# Calculation Cover Sheet

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|---|---|---|---|
| Subject | Short-Circuit Calculations | Project | KARSTO |
| Discipline | Electrical | Job No. | 25474-000 |
| | | Calc. No. | 25474-000-E0C-ES-00002 |
| | | Sheet | 1 of 9 |

| Calculation Status Designation | Preliminary | Confirmed with Preliminary Information | Confirmed | Superseded | Voided |
|---|---|---|---|---|---|
| | X | | | | |

| Computer Program/Type | SCP | Program Name. | Version/Release | Operating System |
|---|---|---|---|---|
| | X | ETAP | 6.0.0 | Windows XP |

| Nuclear Quality Classification | Safety-Related | Augmented Quality | Nonsafety-Related |
|---|---|---|---|
| | | | |

Use of these calculations by person, without access to pertinent factors and without proper regard for their purpose, could lead to erroneous conclusions.

Should it become necessary to use these calculations in your work in the future, it is suggested that the calculations be reviewed with authorized Bechtel personnel to ensure that the purposes, assumptions, judgments and limitations are thoroughly understood. Bechtel cannot assume responsibility for the use of these calculations not under our direct control.

Owner Document No. 10112936-PB-E-TDO-0002

| Rev. No. | Reason for Revision | Total No. of Sheets | Last Sheet No. | By | Checked | Approved/ Accepted | Date |
|---|---|---|---|---|---|---|---|
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| 0 | Issued for Comment | 21 | Attachment 5, Sheet 1 of 1 | VS | WK | SMS | 11/21/08 |

**Record of Revisions**

# Contents

# Short-Circuit Calculations

## 1.0 SCOPE

The scope of this Report includes a review and analysis of the electrical power system for the $CO_2$ Capture and Compression (CCC) facility adjacent to the gas-fired Combined Cycle Power Plant (CCPP) at Kårstø in the South-West of Norway. An electrical model was developed and various studies were conducted as a preliminary investigation of the power system performance to determine sizes and ratings of the major electrical equipment based on the system information available at this stage of the project. In order to complete these calculations some assumptions were made which are explained later in this report.

The 22kV Substation located in CCC facility is supplied with 20kV (Feeder A) and 6.6kV (Feeder B) in-feeds from the CCPP 20kV Generator Isophase Bus and 6.6kV Switchgear 10BBE through power transformers CCC FACILITY XFMR 1ESETP01 (50MVA, 20-23kV) located in CCPP facility and DEAD TIME XFMR 1ESETP02 (3MVA, 6.6-23Kv) located outdoor in the CCC facility. The 22kV Switchgear (1ESESI01) 22kV-SWGR is indoor switchgear with manual bus transfer arrangement. The voltage is further stepped down to 6.6kV and 400V distribution levels to feed various loads. Additionally, three large motors (compressor and blowers) are supplied from 22kV-switchgear (1ESESI01) via isolation transformers and controlled through adjustable speed drive systems (ASDS).

The purpose of Short-Circuit (SC) Calculations is to:

- Determine fault currents expected at different parts of the electrical system under various operating conditions.
- Determine maximum and minimum SC Currents under various fault conditions
- Establish electrical equipment's momentary rating (mechanical requirements of bus bracing) and short circuit interrupting capability.
- Determine spare SC capacity per main switchgear
- Determine transformer sizes and impedances.

Calculations reflect the most unfavorable operation and the pessimistic equipment parameter assumption.

## 2.0 METHODOLOGY

The electrical model was developed using ETAP PowerStation (Version 6.0.0) software based on Load List and Single Line Diagrams (SLD) as available at time of calculations and the system information provided by GASSNOVA as Owner and FICHTNER as Owner's Engineer.

For equipment withstanding rating, the maximum fault currents that equipment can be subjected to must be defined. ETAP PowerStation calculates maximum faults when study is run using "Balanced System Study (IEC-60909)" function, calculation Method "C" for X/R peak kA. It calculates peak fault currents, symmetric sub-transient and steady RMS fault currents for 3-phase, phase-to-phase (L-L), phase-to-earth (L-G), phase-to-phase-to-earth (L-L-G) faults. These faults values are used to determine bus bracing requirements and equipment fault interrupting capability.

Calculation cases comprise various scenarios to evaluate options and limitations pertaining to operation of the distribution system under different conditions.

For all calculations, Normal system configuration is when Feeder A in-feed breaker is closed and Feeder B in-feed breaker is open and Low Voltage Switchgear (400V-LdCntr) tie-breaker is open and in-feeds breakers closed. Alternate configurations are when Feeder A in-feed breaker is open and Feeder B in-feed breaker is closed (Stand by Mode) and for 400V-LdCntr in-feed breaker B is open and tie-breaker and in-feed breaker A are closed. For reference the SLDs are listed in Section 6.0.

## 3.0 ASSUMPTIONS AND SETTINGS

The following are detailed descriptions of connections, conditions and equipment assumed for the calculations. Single Line Diagrams using ETAP PowerStation are listed in Section 6.0 ATTACHMENTS.

- 50 MVA Power Transformer Data and 22kV 22kV-SWGR data was provided by FICHTNER as follows:
  - Power transformer connected to the external grid, 50 MVA , 20/23kV, 12.5% impedance, provided by others
  - 22kV switchgear shall be designed for $I_b$(sym)=31.5kA, Ip=80kA
- The estimated available short circuit currents at CCPP switchgear 10BBE were provided by FICHTNER as follows:
  - Minimum available SC is 8kA
  - Maximum available SC is 25kA
- Assumed X/R ratio for Min/Max SC on CCPP switchgear 10BBE is 50.

- The estimated available short circuit currents at the primary side of the 50 MVA transformer were provided by FICHTNER as follows:
  - Minimum available SC is 60kA
  - Maximum available SC is 130kA
- 6.6kV SWGR shall be designed for $I_b$(sym)=31.5kA, Ip = 80kA
- 0.4kV Load Center shall be designed for $I_b$(sym)= 100kA, Ip = 220kA
- 0.4kV MCC shall be designed for $I_b$(sym)= 75kA, Ip = 165kA
- Assumed X/R ratio for Min/Max SC on the primary side of the 50 MVA transformer is 95.
- Transformers sizes were considered as shown on the single line diagrams. Actual data was used for transformer impedances where known, otherwise typical data used where unknown.
- Transformer Impedance negative tolerance is considered in calculations as - 7.5%
- Transformer sizing was checked by ETAP based on IEC standard, connected loads, operating load and ambient temperature 40° C.
- Symbols for two-winding VFD transformers (T1, T2, and T3 on SLD) only for reference purpose and will be defined later by VFD Vendor.
- Voltage tolerance of the 20kV and 6.6kV upstream Owner provided utility systems is estimated as +/- 2%.
- For maximum short-circuit calculations pre-fault voltage of 1.1 p.u. will be used for conservative results.
- For minimum short-circuit calculations pre-fault voltage of 0.95 p.u. will be used for conservative results.
- All loads are based on Load List and Single Line Diagram.
- 50MVA CCC Facility transformer tap set to 0% and all other power transformers tap set to +2.5% on primary.
- Short-Circuit calculations are based on motor "status" (spare motors do not contribute).
- 11kV Motors do not contribute to short circuit current via ASDSs (VFDs)
- Ambient temperature for A/G trays is 40° C and for U/G Ducts is 20° C. Cables temperature range is from 20° C to 80° C.
- Cable Loading factors are from 1 to 1.35 for different loads according to IEC.

- Cable calculations assume short-circuit protection clearing time of 0.1second.
- Cable grouping was assumed as per Exhibit E5.7- Cabling and Cable Trays.
- Cable sizing was verified by ETAP based on ICEA P-54-440 standard for above ground (A/G) tray installations and IEEE 399 standard for under ground (U/G) duct installations.
- Load category is "design" and assumed 100% of nameplate rating for pessimistic results.
- Cable Sizes are as shown on the SLD. Cable impedance values are typical as listed in the ETAP PowerStation cable library.

## 4.0 CALCULATIONS

Two Short Circuit Study cases were run based on operating conditions of the downstream system as follows:

### 4.1 CASE 1: MAXIMUM FAULT CURRENTS:

- System SC contribution at maximum available, supply voltage set to 1.1 p.u.
- 22kV-SWGR Feeder A available and in-feed breaker is closed
- 22kV-SWGR Feeder B unavailable and in-feed breaker open
- 400V-LdCntr Tie-Breaker closed, "CB A" in-feed breaker closed and "CB B" in-feed breaker open
- Motor contributions are included
- Cable resistances adjusted for the temperature of 20° C
- All loads are running on normal plus the largest stand by motor for CO2 Product Sendout Pump B is running

### 4.2 CASE 2: MINIMUM FAULT CURRENTS:

- System SC contribution at minimum available, supply voltage set to 0.95 p.u.
- 22kV-SWGR Feeder A available and in-feed breaker is closed
- 22kV-SWGR Feeder B unavailable and in-feed breaker open
- 400V-LdCntr Tie-Breaker open and both in-feed breakers closed
- Cable resistances adjusted for temperature 80° C
- Only Maintenance Loads are running on normal

## 4.3 RESULTS OF THE CALCULATIONS:

- Reports and SLDs with Calculations Results for 3-phase symmetrical fault and line-to-line, line-to-earth, line-to-line-to-earth are in the 6.0 Attachments.
- The Summary of results of each case for 3-phase symmetrical fault on main busses and at the ends of selected cables is listed in the following table:

**Short Circuit Study Results**

| Bus Name | Bus Volt-age | Bus SC Rating RMS/Pk | SC Case 1 | | | Spare SC Capacity RMS/Pk | SC Case 2 | | | Spare SC Capacity RMS/Pk |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Current | | | | Current | | | |
| | (kV) | Steady/ MaxPeak (kA) | Max Peak (kA) | Sub-T RMS (kA) | Steady RMS (kA) | Steady/ MaxPeak (kA) | Max Peak (kA) | Sub-T RMS (kA) | Steady RMS (kA) | Steady/ MaxPeak (kA) |
| 22kV-SWGR | 22 | 31.5/80 | 31.9 | 12.09 | 10.46 | 21/48 | 21.27 | 7.95 | 7.74 | 23/58 |
| 6.6kV-SWGR | 6.6 | 31.5/80 | 45.9 | 18.16 | 12.06 | 19/34 | N/A | N/A | N/A | N/A |
| 400V-LdCntr-1 | 0.4 | 100/220 | 169.9 | 74.14 | 59.8 | 40/50 | 119.13 | 51.31 | 44.4 | 55/100 |
| 400V-LdCntr-2 | 0.4 | 100/220 | 169.9 | 74.14 | 59.9 | 40/50 | 115.9 | 49.75 | 44.4 | 55/104 |
| 400V-MCC-1 | 0.4 | 75/165 | 139.7 | 64.5 | 52.5 | 22/25 | 100.18 | 45.99 | 39.53 | 35/64 |
| 400V-MCC-2 | 0.4 | 75/165 | 138.8 | 64.15 | 52.5 | 22/26 | 97.32 | 44.5 | 39.53 | 35/67 |
| 400V-EssMCC | 0.4 | 75/165 | 135.2 | 62.0 | 51.4 | 23/29 | 95.0 | 43.19 | 38.84 | 36/70 |
| Cable C-StDwnTr (B-StpDwnTr) | (22) | (80) | 31.72 | 12.05 | 10.4 | N/A | N/A | N/A | N/A | N/A |
| Cable C-CmprsrTr (B-CmprsrTr) | (22) | (80) | 31.39 | 11.99 | 10.4 | N/A | N/A | N/A | N/A | N/A |
| Cable C-LAmin.A (B-LAmin.A) | (6.6) | (80) | 35.85 | 16.76 | 11.44 | N/A | N/A | N/A | N/A | N/A |
| Cable C-RAmin.1A (B-RAmin.1A) | (6.6) | (80) | 34.75 | 16.55 | 11.35 | N/A | N/A | N/A | N/A | N/A |

In the table above:

- SC spare capacity is calculated as (Bus rated steady/max peak current) - (Bus calculated steady/max peak current) respectively for particular bus system.

## 5.0 CONCLUSIONS

The calculations in this Report are based on assumed data and therefore it is considered as preliminary calculations only. At this stage, the results are adequate for equipment sizing. For the next phase of the project these calculations should be revisited when more information on equipment and the system is available.

- The switchgear (SWGR) and motor control centers (MCC) are standard type equipment.
- Chosen SC current rating of equipment has ample spare capacity for future loads.

## 6.0 LIST OF ATTACHMENTS

### 6.1 INPUT DATA

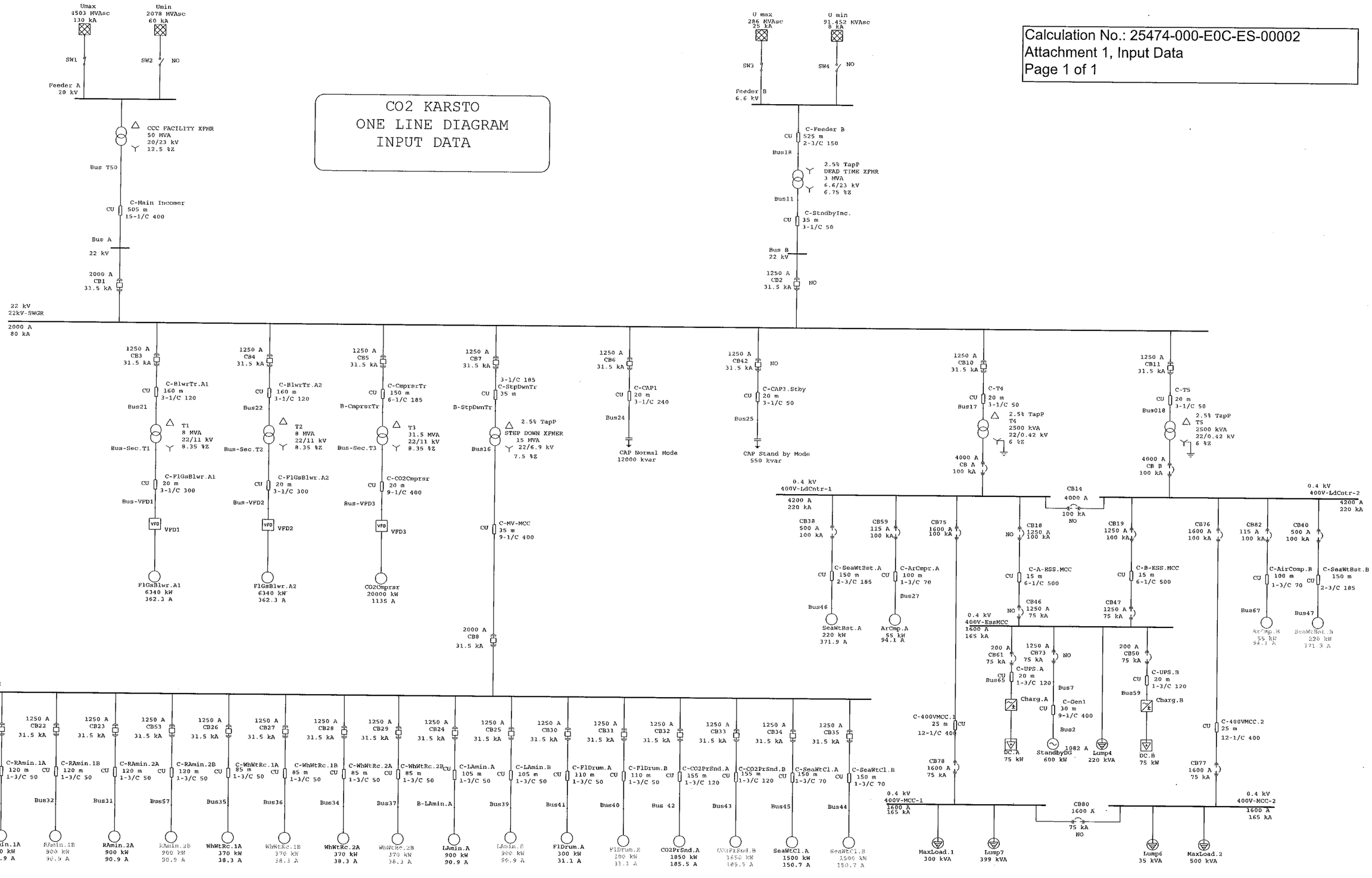
- Attachment 1, Input Data, SLD, 1 page.

### 6.2 SHORT-CIRCUIT CALCULATIONS REPORTS AND SINGLE LINE DIAGRAMS

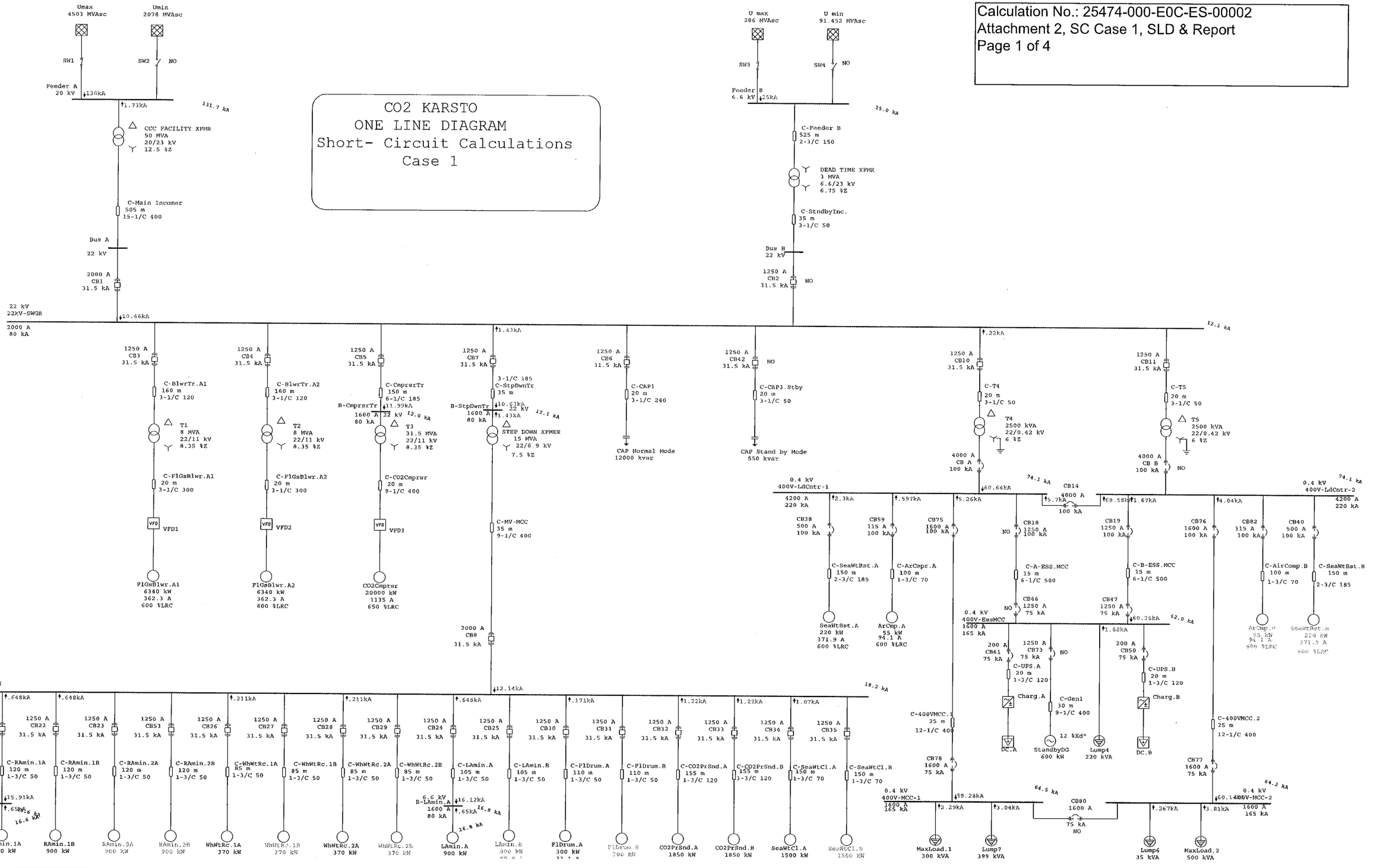
- Attachment 2, SC Case 1, Results on SLD, 1 page; Summary Report for 3-Phase Fault currents and Equipment evaluations, 3 pages.
- Attachment 3, SC Case 1, L-L-E – Results on SLD, 1 page; Summary Report for 3-Phase, Line-Ground, Line-Line, Line-Line-Ground Fault currents, 2 pages
- Attachment 4, SC Case 2, 3-phase results on SLD, 1 page; Summary Report for 3-Phase, Line-Ground, Line-Line, Line-Line-Ground Fault currents, 2 pages.
- Attachment 5, SC Case 2, L-L-E results on SLD, 1 page;

# ATTACHMENTS

# CO2 KARSTO
# ONE LINE DIAGRAM
# INPUT DATA



# CO2 KARSTO
# ONE LINE DIAGRAM
# Short- Circuit Calculations
# Case 1



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|---|---|---|---|
| Project: | CO2 Karsto | **ETAP** | Page: 1 |
| Location: | Karsto, South-West of Norway | 6.0.0C | Date: 19-11-2008 |
| Contract: | Bechtel 25474 | | SN: BANTRELENG |
| Engineer: | Victor Skavitine | Study Case: SC Case1RevA | Revision: Base |
| Filename: | KARSTO | | Config.: UmaxLmaxC1.1 |

Preliminary Design

## Short-Circuit Summary Report

3-Phase Fault Currents

| Bus | | Device | | Device Capacity (kA) | | | | Short-Circuit Current (kA) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ID | kV | ID | Type | Making Peak | Ib sym | Ib asym | Idc | I"k | ip | Ib sym | Ib asym | Idc | Ik |
| 6.6kV-SWGR | 6.600 | 6.6kV-SWGR | SwtchGear | 80.000 | | | | 18.160 | 45.909 | | | | 12.058 |
| | 6.600 | CB8 | CB | 80.000 | 31.500 | 34.482 | 14.027 | 18.160 | 45.909 | 15.775 | 18.148 | 8.973 | |
| | 6.600 | CB21 | CB | 80.000 | 31.500 | 34.482 | 14.027 | 18.160 | 45.909 | 15.775 | 18.148 | 8.973 | |
| | 6.600 | CB22 | CB | 80.000 | 31.500 | 34.482 | 14.027 | 18.160 | 45.909 | 15.775 | 18.148 | 8.973 | |
| | 6.600 | CB23 | CB | 80.000 | 31.500 | 34.482 | 14.027 | 18.160 | 45.909 | 15.775 | 18.148 | 8.973 | |
| | 6.600 | CB24 | CB | 80.000 | 31.500 | 34.482 | 14.027 | 18.160 | 45.909 | 15.775 | 18.148 | 8.973 | |
| | 6.600 | CB25 | CB | 80.000 | 31.500 | 34.482 | 14.027 | 18.160 | 45.909 | 15.775 | 18.148 | 8.973 | |
| | 6.600 | CB26 | CB | 80.000 | 31.500 | 34.482 | 14.027 | 18.160 | 45.909 | 15.775 | 18.148 | 8.973 | |
| | 6.600 | CB27 | CB | 80.000 | 31.500 | 34.482 | 14.027 | 18.160 | 45.909 | 15.775 | 18.148 | 8.973 | |
| | 6.600 | CB28 | CB | 80.000 | 31.500 | 34.482 | 14.027 | 18.160 | 45.909 | 15.775 | 18.148 | 8.973 | |
| | 6.600 | CB29 | CB | 80.000 | 31.500 | 34.482 | 14.027 | 18.160 | 45.909 | 15.775 | 18.148 | 8.973 | |
| | 6.600 | CB30 | CB | 80.000 | 31.500 | 34.482 | 14.027 | 18.160 | 45.909 | 15.775 | 18.148 | 8.973 | |
| | 6.600 | CB31 | CB | 80.000 | 31.500 | 34.482 | 14.027 | 18.160 | 45.909 | 15.775 | 18.148 | 8.973 | |
| | 6.600 | CB32 | CB | 80.000 | 31.500 | 34.482 | 14.027 | 18.160 | 45.909 | 15.775 | 18.148 | 8.973 | |
| | 6.600 | CB33 | CB | 80.000 | 31.500 | 34.482 | 14.027 | 18.160 | 45.909 | 15.775 | 18.148 | 8.973 | |
| | 6.600 | CB34 | CB | 80.000 | 31.500 | 34.482 | 14.027 | 18.160 | 45.909 | 15.775 | 18.148 | 8.973 | |
| | 6.600 | CB35 | CB | 80.000 | 31.500 | 34.482 | 14.027 | 18.160 | 45.909 | 15.775 | 18.148 | 8.973 | |
| | 6.600 | CB53 | CB | 80.000 | 31.500 | 34.482 | 14.027 | 18.160 | 45.909 | 15.775 | 18.148 | 8.973 | |
| 22kV-SWGR | 22.000 | 22kV-SWGR | SwtchGear | 80.000 | | | | 12.092 | 31.920 | | | | 10.459 |
| | 22.000 | CB1 | CB | 80.000 | 31.500 | 33.206 | 10.508 | 12.092 | 31.920 | 11.553 | 13.782 | 7.515 | |
| | 22.000 | CB3 | CB | 80.000 | 31.500 | 33.206 | 10.508 | 12.092 | 31.920 | 11.553 | 13.782 | 7.515 | |
| | 22.000 | CB4 | CB | 80.000 | 31.500 | 33.206 | 10.508 | 12.092 | 31.920 | 11.553 | 13.782 | 7.515 | |
| | 22.000 | CB5 | CB | 80.000 | 31.500 | 33.206 | 10.508 | 12.092 | 31.920 | 11.553 | 13.782 | 7.515 | |
| | 22.000 | CB6 | CB | 80.000 | 31.500 | 33.206 | 10.508 | 12.092 | 31.920 | 11.553 | 13.782 | 7.515 | |
| | 22.000 | CB7 | CB | 80.000 | 31.500 | 33.206 | 10.508 | 12.092 | 31.920 | 11.553 | 13.782 | 7.515 | |
| | 22.000 | CB10 | CB | 80.000 | 31.500 | 33.206 | 10.508 | 12.092 | 31.920 | 11.553 | 13.782 | 7.515 | |
| | 22.000 | CB11 | CB | 80.000 | 31.500 | 33.206 | 10.508 | 12.092 | 31.920 | 11.553 | 13.782 | 7.515 | |
| 400V-EssMCC | 0.400 | 400V-EssMCC | MCC | 165.000 | | | | 62.004 | 135.226 | | | | 51.404 |
| | 0.400 | CB47 | CB | 165.000 | 75.000 | 76.583 | | 62.004 | 135.226 | 59.671 | 61.343 | 14.221 | |
| | 0.400 | CB50 | CB | 165.000 | 75.000 | 76.583 | | 62.004 | 135.226 | 59.671 | 61.343 | 14.221 | |
| | 0.400 | CB61 | CB | 165.000 | 75.000 | 76.583 | | 62.004 | 135.226 | 59.671 | 61.343 | 14.221 | |
| 400V-LdCntr-1 | 0.400 | 400V-LdCntr-1 | SwtchGear | 220.000 | | | | 74.136 | 169.882 | | | | 59.855 |
| | 0.400 | CB A | CB | 220.000 | 100.000 | 100.000 | | 74.136 | 169.882 | 67.167 | 67.180 | 1.340 | |
| | 0.400 | CB14 | CB | 220.000 | 100.000 | 100.000 | | 74.136 | 169.882 | 67.167 | 67.180 | 1.340 | |
| | 0.400 | CB38 | CB | 220.000 | 100.000 | 100.000 | | 74.136 | 169.882 | 67.167 | 67.180 | 1.340 | |

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|---|---|---|---|
| Project: | CO2 Karsto | **ETAP** | Page: 2 |
| Location: | Karsto, South-West of Norway | 6.0.0C | Date: 19-11-2008 |
| Contract: | Bechtel 25474 | | SN: BANTRELENG |
| Engineer: | Victor Skavitine | Study Case: SC Case1RevA | Revision: Base |
| Filename: | KARSTO | | Config.: UmaxLmaxC1.1 |

Preliminary Design

3-Phase Fault Currents

| Bus | | Device | | Device Capacity (kA) | | | | Short-Circuit Current (kA) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ID | kV | ID | Type | Making Peak | Ib sym | Ib asym | Idc | I"k | ip | Ib sym | Ib asym | Idc | Ik |
| 400V-LdCntr-1 | 0.400 | CB75 | CB | 220.000 | 100.000 | 100.000 | | 74.136 | 169.882 | 67.167 | 67.180 | 1.340 | |
| | 0.400 | CB59 | CB | 220.000 | 100.000 | 100.000 | | 74.136 | 169.882 | 67.167 | 67.180 | 1.340 | |
| 400V-LdCntr-2 | 0.400 | 400V-LdCntr-2 | SwtchGear | 220.000 | | | | 74.136 | 169.882 | | | | 59.855 |
| | 0.400 | CB14 | CB | 220.000 | 100.000 | 100.000 | | 74.136 | 169.882 | 67.167 | 67.180 | 1.340 | |
| | 0.400 | CB19 | CB | 220.000 | 100.000 | 100.000 | | 74.136 | 169.882 | 67.167 | 67.180 | 1.340 | |
| | 0.400 | CB40 | CB | 220.000 | 100.000 | 100.000 | | 74.136 | 169.882 | 67.167 | 67.180 | 1.340 | |
| | 0.400 | CB76 | CB | 220.000 | 100.000 | 100.000 | | 74.136 | 169.882 | 67.167 | 67.180 | 1.340 | |
| | 0.400 | CB82 | CB | 220.000 | 100.000 | 100.000 | | 74.136 | 169.882 | 67.167 | 67.180 | 1.340 | |
| 400V-MCC-1 | 0.400 | 400V-MCC-1 | MCC | 165.000 | | | | 64.520 | 139.654 | | | | 52.463 |
| | 0.400 | CB78 | CB | 165.000 | 75.000 | 75.000 | | 64.520 | 139.654 | 58.721 | 58.721 | 0.199 | |
| 400V-MCC-2 | 0.400 | 400V-MCC-2 | MCC | 165.000 | | | | 64.151 | 138.816 | | | | 52.463 |
| | 0.400 | CB77 | CB | 165.000 | 75.000 | 75.000 | | 64.151 | 138.816 | 58.618 | 58.619 | 0.198 | |
| B-CmprsrTr | 22.000 | B-CmprsrTr | Cable Bus | 80.000 | | | | 11.987 | 31.386 | | | | 10.381 |
| B-LAmin.A | 6.600 | B-LAmin.A | MCC | 80.000 | | | | 16.763 | 35.851 | | | | 11.443 |
| B-RAmin.1A | 6.600 | B-RAmin.1A | MCC | 80.000 | | | | 16.554 | 34.750 | | | | 11.350 |
| B-StpDwnTr | 22.000 | B-StpDwnTr | Cable Bus | 80.000 | | | | 12.055 | 31.725 | | | | 10.423 |
| Feeder A | 20.000 | Feeder A | Bus | | | | | 131.717 | 366.109 | | | | 130.000 |
| Feeder B | 6.600 | Feeder B | Bus | | | | | 25.000 | 68.693 | | | | 25.000 |

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

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

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

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

| | | | | | |
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| Project: | CO2 Karsto | ETAP | | Page: | 3 |
| Location: | Karsto, South-West of Norway | 6.0.0C | | Date: | 19-11-2008 |
| Contract: | Bechtel 25474 | | | SN: | BANTRELENG |
| Engineer: | Victor Skavitine | Study Case: | SC Case1RevA | Revision: | Base |
| Filename: | KARSTO | | | Config.: | UmaxLmaxC1.1 |

Preliminary Design

## Short-Circuit Summary Report

| Bus ID | Device ID | Device Capacity Ithr (kA) | Device Capacity Tkr (sec.) | 3-Phase Short-Circuit Current Ith (kA) |
|---|---|---|---|---|
| 400V-EssMCC | CB47 | 75.000 | 1.00 | 58.123 |
| 400V-EssMCC | CB50 | 75.000 | 1.00 | 58.123 |
| 400V-EssMCC | CB61 | 75.000 | 1.00 | 58.123 |
| 400V-LdCntr-1 | CB A | 75.000 | 1.00 | 69.184 |
| 400V-LdCntr-1 | CB14 | 75.000 | 1.00 | 69.184 |
| 400V-LdCntr-1 | CB38 | 75.000 | 1.00 | 69.184 |
| 400V-LdCntr-1 | CB75 | 75.000 | 1.00 | 69.184 |
| 400V-LdCntr-1 | CB59 | 75.000 | 1.00 | 69.184 |
| 400V-LdCntr-2 | CB14 | 75.000 | 1.00 | 69.184 |
| 400V-LdCntr-2 | CB19 | 75.000 | 1.00 | 69.184 |
| 400V-LdCntr-2 | CB40 | 75.000 | 1.00 | 69.184 |
| 400V-LdCntr-2 | CB76 | 75.000 | 1.00 | 69.184 |
| 400V-LdCntr-2 | CB82 | 75.000 | 1.00 | 69.184 |
| 400V-MCC-1 | CB78 | 75.000 | 1.00 | 60.147 |
| 400V-MCC-2 | CB77 | 75.000 | 1.00 | 59.896 |

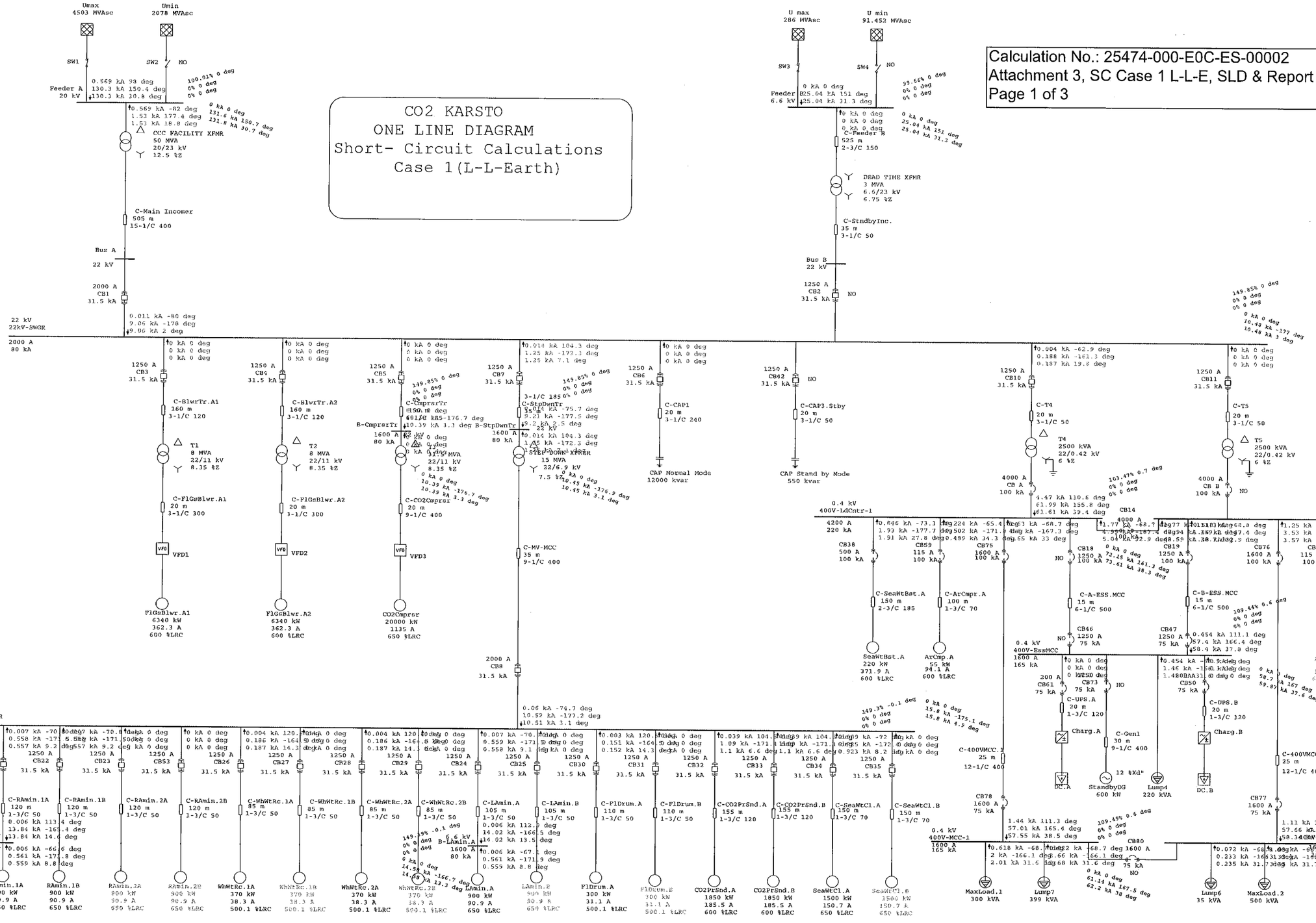
Ithr = Rated short-circuit withstand current
Tkr = Rated short-time
Ith = Thermal equivalent short-time current

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

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

Calculation No.: 25474-000-E0C-ES-00002
Attachment 3, SC Case 1 L-L-E, SLD & Report
Page 1 of 3

# CO2 KARSTO
# ONE LINE DIAGRAM
# Short- Circuit Calculations
# Case 1(L-L-Earth)



| | | | |
|---|---|---|---|
| Project: | CO2 Karsto | ETAP | Page: 1 |
| Location: | Karsto, South-West of Norway | 6.0.0C | Date: 19-11-2008 |
| Contract: | Bechtel 25474 | | SN: BANTRELENG |
| Engineer: | Victor Skavitine | Study Case: SC Case1RevA | Revision: Base |
| Filename: | KARSTO | | Config.: UmaxLmaxC1.1 |

Preliminary Design

## Short-Circuit Summary Report

3-Phase, LG, LL, LLG Fault Currents

| Bus | | 3-Phase Fault | | | Line-to-Ground Fault | | | | Line-to-Line Fault | | | | *Line-to-Line-to-Ground | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ID | kV | I"k | ip | Ik | I"k | ip | Ib | Ik | I"k | ip | Ib | Ik | I"k | ip | Ib | Ik |
| 6.6kV-SWGR | 6.600 | 18.160 | 45.909 | 12.058 | 0.000 | 0.000 | 0.000 | 0.000 | 15.801 | 39.945 | 15.801 | 15.801 | 15.801 | 39.945 | 15.801 | 15.801 |
| 22kV-SWGR | 22.000 | 12.092 | 31.920 | 10.459 | 0.000 | 0.000 | 0.000 | 0.000 | 10.483 | 27.672 | 10.483 | 10.483 | 10.483 | 27.672 | 10.483 | 10.483 |
| 400V-EssMCC | 0.400 | 62.004 | 135.226 | 51.404 | 55.631 | 121.328 | 55.631 | 55.631 | 53.559 | 116.809 | 53.559 | 53.559 | 59.865 | 130.563 | 59.865 | 59.865 |
| 400V-LdCntr-1 | 0.400 | 74.136 | 169.882 | 59.855 | 71.526 | 163.901 | 71.526 | 71.526 | 64.001 | 146.658 | 64.001 | 64.001 | 73.607 | 168.669 | 73.607 | 73.607 |
| 400V-LdCntr-2 | 0.400 | 74.136 | 169.882 | 59.855 | 71.526 | 163.901 | 71.526 | 71.526 | 64.001 | 146.658 | 64.001 | 64.001 | 73.607 | 168.669 | 73.607 | 73.607 |
| 400V-MCC-1 | 0.400 | 64.520 | 139.654 | 52.463 | 57.846 | 125.208 | 57.846 | 57.846 | 55.729 | 120.628 | 55.729 | 55.729 | 62.205 | 134.644 | 62.205 | 62.205 |
| 400V-MCC-2 | 0.400 | 64.151 | 138.816 | 52.463 | 57.648 | 124.742 | 57.648 | 57.648 | 55.411 | 119.904 | 55.411 | 55.411 | 61.907 | 133.959 | 61.907 | 61.907 |
| B-CmprsrTr | 22.000 | 11.987 | 31.386 | 10.381 | 0.000 | 0.000 | 0.000 | 0.000 | 10.392 | 27.209 | 10.392 | 10.392 | 10.392 | 27.209 | 10.392 | 10.392 |
| B-LAmin.A | 6.600 | 16.763 | 35.851 | 11.443 | 0.000 | 0.000 | 0.000 | 0.000 | 14.576 | 31.174 | 14.576 | 14.576 | 14.576 | 31.174 | 14.576 | 14.576 |
| B-RAmin.1A | 6.600 | 16.554 | 34.750 | 11.350 | 0.000 | 0.000 | 0.000 | 0.000 | 14.393 | 30.213 | 14.393 | 14.393 | 14.393 | 30.213 | 14.393 | 14.393 |
| B-StpDwnTr | 22.000 | 12.055 | 31.725 | 10.423 | 0.000 | 0.000 | 0.000 | 0.000 | 10.451 | 27.503 | 10.451 | 10.451 | 10.451 | 27.503 | 10.451 | 10.451 |
| Feeder A | 20.000 | 131.717 | 366.109 | 130.000 | 131.706 | 366.079 | 131.706 | 131.706 | 114.080 | 317.087 | 114.080 | 114.080 | 131.778 | 366.278 | 131.778 | 131.778 |
| Feeder B | 6.600 | 25.000 | 68.693 | 25.000 | 25.085 | 68.927 | 25.085 | 25.085 | 21.651 | 59.490 | 21.651 | 21.651 | 25.043 | 68.811 | 25.043 | 25.043 |

All fault currents are in rms kA. Current ip is calculated using Method C.

* LLG fault current is the larger of the two faulted line currents.

| | | | |
|---|---|---|---|
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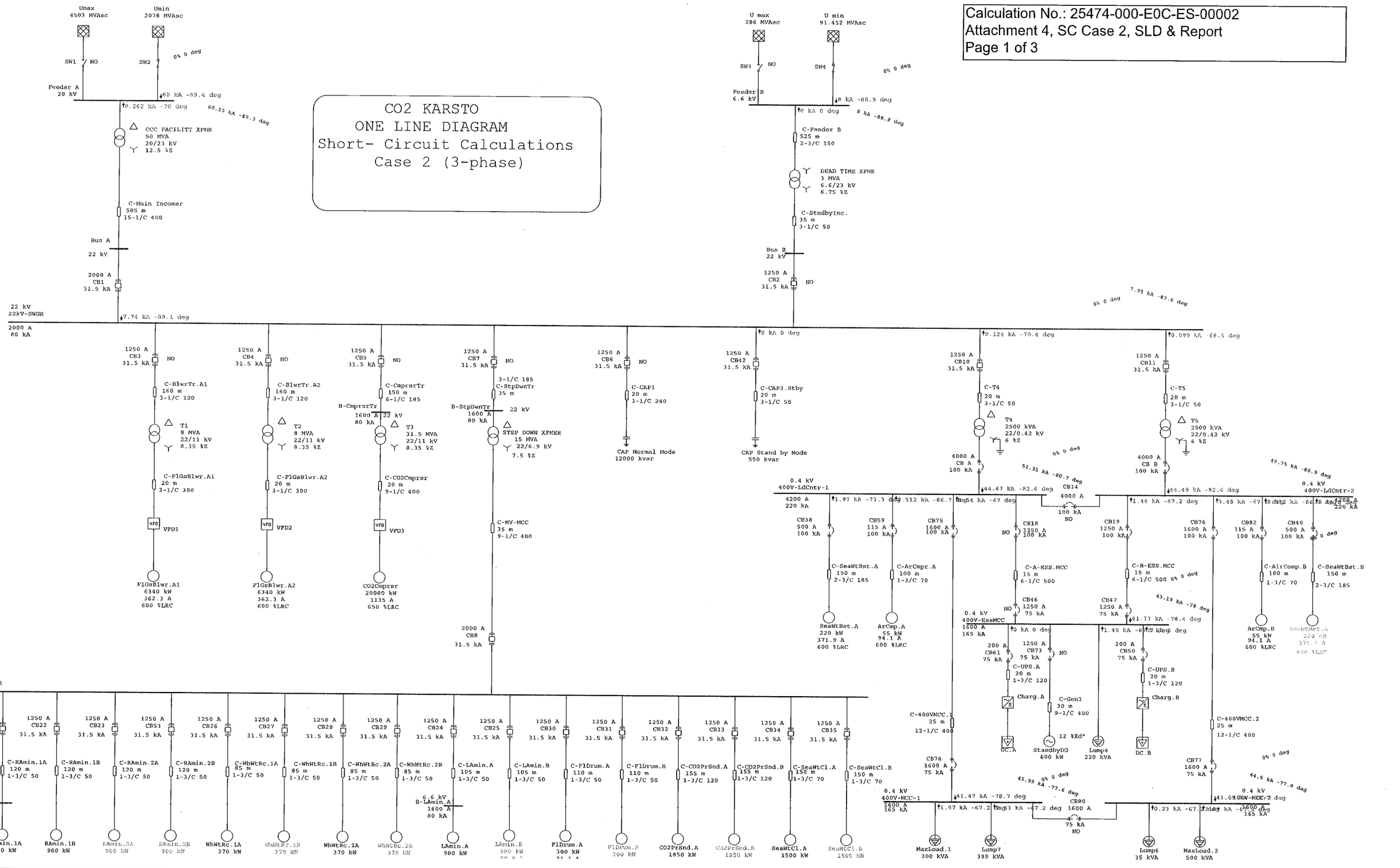
| Contract: | Bechtel 25474 | | SN: BANTRELENG |
| Engineer: | Victor Skavitine | Study Case: SC Case1RevA | Revision: Base |
| Filename: | KARSTO | | Config.: UmaxLmaxC1.1 |

Preliminary Design

## Sequence Impedance Summary Report

| Bus | | Positive Seq. Imp. (ohm) | | | Negative Seq. Imp. (ohm) | | | Zero Seq. Imp. (ohm) | | | Fault Zf (ohm) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ID | kV | Resistance | Reactance | Impedance | Resistance | Reactance | Impedance | Resistance | Reactance | Impedance | Resistance | Reactance | Impedance |
| 6.6kV-SWGR | 6.600 | 0.01950 | 0.22998 | 0.23081 | 0.01977 | 0.22780 | 0.22865 | | | | 0.00000 | 0.00000 | 0.00000 |
| 22kV-SWGR | 22.000 | 0.05950 | 1.15389 | 1.15542 | 0.05971 | 1.15151 | 1.15306 | | | | 0.00000 | 0.00000 | 0.00000 |
| 400V-EssMCC | 0.400 | 0.00090 | 0.00400 | 0.00410 | 0.00089 | 0.00402 | 0.00412 | 0.00100 | 0.00539 | 0.00549 | 0.00000 | 0.00000 | 0.00000 |
| 400V-LdCntr-1 | 0.400 | 0.00060 | 0.00337 | 0.00343 | 0.00060 | 0.00340 | 0.00345 | 0.00053 | 0.00374 | 0.00378 | 0.00000 | 0.00000 | 0.00000 |
| 400V-LdCntr-2 | 0.400 | 0.00060 | 0.00337 | 0.00343 | 0.00060 | 0.00340 | 0.00345 | 0.00053 | 0.00374 | 0.00378 | 0.00000 | 0.00000 | 0.00000 |
| 400V-MCC-1 | 0.400 | 0.00089 | 0.00384 | 0.00394 | 0.00088 | 0.00386 | 0.00396 | 0.00102 | 0.00518 | 0.00528 | 0.00000 | 0.00000 | 0.00000 |
| 400V-MCC-2 | 0.400 | 0.00089 | 0.00386 | 0.00396 | 0.00089 | 0.00388 | 0.00398 | 0.00102 | 0.00518 | 0.00528 | 0.00000 | 0.00000 | 0.00000 |
| B-CmprsrTr | 22.000 | 0.06703 | 1.16364 | 1.16557 | 0.06724 | 1.16126 | 1.16321 | | | | 0.00000 | 0.00000 | 0.00000 |
| B-LAmin.A | 6.600 | 0.05715 | 0.24343 | 0.25004 | 0.05747 | 0.24127 | 0.24802 | | | | 0.00000 | 0.00000 | 0.00000 |
| B-RAmin.1A | 6.600 | 0.06249 | 0.24538 | 0.25321 | 0.06283 | 0.24322 | 0.25121 | | | | 0.00000 | 0.00000 | 0.00000 |
| B-StpDwnTr | 22.000 | 0.06227 | 1.15730 | 1.15898 | 0.06246 | 1.15490 | 1.15659 | | | | 0.00000 | 0.00000 | 0.00000 |
| Feeder A | 20.000 | 0.00118 | 0.09642 | 0.09643 | 0.00118 | 0.09641 | 0.09642 | 0.00102 | 0.09647 | 0.09647 | 0.00000 | 0.00000 | 0.00000 |
| Feeder B | 6.600 | 0.00335 | 0.16763 | 0.16766 | 0.00335 | 0.16763 | 0.16766 | 0.00332 | 0.16592 | 0.16595 | 0.00000 | 0.00000 | 0.00000 |

# CO2 KARSTO
# ONE LINE DIAGRAM
# Short- Circuit Calculations
# Case 2 (3-phase)



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|---|---|---|---|---|---|
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| Location: | Karsto, South-West of Norway | 6.0.0C | | Date: | 19-11-2008 |
| Contract: | Bechtel 25474 | | | SN: | BANTRELENG |
| Engineer: | Victor Skavitine | | Study Case: SC Case2RevA | Revision: | Base |
| Filename: | KARSTO | | | Config.: | UminLminC.95 |

Preliminary Design

## Short-Circuit Summary Report

3-Phase, LG, LL, LLG Fault Currents

| Bus | | 3-Phase Fault | | | Line-to-Ground Fault | | | | Line-to-Line Fault | | | | *Line-to-Line-to-Ground | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ID | kV | I"k | ip | Ik | I"k | ip | Ib | Ik | I"k | ip | Ib | Ik | I"k | ip | Ib | Ik |
| 22kV-SWGR | 22.000 | 7.954 | 21.270 | 7.742 | 0.000 | 0.000 | 0.000 | 0.000 | 6.885 | 18.412 | 6.885 | 6.885 | 6.885 | 18.412 | 6.885 | 6.885 |
| 400V-EssMCC | 0.400 | 43.187 | 95.011 | 38.837 | 40.467 | 89.027 | 40.467 | 40.467 | 37.373 | 82.220 | 37.373 | 37.373 | 42.091 | 92.600 | 42.091 | 42.091 |
| 400V-LdCntr-1 | 0.400 | 51.310 | 119.134 | 44.412 | 50.796 | 117.940 | 50.796 | 50.796 | 44.260 | 102.763 | 44.260 | 44.260 | 51.320 | 119.157 | 51.320 | 51.320 |
| 400V-LdCntr-2 | 0.400 | 49.746 | 115.927 | 44.412 | 49.861 | 116.196 | 49.861 | 49.861 | 43.042 | 100.305 | 43.042 | 43.042 | 50.051 | 116.638 | 50.051 | 50.051 |
| 400V-MCC-1 | 0.400 | 45.991 | 100.184 | 39.529 | 42.555 | 92.699 | 42.555 | 42.555 | 39.696 | 86.470 | 39.696 | 39.696 | 44.520 | 96.978 | 44.520 | 44.520 |
| 400V-MCC-2 | 0.400 | 44.502 | 97.321 | 39.529 | 41.760 | 91.324 | 41.760 | 41.760 | 38.511 | 84.219 | 38.511 | 38.511 | 43.319 | 94.733 | 43.319 | 43.319 |
| Feeder A | 20.000 | 60.247 | 167.593 | 60.000 | 73.578 | 204.676 | 73.578 | 73.578 | 52.172 | 145.129 | 52.172 | 52.172 | 70.412 | 195.870 | 70.412 | 70.412 |
| Feeder B | 6.600 | 8.000 | 21.982 | 8.000 | 10.351 | 28.441 | 10.351 | 10.351 | 6.928 | 19.037 | 6.928 | 6.928 | 10.086 | 27.712 | 10.086 | 10.086 |

All fault currents are in rms kA. Current ip is calculated using Method C.

* LLG fault current is the larger of the two faulted line currents.

| | | | |
|---|---|---|---|
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| Location: | Karsto, South-West of Norway | 6.0.0C | Date: 19-11-2008 |
| Contract: | Bechtel 25474 | | SN: BANTRELENG |
| Engineer: | Victor Skavitine | Study Case: SC Case2RevA | Revision: Base |
| Filename: | KARSTO | | Config.: UminLminC.95 |

Preliminary Design

## Sequence Impedance Summary Report

| Bus | | Positive Seq. Imp. (ohm) | | | Negative Seq. Imp. (ohm) | | | Zero Seq. Imp. (ohm) | | | Fault Zf (ohm) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ID | kV | Resistance | Reactance | Impedance | Resistance | Reactance | Impedance | Resistance | Reactance | Impedance | Resistance | Reactance | Impedance |
| 22kV-SWGR | 22.000 | 0.06823 | 1.59545 | 1.59691 | 0.06744 | 1.59699 | 1.59841 | | | | 0.00000 | 0.00000 | 0.00000 |
| 400V-EssMCC | 0.400 | 0.00105 | 0.00497 | 0.00508 | 0.00105 | 0.00498 | 0.00509 | 0.00119 | 0.00598 | 0.00610 | 0.00000 | 0.00000 | 0.00000 |
| 400V-LdCntr-1 | 0.400 | 0.00069 | 0.00422 | 0.00428 | 0.00068 | 0.00426 | 0.00431 | 0.00061 | 0.00433 | 0.00437 | 0.00000 | 0.00000 | 0.00000 |
| 400V-LdCntr-2 | 0.400 | 0.00070 | 0.00436 | 0.00441 | 0.00069 | 0.00436 | 0.00442 | 0.00061 | 0.00433 | 0.00437 | 0.00000 | 0.00000 | 0.00000 |
| 400V-MCC-1 | 0.400 | 0.00103 | 0.00466 | 0.00477 | 0.00102 | 0.00469 | 0.00480 | 0.00122 | 0.00577 | 0.00589 | 0.00000 | 0.00000 | 0.00000 |
| 400V-MCC-2 | 0.400 | 0.00104 | 0.00482 | 0.00493 | 0.00104 | 0.00483 | 0.00494 | 0.00122 | 0.00577 | 0.00589 | 0.00000 | 0.00000 | 0.00000 |
| Feeder A | 20.000 | 0.00229 | 0.19165 | 0.19166 | 0.00228 | 0.19167 | 0.19169 | 0.00092 | 0.08745 | 0.08746 | 0.00000 | 0.00000 | 0.00000 |
| Feeder B | 6.600 | 0.00952 | 0.47622 | 0.47631 | 0.00952 | 0.47622 | 0.47631 | 0.00303 | 0.15174 | 0.15177 | 0.00000 | 0.00000 | 0.00000 |

Calculation No.: 25474-000-E0C-ES-00002
Attachment 5, SC Case 2 L-L-E, SLD
Page 1 of 1

# CO2 KARSTO
# ONE LINE DIAGRAM
# Short- Circuit Calculations
# Case 2(L-L-Earth)