Station service calculation

Project	Client	Location	Revision	Date
Sample 230/34.5 kV pooling substation	Sample client	Sample site	0	4 Nov 2026

Document no.	Prepared	Checked	Approved
SSL-C-AUX-001	Sample engineer	Sample engineer	Sample engineer

Rev	Date	Description	By
0	4 Nov 2026	Issued	Sample engineer

230/34.5 kV pooling substation, 250 MW. Load ratings are the design's values unless marked * (edited or added by you in the load list).

1. 480Y/277 V AC load list

Duty factor: continuous 1, intermittent 0.5, standby 0. Demand kW = quantity × kW × duty factor.

Group	Load	Qty	kW per unit	pf	Duty	Demand kW
Transformers	Transformer cooler fans (ONAF), 168 MVA	2	8.4	0.85	continuous	16.8
Transformers	Transformer LTC drive motor	2	1.1	0.80	intermittent	1.1
Transformers	Transformer marshalling box heaters and lighting	2	0.5	1.00	continuous	1.0
230 kV switchyard	CB spring-charging motor	5	1.5	0.80	intermittent	3.8
230 kV switchyard	Disconnect switch / grounding switch motor	15	0.75	0.80	intermittent	5.6
230 kV switchyard	Bay marshalling kiosk heaters and lighting	7	0.3	1.00	continuous	2.1
Lighting	Switchyard flood lighting (LED, 0.0929 W/ft²)	1	28.2	0.95	continuous	28.2
Lighting	Peripheral road lighting (one 100 W pole per 98.4 ft)	23	0.1	0.95	continuous	2.3
Lighting	Building lighting (0.929 W/ft²)	1	6.5	0.95	continuous	6.5
HVAC	Air conditioning: control, relay and battery rooms (5.57 W/ft²)	1	15.1	0.85	continuous	15.1
HVAC	Switchgear hall ventilation (1.86 W/ft²)	1	6.5	0.80	continuous	6.5
DC system	125 V battery charger (duty, at equalize)	1	10.4	0.80	continuous	10.4
DC system	125 V battery charger (standby)	1	10.4	0.80	standby	0.0
DC system	48 V DC telecom / PLCC charger	1	2	0.80	continuous	2.0
Control	SCADA, RTU, SAS servers and network	1	3	0.90	continuous	3.0
Control	Fire detection and alarm panel	1	1	0.90	continuous	1.0
Control	CCTV, access control and boundary security	1	2	0.90	continuous	2.0
STATCOM and filters	STATCOM cooling and auxiliaries (0.3 kW/Mvar)	2	12.4	0.85	continuous	24.8
Fire fighting	Electric fire-water pump (main)	1	37	0.85	standby	0.0
Fire fighting	Jockey pump	1	5.5	0.85	intermittent	2.8
Utilities	Raw water / service water pump	1	3.7	0.85	intermittent	1.9
Utilities	Building power sockets	1	5	0.90	intermittent	2.5
Utilities	Transformer oil filtration machine outlet	1	30	0.85	standby	0.0
Utilities	Switchyard welding / maintenance outlets	1	20	0.80	standby	0.0
34.5 kV switchgear	Panel heaters, lighting and spring-charging motors	23	0.4	0.90	continuous	9.2
	Connected kW (total)		263.4			148.5

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Calculation trail

1 · Maximum demand

Design rule

$$P = \sum q_i P_i d_i, \quad Q = \sum P_i \tan(\arccos \mathrm{pf}_i), \quad S = \sqrt{P^2 + Q^2}$$

25 loads, connected 263.4 kW → P = 148.5 kW, Q = 80.8 kvar, S = 169.0 kVA

2 · Station service transformer

Design rule

$$S_{\mathrm{TR}} = 1.2 S$$

required 202.8 kVA → 2 × 225 kVA (one duty, one standby)

3 · DC duty cycle

IEEE 485 §5

$$I(t) = I_{\mathrm{cont}} + I_{\mathrm{light}}(t) + I_{\mathrm{trip}}(t) + I_{\mathrm{close}}(t)$$

4 periods, 60 cells at 135.0 V float → continuous 19.8 A

4 · Cell sizing sections

IEEE 485 §6.3

$$F_S = \sum (A_p - A_{p-1}) K_t$$

4 sections → largest section 175.6 Ah

5 · Battery capacity

IEEE 485 §6.4

$$C = F_S \, k_{\mathrm{aging}} \, k_{\mathrm{margin}} \, k_{\mathrm{temp}}$$

required 241.4 Ah → 2 × 300 Ah 8 h

6 · Chargers

IEEE 946

$$I = L + \frac{1.1\,C}{H}$$

L 19.8 A, C 300 Ah → 2 × 63 A battery chargers, 10.4 kW each

7 · Standby generator and motor-start dip

ISO 8528-5 (class G3)

$$S_{\mathrm{DG}} = 1.2 \max(S, P/0.8), \quad \Delta U = \frac{S_{\mathrm{start}}}{S_{\mathrm{start}} + S_{\mathrm{DG}} x''_d} \le 15\%$$

required 222.7 kVA, largest motor Electric fire-water pump (main) 37 kW → 250 kVA, dip 14.8 %

8 · Switchgear ratings

IEEE C37.13-2015 §5.4 (LVPCB frames); molded-case breaker, fuse and panelboard ratings typical

$$I = \frac{S}{\sqrt{3}\,U}, \quad I_n \ge I$$

18 devices at 480 V and 125 V DC → AC switchboard 800 A, DC panelboard 400 A

Device	Type	Full-load current (A)	Rated current
STATION SERVICE TR-1 incomer	LVPCB	271	800 A
STATION SERVICE TR-2 incomer	LVPCB	271	800 A
Standby generator incomer	LVPCB	301	800 A
Bus coupler	LVPCB	271	800 A
480Y/277 V AC switchboard	bus	271	800 A
Transformers feeder	MCCB	26	100 A
230 kV switchyard feeder	MCCB	16	100 A
Lighting feeder	MCCB	47	100 A
HVAC feeder	MCCB	31	100 A
DC system feeder	MCCB	19	100 A
Control feeder	MCCB	8	100 A
STATCOM and filters feeder	MCCB	35	100 A
Fire fighting feeder	MCCB	4	100 A
Utilities feeder	MCCB	6	100 A
34.5 kV switchgear feeder	MCCB	12	100 A
BC-1 charger	class J fuse	63	100 A
BC-2 charger	class J fuse	63	100 A
BATTERY-1	class J fuse	103	200 A
BATTERY-2	class J fuse	103	200 A
125 V DC panelboard	bus	263	400 A

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2. Station service transformer

Quantity	Formula	Result
Active demand	$P = \sum q_i P_i d_i$	148.5 kW
Reactive demand	$Q = \sum P_i \tan(\arccos \mathrm{pf}_i)$	80.8 kvar
Maximum demand	$S = \sqrt{P^2 + Q^2}$	169.0 kVA
With margin	$S_{\mathrm{TR}} = 1.2S$	202.8 kVA
Selected	next standard size	2 × 225 kVA (one duty, one standby)

3. Standby generator

Quantity	Formula	Result
Full station service load	$S_{\mathrm{DG}} = 1.2\max(S, P/0.8)$	222.7 kVA
Largest motor	Across-the-line start, 6 × FLC	Electric fire-water pump (main) 37 kW
Start dip	$\Delta U = \frac{S_{\mathrm{start}}}{S_{\mathrm{start}} + S_{\mathrm{DG}}/x''_d}$	14.8 % (limit 15 %)
Selected	next standard size that meets both	250 kVA, 480Y/277 V, automatic transfer

4. 125 V DC battery (IEEE 485)

Vented lead-calcium, rated at the 8 h rate to 1.75 V per cell (RUS 1724E-300 §15.2.5.1), 60 cells. Equalize 139.8 V, float 135.0 V, end of discharge 105.0 V at 1.75 V/cell, within the 125 V DC control range of 100 V to 140 V (IEEE C37.04-2018 Table 23, closing, class S1; 90 V for class S2 and 100 kV and above):

$$N = \lfloor 140 / V_{\mathrm{equalize}} \rfloor$$

Period	Duration	Load (A)	Load
1	1 min	102.8	continuous + emergency lighting + breaker tripping
2	59 min	31.8	continuous + emergency lighting
3	419 min	19.8	continuous
4	1 min	29.8	continuous + largest breaker closing

Section	Required (Ah, before factors)	Formula
1	74.5	$F_S = \sum (A_p - A_{p-1}) K_t$
2	58.0	$F_S = \sum (A_p - A_{p-1}) K_t$
3	168.1	$F_S = \sum (A_p - A_{p-1}) K_t$
4	175.6	$F_S = \sum (A_p - A_{p-1}) K_t$

Quantity	Formula	Result
Largest section	max FS	175.6 Ah
Factors	$C = F_S \, k_{\mathrm{aging}} \, k_{\mathrm{margin}} \, k_{\mathrm{temp}}$	241.4 Ah
Selected	next standard 8 h rating	2 × 300 Ah

5. Chargers (IEEE 946)

Quantity	Formula	Result
Charger current	$I = L + \frac{1.1C}{H}$	19.8 + 1.1 × 300/10 = 52.8 A
Selected	next standard rating	2 × 63 A battery chargers
AC input	$P_{\mathrm{AC}} = \frac{N V_{\mathrm{equalize}} I}{\eta}$	10.4 kW each

6. Assumptions

1. The capacity rating factor Kt is the 8 h curve of the vented lead-calcium cell of RUS 1724E-300 Example 15-1 (its

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8, 5, 3 and 1 h and 1 min capacities) to 1.75 V per cell. The battery vendor's own curve applies at detail design.

2. DC loads: 150 W per 230 kV bay, 40 W per 34.5 kV panel, 500 W common. Emergency lighting 1.5 kW for 1 h. Trip 5 A per 230 kV CB, 2 A per 34.5 kV CB. Closing 10 A.

3. The design assumes an air-conditioned battery room (temperature factor 1.0).

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