks not supplied);
■ **four knock outs** that may be used for keylocks (supplied on request) for mechanism locking functions.

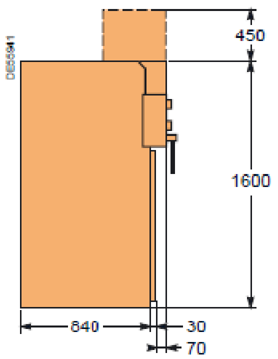
Unit interlock

units	Interlock A1	C1	C4	A3	A4	A5	50	P1	P2	P3	P5
IM, IMB, IMC				■	■			■			
PM, QM, QMB, QMC, DM1-A, DM1-D, DM1-W, DM1-Z, DM1-S, DMV-A, DMV-D, DMV-S	■	■	■				■				
CRM		■									
NSM				■				■			
CAM						■	■				■
SM									■	■	

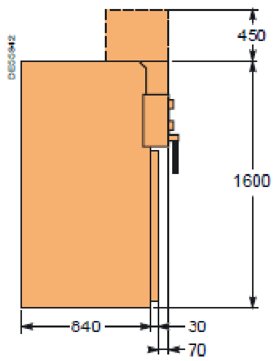
Installation

Units dimensions

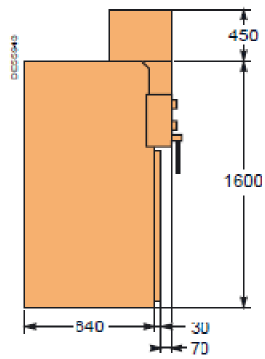
IM, IMB, PM, QM, QMB, SM



IMC, QMC, CM, CM2



CRM



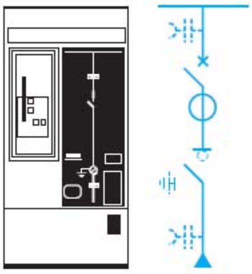


ABB Unigear ZS1

IEC electrical characteristics of UniGear ZS1 - Single Busbar System

Rated voltage	kV	7.2	12	17.5	24
Rated insulation voltage	kV	7.2	12	17.5	24
Rated power frequency withstand voltage	kV 1min	20	28	38	50
Rated lightning impulse withstand voltage	kV	60	75	95	125
Rated frequency	Hz	50/60	50/60	50/60	50/60
Rated short time withstand current	kA 3 s	...50	...50	...50	...31.5
Peak current	kA	...125	...125	...125	...80
Internal arc withstand current	kA 1 s	...50	...50	...50	...31.5
Main busbar rated current	A	...4,000	...4,000	...4,000	...3,150
Circuit-breaker rated current	A	630	630	630	630
		1,250	1,250	1,250	1,250
		1,600	1,600	1,600	1,600
		2,000	2,000	2,000	2,000
		2,500	2,500	2,500	2,300
		3,150	3,150	3,150	–
Circuit-breaker rated current with forced ventilation	A	3,600	3,600	3,600	2,500
		4,000	4,000	4,000	–

1) For other versions, please refer to the chapters no. 2 (Double Busbar System) and chapter no. 3 (Marine Applications).
2) GB/DL version is available with higher request in dielectric characteristics (42 kV) and short time withstand current (4 s).
3) The values indicated are valid for both vacuum and SF6 circuit-breaker.

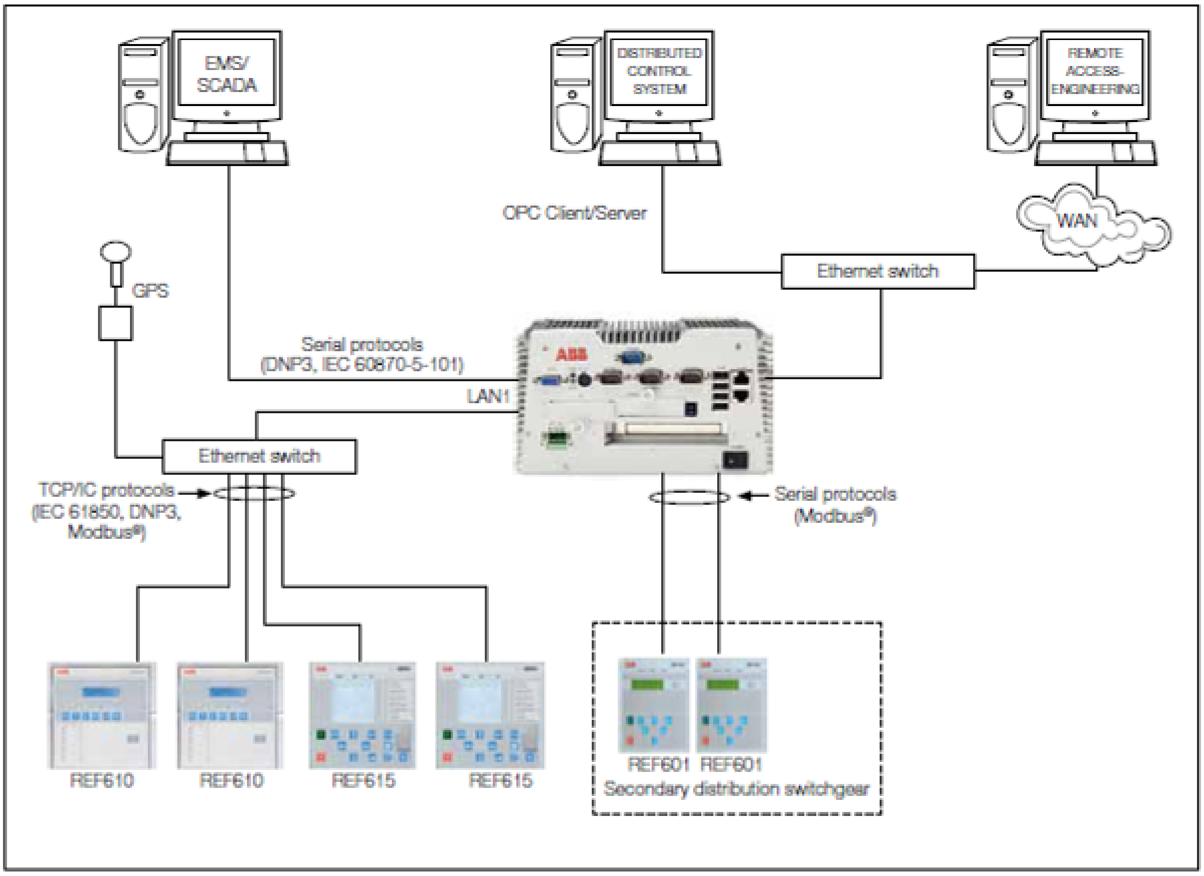


Figure 54: Overview of a system using Station Automation COM600

SafeRing / SafePlus

SafeRing / SafePlus con interruttore in vuoto in accordo alla norma IEC 60056

In questa unità, il trasformatore è protetto mediante un interruttore in vuoto combinato con relè e trasformatori amperometrici.

I relè in dotazione sono basati sulla tecnologia digitale e non richiedono l'uso di un alimentatore esterno.

Per ulteriori informazioni, consultare i cataloghi tecnici SafeRing e SafePlus.

The switchgear for 12kV can be operated at 6kV level.

Quadri isolati in aria SafeGear

Generale | Contatti

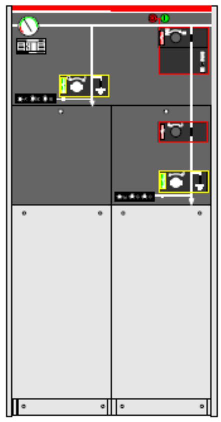
SafeGear arc resistant switchgear meets applicable ANSI standards.

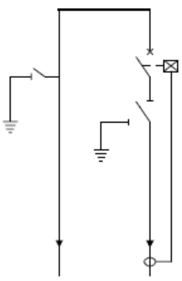
SafeGear è il quadro blindato più all'avanguardia sotto ogni punto di vista, in quanto unisce i requisiti di sicurezza tradizionali delle norme ANSI a numerose altre caratteristiche di preferenza dei clienti nordamericani, oltre alla costruzione a tenuta d'arco interno.

Caratteristiche	
Tensione nominali (kV)	5 - 27
Tensioe di tenuta a impulso (kV)	60 - 125
Corrente nominale delle sbarre (A)	1200 - 3000
Corrente di breve durata (kA)	50

La costruzione a tenuta d'arco interno riduce notevolmente il rischio di esposizione del personale ad un'esplosione dovuta ad un guasto per arco interno. Nel caso di guasto i danni alle apparecchiature e i tempi di inattività vengono quindi ridotti al minimo. La tenuta all'arco è ottenuta utilizzando porte e pannelli rinforzati, manovre di inserzione e estrazione a porta chiusa, una struttura a pareti laterali doppie e un sistema di deflettori di sfogo ad azione rapida. Questo sistema permette di scaricare la pressione e il calore, liberando i gas attraverso la parte superiore del quadro, la parte anteriore, posteriore e laterale.

SafePlus/SafeRing — SF_6 insulated CSG / RMU





Technical data

SafeRing		C module		F module		V module	
		Switch disconnector	Earthing switch	Switch fuse	Downstream earthing switch	Vacuum circuit breaker	Earthing switch
Rated voltage	kV	12/15/17,5/24	12/15/17,5/24	12/17,5/24	12/17,5/24	12/15/17,5/24	12/15/17,5/24
Power frequency withstand voltage	kV	28/38/38/50	28/38/38/50	28/38/50	28/38/50	28/38/38/50	28/38/38/50
Impuls withstand voltage	kV	95/95/95/125	95/95/95/125	95/95/125	95/95/125	95/95/95/125	95/95/95/125
Rated current	A	630/630/630/630		see 1)		200/200/200/200	
Breaking capacities:							
active load	A	630/630/630/630					
closed loop	A	630/630/630/630					
off load cable charging	A	135/135/135/135					
off load transformer	A			20/20/20			
earth fault	A	200/150/150/150					
earth fault cable charging	A	115/87/87/87					
short circuit breaking current	kA			see 2)		21/21/16/16	
Making capacity	kA	52,5/52,5/40/40	52,5/52,5/40/40	see 2)	12,5/12,5/12,5	52,5/52,5/40/40	52,5/52,5/40/40
Short time current 1 sec.	kA	3)			5/5/5		
Short time current 3 sec.	kA	21/21/16/16	21/21/16/16			21/21/16/16 4)	21/21/16/16

1) Depending on the current rating of the fuse
2) Limited by High Voltage fuse
3) Other ratings available on request
4) Only valid with 400 series bushings
SafeRing is tested according to IEC publications IEC 60265, IEC 60129, IEC 60056, IEC 60420, IEC 60694 and IEC 60298

SafePlus is a metal enclosed compact switchgear system for up to 24 kV distribution applications. The switchgear has a unique flexibility due to its extendibility and the possible combination of fully modular and semi modular configurations.
When SafePlus is used in a fully modular configuration with covered external busbars, SafePlus is a metal clad switchgear. When combined with SafeRing, which is ABBs standard ring main unit, they represent a complete solution for 12/24 kV distribution networks.
SafePlus and SafeRing have identical user interfaces.

SafePlus is a completely sealed system with a stainless steel tank containing all the live parts and switching functions

A sealed steel tank with constant atmospheric conditions ensures a high level of reliability as well as personnel safety and a virtually maintenance-free system. As an option an external busbar can be provided to obtain full modularity.
This external busbar kit has to be mounted to the switchgears on site. And it is fully insulated and screened to ensure the reliability and climatic independence.

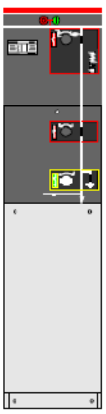
The SafePlus system offers a choice of either a switch fuse combination or a circuit breaker
with relay for protection of the transformer.
SafePlus accommodates a wide selection of
protection relays for most applications
SafePlus can also be supplied with or retrofitted with remote control and monitoring equipment

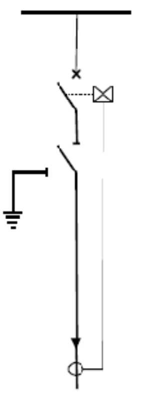
SafePlus (not M module) is supplied with the following standard equipment:

- Earthing switches (not D module)
- Operating mechanisms with integral mechanical interlocking
- Operating handle
- Facilities for padlocks on all switching functions
- Bushings for cable connection in front (not Sl, Sv and Be module)
- Cable compartment cover
- Manometer for SF6 pressure/ density monitoring
- Lifting lugs for easy handling

SafePlus/SafeRing SF_6 insulated CSG / RMU

V- Vacuum Circuit Breaker 4.4





Depth: 765 mm
Width: 325 mm
Height: 1336 mm

Technical data

Rated voltage	kV	12	15	17,5	24
Power frequency withstand voltage	kV	28	38	38	50
Impulse withstand voltage	kV	95	95	95	125
Rated current	A	200/630			
Breaking capacities:					
Short circuit breaking current	kA	21	21	21	21
Making capacity	kA	52,5	52,5	40	40
Short time current 3 sec	kA	21	21	16	16
Number of mechanical operations	2000 CO manual				
Earthing Switch					
Rated voltage	kV	12	15	17,5	24
Power frequency withstand voltage	kV	28	38	38	50
Impulse withstand voltage	kV	95	95	95	125
Making capacity	kA	52,5	52,5	40	40
Short time current 3 sec.	kA	21	21	16	16
Number of mechanical operations	1000 CO manual				

Standard features

- 200 A VCB for transformer protection or 630 A VCB for feeder protection
- Two positioning double spring mechanism for VCB
- Three positioning Isolator/Earthing switch downstream VCB
- Three positioning single spring mechanism Isolator/Earthing switch
- Interlocking between VCB and Isolator/Earthing switch
- Switch positioning indication for VCB and Isolator/earthing switch
- Self powered electronic protection relay with ring core CTs on cables (only standard on 200 A)
- Trip coil (for relay tripping)
- Cable bushings horizontally in front.
  200 series plug in (200 A VCB) with integrated voltage sensor for voltage indication
  400 series bolted (630 A VCB) with integrated voltage devider for voltage indicatior
- Cable compartment cover allowing surge arrestor type Raychem RDA and double cable connection with ABB Kabeldon cable adapters
- Busbars, 630 A
- Earthing bar

Optional features

- Bushings for connection of external busbar
- Cable bushings
  400 series plug-in
  600 series bolted
  400 series bolted combisensor with integrated screen for voltage indication and integrated sensor for current and voltage monitoring
- Interlocking
  Cable compartment front cover interlocked with earthing switch
- Arc suppressor (only for 630 A version)
- Signal (1NO) from arc suppressors wired to terminals (only one each SF6 tank)
- Signal (1NO) from internal pressure indicator wired to terminals (only one each SF6 tank)

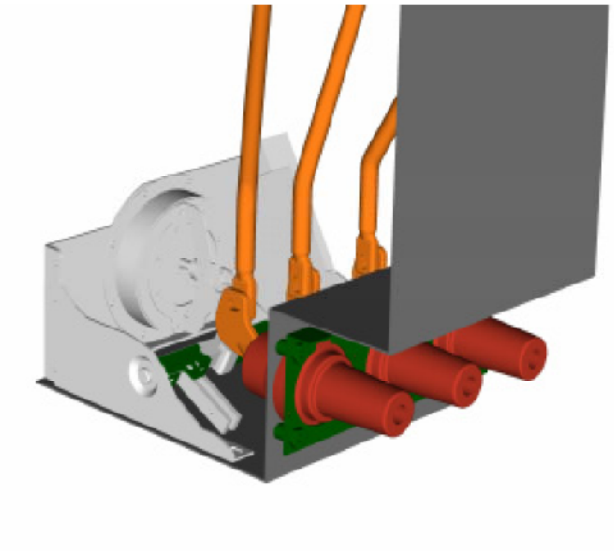
SF_6 insulated Compact Switchgear and Ring Main Unit NOPOWSR6104GB

Optional features also available as retrofit

- External busbars
- Trip coil open
- Trip coil open and close
- Motor operation for VCB
- Low voltage compartment / Top entry box
- Capacitive voltage indicator
  - HR-module (Voltage Detecting System, VDS, acc. to IEC 61243 5, alternatively VPIS, acc.to IEC 61958 with integrated indicator lamps (LED)
  - Indicator lamps, 3-phase VIM-3
  - Indicator lamp, 1-phase VIM-1, alternatively VPIS, acc.to IEC 61958 with integrated indicator lamps (LED)
- Short circuit indicators (only 630 A VCB)
  - Horstmann Alpha/E
  - Horstmann Alpha/M
  - Horstmann Gamma
- Short circuit and earth fault indicator (only 630 A VCB)
  - Horstmann Delta/E
- Cable compartment cover
  - with window
  - with extra depth (double I, surge arrestors)
  - arc proof (if existing module have interlocked cable compartment)
- Auxiliary switches
  - Vacuum circuit breaker position 2NO+2NC
  - Disconnector position 2NO+2NC
  - Earthing switch position 2NO+2NC
  - Vacuum circuit breaker tripped signal 1NO
- Cable support bars, non-magnetic or adjustable
- Ronis key interlock on disconnector earthing switch
- Advanced relays type SPAJ, REF and others.

SafePlus/SafeRing SF6 insulated CSG / RMU

Arc Suppressor 5.6



The Arc Suppressor is an optimal quick-make short circuit device with a mechanical pressure detector that can be installed with each incoming feeder inside the sealed SF6 tank of the SafeRing and SafePlus switchgear.

If an arc fault should occur inside the SF6 tank the pressure detector of the Arc Suppressor will automatically trip the short circuit device of the incoming feeder(s) within milliseconds, thereby transforming the arc fault into a bolted fault.
The arc is extinguished without any emission of hot gases and the bolted short circuit will be interrupted by the upstream circuit breaker.

No links or release mechanisms are installed outside the tank. Corrosion and any enviromental influences are therefore prevented, giving optimum reliability.

The pressure detector is insensitive to pressure changes due to variation in atmospheric temperature or pressure as well as external phenomena such as vibrations or shocks.

The arc suppressor will operate for short-circuit currents in the range of 1kArms to 21kArms and it will reduce the generated arc energy to less than 5% of the arc energy released during an arcing time of 1 sec.

A signalling device (1NO) will indicate local or remote the tripping of one or more arc suppressors.

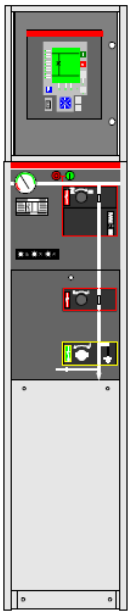
Since the system is self-contained, an internal arc fault will have no impact on the surroundings. No arc fault tests have to be repeated in combination with channel release systems or transformer stations.
The costs of the cleaning work which has to be done after an internal arc fault when the release flap has opened, are reduced to zero.

Ring core current transformers and earth fault transformer

MPRB 99-1.0-GF transformer protection and cable protection kit (selfpowered)	Ring core current ransformer type	Ratio
Transformer type	CT1 CT2	14,4 - 41,4 / 117,4 - 335 /0,3 A
SEG WIC1 transformer protection and cable protection kit (selfpowered	Ring core current transformer type	Current range
Transformer type (Thermal load capacity: Permanently: 2,5 x highest rated current)	W2 W3 W4 W5	16 - 56 A 32-112 A 64 - 224 A 128 - 448 A
PR 521 transformer protection and cable protection kit (selfpowered)	Ring core current transformer type	Ratio
Transformer type		40 / 1 A 80 / 1 A 250 / 1 A
Protection relay standard CT's typical	Ring core current transformer type	Ratio - burden
Transformer type : class 10P10	GSA 100 / 42 GSA 100 / 42 GSA 100 / 42 GSA 100 / 42 GSA 100 / 42 GSA 100 / 42	100 / 5 A - 4 VA 200 / 5 A - 4 VA 300 / 5 A - 5 VA 400 / 5 A - 5 VA 500 / 5 A - 5 VA 600 / 5 A - 5 VA
Earth fault transformer		
Earth fault transformer, class 10P10, burden 0,5 - 15 VA dependent on selcted ratio	KOLMA 06A1 (90 mm)	Multi-tap secondary: 50 - 150 /1A or 50 - 750 / 5A
Earth fault transformer, class 10P10, burden 0,5 - 15 VA dependent on selcted ratio	KOLMA 06D1 (180 mm)	Multi-tap secondary: 50 - 150 /1A or 50 - 750 / 5A

SafePlus/SafeRing SF_6 insulated CSG / RMU

Relays



REF SafePlus

Technology summary REF SafePlus and REF542*plus*:
(configurable functions)

Protection:
non-directional overcurrent protection, 3 stages
- directional overcurrent protection, 3 stages
- non-directional earth-fault protection
- directional earth-fault protection
- residual overvoltage protection
- 3-phase thermal overload
- 3-phase overvoltage protection
- 3-phase undervoltage protection
- Under- or overfrequenzy incl. rate of change, 5 stages

Optional functionality
- Capacitor bank protection
- Capacitor bank control
- Power quality

Measurement:
- 3-phase current
- neutral current
- 3-phase voltage
- residual voltage
- 3-phase power and energy incl cos phi
- transient disturbance recorder

REF 541/543/545

Unità multifunzione di protezione, controllo e automazione di sottostazione

- Facile modifica e adeguamento delle funzioni attraverso il software di configurazione
- Interfaccia operatore di tipo grafico con display a cristalli liquidi
- Hardware e software modulari
- Unità di campo per sistemi di automazione di sottostazione
- Accurata localizzazione dei guasti
- Monitoraggio delle condizioni operative
- Unica tipologia di ricambi e accessori: un solo tipo di hardware
- Drastica riduzione della manutenzione preventiva, forte limitazione dei guasti causati da manomissioni ed errori

Le unità REF541/543/545 fanno parte della serie RE500 e sono progettate per la protezione e il controllo dei quadri elettrici e per essere inserite in sistemi di automazione delle sottostazioni.
Grazie all'impiego di tecnologia digitale integrata, le unità REF offrono funzioni complete di misura, protezione, controllo e monitoraggio.
Tutte le funzioni necessarie sono presenti in un unico dispositivo. Di conseguenza vengono ridotti l'impiego di apparecchiature accessorie e delle operazioni di cablaggio del quadro.
Il software di configurazione di uso semplice e intuitivo permette di realizzare configurazioni specifiche.
L'interfaccia grafica consente di visualizzare gli eventi, lo stato dei dispositivi, le misure, gli allarmi, ecc. adattandosi alle varie esigenze di impianto.
Le unità REF541/543/545 dispongono di un unico sistema di configurazione comune a tutta la serie 500 facilitandone notevolmente l'utilizzo da parte degli operatori.
L'ampia gamma di protocolli di comunicazione consente il collegamento e l'integrazione nel sistema di gestione dell'impianto.

Catalogo tecnico: 1MRS751818.

Protezioni
- Autorichiusura fino a 5 cicli
- Discontinuità di fase
- Guasto a terra 3 soglie
- Guasto a terra direzionale 3 soglie
- Massima corrente di fase 3 soglie
- Massima corrente di fase direzionale 3 soglie
- Massima e minima frequenza 1...5
- Funzione di inrush
- Massima tensione 3 soglie
- Minima tensione 3 soglie
- Massima tensione residua 3 soglie
- Synchrocheck
- Sovraccarico termico
- Protezione banchi di rifasamento
- Controllo banchi di rifasamento
- Sovraccarico termico con sonde PT100
- Carico sbilanciato
- Controllo fattore di potenza

Misure
- Correnti di fase
- Corrente di terra residua
- Tensione di fase
- Tensione residua
- Potenza, energia e fattore di potenza
- Registrazione transitori e disturbi
- Localizzazione guasti per cortocircuito e guasto a terra

Monitoraggio Power Quality
- Misura della distorsione della forma d'onda della corrente
- Misura della distorsione della forma d'onda della tensione
- Fluttuazione della tensione

Ingressi e uscite
- Fino a 34 ingressi digitali
- Fino a 26 uscite digitali incluse 2 uscite per supervisione intervento per sgancio
- 8 ingressi RTD/DT100
- Sincronizzazione a mezzo ingresso binario
- 4 uscite 4...20 mA

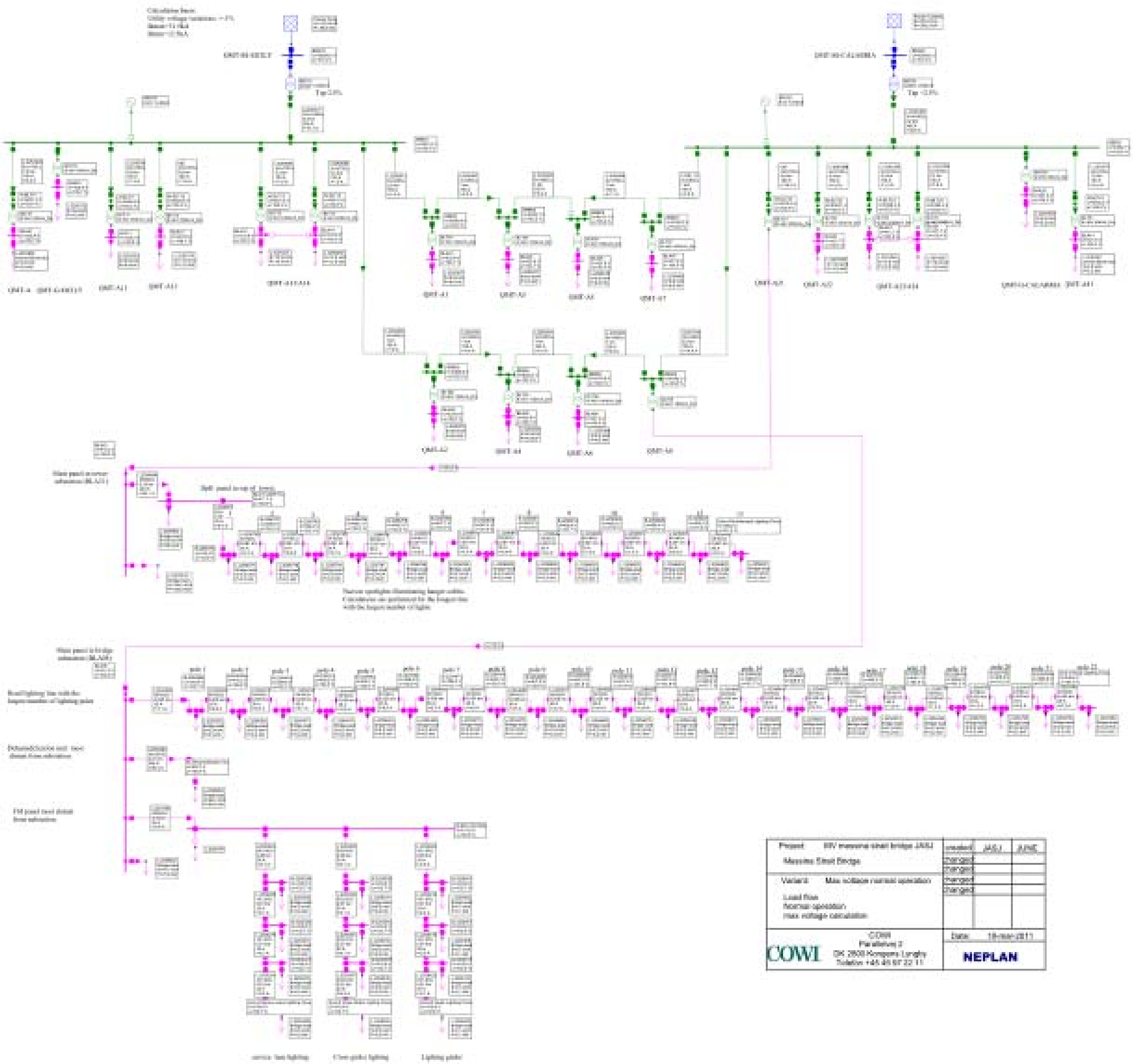
Ingressi analogici
- Connessioni per 4 trasformatori di corrente 1 A e 5 A
- Connessioni per 1 trasformatore di corrente 0,2 A e 1 A
- Connessioni per 4 trasformatori di tensione 100 V e 120 V
- 9 ingressi per sensori di corrente/tensione

Comunicazione
LON / SPA / Modbus / DNP 3.0 /PROFIBUS / IEC 61850 / IEC 60870-5-103

Monitoraggio condizioni operative
- Supervisione interventi
- Guasto fusibili
- Usura interruttore
- Tempo corsa interruttore
- Nr. manovre interruttore
- Tempo di inattività interruttore
- Allarme per manutenzione programmata
- Tempo di carica delle molle di chiusura
- Supervisione misure
- Allarme pressione gas
- Temporizzatori

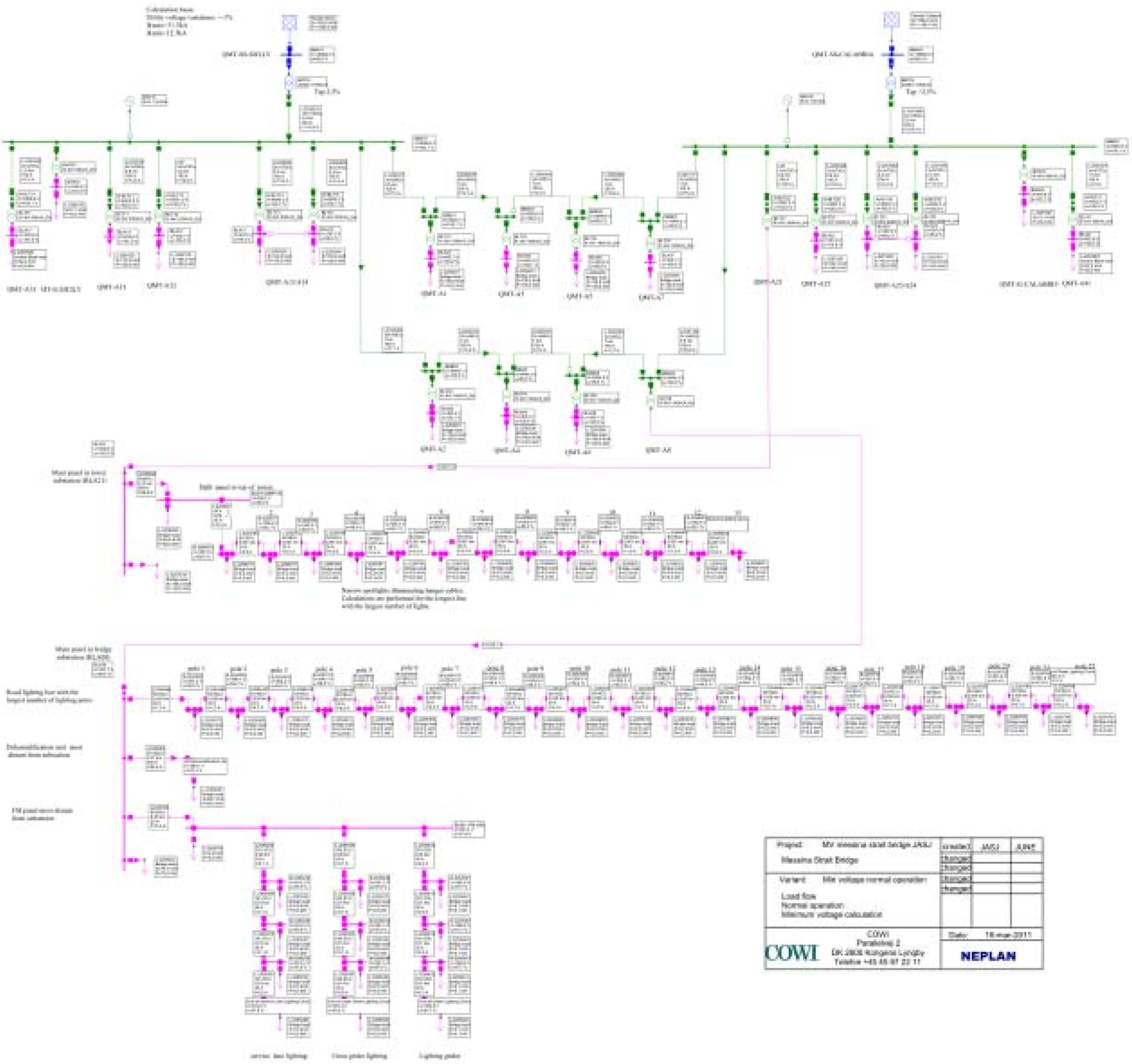
Appendix A – Max. voltage calculation scenario 1

To view details of the calculation zoom to paper size A1.



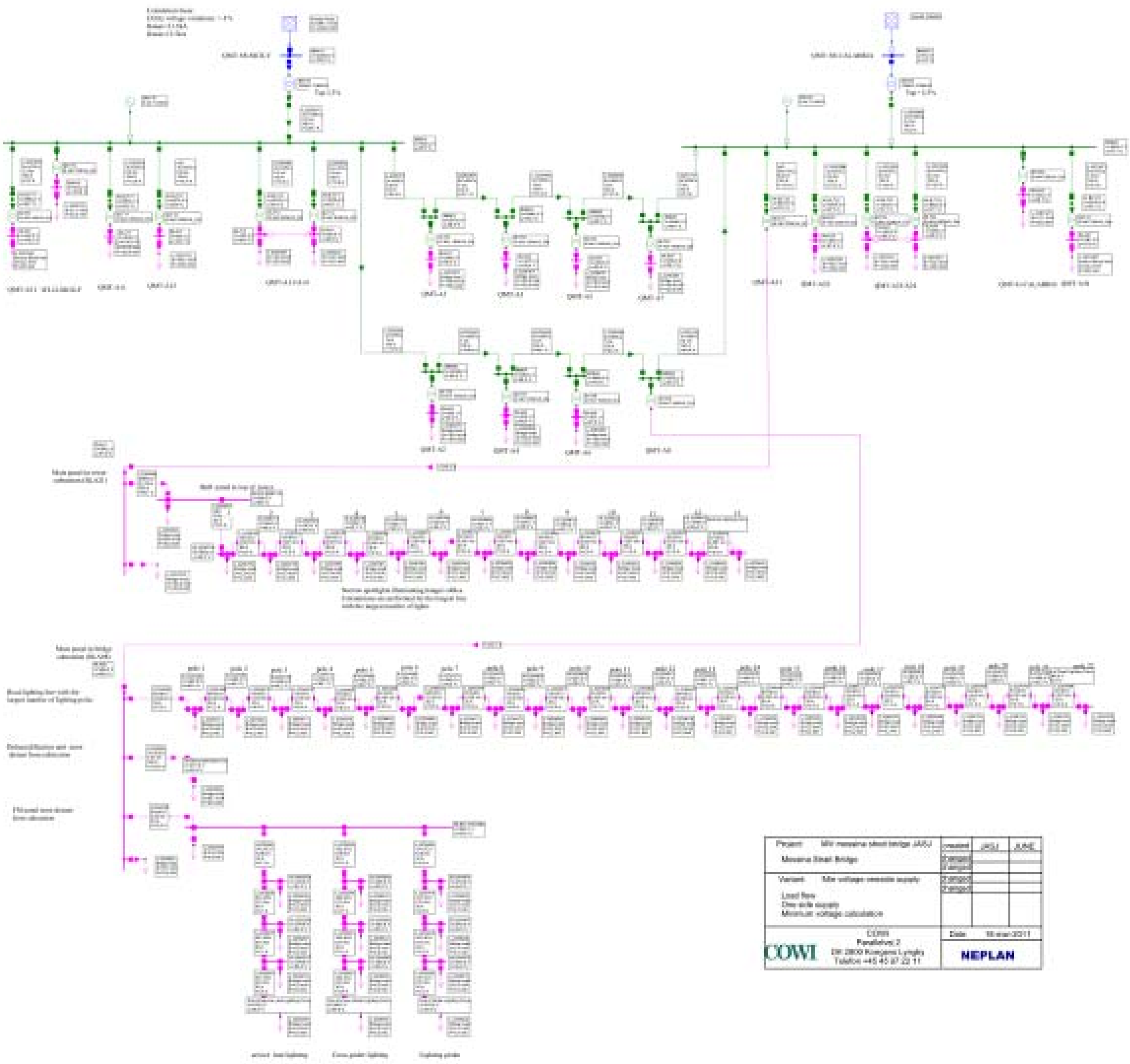
Appendix B – Min. voltage calculation scenario 1

To view details of the calculation zoom to paper size A1.



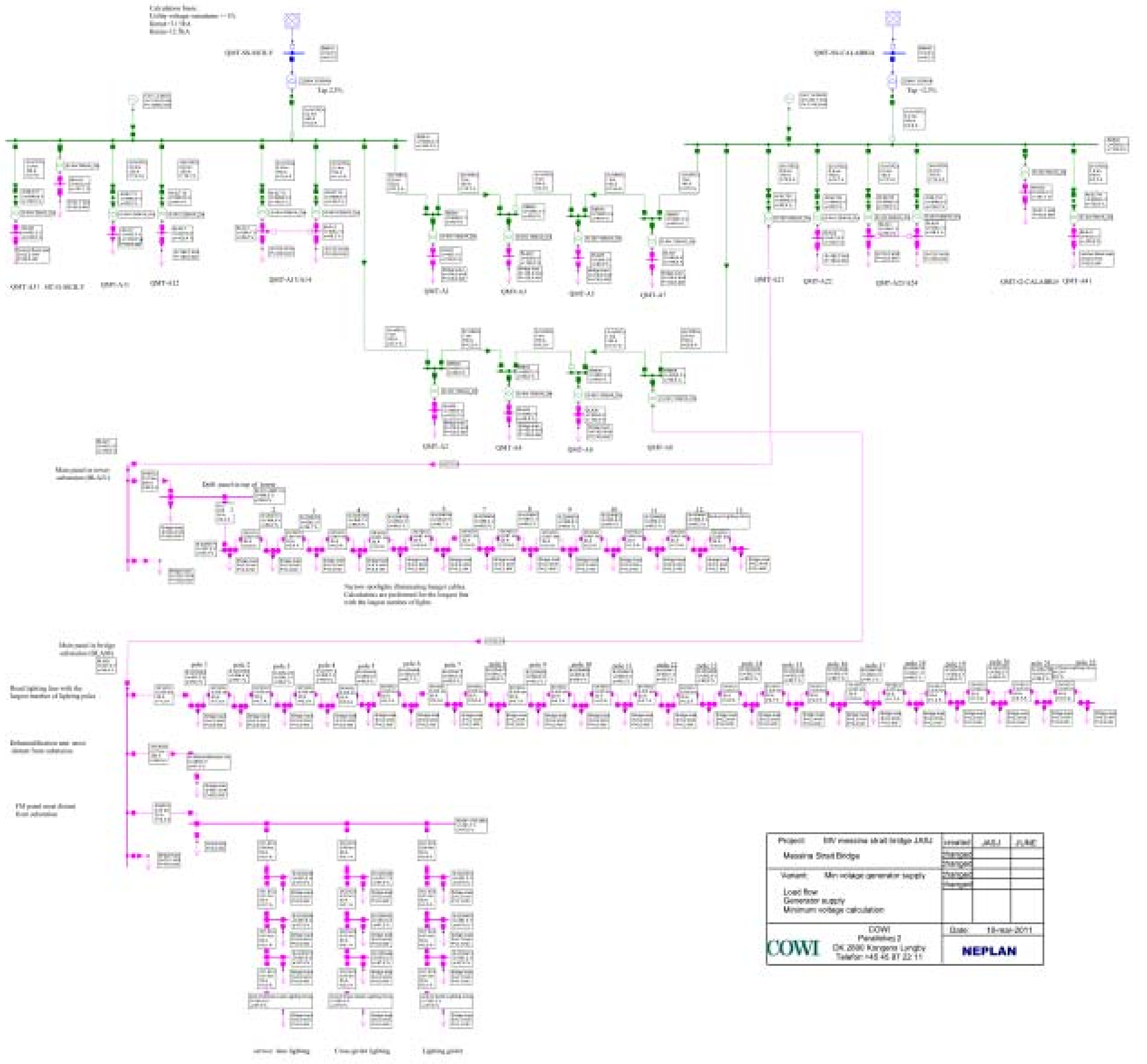
Appendix C – Min. voltage calculation scenario 2

To view details of the calculation zoom to paper size A1.



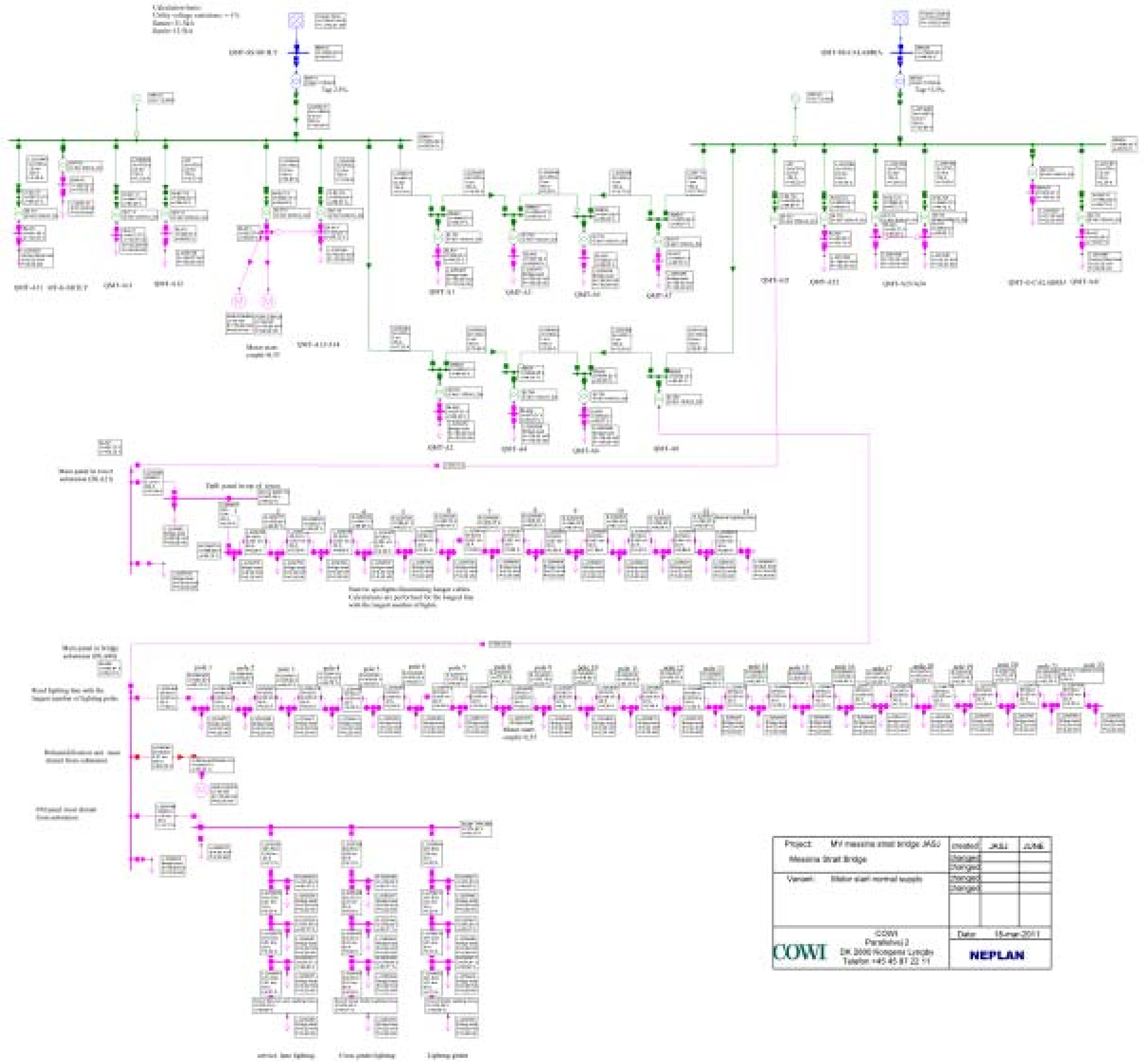
Appendix D – Min. voltage calculation scenario 3

To view details of the calculation zoom to paper size A1.



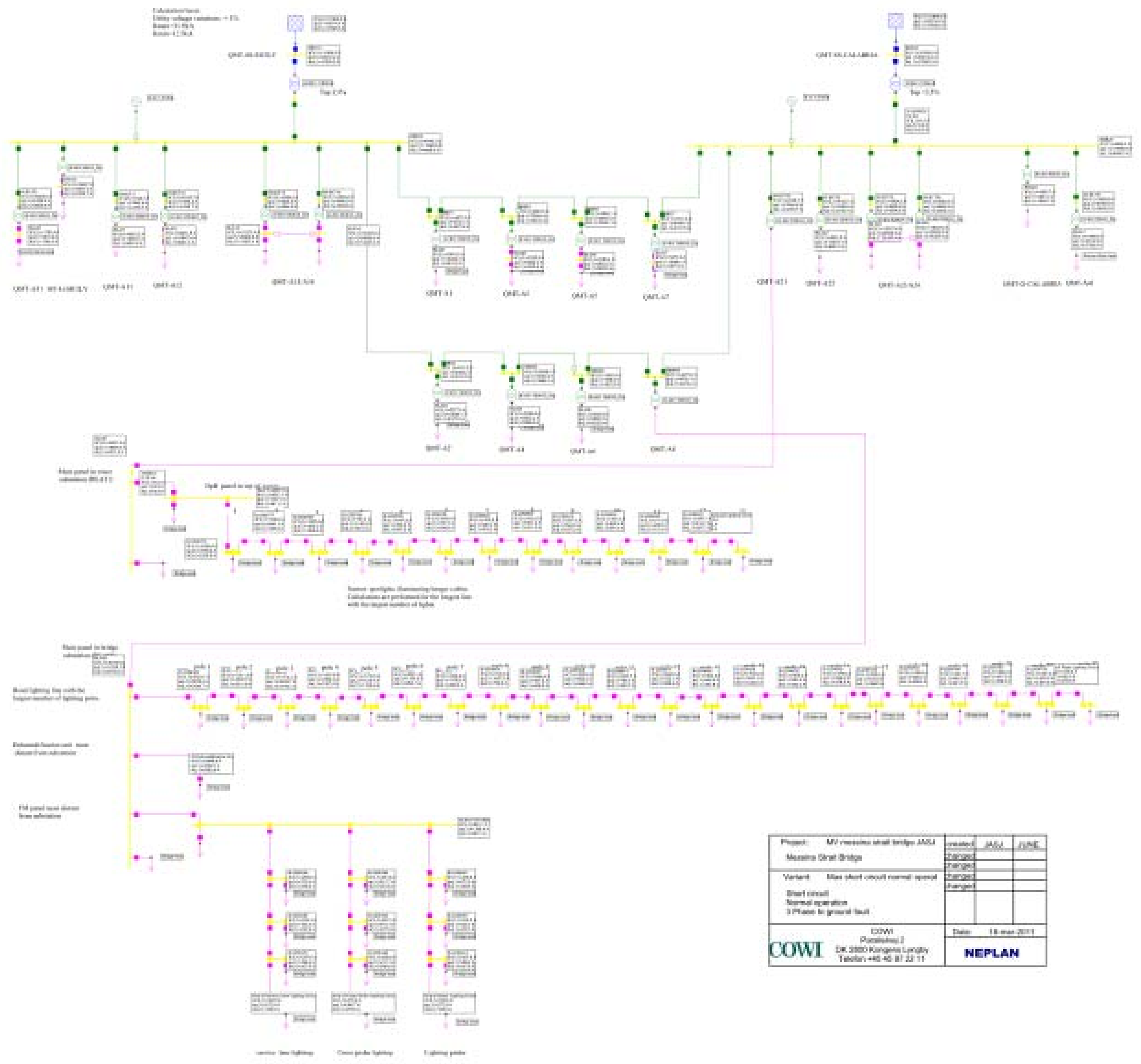
Appendix E – Min. voltage calculation motor start

To view details of the calculation zoom to paper size A1.



Appendix F – Max. short circuit calculation scenario 1

To view details of the calculation zoom to paper size A1.



Appendix G – Min. short circuit calculation scenario 2

To view details of the calculation zoom to paper size A1.