

OWNER

Cable Sizing, Short Circuit and Arc-Flash Assessment

Calculation



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TORUS

[REDACTED], [REDACTED] County, [REDACTED]

ISSUE SUMMARY AND APPROVAL

This page records each issue of ELE-CAL-004. The preparer, reviewer and approver sign for each revision.

Rev.	Date	Issue purpose	Description
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Contributors

Rev.	Discipline	Prepared by	Reviewed by	Approved by
A	Electrical			

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1. OBJECTIVE

This calculation sizes every power feeder and branch circuit in the for ampacity, overcurrent protection and voltage drop. It calculates the available fault current at each bus, selects the protective devices and their interrupting ratings, and assigns arc-flash personal protective equipment and label data to each piece of equipment that may be worked on while energized.

2. METHODOLOGY

Circuit currents follow NFPA 70: motor conductors at 125 % of the full-load current in Table 430.250 or 430.248, with an inverse-time breaker of not more than 250 % (430.52, 15 A minimum); continuous non-motor loads at 125 %; air conditioners at the nameplate minimum circuit ampacity and maximum overcurrent device. Each conductor is the smallest copper size whose 75 °C ampacity carries the design current, is protected by its breaker (240.4), and holds voltage drop to 3 % on the branch and 5 % from the service to the load, as the informational notes to 210.19 and 215.2 recommend. Cable lengths come from the routing on ELE-DWG-003 plus risers, terminations and 5 % slack. Where cables share an underground conduit, they were only combined where the 310.15(C)(1) adjustment factor still leaves each conductor above its design current and protected by its breaker.

Fault currents were calculated by the ohmic method on a 480 V base, with the utility source, transformer XF-101 and each conductor as series impedances, and checked independently by the MVA method. The 208 V bus is reflected through XF-102, and the generator-only case uses the subtransient reactance of G-101.

Arc-flash hazard is assessed by the PPE category method of NFPA 70E Table 130.7(C)(15)(a). That table applies only where the available fault current and the clearing time of the upstream device are within its limits, so TORUS verified both at every bus. The clearing time was checked for the lowest credible arcing current, taken as 50 % of the bolted fault current, against the instantaneous pickup of the upstream breaker with its +20 % tolerance. TORUS chose this method over an incident-energy calculation at this stage because the utility has not yet confirmed its fault level or fuse (HOLD H-10); an incident-energy calculation built on assumed utility data would give labels with false precision. An incident-energy study to IEEE 1584-2018 shall be performed once the utility data is confirmed, before the equipment is energized.

3. DESIGN INPUTS

Table 3-1 lists the inputs.

Table 3-1: Design Inputs

Input	Value	Source
Utility primary	12.47 kV; available three-phase fault 10 kA, X/R 8	Assumed, HOLD H-10
Transformer XF-101	75 kVA, 12.47 kV delta to 480Y/277 V, 1.5 % impedance, X/R 1.8	Assumed low impedance, HOLD H-10
Transformer XF-102	15 kVA, 480 V delta to 208Y/120 V, 3.5 % impedance	Typical, HOLD H-15
Generator G-101	75 kVA, subtransient reactance 0.15 per unit	ELE-CAL-002, HOLD H-15
Battery BT-101	12 cells, 0.40 milliohm internal resistance per cell	Typical, HOLD H-15
Conductors	Copper, XHHW-2, ampacity at 75 °C terminations	NFPA 70 110.14(C)
Conductor impedance	NFPA 70 Chapter 9 Table 9 (AC) and Table 8 (DC)	NFPA 70
Voltage drop limits	3 % branch, 5 % total	NFPA 70 210.19, 215.2 notes
Loads	Load register	ELE-CAL-001

4. ASSUMPTIONS

1. The utility primary fault level and the XF-101 impedance are assumed. The 1.5 % impedance is at the low end of the pad-mount range, which gives the highest secondary fault current and so is conservative for interrupting ratings. *Verification required (HOLD H-10).*
2. The lowest credible arcing current is 50 % of the bolted fault current at 480 V and 208 V.
3. Molded-case breakers clear in 1.5 cycles (0.025 s) when the current exceeds 120 % of the instantaneous pickup.
4. Cable lengths follow the routing on ELE-DWG-003; final lengths will change with final equipment locations.
5. Actuator, HVAC and heater nameplates are typical values. *Verification required (HOLD H-15).*

5. REFERENCES

1. NFPA 70, National Electrical Code, 2023 Edition: 110.9, 110.10, 110.16, 110.24, 210.19, 215.2, 240.4, 240.21, 250.122, 310.15, 310.16, Chapter 9, 430.22, 430.52, 440, 445, 450.3, 501.
2. NFPA 70E, Standard for Electrical Safety in the Workplace, 2024 Edition: 130.4, 130.5, Table 130.7(C)(15)(a).
3. IEEE 1584-2018, Guide for Performing Arc-Flash Hazard Calculations.
4. IEEE 3002.3-2018, Recommended Practice for Conducting Short-Circuit Studies; IEEE 242-2001, Protection and Coordination (Buff Book).

5. ELE-CAL-001, Electrical Load Analysis; ELE-CAL-002, Standby Generator and Transfer Switch; ELE-CAL-003, UPS and Battery Sizing.
6. ELE-LST-001, Cable Schedule; ELE-LST-002, Panel Schedules; ELE-DWG-001, One-Line Diagram (Appendix B); ELE-DWG-003, Cable Routing Plan.

6. CALCULATION

6.1. FEEDERS

Table 6-1 lists the feeders. Their voltage drop was calculated at the coincident peak current from ELE-CAL-001 (57 A at the service and 22 A on LP-101), not at the breaker rating, because that is the current they carry at peak.

Table 6-1: Feeders

Cable	From	To	Breaker, A	Conductors	Length, ft	Voltage drop, %
P-001	XF-101 (utility secondary)	MCB-101	125	4-1/C #1/0 XHHW-2 + 1-1/C #6 G	55	0.12
P-002	MCB-101	ATS-101 (normal)	125	4-1/C #1/0 XHHW-2 + 1-1/C #6 G	45	0.10
P-003	G-101 (generator breaker)	ATS-101 (emergency)	110	4-1/C #1/0 XHHW-2 + 1-1/C #6 G	50	0.11
P-004	ATS-101	DP-101	125	4-1/C #1/0 XHHW-2 + 1-1/C #6 G	20	0.04
P-005	DP-101	XF-102 primary	25	3-1/C #10 XHHW-2 + 1-1/C #10 G	25	0.11
P-006	XF-102 secondary	LP-101 main	60	4-1/C #6 XHHW-2 + 1-1/C #10 G	20	0.19
P-007	UPS-101 output	UP-101 main	20	2-1/C #10 XHHW-2 + 1-1/C #12 G	25	0.72
D-001	BC-101A	DCP-101 (charger A breaker)	70	2-1/C #1/0 XHHW-2 + 1-1/C #8 G	25	1.59
D-002	BC-101B	DCP-101 (charger B breaker)	70	2-1/C #1 XHHW-2 + 1-1/C #8 G	20	1.60
D-003	BT-101	DCP-101 (battery disconnect)	100	2-1/C #1/0 XHHW-2 + 1-1/C #8 G	30	0.80

Note 1: Service, generator and transfer switch feeders are sized for the 125 A service and 110 A generator breaker, not for the peak demand.

Note 2: DC feeders D-001 to D-003 are held to 2 % because the chargers regulate at their own terminals.

6.2. BRANCH CIRCUITS AND VOLTAGE DROP

The branch circuit with the largest total voltage drop on AC is P-204, which feeds AC-101 (B-101 wall-mount AC 1.5 ton). Its design current and routed length are 13.4 A and 235 ft. On #10 AWG copper, with $R = 1.2 \Omega$ and $X = 0.05 \Omega$ per 1,000 ft:

NFPA 70 Chapter 9, Table 9, effective impedance

$$\Delta V = \frac{2 I L (R \cos \phi + X \sin \phi)}{1000 V} \times 100 = \frac{2(10.68)(235)(1.2(0.90) + 0.05(0.44))}{1000(208)} \times 100 = 2.66 \%$$

Adding the 0.56 % drop in the feeders to LP-101 gives 3.22 %, within the 5 % limit. The largest total on any circuit is 3.69 %, on 24 VDC circuit D-106 to the analyzer shelter. At 24 V a 3 % drop is only 0.7 V, so the long DC feeders to the analyzer shelter and the meter skid need conductors well above their ampacity requirement (CP-102B #10, JB-140D #4, JB-110D #10). At the end of battery discharge (21.6 V) the analyzers still see more than the 18 V minimum typical of their power supplies.

All branch circuits meet 3 % and all circuits meet 5 % total. The worst branch drop is 2.89 % and the worst total 3.69 %. Every branch circuit is listed with its size, breaker and voltage drop in Appendix A.

6.3. SHORT CIRCUIT

The utility source and XF-101 impedances referred to 480 V are:

IEEE 3002.3, ohmic method

$$Z_{util} = \frac{V_{prim}}{\sqrt{3} I_{sc}} \left(\frac{480}{12470} \right)^2 = 1.07 \text{ m}\Omega, \quad Z_{XF} = Z_{pu} \frac{480^2}{S_{XF}} = 0.015 \frac{480^2}{75000} = 46.1 \text{ m}\Omega$$

Adding the service, transfer switch and panel feeder conductors, the impedance at DP-101 is $36.9 + j46.6 \text{ m}\Omega$ (59.5 mΩ), and the available fault current is:

IEEE 3002.3, ohmic method

$$I_{sc} = \frac{V_{LN}}{|Z|} = \frac{277.1}{0.05946} = 4,661 \text{ A}$$

Table 6-2 lists the fault current at each bus. Motor contribution adds about 120 A at DP-101. An independent calculation by the MVA method agrees within 5 % at every bus.

Table 6-2: Available Fault Current

Bus	Voltage	Symmetrical fault current, A	X/R
XF-101 secondary / MCB-101 line side	480	5,887	1.84

Bus	Voltage	Symmetrical fault current, A	X/R
MCB-101 load side	480	5,273	1.50
ATS-101	480	4,837	1.33
DP-101	480	4,661	1.26
LP-101 (208 V)	208	973	1.01
DP-101 on G-101 (subtransient)	480	596	8.51
DCP-101, battery and chargers	24 DC	2,329	-
UP-101, UPS inverter limit	120	25	-

The available fault current is 5.9 kA at the XF-101 secondary, 4.7 kA at DP-101 and 0.97 kA at LP-101. Equipment at 480 V shall be rated 22 kA and at 208 V and 120 V 10 kA; the margin covers a utility change to a larger or lower-impedance transformer.

6.4. PROTECTIVE DEVICES

Table 6-3 gives the protective devices and their settings.

Table 6-3: Protective Devices

Device	Rating	Interrupting rating	Settings and notes
MCB-101 service breaker	125 A, three-pole, 480 V, service-entrance rated	22 kA	Thermal-magnetic, instantaneous 10 x In; main bonding jumper here only
G-101 generator breaker	110 A, three-pole	22 kA	Electronic trip; instantaneous 2 x In (220 A), no intentional delay
ATS-101	150 A, three-pole, open transition	22 kA withstand	See ELE-CAL-002
DP-101 panelboard	225 A bus, main lugs	22 kA	Protected by MCB-101 or the G-101 breaker
XF-102 primary breaker	25 A, three-pole	22 kA	125 % of rated primary current, Table 450.3(B)
LP-101 main breaker	60 A, three-pole	10 kA	Adjustable instantaneous 5 x In (300 A)
UP-101 branch breakers	10 A, one-pole	10 kA	Small enough for the UPS inverter or static bypass to clear
DCP-101 breakers	6 A to 45 A DC; 100 A battery disconnect	10 kA at 48 VDC	DC-rated, UL 489
Motor branch breakers	15 A, three-pole	22 kA	Inverse time, 430.52; actuator has its own overload protection
Heat tracing breakers	20 A, one-pole	10 kA	Equipment ground-fault protection 30 mA, 427.22

Device	Rating	Interrupting rating	Settings and notes
Receptacle breakers	20 A, one-pole	10 kA	GFCI, 210.8(B)

6.5. ARC-FLASH ASSESSMENT

For DP-101 on utility power, the bolted fault current is 4,661 A, so the lowest credible arcing current is 2,330 A. MCB-101's instantaneous element picks up at no more than:

Breaker time-current data, +20 % tolerance

$$I_{pickup} = 1.2 \times 10 \times 125 = 1,500 \text{ A} < 2,330 \text{ A}$$

so the breaker clears the arc in 1.5 cycles (0.025 s). This is within the 2-cycle (0.03 s) and 25 kA limits of NFPA 70E Table 130.7(C)(15)(a) for panelboards above 240 V, and the table assigns PPE category 2 with a 36 in arc-flash boundary. Table 6-4 repeats the check for each bus.

Table 6-4: Arc-Flash Table Method Conditions

Equipment	Bolted fault, A	Lowest arcing, A	Upstream device	Pickup with tolerance, A	Table applies	PPE and boundary
MCB-101 line side, 480 V	5,887	2,944	Utility primary fuse (HOLD H-10)	-	No	-
MCB-101 load side and ATS-101 (utility), 480 V	5,273	2,636	MCB-101, 125 A, instantaneous 10 x In	1,500	Yes	Category 2, 36 in
DP-101 (utility), 480 V	4,661	2,330	MCB-101, 125 A, instantaneous 10 x In	1,500	Yes	Category 2, 36 in
DP-101 and ATS-101 (generator), 480 V	596	298	G-101 breaker, 110 A, instantaneous 2 x In	264	Yes	Category 2, 36 in
LP-101, 208 V	973	486	LP-101 main, 60 A, instantaneous 5 x In	360	Yes	Category 1, 19 in

Note 1: The MCB-101 line side is protected only by the utility's primary fuse, whose rating and clearing time are not yet known (HOLD H-10). The table method does not apply there.

Note 2: PPE category 2 applies to equipment above 240 V and category 1 to 240 V and below, per NFPA 70E Table 130.7(C)(15)(a).

On generator power the fault current at DP-101 falls to about 600 A. A thermal-magnetic 110 A breaker would then clear an arcing fault in its thermal band, far beyond 2 cycles, and the table would no longer apply. This is why the generator breaker has an electronic trip with its instantaneous element set at 2 x In: the 264 A pickup is below the 298 A lowest arcing current. For the same reason the LP-101 main breaker has an adjustable instantaneous element set at 5 x In.

Table 6-5 gives the label data required by NFPA 70E 130.5(H) and NFPA 70 110.24.



Table 6-5: Arc-Flash and Shock Label Data

Label field	MCB-101 line side	MCB-101, ATS-101, DP-101	LP-101, UP-101	DCP-101
Nominal voltage	480 VAC	480 VAC	208Y/120 VAC, 120 VAC	24 VDC
Available fault current	5.9 kA	5.3 kA maximum	0.97 kA	2.33 kA
Arc-flash PPE	Not assessed; de-energize before work	PPE category 2	PPE category 1	Not required below 100 VDC
Arc-flash boundary	Not assessed	36 in	19 in	-
Limited approach, movable / fixed	10 ft 0 in / 3 ft 6 in	10 ft 0 in / 3 ft 6 in	10 ft 0 in / 3 ft 6 in	Not specified
Restricted approach	1 ft 0 in	1 ft 0 in	Avoid contact	-
Signal word	DANGER	WARNING	WARNING	WARNING

Every bus downstream of MCB-101 meets the conditions of the NFPA 70E table method, on both utility and generator power. The MCB-101 line side shall be labeled DANGER and worked only de-energized until the utility fuse data allows an assessment.

7. RESULTS AND CONCLUSIONS

TORUS draws the following conclusions:

1. All branch circuits are #12 AWG copper except RCP-101 (#10), AC-101 (#10), CP-102B (#10), JB-140D (#4) and JB-110D (#10). The service, generator and transfer switch feeders are 4-1/C 1/0 AWG.
2. The worst branch voltage drop is 2.89 % and the worst total 3.69 %, within 3 % and 5 %.
3. The available fault current is 4.7 kA at DP-101. Equipment shall be rated 22 kA at 480 V and 10 kA at 208 V and 120 V.
4. The G-101 breaker shall have an electronic trip set at 2 x In instantaneous, and the LP-101 main an adjustable instantaneous set at 5 x In.
5. Arc-flash labels shall carry the data in Table 6-5. An incident-energy study to IEEE 1584-2018, with protective device coordination, shall be performed before energization once the utility confirms its fault level, X/R and primary fuse.

The following items remain open: utility fault data and primary fuse (HOLD H-10) and equipment nameplates (HOLD H-15).

APPENDIX A. BRANCH CIRCUIT SCHEDULE



Table A-1 lists every branch circuit. Voltage drop is at the load's full-load current over the routed length.

Table A-1: Branch Circuits

Cable	Load (panel, voltage)	Design current, A	Breaker, A	Size, AWG	Length, ft	Branch drop, %	Total drop, %
P-101	SDV-101 (DP-101, 480 V)	2.6	15	#12	205	0.25	0.52
P-102	SDV-102 (DP-101, 480 V)	2.6	15	#12	130	0.16	0.42
P-103	SDV-103 (DP-101, 480 V)	2.6	15	#12	115	0.14	0.41
P-104	MOV-111 (DP-101, 480 V)	3.8	15	#12	235	0.42	0.68
P-105	MOV-112 (DP-101, 480 V)	3.8	15	#12	235	0.42	0.68
P-106	MOV-121 (DP-101, 480 V)	3.8	15	#12	235	0.42	0.68
P-107	MOV-122 (DP-101, 480 V)	3.8	15	#12	235	0.42	0.68
P-108	MOV-115 (DP-101, 480 V)	3.8	15	#12	235	0.42	0.68
P-109	FCV-131 (DP-101, 480 V)	2.6	15	#12	160	0.19	0.46
P-110	FCV-132 (DP-101, 480 V)	2.6	15	#12	160	0.19	0.46
P-111	UH-101 (DP-101, 480 V)	11.3	15	#12	235	1.53	1.80
P-112	EF-101A (DP-101, 480 V)	1.4	15	#12	235	0.14	0.41
P-113	EF-101B (DP-101, 480 V)	1.4	15	#12	235	0.14	0.41
P-114	AC-102A (DP-101, 480 V)	8.5	15	#12	50	0.24	0.50
P-115	AC-102B (DP-101, 480 V)	8.5	15	#12	30	0.14	0.41
P-116	GO-101A (DP-101, 480 V)	1.4	15	#12	100	0.06	0.33
P-117	GO-101B (DP-101, 480 V)	1.4	15	#12	130	0.08	0.34
P-118	RCP-101 (DP-101, 480 V)	30.0	30	#10	225	1.20	1.47



Cable	Load (panel, voltage)	Design current, A	Breaker, A	Size, AWG	Length, ft	Branch drop, %	Total drop, %
P-119	E-161 (DP-101, 480 V)	7.5	15	#12	25	0.11	0.38
P-120	LTG-1 (LC-101 / DP-101, 277 V)	4.7	15	#12	420	1.31	1.58
P-121	LTG-2 (LC-101 / DP-101, 277 V)	4.6	15	#12	390	1.18	1.45
P-122	LTG-3 (LC-101 / DP-101, 277 V)	3.7	15	#12	420	1.03	1.30
P-123	E-161 (HCP-161, 480 V)	7.5	15	#12	190	0.82	1.20
P-201	BC-101A (LP-101, 208 V)	11.1	15	#12	35	0.54	1.11
P-202	BC-101B (LP-101, 208 V)	11.1	15	#12	40	0.62	1.19
P-203	UPS-101 (LP-101, 120 V)	13.2	20	#12	30	1.01	1.57
P-204	AC-101 (LP-101, 208 V)	13.4	20	#10	235	2.66	3.22
P-205	LTG-B102 (LP-101, 120 V)	2.6	20	#12	25	0.17	0.73
P-206	LTG-B101 (LP-101, 120 V)	0.9	20	#12	235	0.53	1.09
P-207	REC-B102-1 (LP-101, 120 V)	20.0	20	#12	25	0.34	0.91
P-208	REC-B102-2 (LP-101, 120 V)	20.0	20	#12	25	0.34	0.91
P-209	REC-B101 (LP-101, 120 V)	20.0	20	#12	235	2.14	2.71
P-210	REC-EXT-1 (LP-101, 120 V)	20.0	20	#12	230	2.10	2.66
P-211	REC-EXT-2 (LP-101, 120 V)	20.0	20	#12	210	0.96	1.52
P-212	REC-EXT-3 (LP-101, 120 V)	20.0	20	#12	185	0.84	1.41
P-213	AE-141H (LP-101, 120 V)	3.6	20	#12	235	2.28	2.85
P-214	SCS-141 (LP-101, 120 V)	2.1	20	#12	235	1.31	1.87

Cable	Load (panel, voltage)	Design current, A	Breaker, A	Size, AWG	Length, ft	Branch drop, %	Total drop, %
P-215	HT-1080 (LP-101, 120 V)	3.5	20	#12	235	2.22	2.78
P-216	HT-1139 (LP-101, 120 V)	2.5	20	#12	235	1.57	2.13
P-217	AHT-142/143 (LP-101, 120 V)	2.1	20	#12	235	1.31	1.87
P-218	CP-150 (LP-101, 120 V)	3.3	20	#12	185	1.41	1.98
P-219	SDV-165 (LP-101, 120 V)	7.2	15	#12	190	2.64	3.21
P-220	G-101BH (LP-101, 120 V)	15.6	20	#12	60	2.50	3.06
P-221	G-101BC (LP-101, 120 V)	1.2	20	#12	60	0.17	0.73
P-222	RECT-101 (LP-101, 120 V)	3.7	20	#12	20	0.17	0.73
P-301	HMI-101 (UP-101, 120 V)	1.9	10	#12	30	0.14	0.86
P-302	NVR-101 (UP-101, 120 V)	1.2	10	#12	40	0.12	0.84
P-303	JB-W01 (UP-101, 120 V)	1.2	10	#12	270	0.76	1.48
P-304	LCV-104 (UP-101, 120 V)	0.8	10	#12	205	0.35	1.07
P-305	SDV-106 (UP-101, 120 V)	1.3	10	#12	195	0.55	1.27
P-306	ANT-201 (UP-101, 120 V)	0.6	10	#12	135	0.19	0.91
D-101	CP-102A (DCP-101, 24 V)	5.6	6	#12	35	2.58	3.39
D-102	CP-102B (DCP-101, 24 V)	11.2	12	#10	30	2.77	3.57
D-103	CP-102C (DCP-101, 24 V)	2.5	6	#12	30	1.01	1.81
D-104	TR-102 (DCP-101, 24 V)	4.4	6	#12	25	1.46	2.26
D-105	WDP-101 (DCP-101, 24 V)	0.5	6	#12	40	0.28	1.08

Owner

Project No.:

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ELE-CAL-004

Rev. A

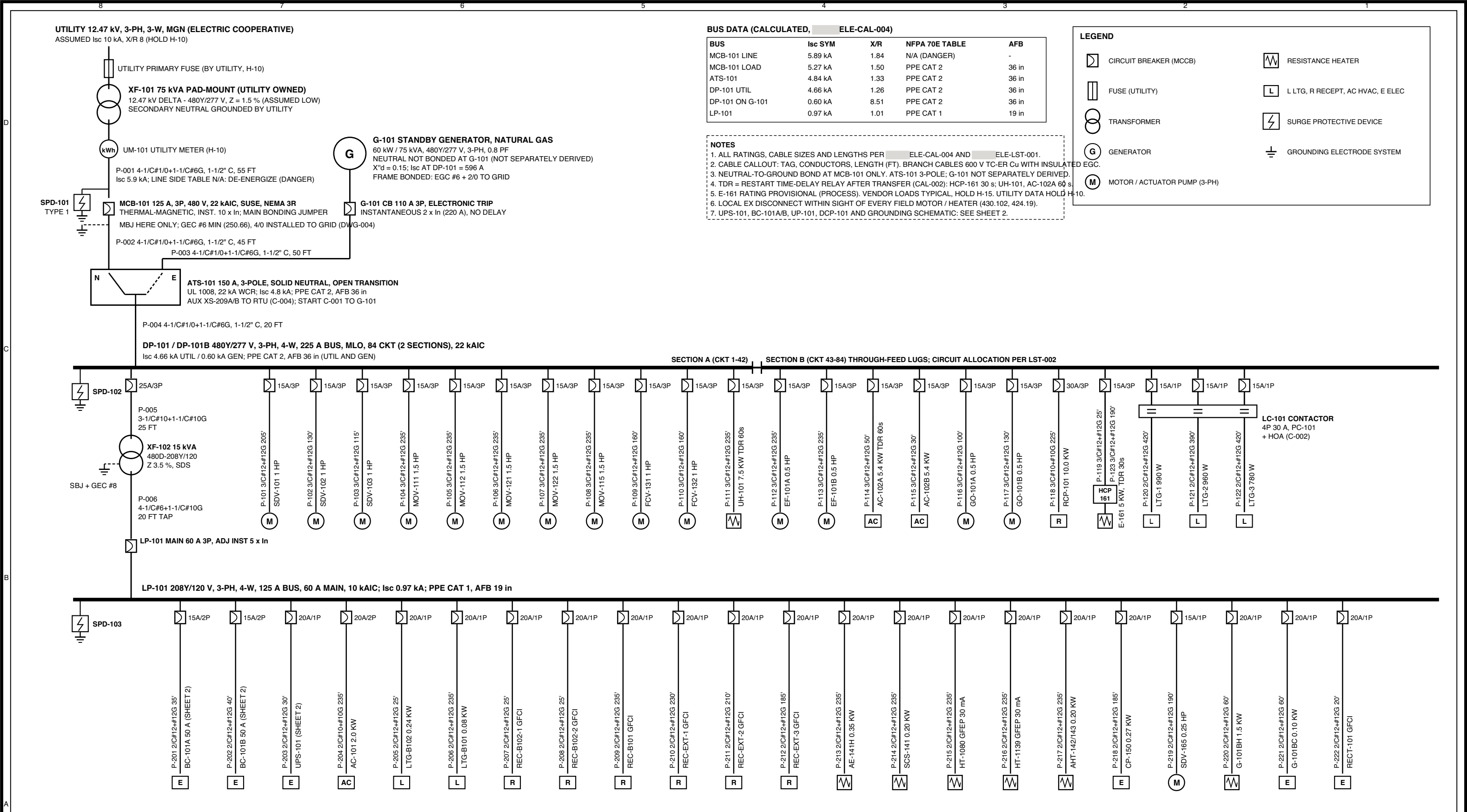
September 29, 2026

Cable	Load (panel, voltage)	Design current, A	Breaker, A	Size, AWG	Length, ft	Branch drop, %	Total drop, %
D-106	JB-140D (DCP-101, 24 V)	6.0	6	#4	235	2.89	3.69
D-107	JB-110D (DCP-101, 24 V)	1.0	6	#10	230	1.98	2.78
D-108	FT-163 (DCP-101, 24 V)	0.4	6	#12	190	0.91	1.72



APPENDIX B. ONE-LINE DIAGRAM





NOTES / REFERENCES

- LOADS PER ELE-CAL-001; CABLES AND PROTECTION PER ELE-CAL-004.
- SHORT CIRCUIT AND ARC FLASH SCREENING PER ELE-CAL-004 (FINAL STUDY)
- IEEE 1584-2018 AFTER HOLD H-10 CLOSSES).
- LOAD DATA TYPICAL, CONFIRM WITH VENDOR DATA (HOLD H-15).

REF: ELE-CAL-001/002/004
REF: ELE-LST-001/002
REF: ELE-DWG-004

REVISIONS

REV	DATE	DESCRIPTION	BY	CHK	APP
A	2026-09-29	ISSUED FOR REVIEW (IFR)			

PRELIMINARY - ISSUED FOR REVIEW - NOT FOR CONSTRUCTION

ENGINEER OF RECORD SEAL

NOT SEALED
PRELIMINARY

PE NO. _____

PROJECT

120 MMSCFD RECEIPT INTO _____

COUNTY, _____
DISCIPLINE: ELECTRICAL
SCALE: NTS

ONE-LINE DIAGRAM

480 V AND 208Y/120 V DISTRIBUTION

DRAWN: _____ CHECKED: _____ APPROVED: _____

DWG NO. _____
ELE-DWG-001
SHEET 1 OF 2 REV A

SHEET 2 OF 2 REV A