Designing a Pumped-Up Power System

With supply conductors in place, your next step to installing a power supply system for oil-well units is choosing the correct motor size.

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In last month's column, we presented basic design guidelines for sizing the secondary conductors required to supply motors powering several oil-well pumping units. This month we'll discuss how to size a motor for one pumping unit when the supply conductors are already in place. While some of the calculation specifics presented here apply only to oil fields, the Code concepts are typical to most industrial motor calculations.

Follow this 12-step program for designing these electrical components. Only properly sized electrical system components will allow the motor to start under load and drive it continuously. The Figure at the right shows the components of a typical supply system.

Step 1: Size the motor for the pumping unit. The motor size for a pumping unit depends on the polished rod horsepower (output horsepower). Use this standard oil industry formula to size the motor for driving an oil-well pump:

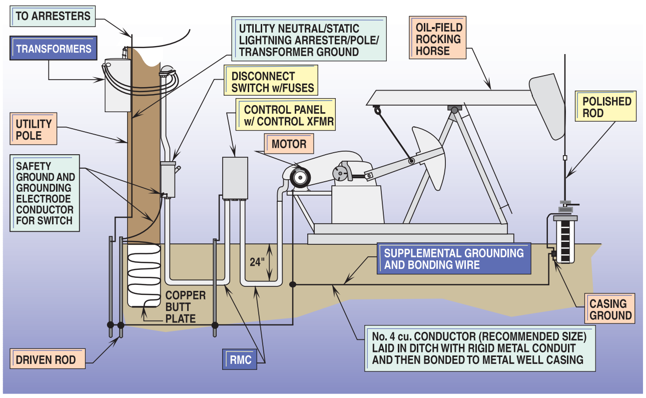
hp=(Polished-rod hp÷0.75)×0.70

For example, 15.7hp (460V, 3-phase) is necessary at the required point to drive the pumping unit.

TABLE 1
NEMA SIZE DISCONNECT (SAFETY) SWITCHES
AMPERAGE
30
60
100
200
400

TABLE 2		
NEMA SIZE MOTOR STARTERS		
NEMA SIZE	MAX. AMPS	MAX. hp 460V
0	18	5
1	27	10
2	45	25
3	90	50
4	135	100
5	270	200
6	540	400

TABLE 3	
OVERLOAD CHART PER MANUFACTURER	
AMPERAGE	OVERLOAD UNITS
20.6 – 23.3	H1042
23.4 – 26.0	H1043
26.1 – 30.5	H1044
30.6 – 33.6	H1045
33.7 – 37.9	H1046
38.0 – 42.9	H1047
43.0 – 48.2	H1048
48.3 – 54.6	H1049
54.7 – 61.2	H1050
61.3 – 67.6	H1051
67.7 – 75.9	H1052
76.0 – 87.1	H1053
87.2 – 97.5	H1054
97.6 – 109.0	H1055
110.0 – 122.0	H1057
123.0 – 135.0	H1058



A typical supply system for oil-well pumping units.

- 0.75 is the assumed mechanical efficiency of the pumping unit.
- 0.70 is the motor heating factor on pumping duty cycle.
- Supply voltage is 480V, 3-phase.

Therefore:

hp=15.7÷(0.75×0.70)

hp=29.9 (round up to 30 hp)

Data for design:

- 30 hp motor, with a 1.15 service factor, Class B, 460V, 3-phase, induction.
- 37A nameplate amps (Design B or Code letter C).
- THWN 75°C cu. conductors.
- Galvanized rigid conduit.
- 96°F to 104°F ambient temperature.
- Combination starter with 150VA control transformer.
- Ground rod made of steel or iron.
- Rigid conduit cannot be used for equipment grounding conductor.
- Rigid conduit is buried 2 ft deep.
  (a) Distance from disconnect to starter is 70 ft.

(b) Distance from starter to motor is 35 ft.

- Design per minimum standards of NEC.
- Use time-delay fuses.

Step 2: Size the conductors.

Step 2a: Determine motor amps per Sec. 430-6(a)(1) and Table 430-150.

30 hp motor=40A

Step 2b: Calculate ampacity per Sec. 430-22(a).

40A×125%=50A

Step 2c: Size conductors per Table 310-16.

50A requires No. 8 cu. conductor. However, because of ambient temperature correction factors, you must select a conductor with an ampacity you can derate from. The next largest conductor is No. 6, which has an ampacity of 65A.

Step 2d: Calculate ampacity for correction factors per Table 310-16.

65A×0.88=57.2A

A No. 6 conductor meets the Code, but if derating had provided a value less than 50A, you would have needed a larger conductor.

Step 3: Size the time-delay fuses in the disconnect to allow the motor to start and run.

Step 3a: Calculate the full load current per Sec. 430-52(c)(1) and Table 430-152.

40A×175%=70A

Step 3b: Select the appropriate time-delay fuses (dual-element) per Sec. 240-6(a).

A 70A load requires a 70A fuse.

Step 4: Size the disconnect.

Step 4a: Calculate the current per Secs. 430-110(a) and 430-57.

40A×115%=46A

Step 4b: Use a 60A nonfused disconnect per Table 1 on page 80.

A 70A time-delay fuse=100A disconnect

Step 5: Size the starter.

Step 5a: Size the starter per Sec. 430-83 and Table 2 on page 80. You need a controller no smaller than 30 hp (NEMA Size 3).

Step 6: Size the time-delay fuse (dual-element) for the starter just as you did in Step 3.

A 70A load requires a 70A fuse.

Step 7: Size the overloads.

Step 7a: Calculate current (nameplate rating) per Sec. 430-32(a)(1).

37A×125%=46.25A

Step 7b: Size the overloads per

Sec. 240-6(a) and Table 3 on page 80.

OLP=45A time-delay fuses

Backup OLP=50A time-delay fuses

OL relays as protection size H1046

Step 8: Size fuses for primary and secondary of control transformer.

Step 8a: Calculate primary current per Sec. 450-3(b).

150VA control transformer

150VA÷480V=0.3125A

0.3125A×250%=0.78125A

Step 8b: Size primary fuses per Sec. 240-6(a).

0.78125A use a 1A fuse. Note: You can use a smaller fuse, such as a 3/4A non-standard fuse.

Step 8c: Calculate secondary current per Sec. 450-3(b).

150VA control transformer

150VA÷120V=1.25A

1.25A×167%=2.0875A

Step 8d: Size secondary control transformer fuses per Sec. 240-6(a).

2.0875A requires a 1A fuse. Note: You can use a smaller fuse, such as a 2A non-standard fuse.

Step 9: Size the equipment grounding conductor (EGC) per Table 250-122. A 70A OCPD requires a No. 8 cu. conductor.

Step 10: Size the rigid conduit.

Step 10a: Find area, in sq. in., per Table 5, Ch. 9.

No. 6 THWN cu.=0.0507 sq. in.

No. 8 THWN cu.=0.0366 sq. in.

Step 10b: Calculate area, in sq. in., per Table 5, Ch. 9.

0.0507 sq. in.×3=0.1521 sq. in.

0.0366 sq. in.×1=0.0366 sq. in.

Total=0.1887 sq. in.

Step 10c: Size RMC per Table 4, Ch. 9.

0.1887 sq. in. requires ¾ in. not lead covered.

Note: You can use a larger conduit in this case.

Step 11: Size grounding electrode conductor (GEC). Because it has its own service, each pump requires a GEC.

Step 11a: Size the GEC per Table 250-66 or Section 250-66(a). No. 8 (per Table, requires conduit) or No. 6 (per Section) cu. conductors.

Step 12: Size the driven rod used as the grounding electrode, per Sec. 250-52(c)(2).

A $^{5}/_{8}$ in.×8 ft rod is required.

Now we've walked through the 12 steps for designing an electrical system to power an oil-well pumping unit motor. Remember, always start with the load. EC&M