Industrial Calculations: Feeder Loads

By James Stallcup, Jr., NECA and OSHA Consultant

Over the last three months in this column, we've discussed how to calculate various loads in an industrial facility. We've looked at lighting loads, receptacle loads, appliance loads, motor loads, compressor loads, and heating or AC loads. Now we'll show you how to use a one-line diagram to calculate feeder loads.

When computing the feeder load for an existing electrical system—or when designing an entirely new system—an up-to-date electrical one-line diagram is important to the success of your calculations. (Fig. 1).

As we work through our calculations, you'll see just how important the one-line diagrams are: The diagram supplies the crucial information at the beginning of each example.

Now, using a one-line diagram and the information supplied in the following tables, let's try to calculate the load for a system with three feeders.

Feeder No. 1. Based on the following loads, compute the amps and size the conductors (three per phase) and overcurrent protection device (OCPD) for the panelboard per Part B to Art. 220:

Number	Type load	Phases	Volts	Amps
60	2 ballast	1Ø	277V	0.38A (ea.)
42	HID 1000W	1Ø	480V	0.86A (ea.)
6	Large equipment	3Ø	480V	21.0A (ea.)
10	Process units	3Ø	480V	34.0A (ea.)

Step 1: Calculate total amps for all loads per Secs. 215-2(a), 220-4(b), and 440-34.
2 ballast at 0.38A (ea.)=
$60 \times 2 \times 0.38A \times 125\% = 57.0A$
HID 1000W at 0.86A (ea.)=
$42 \times 0.86A \times 125\% = 45.15A$
Large equipment at 21.0A (ea.)=
$6 \times 21.0A \times 125\% = 157.5A$
Process units at 34.0A (ea.)=
$10 \times 34.0A \times 125\% = 425.0A$

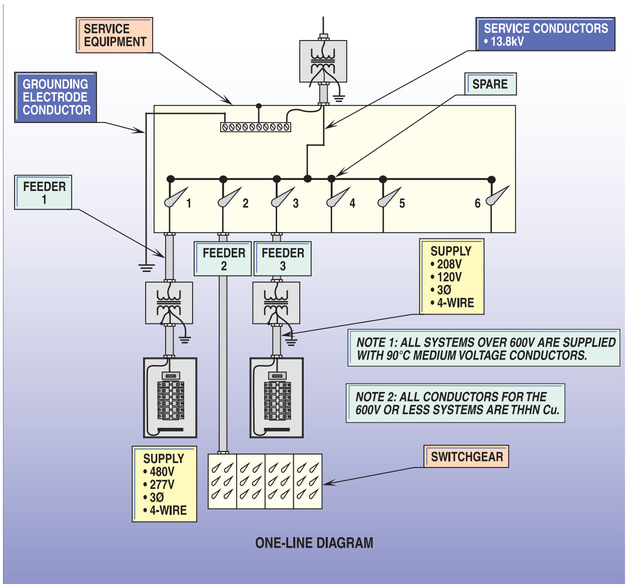

Fig. 1. *The above is a one-line diagram depicting typical electrical equipment in an industrial plant.*

Total load = 684.65A
Rounded up to 685A per Sec. 220-2(b).

Step 2: Size conductors for feeder No. 1 by paralleling conductors (three per phase), per Sec. 310-4.
Ampacity of one conductor (A) =
Total Ampacity ÷ No. of conductors
$A = 685A \div 3$
$A = 229A$

Step 3: Select conductors for feeder No. 1 per Table 310-16 (use 75°C column).
229A requires No. 4/0 cu.
No. 4/0 THHN cu. = 230A

Step 4: Select total ampacity of conductors per Sec. 310-4.
No. 4/0 cu. $= 230A \times 3 = 690A$
690A > 685A

Solution: Use three paralleled No. 4/0 THHN copper conductors, paralleled three times (once per phase).

Now let's size the OCPD:
Size OCPD based upon load per Secs. 240-3(b) and 240-6(a).
685A or 690A requires a 700A OCPD.

Feeder No. 2. Based on the following loads, compute what size 90°C, medium-voltage copper conductors are required and how many mains are permitted to supply power to the switchgear per Part B to Art. 220 and Art. 215:

Number	Type load	Phases	Volts	Amps
2	Heavy equipment	3Ø	13.8 kV	2.0A (ea.)
2	Large motors	3Ø	13.8 kV	1.5A (ea.)
1	Distribution center	3Ø	13.8 kV	15.0A

Step 1: Calculate total amps for all loads per Secs. 215-2(a), 230-202, 230-208(b), and 430-24.
2 heavy equipment at 2.0A (ea.) =
2×2.0A×125% = 5.0A
2 large motors at 1.5A (ea.) =
2×1.5A×125% = 3.75A
1 distribution center at 15.0A =
1×15.0A×125% = 18.75A
Largest motor load at 1.5A (ea.) =
1.5A×25% = .375A
Total load = 27.875A

Step 2: Size conductors for feeder No. 2 per Fig. 310-60, Detail 3, and Table 310-77.
27.875A requires No. 6 cu. conductor (the minimum size for 15kV).

Step 3: Find number of mains per Secs. 225-33(a) and 225-34(a).
The number of mains per minute required is six.

Solution: Use No. 6 copper and six mains for underground feeder No. 2.

Feeder No. 3. Based on the following loads, what size OCPD and 90°C, medium-voltage conductors are required per Part B to Art. 220:

Number	Type loads	Phases	Volts	Amps
150	4W-34W fluorescent	1Ø	120V	0.86A (ea.)
50	Recess fixtures	1Ø	120V	1.25A (ea.)
40	150W bulbs	1Ø	120V	1.25A (ea.)
200	Receptacles (180W ea.)	1Ø	120V	1.5A (ea.)
10	10-ft. multi-outlet assembly	1Ø	120V	1.5A per ft.
10	Isolation receptacles	1Ø	120V	1.5A (ea.)

Step 1: Calculate total amps for all loads per Secs. 215-2(a), 220-3(b)(8)(b), 220-3(b)(9) and Table 220-13.
150 fluorescent at 0.86A (ea.) =
150×0.86A×125% = 161.25A
50 recess fixtures at 1.25A (ea.) =
50×1.25A×125% = 78.125A
40 150W bulbs at 1.25A (ea.) =
40×1.25A×125% = 62.5A
200 receptacles at 1.5A (ea.) =
200×180W = 36,000W
First 10,000W×100% = 10,000VA
Next 26,000W×50% = 13,000VA
Total load = 23,000VA
I = 23,000VA / 360V = 63.9A
10 10-ft. multioutlet assemblies at 1.5A per ft =
10×10 ft×1.5A = 150.0A
10 isolation receptacles at 1.5A (ea.) =
10×1.5A×125% = 18.75A
Total load = 534.525A

Now find the minimum size OCPD for primary side protection of the transformer.

Step 1: Size the transformer based on secondary loads (based on 125% of load).
kVA = I×V×(√3) ÷ 1000
kVA = 534.525×208V×1.732 ÷1000
kVA = 192.566

Step 2: Select the correct size transformer (based on 125% of load).
192.428kVA requires a 225kVA transformer

Step 3: Find FLA of transformer
I=(kVA × 1000)÷(V × √3)
I=(225kVA × 1000)÷(13,800V × 1.732)
I=9.4A

Step 4: Size OCPD for primary per Sec. 240-6(a) and Table 450-3(a).
9.4A × 600% = 56.4A
56.4A requires a 50A OCPD.

Now, size the 90°C medium-voltage copper conductors to supply the primary side of the transformer.

Step 1: Select appropriate conductors based on OCPD size, Sec. 110-40 and Table 310-77.
50A OCPD requires a No. 6 cu conductor.

Note: All continuous loads are computed at 125%. EC&M