Base Load Power Hub (BLPH)

Electrical System Study Report - Arc Flash Energy Calculation

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Table of contents

1 INTRODUCTION 6
1.1 PROJECT OVERVIEW 6
1.1.1 Project Location 6
1.1.2 Project Concept 7
2 DOCUMENT SCOPE 9
2.1 REFERENCES 9
2.2 DEFINITIONS AND ABBREVIATIONS 9
3 DESIGN BASIS 11
3.1 SYSTEM OVERVIEW 11
3.2 MODEL OVERVIEW 11
3.3 SYSTEM STUDIES BACKGROUND 12
3.4 ANALYSIS DESIGN DATA 12
3.4.1 Supply network 12
3.4.2 Power Sources 13
3.4.3 Transformers 13
3.4.4 Bulk Load 0.4kV 13
3.4.5 Bulk Load 6.6kV 14
3.4.6 Switchgear Data 14
3.4.7 Cables Data 14
3.5 ARC FLASH EVALUATION 15
3.6 Working Distance, Gaps and Cubicle Dimensions 16
3.7 Arc Flash Protective Equipment 17
4 ARC FLASH CALCULATIONS 18
4.1 ETAP Basic Settings 18
5 SHORT CIRCUIT CURRENT CALCULATION 19
5.1 ETAP Study Assumptions 19
5.2 CASE 1: SCCMAX 19
5.3 CASE 2: SCCMIN with Network 19

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5.4 Case 3: SCCMAX Island Mode 20
5.5 Case 4: SCCMIN Island Mode 20
6 STUDY RESULTS 22
7 CONCLUSION 23
8 ATTACHMENTS 24

List of Figures

Figure 1 HOLLANDSE KUST NOORD WIND PARK Location Map 6
Figure 2 - Wind Park Details 7
Figure 3 – BLPH Concept 7

List of tables

Table 1 - Reference Documents 9
Table 2 - Definitions and Abbreviations 10
Table 3 - Data for External Network 12
Table 4 - Data for Internal Power Sources 13
Table 5 - Data for Main Transformers 13
Table 6 - Data for Bulk Load 0.4kV 13
Table 7 - Data for Bulk Load 0.4kV 14
Table 8 – Data for Main Switchgears 14
Table 9: IEEE Std Applicable Range from 0.208 to 0.600 kV 15
Table 10: IEEE Std Applicable Range from 0.600 to 15 kV 15
Table 11: Electrode Configuration 16
Table 12: Working Distance, Gaps and Cubicle Dimensions 16

List of Attachments

Attachment 1 Single Line Diagram
Attachment 2 Arc flash Result without Maintenance Switch on SG-200N1 switchgear
Attachment 3 Arc flash Result with Maintenance Switch on SG-200N1 switchgear
Attachment 4 Arc flash PPE label - Bus side with Maintenance Switch on SG-200N1 switchgear
Attachment 5 Arc flash PPE label - Cable Entry (Incomer) with Maintenance Switch on SG-200N1 switchgear

1 INTRODUCTION

1.1 PROJECT OVERVIEW

Crosswind, a Shell and Eneco joint venture, was awarded the tender to develop the offshore Hollandse Kust Noord (HKN) wind farm, located 18.5km off the coast of Netherlands near the town of Egmond aan Zee. The consortium plans to have HKN operational in 2023 with an installed capacity of 759MW generating at least 3.3TWh per year. This is sufficient renewable power to supply more than 1 million Dutch households with green electricity.

Offshore wind farms produce intermittent electricity and balancing these dips and peaks and integrating this electricity into the national energy system requires new technologies. For this reason, the offshore wind farm will include several new technologies that could be implemented at full-scale in the future. The new technologies being explored include a floating solar park, a short-duration battery storage as well as long-term storage via green hydrogen produced by water electrolysis and subsequently consumed in a fuel cell. The combination of these individual measures, herein referred to as the Base Load Power Hub (BLPH) will ensure a continuous power supply regardless of the wind situation.

1.1.1 Project Location

The Hollandse Kust Noord (HKN) wind farm is located 18.5km off the coast of the Netherlands near the town of Egmond aan Zee.

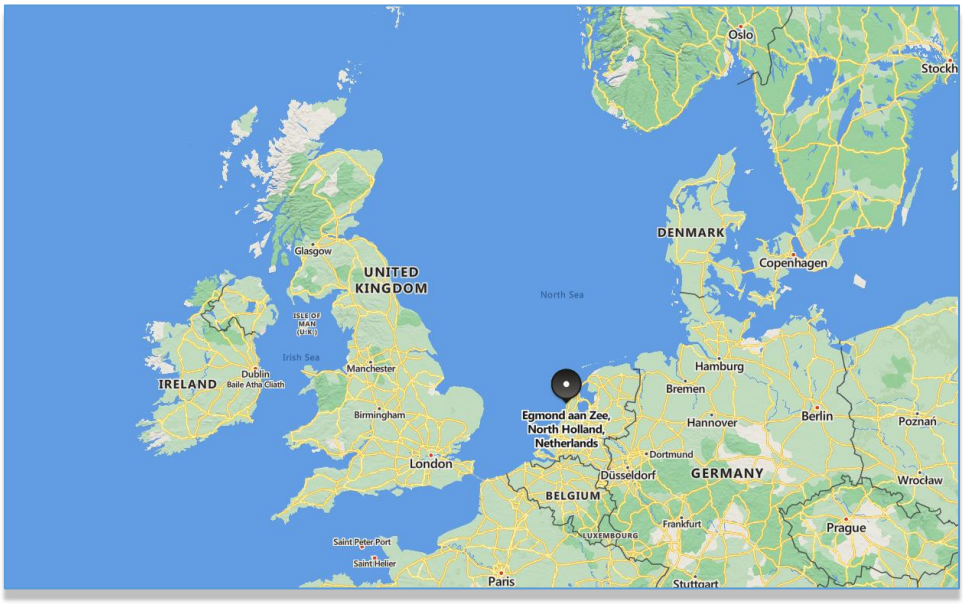


Figure 1 HOLLANDSE KUST NOORD WIND PARK Location Map

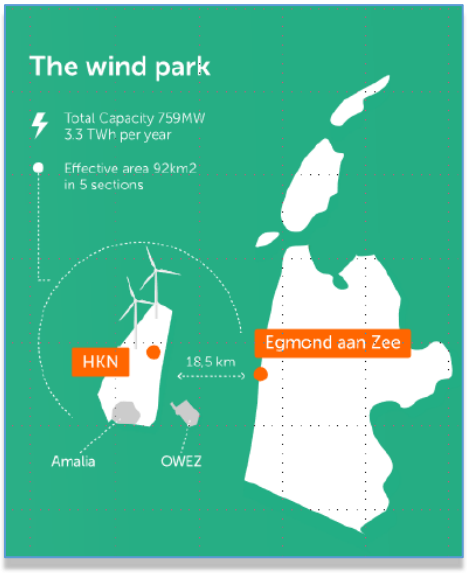


Figure 2 - Wind Park Details

The wind farm will consist of No. 69 x 11.5MW wind turbine generators each to be installed on a dedicated monopile structure. A 70th monopile located on coordinates E 590719.1, N 5841602.3 is reserved for installing the platform accommodating the BLPH. The monopile structure was designed and installed by Van Oord Offshore Wind (VooW) and therefore not part of the BLPH scope.

1.1.2 Project Concept

All components included in the BLPH will be integrated onshore on a topsides and installed in an offshore location within the boundaries of the HKN wind farm. At its simplest, the BLPH will store energy during periods of high electricity generation from renewable sources (a wind turbine generator and the floating solar PV farm) and release it during periods of low generation. In practice. It is expected that the energy stored will supplement generation from renewable sources to ensure that at least 1.0MW of power is exported to the electrical grid regardless of wind/solar availability.

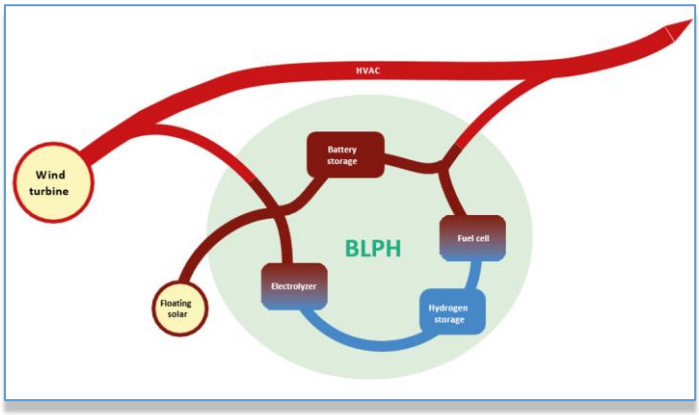


Figure 3 – BLPH Concept

Electricity in the BLPH will be stored in the form of electrons in a battery energy storage system (BESS) as well as converted into green hydrogen via water electrolysis. When the power output from the connecting wind turbine drops to below 1 MWe, the BLPH will return its stored energy to supplement the remaining power output. This will be by discharging the BESS, while stored hydrogen will be converted back into electricity using a fuel cell to extend the discharge duration.

The purpose of the BLPH s to function as a testbed for the integration of energy storage technologies with renewable generation. It is expected that equipment installed on the BLPH will operate as Normally Unmanned Installation for at least two (2) years with no or minimal maintenance and it will have its own independent control room with the ability to communicate with Crosswind's control room.

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2 DOCUMENT SCOPE

The purpose of this study is to enable safe operation of the power equipment in BLPH. Arc flash energy calculation for the MV and LV switchgears in accordance with IEEE 1584-2018 as specified in K559-2254-EL-PHI-001-01 is covered in this report.

2.1 REFERENCES

Doc. No.	Description
K559-2254-EL-PHI-001-01	Electrical Protection Philosophy
OPP-23-6013923-1-TS_MCC	Technical Specification for MV switchgear with Unigear Digital
OPP-23-6013923 Rev. B	Offer document from factory
1TWD034988K0101 rev. A	General Arrangement Drawing for LV switchgear
NFPA 70E - 2024	Standard for Electrical Safety in the Workplace - 2018 Edition
IEEE 1584-2018	IEEE Guide for Performing Arc-Flash Hazard Calculations
Catalogue UG ZS1	Unigear ZS1 Medium voltage air-insulated switchgear up to 24 kV
Catalogue Emax E4.2N 3200A w/Ekip Hi-Touch LSIG	Technical Catalogue SACE Emax2 Low voltage air circuit-breakers
123A90-DDL-EL-RE-20171	Electrical System Study Report – Short circuit
123A90-DDL-EL-RE-20168	Electrical Protection Relay Selectivity Study Report

Table 1 - Reference Documents

2.2 DEFINITIONS AND ABBREVIATIONS

AC	Alternating Current
BESS	Battery Energy Storage System
BLPH	Base Load Power Hub
cal	calories
CB	Circuit Breaker
COMPANY or Client (CPY):	Crosswind
CONTRACTOR (CTR):	ROSETTI MARINO S.p.A.
PPE	Personal Protective Equipment
PROJECT:	HOLLANDSE KUST NOORD WIND PARK Project

Ref.	Refer to
Arcing current	Fault current flowing through an electrical arc plasma
Incident energy	The amount of thermal energy impressed on a surface, a certain distance from the source, generated during an electric arc event. It is calculated at the working distance.
Arc flash hazard calculation	It uses equations to compute the incident energy at a specific working distance and the arc flash boundary.
Fault Clearing Time (FCT)/arc duration time	Time it takes the upstream energizing source of arcing current to stop providing current or energy to the arc fault.
Arc Flash Boundary (AFB)	A distance from a prospective arc source at which the incident energy is calculated to be 5.0 J/ cm2 (or 1.2 calories/ cm2).

Table 2 - Definitions and Abbreviations

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3 DESIGN BASIS

This section presents the details of all the input data, as well as assumptions used for the system studies for BLPH.

3.1 SYSTEM OVERVIEW

The system studied in this report is based on the single line diagram, 123A90-DDL-EL-DG-20158 Rev. 1. The WTG-57 is the wind turbine being connected to the BLPH. It is connected to the rest of the Crosswind offshore windfarm at the end of string A at a 66 kV busbar. The BLPH is also connected to this busbar via a 66/6.9 kV transformer. At the BLPH 6.6 kV BLPH busbar the BESS, electrolyser, fuel cell and solar farm is connected. There is also a 6.6/0.42 kV transformer supplying different loads at the BLPH.

3.2 MODEL OVERVIEW

WTG-57 is connected to the Crosswind offshore windfarm, via string A. WTG-57 is at the end of this string A.

BLPH is connected to the Crosswind offshore windfarm at the common 66 kV busbar with the WTG-57.

At this 66 kV busbar, the rest of the components in the string A is modelled as the supply network. This is termed as "windfarm" in the model.

Other electrical components connected to this 66 kV busbar, 6.6 kV busbar and 400 V busbar are in accordance with the single line diagram in 123A90-DDL-EL-DG-20158 Rev. 1, as well as datasheets of transformers.

Data provided in the single line diagram 123A90-DDL-EL-DG-20158 Rev. 1 were used to model these transformers.

The study has been performed using ETAP (Electrical Transient Analyzer Program) Version 22.0.5.

3.3 SYSTEM STUDIES BACKGROUND

According to the design philosophy, 9 operation modes are defined. Here under the main 5 operation mode are presented.

These modes of operation are as listed below:

1. CCS MODE 1: IMPORT / CHARGING (corresponding to project IDLE and IMPORT modes): Power generation from WTG-57 is greater than 1 MW. Surplus renewable energy is imported to BLPH from wind farm and/or solar farm for charging BESS and running the electrolyser whilst also supplying the balance of plant loads.
2. CCS MODE 2: EXPORT: Power generation from WTG-57 has dropped below 1 MW. Export of power is required from BLPH from all sources available i.e. BESS, Fuel Cell and/or solar farm.
3. CCS MODE 3: HOT STANDBY: BLPH is capable of exporting power should generation from WTG-57 drop below 1 MW. Renewable energy is imported to BLPH from wind farm and/or solar farm for charging BESS and running the electrolyser whilst also feeding the BLPH loads.
4. CCS MODE 4: COLD STANDBY: BLPH is not capable of exporting power should generation from WTG-57 drop below 1 MW. Renewable energy is imported to BLPH from wind farm and/or solar farm for charging BESS and running the electrolyser whilst also feeding the BLPH loads.
5. CCS MODE 5: EMERGENCY/ISLAND: Windfarm is no longer connected. BLPH consumes its stored renewable energy and/or renewable energy from the solar farm.

3.4 ANALYSIS DESIGN DATA

In the following paragraphs, a brief summary of BLPH Platform main equipment data is presented.

More details are available in the attached ETAP calculations reports.

3.4.1 Supply network

ITEM	3-PH SCC Max [kA]	X/R	3-PH SCC Min [kA]	X/R [pu]
66kV Network 3Ph	15.5	10.0	8.7	10.0
66kV Network 1Ph	7.10	10.0	6.3	10.0

Table 3 - Data for External Network

3.4.2 Power Sources

ITEM	Rated Power [kVA]	Vn [kV]	In [A]	Maximum Generated Active Power [kW]	Sustained SCC [% In]
A-85000 BESS package	1250.0	6.6	109.3	1000.0	150.0
A-80000 Fuel cell package	1250.0	6.6	109.3	1000.0	150.0
PV Plant	660.0	0.8	476.3	480.0	100.0

Table 4 - Data for Internal Power Sources

3.4.3 Transformers

ITEM	An [kVA]	V1n/V2n [kV]	I1n/I2n [A]	Zcc [%]	X/R [pu]	Vector Group
TR-100AD1	7000.0	66.0+/-8x1.25%/0.69	61.2/585.7	8.0	16.01	Dyn11
TR-200DE1	1600.0	6.6/0.42	139.9/2199.5	6.0	7.94	Dyn11
TR-200ED1	500.0	6.6/0.8	43.7/360.8	6.0	7.63	Dyn11

Table 5 - Data for Main Transformers

3.4.4 Bulk Load 0.4kV

ITEM	An [kVA]	Vn [kV]	In [A]	PF [%]
DC-Battery-System_SWGR	11.5	0.4	16.6	100.0
NAVAID_System	3.16	0.4	4.6	100.0
AC_UPS_F&G	12.5	0.4	18.0	80.0
AC_UPS_PAS	32.5	0.4	46.9	80.0
BL_SG-200N1	982.4	0.4	1418.0	87.78
DB-L&SP-BoP	37.3	0.4	53.8	88.4
DB-L&SP-HVMV	1.7	0.4	2.5	80.0
DB-L&SP-Inst.	1.7	0.4	2.5	80.0
DB-L&SP-LV	1.7	0.4	2.5	80.0
DB-L&SP-UPS	1.7	0.4	2.5	80.0

Table 6 - Data for Bulk Load 0.4kV

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3.4.5 Bulk Load 6.6kV

ITEM	An [kVA]	Vn [kV]	In [A]	PF [%]
A-20000	3.2	6.6	279.9	96.0

Table 7 - Data for Bulk Load 0.4kV

3.4.6 Switchgear Data

ITEM	Rated Voltage [kV]	Rated Ampacity [A]	Short Circuit Rating [kA - s]
HNA6-AFA70	66.0	1250.0	31.5 - 1s
SG-100D1	6.6	630.0	25.0 – 1s
SG-200N1	0.4	2500.0	50.0 – 1s

Table 8 – Data for Main Switchgears

3.4.7 Cables Data

Main cables data are as per 123A90-DDL-EL-LIS-20148 Rev 00 - Electrical Power and Control Cable Schedule.

Cable electrical parameters are as per 123A90-DDL-EL-RE-20151.

3.5 ARC FLASH EVALUATION

The calculation formulae to determine the arcing current, the incident energy normalised, the incident energy and the flash protection boundary as per IEEE Std 1584 are hereunder presented.

The conditions for which the mentioned formulae are applicable are the following:

PARAMETER	APPLICABLE RANGE
System voltage [kV]	0.208 to 0.600 kV
Frequencies [Hz]	50 or 60 Hz
Bolted fault current [kA]	0.5 to 106 kA
Gap between electrodes [mm]	6.35 to 76.2 mm
Equipment enclosure type	Open air, box, MCC, panel, switchgear, cables
Grounding type	Ungrounded, grounded, high resistance grounded
Phases	3 Phase fault

Table 9: IEEE Std Applicable Range from 0.208 to 0.600 kV

PARAMETER	APPLICABLE RANGE
System voltage [kV]	0.600 to 15 kV
Frequencies [Hz]	50 or 60 Hz
Bolted fault current [kA]	0.2 to 65 kA
Gap between electrodes [mm]	19.05 to 254 mm
Equipment enclosure type	Open air, box, MCC, panel, switchgear, cables
Grounding type	Ungrounded, grounded, high resistance grounded
Phases	3 Phase fault

Table 10: IEEE Std Applicable Range from 0.600 to 15 kV

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VCB	Vertical conductors/electrodes inside a metal box/enclosure
VCBB	Vertical conductors/electrodes terminated in insulating barrier inside a metal box/enclosure
HCB	Horizontal conductors/electrodes inside a metal box/enclosure
VOA	Vertical conductors/electrodes in open air
HOA	Horizontal conductors/electrodes in open air

Table 11: Electrode Configuration

3.6 WORKING DISTANCE, GAPS AND CUBICLE DIMENSIONS

In order to calculate the arcing current and incident energy is necessary to define the gap (distance between conductors), working distance and cubicle dimensions. The table below shows the considered gap values as per IEEE 1584 typical data and the cubicle dimensions as per vendor communication.

Equipment type	Gap mm	WD mm	H mm	W mm	D mm
SG-100D1 Cable Cubicle	152	91.44	1710	600	960
SG-100D1	152	91.44	780	600	960
SG-200N1 Cable Cubicle	32	60.96	562	800	678
SG-200N1	32	60.96	280	700	280
SG-200D2	32	60.96	615	615	615
DP-200N1	32	60.96	580	508	508

Table 12: Working Distance, Gaps and Cubicle Dimensions

Where:

- Gap Conductor Gap (mm)
- WD Working distance (inch or mm)
- H Enclosure height (inch or mm)
- W Enclosure width (inch or mm)
- D Enclosure depth (inch or mm)

3.7 ARC FLASH PROTECTIVE EQUIPMENT

In this paragraph the NFPA 70E - 2024 Table 130.7(C)(15)(c) Personal Protective Equipment (PPE) has been reported.

- PPE Category 1: Arc-Rated Clothing, minimum arc rating of 4 cal/cm2 (16.75 J/cm2)
- PPE Category 2 Arc-Rated Clothing, minimum arc rating of 8 cal/cm2 (33.5 J/cm2)
- PPE Category 3: Arc-Rated Clothing selected so that the system arc rating meets the required minimum arc rating of 25 cal/cm2 (104.7 J/cm2)
- PPE Category 4: Arc-Rated selected so that the system arc rating meets the required minimum arc rating of 40 cal/cm2 (167.5 J/cm2)

Where incident energy exceeds 40 cal/cm2 at the working distance, suitable clothing is available, but NFPA 70E strongly recommend placing greater emphasis than normal on de-energizing before working on or near the exposed electrical conductors or circuit parts.

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4 ARC FLASH CALCULATIONS

4.1 ETAP BASIC SETTINGS

To perform AF calculations, the considered ETAP options and basic settings have been set to the following:

- Report only Bus and Source PD Incident Energy: True
- PPE Requirements: Table 130.7(C)(15)(c) – NFPA 70E 2024
- Arc Flash Analysis Data: Typical values as per IEEE Std. 1584-2018 have been considered.
- Shock Hazard Analysis Data:
  - Typical Approach Boundaries to Live Parts: NFPA70E 2021
  - Voltage-Rated Gloves: ASTM D 120-14a
- Bus Arc Flash Typical Data:
  - Arc Flash Analysis Data: IEEE 1584-2018 – Typical Value
  - Shock Hazard Analysis Data: NFPA 70E 2021, ASTM D 120-14a

As per IEEE 1584-2018, in the Rating Tab of the Bus Editor "Main PD isolated" check box has been checked only for cable bus, low and medium voltage switchgears.

For all the study cases later detailed at par. 10, the considered AF calculation settings in the Short Circuit Study Case Editor have been the following:

- Arc Flash Method: IEEE 1584-2018, Apply Iarc variation <= 0.6kV and Apply Iarc variation > 0.6kV
- Bus Fault Current: Calculate, 3-Phase System, Max/Min
- Fault Clearing Time: Auto Select Source Protective Device (PD)
  - Except if PD is Selected in Bus Editor/Enclosure Editor
  - Limit Maximum FCT = 2 seconds
- Consider Main Protective Device Isolation: Individual (Bus Editor)
- Current Limiting Devices: Determine CLF operation based on Peak Let-Through Curves
  - For Class L & RK1, use IEEE 1584 Equations (if applicable)
  - Use bottom of CLF TCC (if peak let-through curve is not available)
- Bus Gaps & Working Distance: Individual (Bus / Enclosure Editor) – as per IEEE 1584-2018 Typical Value
- Incident Energy Level: NFPA 70E 2021
- Shock Risk Assessment:
- Shock Protection Boundaries: Individual (Bus Editor)
- Global Voltage-Rated Glove Class: ASTM D 120-14a

5 SHORT CIRCUIT CURRENT CALCULATION

5.1 ETAP STUDY ASSUMPTIONS

SC Standard:	IEC
X/R for Peak kA Calculation Method:	Method C
Transformer Tap:	Use Nominal Tap
IEC 61363 Prefault Condition:	Prefault Load Flow
cmax for Z adj. (V < 1000V)	1.05%
Protect. Device Duty:	Based on Total Bus Fault Current
Adjustment: Impedance Tolerance	Transformer Impedance +/-10%

5.2 CASE 1: SCCMAX

Short circuit calculation case relevant to normal operation conditions, with minimum source short circuit impedance. This study case leads to the calculation of ultimate maximum 3-phase short circuit fault currents on network buses, in order to check adequacy of electrical equipment in terms of short circuit capability.

- Generation Category: Export
- Loading Category: Export
- Load Diversity Factor: None.
- Power Grid 66kV in service, with maximum short circuit power.
- resistance temperature correction: Global 20°C.
- A-85000 Bess Package in service – in discharging condition.
- A-20000 Electrolyser Package in standby
- A-80000 Fuel Cell Package in service – in discharging condition
- PV Solar Package in service
- LV loads stated as "continuous and intermittent operation" in service and loaded according to load schedule usage factor.
- LV loads stated as "stand-by operation" in standby.

5.3 CASE 2: SCCMIN WITH NETWORK

Short circuit calculation case relevant to minimum operation conditions, with maximum source short circuit impedance. This study case leads to the calculation of minimum 3-phase short circuit fault currents on network buses.

- Generation Category: Hot standby
- Loading Category: Hot standby

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- Load Diversity Factor: None.
- Power Grid 66kV in service, with minimum short circuit power.
- resistance temperature correction: Global 90°C.
- A-85000 Bess Package out of service
- A-20000 Electrolyser Package out of service
- A-80000 Fuel Cell Package out of service
- PV Solar Package out of service
- LV loads stated as "continuous and intermittent operation" in service and loaded according to load schedule usage factor.
- LV loads stated as "stand-by operation" in standby.

5.4 CASE 3: SCCMAX ISLAND MODE

Short circuit calculation case relevant to island operation conditions, with minimum source short circuit impedance. This study case leads to the calculation of ultimate maximum 3-phase short circuit fault currents on network buses, in service in island.

- Generation Category: Emergency
- Loading Category: Emergency
- Load Diversity Factor: None.
- Power Grid 66kV out of service.
- resistance temperature correction: Global 90°C.
- A-85000 Bess Package in service – in discharging condition
- A-20000 Electrolyser Package out of service
- A-80000 Fuel Cell Package in service
- PV Solar Package is service
- LV loads stated as "continuous and intermittent operation" in service and loaded according to load schedule usage factor.
- LV loads stated as "stand-by operation" in standby.

5.5 CASE 4: SCCMIN ISLAND MODE

Short circuit calculation case relevant to island operation conditions, with maximum source short circuit impedance. This study case leads to the calculation of minimum 3-phase short circuit fault currents on network buses, in service in island.

- Generation Category: Emergency

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- Loading Category: Emergency
- Load Diversity Factor: None.
- Power Grid 66kV out of service.
- resistance temperature correction: Global 90°C.
- A-85000 Bess Package in service – in discharging condition
- A-20000 Electrolyser Package out of service
- A-80000 Fuel Cell Package out of service
- PV Solar Package out of service
- LV loads stated as "continuous and intermittent operation" in service and loaded according to load schedule usage factor.
- LV loads stated as "stand-by operation" in standby.

6 STUDY RESULTS

For each study case, the complete ETAP Arc Flash Analysis report is available in attachments.

The result summary tables (Bus Side and Line Side) obtained with AF Report Analyzer and showing for each switchgear the total energy, the arc flash boundary (AFB), the energy level, the final FCT, the total Ibf'' for the worst case are available in attachment as well.

7 CONCLUSION

Regarding the 6.6kV and LV switchgear, considering that men work on the secondary side of the transformer or near the switchgear, the minimum arc rating of PPE is lower than 40 cal/cm2.

The maximum risk category for 6.6kV switchgear, for a fault on the bus or the line side, is Level 1.

The maximum risk category for LV panels DP-200N1 and SG-200D2 is Level 1 for both faults on the bus and line sides.

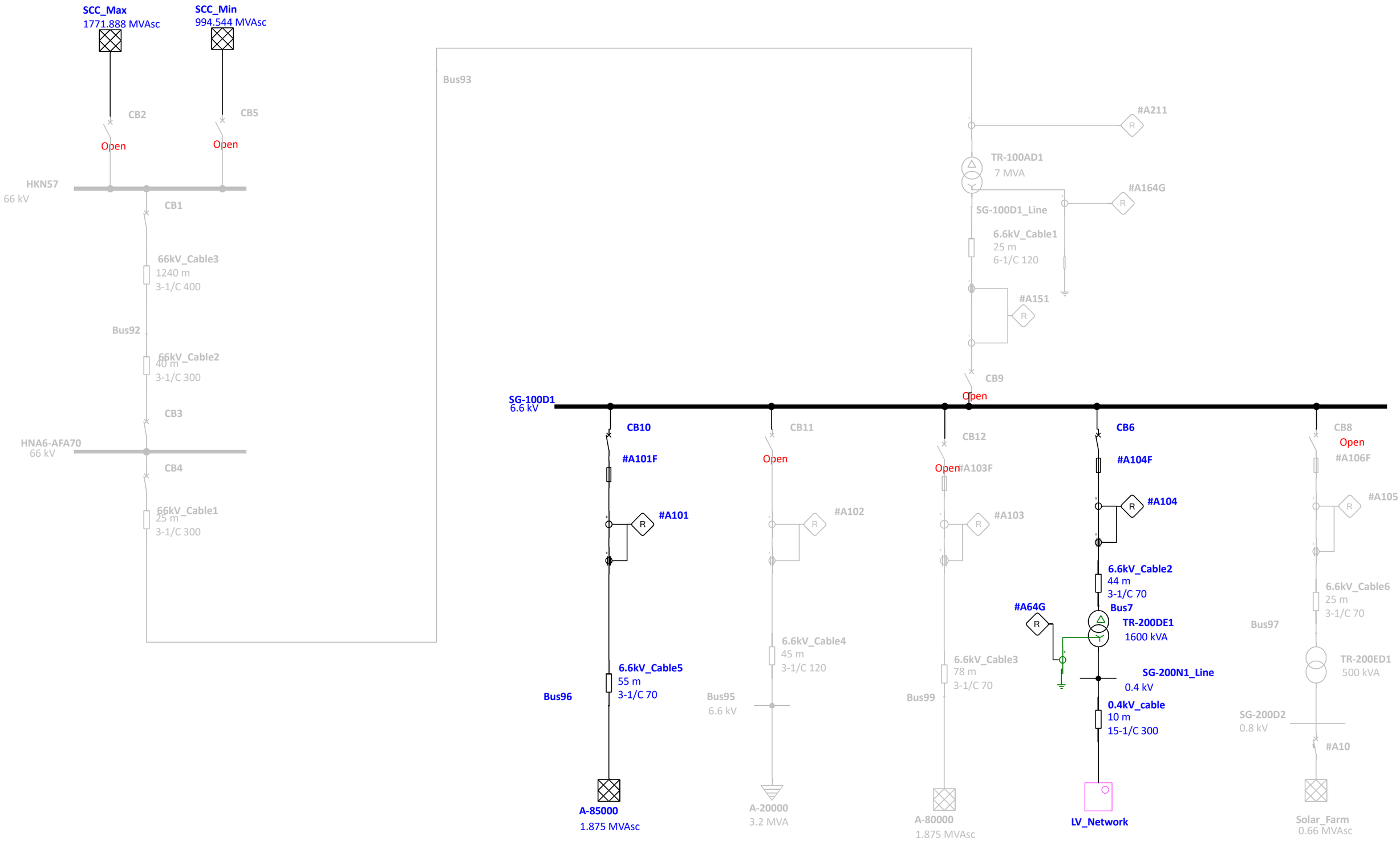
The maximum risk category for LV switchgear SG-200N1 is Level 1 for a fault on the line side and Level 3 on the bus side. A maintenance switch has been foreseen to reduce the risk category for LV switchgear SG-200N1. With this solution, the maximum risk category for LV switchgear SG-200N1 is Level 2 for a fault on the bus side.

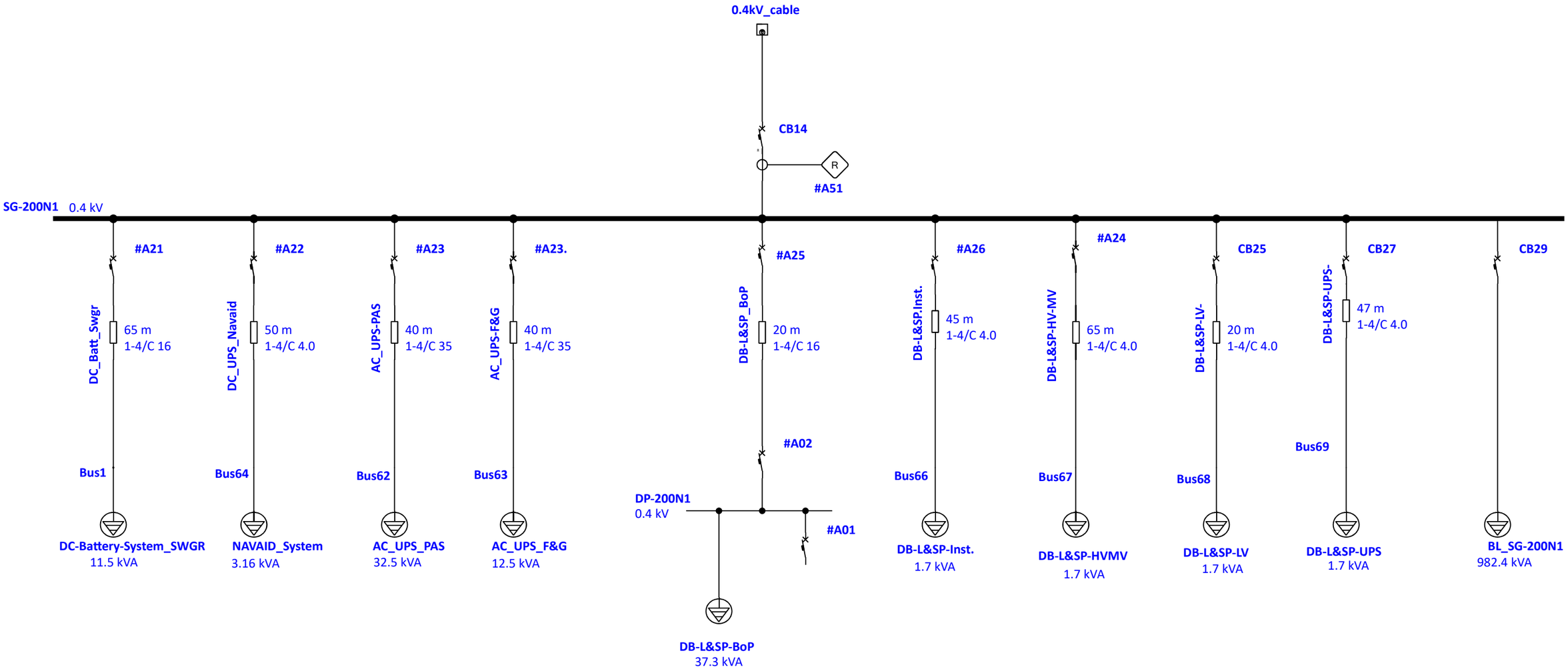
With respected to the 66kV GIS, even if the Arc Flash calculation has not been performed (IEEE 1584 can be applicated up to 15kV), not PPE are required since the GIS is arc resistant with fully insulated buses, it doesn't require any maintenance while in service and considering that each local operation on the GIS has to be done from the local panel, which is placed in safe area.

More details are indicated in Attachment 2 and 3.

8 ATTACHMENTS

Attachment 1 Single Line Diagram


SCC_Max
1771.888 MVAsc
SCC_Min
994.544 MVAsc
CB2
Open
CB5
Open
HKN57
66 kV
CB1
66kV_Cable3
1240 m
3-1/C 400
Bus92
66kV_Cable2
40 m
3-1/C 300
CB3
HNA6-AFA70
66 kV
CB4
66kV_Cable1
25 m
3-1/C 300
Bus93
#A211
TR-100AD1
7 MVA
#A164G
SG-100D1_Line
6.6kV_Cable1
25 m
6-1/C 120
#A151
CB9
Open
SG-100D1
6.6 kV
CB10
#A101F
#A101
6.6kV_Cable5
55 m
3-1/C 70
Bus96
A-85000
1.875 MVAsc
CB11
Open
#A102
6.6kV_Cable4
45 m
3-1/C 120
Bus95
6.6 kV
A-20000
3.2 MVA
CB12
Open
#A103F
#A103
6.6kV_Cable3
78 m
3-1/C 70
Bus99
A-80000
1.875 MVAsc
CB6
#A104F
#A104
6.6kV_Cable2
44 m
3-1/C 70
#A64G
Bus7
TR-200DE1
1600 kVA
SG-200N1_Line
0.4 kV
0.4kV_cable
10 m
15-1/C 300
LV_Network
CB8
Open
#A106F
#A105
6.6kV_Cable6
25 m
3-1/C 70
Bus97
TR-200ED1
500 kVA
SG-200D2
0.8 kV
#A10
Solar_Farm
0.66 MVAsc


0.4kV_cable
CB14
R
#A51
SG-200N1 0.4 kV
#A21
#A22
#A23
#A23.
#A25
#A26
#A24
CB25
CB27
CB29
DC_Batt_Swgr
65 m
1-4/C 16
DC_UPS_Navaid
50 m
1-4/C 4.0
AC_UPS-PAS
40 m
1-4/C 35
AC_UPS-F&G
40 m
1-4/C 35
DB-L&SP_BoP
20 m
1-4/C 16
DB-L&SP.Inst.
45 m
1-4/C 4.0
DB-L&SP-HV-MV
65 m
1-4/C 4.0
DB-L&SP-LV-
20 m
1-4/C 4.0
DB-L&SP-UPS-
47 m
1-4/C 4.0
#A02
DP-200N1
0.4 kV
#A01
Bus1
Bus64
Bus62
Bus63
Bus66
Bus67
Bus68
Bus69
DC-Battery-System_SWGR
11.5 kVA
NAVAID_System
3.16 kVA
AC_UPS_PAS
32.5 kVA
AC_UPS_F&G
12.5 kVA
DB-L&SP-BoP
37.3 kVA
DB-L&SP-Inst.
1.7 kVA
DB-L&SP-HVMV
1.7 kVA
DB-L&SP-LV
1.7 kVA
DB-L&SP-UPS
1.7 kVA
BL_SG-200N1
982.4 kVA

Attachment 2 Arc flash Result without Maintenance Switch on SG-200N1 switchgear

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Attachment 2: Arc flash Result without Maintenance Switch on SG-200N1 switchgear

ARC FLASH CALCULATION RESULT BUS SIDE FAULT											
ID	**kV**	**Type**	**Conductor Gap LL (mm)**	**Working Distance LL (cm)**	**Total Ibf at FCT (kA)**	**Total Energy (cal/cm²)**	**AFB (m)**	**Energy Levels**	**Final FCT (sec)**	**Output Rpt.**	**Configuration**
SG-100D1	6.6	Switchgear	152	91.4	8.112	0.495207	0.52	Level 1	0.05	AF_Case1_MS	SCCMax
SG-200D2	0.8	Switchgear	32	61	2.712	2.57	0.975	Level 1	0.78	AF_Case2_MS	SCCMax-Isl
SG-200N1	0.4	Switchgear	32	61	31.348	6.51	1.551	Level 2	0.15	AF_Case1_MS	SCCMax
DP-200N1	0.4	Switchgear	32	61	9.63	0.120018	0.144	Level 1	0.012	AF_Case1_MS	SCCMax

ARC FLASH CALCULATION RESULT LINE SIDE FAULT											
ID	**kV**	**Type**	**Conductor Gap LL (mm)**	**Working Distance LL (cm)**	**Total Ibf at FCT (kA)**	**Total Energy (cal/cm²)**	**AFB (m)**	**Energy Levels**	**Final FCT (sec)**	**Output Rpt.**	**Configuration**
SG-100D1	6.6	Switchgear	152	91.4	8.505	0.463324	0.498	Level 1	0.05	AF_Case1_MS	SCCMax
SG-200D2	0.8	Switchgear	32	61	2.712	2.57	0.975	Level 1	0.78	AF_Case2_MS	SCCMax-Isl
SG-200N1	0.4	Switchgear	32	61	32.092	2.15	0.841	Level 1	0.05	AF_Case1_MS	SCCMax
DP-200N1	0.4	Switchgear	32	61	9.63	0.120018	0.144	Level 1	0.012	AF_Case1_MS	SCCMax

Attachment 3 Arc flash Result with Maintenance Switch on SG-200N1 switchgear

Attachment 3: Arc flash Result with Maintenance Switch on SG-200N1 switchgear

ARC FLASH CALCULATION RESULT BUS SIDE FAULT											
ID	**kV**	**Type**	**Conductor Gap LL (mm)**	**Working Distance LL (cm)**	**Total Ibf at FCT (kA)**	**Total Energy (cal/cm²)**	**AFB (m)**	**Energy Levels**	**Final FCT (sec)**	**Output Rpt.**	**Configuration**
SG-100D1	6.6	Switchgear	152	91.4	8.112	0.495207	Level 1	0.52	0.05	AF_Case1	SCCMax
DP-200N1	0.4	Switchgear	32	61	9.63	0.120018	Level 1	0.144	0.012	AF_Case1	SCCMax
SG-200D2	0.8	Switchgear	32	61	2.712	2.57	Level 1	0.975	0.78	AF_Case2	SCCMax-Isl
SG-200N1	0.4	Switchgear	32	61	31.348	14.32	Level 3	2.399	0.33	AF_Case1	SCCMax

ARC FLASH CALCULATION RESULT LINE SIDE FAULT											
ID	**kV**	**Type**	**Conductor Gap LL (mm)**	**Working Distance LL (cm)**	**Total Ibf at FCT (kA)**	**Total Energy (cal/cm²)**	**AFB (m)**	**Energy Levels**	**Final FCT (sec)**	**Output Rpt.**	**Configuration**
SG-100D1	6.6	Switchgear	152	91.4	8.505	0.463324	Level 1	0.498	0.05	AF_Case1	SCCMax
DP-200N1	0.4	Switchgear	32	61	9.63	0.120018	Level 1	0.144	0.012	AF_Case1	SCCMax
SG-200D2	0.8	Switchgear	32	61	2.712	2.57	Level 1	0.975	0.78	AF_Case2	SCCMax-Isl
SG-200N1	0.4	Switchgear	32	61	32.092	2.15	Level 1	0.841	0.05	AF_Case1	SCCMax

Attachment 4 Arc flash PPE label - Bus side with Maintenance Switch on SG-200N1 switchgear

DANGER



Arc Flash and Shock Hazard

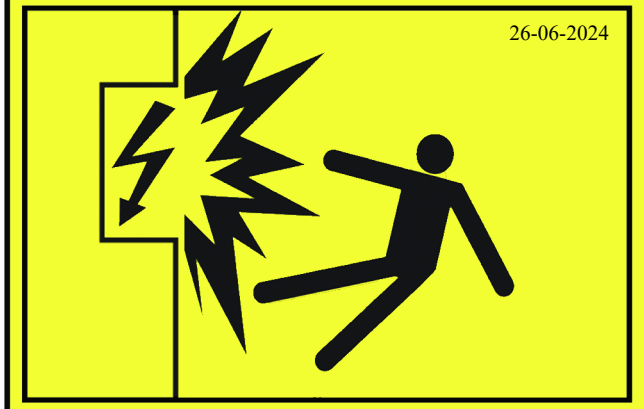
Arc Flash Boundary	0.14 m
Incident Energy (cal/cm²)	0.1
Working Distance	61 cm

Level 1

Shock Hazard Voltage	400 VAC
Limited Approach	1.07 m
Restricted Approach	0.30 m

DP-200N1

DANGER



Arc Flash and Shock Hazard

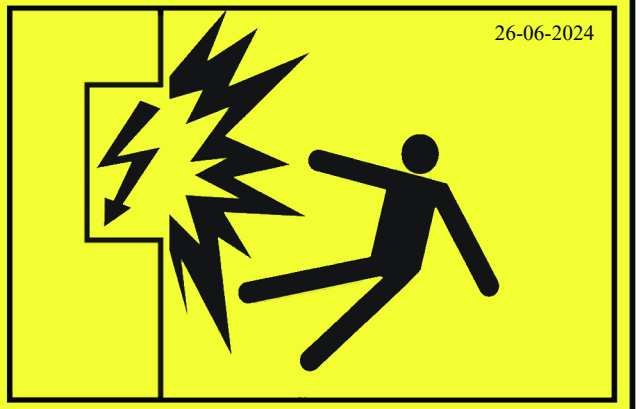
Arc Flash Boundary	0.52 m
Incident Energy (cal/cm²)	0.5
Working Distance	91 cm

Level 1

Shock Hazard Voltage	6600 VAC
Limited Approach	1.52 m
Restricted Approach	0.66 m

SG-100D1

DANGER



Arc Flash and Shock Hazard

Arc Flash Boundary	0.98 m
Incident Energy (cal/cm²)	2.6
Working Distance	61 cm

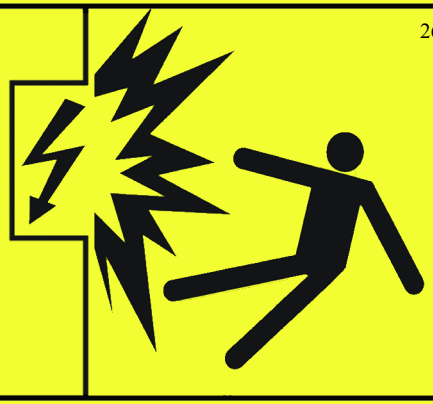
Level 1

Shock Hazard Voltage	800 VAC
Limited Approach	1.52 m
Restricted Approach	0.66 m

SG-200D2

DANGER

26-06-2024



Arc Flash and Shock Hazard

Arc Flash Boundary	**1.55 m**
Incident Energy (cal/cm²)	**6.5**
Working Distance	**61 cm**

Level 2

Shock Hazard Voltage 400 VAC

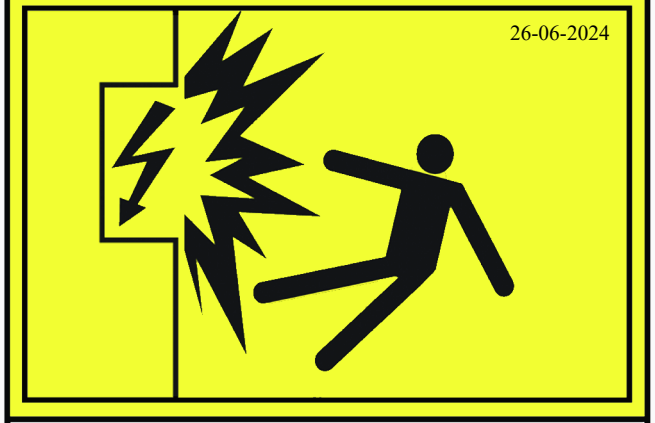
Limited Approach	**1.07 m**
Restricted Approach	**0.30 m**

SG-200N1

Attachment 5 Arc flash PPE label - Cable Entry (Incomer) with Maintenance Switch on SG-200N1 switchgear

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Arc Flash and Shock Hazard

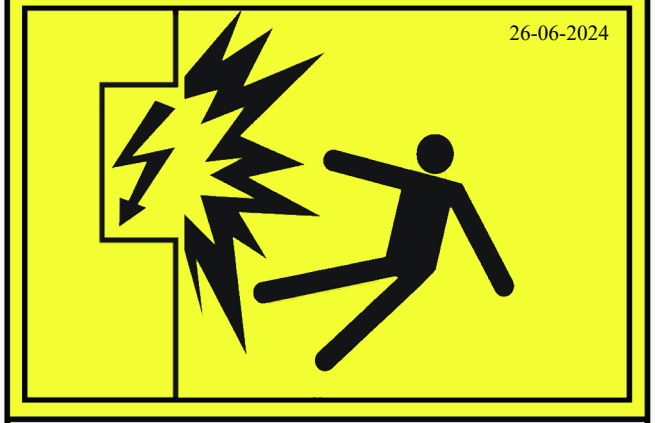
Arc Flash Boundary	0.14 m
Incident Energy (cal/cm²)	0.1
Working Distance	61 cm

Level 1

Shock Hazard Voltage	400 VAC
Limited Approach	1.07 m
Restricted Approach	0.30 m

DP-200N1 - Incomer

DANGER



Arc Flash and Shock Hazard

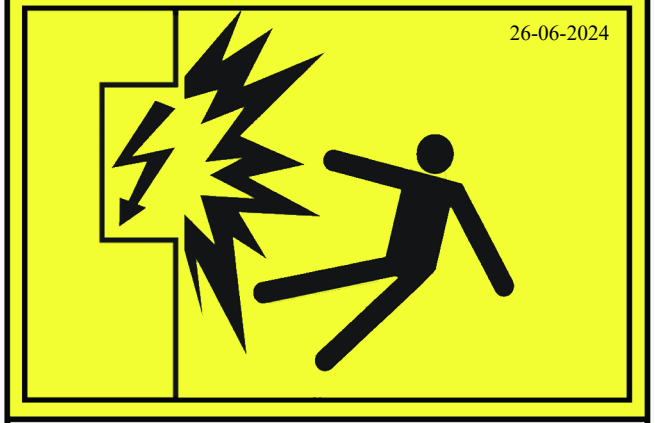
Arc Flash Boundary	0.50 m
Incident Energy (cal/cm²)	0.5
Working Distance	91 cm

Level 1

Shock Hazard Voltage	6900 VAC
Limited Approach	1.52 m
Restricted Approach	0.66 m

SG-100D1 - Incomer

DANGER



Arc Flash and Shock Hazard

Arc Flash Boundary	0.98 m
Incident Energy (cal/cm²)	2.6
Working Distance	61 cm

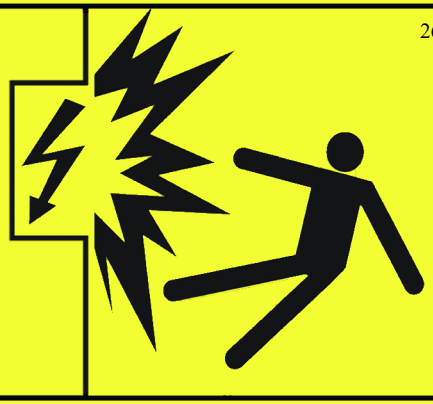
Level 1

Shock Hazard Voltage	800 VAC
Limited Approach	1.52 m
Restricted Approach	0.66 m

SG-200D2 - Incomer

DANGER

26-06-2024



Arc Flash and Shock Hazard

Arc Flash Boundary	**0.84 m**
Incident Energy (cal/cm²)	**2.2**
Working Distance	**61 cm**

Level 1

Shock Hazard Voltage 400 VAC

Limited Approach	**1.07 m**
Restricted Approach	**0.30 m**

SG-200N1 - Incomer