GENERATOR SELECTION

Generators must be sized to handle their load based on the continuous KW, kilowatt load, and KVA, kilovoltamp load, and the worst case starting load KW + KVA. They must be derated for temperature and elevation. They are sized also on whether they are continuous or standby use. The following steps are used to obtain information:

1. Select System Voltage and Phase

    a. Three phase - 120/208V, 3 phase, 4W wye; 277/408, 3 phase, 4W wye;
    * 120/240V 3 phase, 4W Delta

    * Should not use on generator as it overloads 1 phase if there are large 120 volt loads.

    b. 120/208V, 3 phase, 4W- This is a good choice for a three phase system because you can balance 120 volt loads around the wye to equally load the generator. 208V single phase and 208V three phase loads can be used as well as 120V single phase loads. Motors must be rated 200 volt operation; 240 volt resistance heating equipment used on a 208V generator will only produce 75% of its rated KW output.

    c. 277/480, 3 phase, 4W- This voltage is usually used on large systems to reduce incoming service size, wire size and distribution equipment size. Fluorescent and other discharge lighting can be used at 277 volts. 480 volt single phase, 480V three phase, and 277 volt single phase loads can be used on this system. Also good for minimizing voltage drops on long runs. Disadvantages are that a step down transformer is required to get 120/208 or 120/240 volt power for lights and outlets. Motors should be started directly from the generator buss, not from a step down transformer to minimize voltage drop.

    d. 120/240V, 3 phase, 4 W Delta- This is the least desirable voltage to use if there is a large amount of 120 volt load. The generator can not be balanced and may overheat the windings. Advantages are 240 volt motors and equipment are more common than 200 volts.

    e. 120/240V, 1 phase, 3W This is the standard voltage for single phase systems. Motors are limited to 10HP maximum. Either 120 volts or 240 volts can be used to supply loads. 120 volt loads must be balanced across the generator L1 to N and L2 to N. Disadvantages are that single phase motors are more unreliable than three phase motors, especially capacitor start motors. The voltage drop is higher in single phase systems for a given load for the same wire size used in 3 phase systems.

2. <u>List Loads</u> (for each load, list the following)
    a. Voltage
    b. Phase
    c. Horsepower if motor, STARTING CODE LETTER
    d. Running KW, Running KW= starting KW if PF = 1
    e. Starting KW
    f. Running KVA, Running Power Factor
    g. Starting KVA, Starting Power Starting
    h. Motor full load amps from nameplate

See Table 2 Onan book for motor data

3. <u>Resistive Loads</u>

   Resistive loads consist of incandescent lights, water heaters, electric heaters, stoves, and electric furnaces. Power factor = 1, KW = KVA. Running and starting KW are the same.

4. <u>Motors and Inductive Loads</u>

   Motors are inductive loads with KVA always larger than KW. The power factor running usually is between 0.6 and 0.85.

$$P.F. = \frac{KW}{KVA}$$

$$KW = (KVA)\,(PF)$$

$$KVA = \frac{KW}{PF}$$

Determine locked rotor code letter from Table 2, A-R, for a given horsepower motor. If the motor is existing, use nameplate data. If this is a new installation, use shaded blocks in Table 2. Find starting KVA from Table 3. Find starting power factor from Table 2. Calculate KW starting = (KVA start) (PF start).

To find starting KVA if only locked rotor amps are known;

<u>1 phase</u>
KVA start = (locked rotor amps) (voltage)

<u>3 phase</u>
KVA start = $\sqrt{3}$ (locked rotor amps) (voltage)

For submersible water pumps only, use page 24-17,18 for motor data.

To find running KW and KVA if only full load current is known;

<u>1 phase</u>

KVA	=	(I full load current) (voltage)
Kwrun	=	(KVArun) (power factor running)

See Table 2 for given HP, $PF = \frac{KW}{KVA}$

5. <u>Voltage Dip</u>

Determine maximum percentage voltage dip. This is basically what sizes the generator. If voltage dip is too large, the motor will over heat or not start because there is not enough torque to accelerate the motor. Motor torque falls off approximately as the product of reduced squared. For example, with a 30% voltage dip resultant torque, it will be:

T= (.70 volts) 2 = .49 or 49% available torque.

Voltage dip is usually expressed as a percent dip of nominal voltage as measured by light beam oscillograph or pen recorder on the first cycle. This is the voltage dip due to the generator winding resistance before the regulator tries to make the voltage recover. This will last anywhere from 1 cycle to 30 cycles depending on the response of the generator. This voltage dip is usually called the initial or transient voltage dip. After the regulator makes the generator recover, there is a recovery voltage dip from 5 cycles until the motor reaches 70%-90% of synchronous speed.

The sustained voltage dip must be kept low enough to insure that relays and motor starter do not drop out.

6. <u>Voltage Dropout Problems on Motor Control Systems</u>

Recovery dip should be limited to 5% if there are control relays and motor starters unless special precautions are taken in the control system power supply. If the voltage dips low enough to drop out the starters, the motor starters will chatter, burning out the motor. There are three ways to prevent system oscillation.

a. Size generator for 5% initial voltage dip (RMS). This will result in a larger generator size.
b. On small systems where the generator is the only power source, utilize D.C. voltage from the generator battery as the control power.
c. If the generator is a standby unit, utilize a constant voltage transformer in the control system power supply, such as a Sola CVS. This will keep the voltage to the control relays to within 95% of nominal voltage with up to 30% dip on the primary.

7. Recovery Voltage Dip

This voltage dip occurs from 5-30 cycles after load is applied. This dip should be no more than 5%. This dip is not given in the manufacturers standard literature. Each application must be checked with the generator manufacturer.

8. Total Voltage Dip

The total voltage dip is the sum of the generator voltage dip and the voltage drop to the load on the conductors. This total should not exceed 10% on starting.

9. Resistive Voltage Dip

For resistive loads, the starting and running voltage dip in the conductors is the same. The formula for voltage drop is:

1 phase Voltage Drop
$Vd = 2(I)(Z)(L)$

I = Current Amps

Z = Total impedance – ohms per 1,000 feet of conductor

L = One way length of conductors – kilo feet

P.F. = Power Factor = 1.0 (use this when looking up Z)

Refer to Electrical Design/Operation Maintenance Manual R6-1980 (pages 8-1, 8-6 for voltage drop tables). Size feeders for resistive loads at 2% voltage drop.

3 phase Voltage Drop
$Vd = (\sqrt{3})(I)(Z)(L)$ P.F. = 1.0

$\% Vd = \frac{Vd (100)}{\text{Base volts}}$ Example: $\frac{2 \text{ volts} (100)}{240 \text{ volts}} = .8\%$

Use same tables for 1 phase, or 3 phase voltage drop.

Reactive Dip Example

Loads
Voltage: 120/240V, 1 phase
Resistive load: 2 KW, 240V; 1 KW, 120V; 1.5 KW, 120 volt.
Total resistive load:

$$I = \frac{2\ KW}{.23KV} = 8.7\ A \text{ on L1, and L2}$$

$$I = \frac{1\ KW}{.115\ KV} = 8.7\ A \text{ on L1}$$

$$I = \frac{1.5\ KW}{.115\ KV} = 13.04 \text{ on L2}$$

Total Resistance Load:

	L1	L2
2 KW	8.7A	8.7A
1 KW	8.7A	0
1.5 KW		13.04
	17.4	21.74

Use the 21 amps for sizing the generator. A voltage drop calculation normally does not need to be done if the generator is close to the distribution panel where the loads receive their power, say 25 feet or less. Conductors for loads must be sized for their ampacity, use NEC 310-16 first, then check for voltage drop.

For the 2KW load, 2 #12 Cu wire would be used with a 2 pole 15 amp breaker.

For the 1 and 1.5 KW loads 2 #12 Cu with a 1 pole 20 amp breaker would be used.

Refer to O&M Manual, Section 3 for sizing conductors.

These are the wire sizes for ampacity. Now check voltage drop. NEC ampacity tables do not take into account voltage drop.

Conductor Voltage Drop for Resistive Loads and Wire Sizes

I = 8.7A Length = 250 feet

#12 CU in conduit PF = 1

Vd = 2 I Z L from page 24-14 #12, Z = 1.62 / Kft.

Vd= (2) (8.7A) (1.62 /Kft.) (.25Kft.) = 7.04 volts

$$\%Vd = \frac{Vd\ 100}{\text{Base volts}} = \frac{(7.04V)\ (100)}{230V} = 1.92\%$$

So #10 is o.k. for voltage drop.

Motor Voltage Drop In Feeder Conductors

Motor 2HP, 230V, 1 Phase, code letter J, capacitor start, conductor length = 300 ft. Full load current from NEC table 430-148, I = 12 amp.

Onan Book, Table 2, 2 HP, Code J

Starting KVA = 16.4 KVA

Run KVA = 2.6 KVA

Start KW = (KVA start) (PF start) = (16.4) (.9) = 14.76 KW

Run KW = 1.8 KW

$$I_{start} = \frac{16.4\ KVA}{.23KV} = 71.30\ amp$$

Irun= 12 amp

$$Inrush = \frac{71.30\ amp\ start}{12\ amp\ run} = 5.9\ \text{times running current}$$

So if we size the wire for 1% voltage drop on running, we will have about a 6% voltage drop on starting. If this 6% voltage drop is added to the generator recovery voltage drop of 5%, the total overall voltage drop will be about 11%. NEMA says motors need 90% of voltage to start.

Size Conductors

$$Vd = 2\ I\ Z\ L$$

$$Z = \frac{Vd}{2\ I\ L} \qquad L = .3Kft.$$

Vd = 1% = (.01) (230V) = 2.3V

$$Z = \frac{2.3}{2(12\ amp)\ (.3\ Kft.)} = .319/\ Kft.$$

@ .8 P.F. running, page 8-4 O&M, CU wire #4, Z = .2365/Kft.
Voltage Drop for #4 CU
Vd = 2 I Z L = (2) (12) (.2365) (.3 Kft.) = 1.70V

$$\%\ Vd = \frac{(1.70V)\ (100)}{230V} = .74\%$$

Starting voltage drop (cable only) = (.74%) (5.9) = 4.14%

Sizing Gnerator

WHEW—We're finally at the good stuff. How do you size the generator itself? Well first of all, don't use the tables in the Onan book I just gave you. They do not cover voltage drop. Each case must be referred to the manufacturer to size the generator. If the generators are loaded to their maximum output indicated in the tables, there may be as much as 10% or more voltage dip without considering wire voltage drop which may not work with a system with motors. Anyway, on with the procedure:

1. Given Loads

   2HP, 230V, 1 phase, code J
   Start KVA = 16.4
   Run KVA = 2.6
   Start KW = 114.76 start P.F. = 0.8
   Run KW = 1.8

Resistance Loads – 4.5 KW, 230V, 1 phase
Assume resistance loads are balanced

2. Go to Onan Load Sheet, page 24-9; write down resistive loads on column 12 and 13, KW = KVA so entries are the same on line 1.

3. List motor loads with the worst case (largest load applied last) in order on the load form, line 2-16.

If a system manual motor start, starting largest motor first may reduce generator size. If other loads are already running and this starting sequence is not followed, the generator may be overloaded or motors may drop out or not start.

List the following items from Table 2, Onan Book, page 7 for each motor load:

   HP
   Starting Code Letter
   Volts
   Starting KVA, starting power factor
   Starting KW
   Running KVA
   Running KW

4. Column 10: Add column 6 to previous line column 12.
   Column 11: Add column 7 to previous line column 13.
   Column 12: Add column 8 to previous line column 12.
   Column 13: Add column 9 to previous line column 13.

5. Look at the largest numbers in columns 10, 11, 12 and 13. Generator output must be greater than these numbers.

   WARNING – THIS DOES NOT TAKE INTO ACCOUNT VOLTAGE DROP ON GENERATOR. CONSULT MANUFACTURER AT THIS POINT.

   Look at Example pages 24-9.

	10 Max. KVA	11 Max. KW	12 Cont. KVA	13 Cont. KW
	20.9	19.2	7.1	6.3
Onan generator 20ES	42	22	25	20

This applies to Onan only, other generators by other manufacturers have different characteristics.

In this case, a 20 KW generator would handle the continuous KVA and KW, and maximum KVA and KW. Refer to pages 3-6, Onan T-009 Generator Selection Guide.

Sizing for Submersible Water Pump Motors

Submersible water pump motors have a higher than normal locked rotor code letter and running current than Onan tables shown for average motors. The running current is higher than NEC 430-148 when run at their service factor amps. Use the following attached tables:

CUSTOMER ______ RECOMMENDED UNIT ______
ADDRESS ______ VOLTAGE ______ PHASE ______
CITY ______ STATE ______ ZIP ______ KW ______ KVA ______ PF ______
DERATINGS: Altitude ______
DEALER/DISTRIBUTOR ______ Fuel ______ Temperature ______
SALESMAN ______ RATING FOR APPLICATION - KW ______ KVA ______
ONAN REPRESENTATIVE ______ MAXIMUM VOLTAGE DIP ______

	MOTOR INFORMATION FROM MOTOR NAMEPLATE				REDUCED VOLTAGE MOTOR STARTING		MOTOR STARTING LOAD			MOTOR RUNNING LOAD		ACCUMULATED LOAD PLUS LOAD OF INCOMING STARTING MOTOR		ACCUMULATED LOAD		NOTES: NAME OF LOAD, VOLTAGE DIP, ETC.
	1	2	3	4	5		6	PF	7	8	9	10	11	12	13	
	HP	Code	φ	Volts	Tap	Mult.	KVAs		KWs	KVA	KW	Max. KVA Add 6 to 12	Max. KW Add 7 to 13	Cont. KVA Add 8 to 12	Cont. KW Add 9 to 13	
1														4.5	4.5	RESISTANCE LOAD
2	3	J	1	230			16.4	.8	14.76	2.6	1.8	20.9	19.2	7.1	6.3	Motor
3			Propane 20ES Gen 1Ø connect									42	22	25	20	
4				ASSUME RESISTANCE LOAD ON FIRST.												
5				THEN ADD MOTORS. IF motors CAN Come on												
6				at ANY time START LARGEST MOTOR LAST TO GIVE												
7				WORST CASE STARTING LOAD												
8				Generator must Be capable of providing												
9				maximum KVA and KW and ALSO BE LARGER												
10				than the continuous KVA & KW.												
11																
12				THE 20ES Propane Gen. is Large enough for continuous												
13				KW & KVA maximum KW, KVA												
14				Check with generator manufacturer												
15				for voltage drop and for MAX KW allowable.												
16																

8 BO 63

11

CUSTOMER ______________________

ADDRESS ______________________

CITY ____________ STATE ____________ ZIP ________

DEALER/DISTRIBUTOR ______________________

SALESMAN ______________________

ONAN REPRESENTATIVE ______________________

RECOMMENDED UNIT ______________________

VOLTAGE ____________ PHASE ____________

KW ____________ KVA ____________ PF ____________

DERATINGS: Altitude ______________________

Fuel ____________ Temperature ____________

RATING FOR APPLICATION - KW ____________ KVA ____________

MAXIMUM VOLTAGE DIP ______________________

	MOTOR INFORMATION FROM MOTOR NAMEPLATE				REDUCED VOLTAGE MOTOR STARTING		MOTOR STARTING LOAD			MOTOR RUNNING LOAD		ACCUMULATED LOAD PLUS LOAD OF INCOMING STARTING MOTOR		ACCUMULATED LOAD		NOTES: NAME OF LOAD, VOLTAGE DIP, ETC.
	1	2	3	4	5		6	PF	7	8	9	10 Max. KVA	11 Max. KW	12 Cont. KVA	13 Cont. KW	
	HP	Code	φ	Volts	Tap	Mult.	KVAs		KWs	KVA	KW	Add 6 to 12	Add 7 to 13	Add 8 to 12	Add 9 to 13	
1																
2																
3																
4																
5																
6																
7																
8																
9																
10																
11																
12																
13																
14																
15																
16																

Voltage Drop Equations

Voltage Drop Equations

$$\text{Voltage Drop}_{3\varnothing} = \sqrt{3}\, I\, (R \cos\theta + X \sin\theta)\, L$$

$$\text{Voltage Drop}_{1\varnothing} = 21\ (R \cos\theta + \sin\theta)\, L$$

Voltage Drop = in volts (V)
I = Current in Amperes (A)
R = Conductor Resistance in ohms/1000 ft.
X = Conductor inductive reactance in ohms/ 1000 ft.
L = One way length of circuit (source to load) in thousands of feet (K ft.)
Z = Complex impedance ohms/ 1000 ft. Obtain from Tables.
θ = Phase angle of load.

Cos θ = Power Factor: Motors see 6-5,6-6, .6-.8 is usual see 5-1 t0 5-8 for power factor calculations, also 8-2
Given Voltage Drop, Find wire size:

$$\text{Voltage Drop } 3\varnothing = \sqrt{3}\ I\ (Z)\ L$$

$$Z = \frac{\text{Voltage Drop}}{\sqrt{3}\ I\ L} = \frac{Vd}{\sqrt{3}\ IL}$$

$$\text{Voltage Drop } 1\varnothing = 2\ I\ (Z)\ L$$

$$Z = \frac{\text{Voltage Drop}}{\sqrt{2}\ I\ L} = \frac{Vd}{\sqrt{2}\ IL}$$

Procedure (Example)

1. Assume a voltage drop, say 2%, Base voltage 230V, 1∅ Vd = .02(230V) = 4.8 volts drop. Direct burial Copper.

2. Current and Distance must be known I = 30A, L = .56K Ft. = .56K Ft. Power Factor must be known, PF = .85

3. Solve for Z: Z = Vd/2IL = 4.8V/2 (30A) (.5K Ft.) = .16Ω/ K Ft.

4. Look up Z in tables at .16Ω/ K Ft, 85 P.F. Copper Direct burial in nonmagnetic conduit. #1 CU, Z = .16Ω/ K Ft ∴ smaller impedance so use #1 Always use wire with the next smaller impedance Z per 1,000 feet than that calculated.

Three Phase Voltage Drop

Example:

Three phase, Direct Burial Copper

1. Vd = $\sqrt{3}$ (I) (Z) (L)

2. Given: Voltage 230 V, 3 phase, load 5 KW P.F. = 1 heater, L = 480 ft., find wire size.

3. Assume a voltage drop, say 2%, base voltage, 230 volts. Voltage drop maximum = (.02) (230 volts) = 4.6 Volts. $I = \frac{5\ KW}{.23\sqrt{3}} = 21.7A$

Solve for Z:

$$Z = \frac{\text{Voltage Drop}}{\sqrt{3}\ IL} = \frac{4.6\ \text{Volts}}{\sqrt{3}\ (21.7A)\ (.48\ K\ FT)} = .0254\ \text{ohms/K FT.}$$

Look Z up in Table on voltage drop charts. @ P.F. = 1.0 Copper Direct Burial Table 75 degrees C. Use next smaller Z for wire size. Nonmagnetic conduit.
500 MCM = .0270 Ω/ KFT, 600 MCM = .023Ω/ KFT
Use 600 MCM because its impedance is less than that calculated.

Power Factor

$$PF = \cos\theta = \frac{KW}{KVA}$$

Given 10 KW, 12 KVA Load, find PF: $PF = \frac{10KW}{12\ KVA} = .83$

CONDUCTOR IMPEDANCES

POWER FACTOR

COPPER IN MAGNETIC CONDUIT 75C

WIRE SIZE	1.00	.95	.90	.85	.80	.75	.70	.65	.60	.55	.50	.45	.40	.35
14	3.062	2.932	2.788	2.642	2.494	2.346	2.197	2.047	1.897	1.747	1.596	1.445	1.293	1.142
12	1.932	1.858	1.771	1.681	1.590	1.498	1.406	1.313	1.219	1.125	1.031	0.936	0.841	0.746
10	1.214	1.176	1.125	1.071	1.016	0.960	0.903	0.846	0.788	0.730	0.672	0.613	0.554	0.495
8	0.811	0.793	0.762	0.729	0.694	0.658	0.621	0.584	0.546	0.509	0.470	0.432	0.393	0.354
6	0.510	0.505	0.488	0.469	0.449	0.427	0.405	0.383	0.360	0.337	0.314	0.290	0.266	0.242
4	0.321	0.324	0.316	0.306	0.294	0.282	0.269	0.256	0.243	0.229	0.215	0.200	0.186	0.171
3														
2	0.202	0.210	0.207	0.202	0.196	0.190	0.183	0.175	0.168	0.159	0.151	0.143	0.134	0.125
1	0.160	0.169	0.168	0.166	0.162	0.157	0.152	0.147	0.141	0.135	0.129	0.122	0.116	0.109
1/0	0.128	0.138	0.138	0.137	0.134	0.131	0.128	0.124	0.120	0.115	0.110	0.105	0.100	0.095
2/0	0.102	0.113	0.115	0.114	0.113	0.111	0.109	0.106	0.103	0.100	0.097	0.093	0.089	0.085
3/0	0.080	0.092	0.095	0.095	0.095	0.094	0.093	0.091	0.089	0.087	0.085	0.082	0.079	0.076
4/0	0.064	0.076	0.079	0.080	0.081	0.080	0.080	0.079	0.078	0.076	0.075	0.073	0.071	0.068
250	0.055	0.067	0.071	0.072	0.073	0.074	0.073	0.073	0.072	0.071	0.070	0.069	0.067	0.065
300	0.046	0.059	0.063	0.065	0.066	0.067	0.067	0.067	0.067	0.066	0.065	0.064	0.063	0.062
350	0.037	0.051	0.055	0.057	0.059	0.060	0.061	0.061	0.061	0.061	0.061	0.060	0.060	0.059
400	0.035	0.049	0.053	0.056	0.057	0.059	0.059	0.060	0.060	0.060	0.060	0.059	0.059	0.058
500	0.029	0.042	0.046	0.049	0.051	0.052	0.053	0.054	0.054	0.055	0.055	0.054	0.054	0.053
600	0.025	0.038	0.043	0.046	0.048	0.049	0.051	0.051	0.052	0.052	0.052	0.052	0.052	0.052
700														
750	0.021	0.034	0.038	0.041	0.043	0.045	0.046	0.047	0.048	0.049	0.049	0.049	0.049	0.049

CONDUCTOR IMPEDANCES

POWER FACTOR

WIRE SIZE	1.00	.95	.90	.85	.80	.75	.70	.65	.60	.55	.50	.45	.40	.35
14	3.062	2.927	2.782	2.634	2.485	2.336	2.186	2.036	1.885	1.734	1.583	1.431	1.280	1.128
12	1.932	1.854	1.765	1.673	1.581	1.488	1.395	1.301	1.207	1.112	1.018	0.923	0.828	0.732
10	1.214	1.172	1.118	1.063	1.007	0.950	0.892	0.834	0.776	0.718	0.659	0.600	0.540	0.481
8	0.811	0.789	0.756	0.721	0.684	0.648	0.610	0.572	0.534	0.496	0.457	0.418	0.379	0.340
6	0.510	0.501	0.482	0.462	0.440	0.418	0.396	0.373	0.349	0.326	0.302	0.278	0.254	0.229
4	0.321	0.320	0.310	0.299	0.287	0.274	0.260	0.247	0.233	0.218	0.204	0.189	0.174	0.159
3														
2	0.202	0.206	0.202	0.196	0.189	0.182	0.174	0.166	0.158	0.150	0.141	0.132	0.123	0.114
1	0.160	0.166	0.163	0.160	0.155	0.150	0.144	0.138	0.132	0.126	0.119	0.112	0.105	0.098
1/0	0.127	0.134	0.133	0.130	0.127	0.123	0.119	0.115	0.110	0.105	0.100	0.095	0.090	0.084
2/0	0.101	0.109	0.109	0.108	0.106	0.103	0.101	0.098	0.094	0.091	0.087	0.083	0.079	0.075
3/0	0.076	0.085	0.087	0.086	0.086	0.084	0.083	0.081	0.079	0.076	0.074	0.071	0.068	0.065
4/0	0.063	0.072	0.074	0.074	0.074	0.073	0.072	0.071	0.069	0.068	0.066	0.064	0.061	0.059
250	0.054	0.063	0.065	0.066	0.067	0.066	0.066	0.065	0.064	0.062	0.061	0.059	0.057	0.056
300	0.045	0.055	0.057	0.059	0.059	0.059	0.059	0.059	0.058	0.057	0.056	0.055	0.054	0.052
350	0.036	0.047	0.050	0.051	0.053	0.053	0.053	0.053	0.053	0.053	0.052	0.051	0.050	0.049
400	0.034	0.044	0.047	0.049	0.050	0.051	0.051	0.052	0.051	0.051	0.051	0.050	0.049	0.048
500	0.027	0.037	0.041	0.043	0.044	0.045	0.045	0.046	0.046	0.046	0.046	0.045	0.045	0.044
600	0.023	0.034	0.037	0.039	0.041	0.042	0.043	0.043	0.043	0.044	0.043	0.043	0.043	0.043
700														
750	0.019	0.029	0.032	0.035	0.036	0.038	0.039	0.039	0.040	0.040	0.040	0.040	0.040	0.040

COPPER IN NON MAGNETIC CONDUIT
OR DIRECT BURIAL
75C

CONDUCTOR IMPEDANCES

POWER FACTOR

ALUMINUM IN MAGNETIC CONDUIT 90C

WIRE SIZE	1.00	.95	.90	.85	.80	.75	.70	.65	.60	.55	.50	.45	.40	.35
14	5.054	4.817	4.571	4.323	4.075	3.825	3.575	3.325	3.074	2.823	2.572	2.321	2.070	1.818
12	3.186	3.043	2.890	2.736	2.580	2.424	2.268	2.111	1.954	1.796	1.638	1.481	1.322	1.164
10	2.000	1.916	1.823	1.727	1.631	1.535	1.437	1.340	1.242	1.144	1.045	0.947	0.848	0.749
8	1.258	1.211	1.155	1.097	1.038	0.978	0.918	0.857	0.797	0.736	0.674	0.613	0.551	0.489
6	0.847	0.821	0.785	0.747	0.709	0.670	0.630	0.590	0.550	0.510	0.469	0.428	0.387	0.346
4	0.532	0.521	0.500	0.478	0.455	0.432	0.408	0.383	0.359	0.334	0.309	0.284	0.258	0.233
3														
2	0.335	0.332	0.321	0.308	0.295	0.281	0.267	0.252	0.237	0.222	0.207	0.191	0.176	0.160
1	0.265	0.266	0.259	0.250	0.240	0.230	0.219	0.208	0.197	0.185	0.174	0.162	0.149	0.137
1/0	0.210	0.212	0.207	0.201	0.193	0.185	0.177	0.169	0.160	0.151	0.142	0.132	0.123	0.113
2/0	0.167	0.171	0.168	0.163	0.158	0.152	0.146	0.139	0.133	0.126	0.119	0.111	0.104	0.096
3/0	0.133	0.138	0.137	0.134	0.130	0.126	0.121	0.116	0.111	0.106	0.101	0.095	0.089	0.084
4/0	0.106	0.112	0.112	0.110	0.108	0.105	0.102	0.098	0.094	0.090	0.086	0.082	0.078	0.073
250	0.089	0.097	0.097	0.096	0.094	0.092	0.090	0.087	0.084	0.081	0.078	0.074	0.071	0.067
300	0.075	0.082	0.083	0.083	0.082	0.081	0.079	0.077	0.075	0.072	0.069	0.067	0.064	0.061
350	0.064	0.072	0.074	0.074	0.073	0.072	0.071	0.069	0.068	0.066	0.064	0.061	0.059	0.057
400	0.056	0.065	0.066	0.067	0.067	0.066	0.065	0.064	0.063	0.061	0.059	0.058	0.056	0.053
500	0.045	0.054	0.056	0.057	0.058	0.057	0.057	0.056	0.055	0.054	0.053	0.052	0.050	0.049
600	0.038	0.048	0.050	0.051	0.052	0.052	0.052	0.052	0.052	0.051	0.050	0.049	0.048	0.047
700	0.033	0.043	0.045	0.047	0.048	0.048	0.048	0.048	0.048	0.047	0.047	0.046	0.045	0.044
750	0.031	0.040	0.043	0.044	0.045	0.046	0.046	0.046	0.046	0.045	0.045	0.044	0.043	0.043

CONDUCTOR IMPEDANCES

ALUMINUM IN NON MAGNETIC CONDUIT OR DIRECT BURIAL 90C

	POWER FACTOR													
WIRE SIZE	1.00	.95	.90	.85	.80	.75	.70	.65	.60	.55	.50	.45	.40	.35
14	5.054	4.814	4.566	4.318	4.068	3.818	3.567	3.317	3.066	2.814	2.563	2.311	2.060	1.808
12	3.186	3.039	2.885	2.730	2.574	2.417	2.260	2.102	1.945	1.787	1.629	1.471	1.312	1.154
10	2.000	1.913	1.818	1.722	1.625	1.527	1.429	1.331	1.233	1.135	1.036	0.937	0.838	0.739
8	1.258	1.208	1.150	1.091	1.031	0.971	0.910	0.849	0.788	0.726	0.665	0.603	0.541	0.479
6	0.847	0.817	0.780	0.742	0.702	0.663	0.622	0.582	0.541	0.500	0.459	0.418	0.377	0.335
4	0.532	0.517	0.496	0.473	0.449	0.425	0.400	0.376	0.351	0.326	0.300	0.275	0.249	0.223
3														
2	0.335	0.329	0.317	0.304	0.290	0.275	0.260	0.245	0.230	0.215	0.199	0.183	0.167	0.151
1	0.265	0.262	0.253	0.243	0.233	0.221	0.210	0.198	0.187	0.174	0.162	0.150	0.138	0.125
1/0	0.210	0.210	0.203	0.196	0.188	0.179	0.171	0.162	0.153	0.143	0.134	0.124	0.115	0.105
2/0	0.167	0.168	0.164	0.159	0.153	0.147	0.140	0.133	0.126	0.119	0.112	0.104	0.097	0.089
3/0	0.133	0.137	0.135	0.132	0.128	0.124	0.119	0.114	0.109	0.104	0.098	0.092	0.087	0.081
4/0	0.105	0.109	0.108	0.105	0.102	0.099	0.095	0.091	0.087	0.083	0.079	0.074	0.070	0.065
250	0.089	0.094	0.093	0.092	0.089	0.087	0.084	0.081	0.078	0.074	0.071	0.067	0.063	0.060
300	0.074	0.080	0.080	0.079	0.077	0.075	0.073	0.071	0.068	0.066	0.063	0.060	0.057	0.054
350	0.064	0.068	0.068	0.067	0.065	0.064	0.062	0.060	0.058	0.055	0.053	0.050	0.048	0.045
400	0.056	0.062	0.063	0.063	0.062	0.061	0.060	0.058	0.057	0.055	0.053	0.051	0.049	0.046
500	0.045	0.051	0.053	0.053	0.053	0.052	0.051	0.051	0.049	0.048	0.047	0.045	0.044	0.042
600	0.038	0.045	0.046	0.047	0.047	0.047	0.047	0.046	0.045	0.044	0.043	0.042	0.041	0.040
700	0.033	0.040	0.041	0.042	0.043	0.043	0.043	0.042	0.042	0.041	0.040	0.039	0.038	0.037
750	0.030	0.037	0.039	0.040	0.041	0.041	0.041	0.040	0.040	0.039	0.039	0.038	0.037	0.036

4-inch Three Wire Submersible Water Well Motors
60 Hertz Representative Loading and Performance Data

Rated HP	Volts	PH.	Service Factor	Winding Number	Rated HP Input Amps	Rated HP Input Watts	Maximum Input (S.F. Load) Amps	Maximum Input (S.F. Load) Watts	Max. Thrust Load Pounds	Circ. Brk. or Std. Fuse	Dual Element Fuse	KVA Code	Locked Rotor Amps
1/4	115	1	1.85	334253	5.6	375	7.2	620	300	20	8	N	27.2
	230	1	1.85	334254	2.8	375	3.6	620	300	15	4	N	13.6
1/3	115	1	1.75	334255	7.0	500	8.9	770	300	25	10	N	32.8
	230	1	1.75	334256	3.5	500	4.4	770	300	15	5	N	16.4
1/2	115	1	1.6	334257	9.6	700	11.9	1040	300	30	15	M	46.0
	230	1	1.6	334258	4.8	700	5.9	1040	300	15	7	M	23.1
3/4	230	1	1.5	334260	6.4	980	8.0	1400	300	20	9	M	33.1
1	230	1	1.4	334261	8.0	1240	9.6	1700	400	25	12	L	42
1-1/2	230	1	1.3	334493	9.1	1680	11.5	2200	400	30	15	J	52
	230	1	1.3	334493	9.2	1740	11.6	2250	900	30	15	J	52
2	230	1	1.25	334602	10.0	2100	13.2	2800	900	35	15	G	51
3	230	1	1.15	334597	14.0	3150	16.5	3700	900	45	20	F	71
5	230	1	1.15	334517	23.0	5200	27.5	6100	900	80	30	F	118
1-1/2	200	3	1.3	334857	6.0	1520	7.3	2000	400	20	9	K	39
	200	3	1.3	334857	6.1	1570	7.4	2050	900	20	9	K	39
	230	3	1.3	334835	5.2	1520	6.3	2000	400	20	8	K	34
	230	3	1.3	334835	5.3	1570	6.4	2050	900	20	8	K	34
	460	3	1.3	334859	2.6	1520	3.1	2000	400	15	4	K	17
	460	3	1.3	334859	2.7	1570	3.2	2050	900	15	4	K	17
	575	3	1.3	334860	2.1	1520	2.5	2000	400	15	3	K	14
	575	3	1.3	334860	2.2	1570	2.6	2050	900	15	3	K	14
2	200	3	1.25	334814	8.0	2100	9.4	2630	900	25	10	L	53
	230	3	1.25	334603	7.0	2100	8.2	2630	900	20	10	L	46
	460	3	1.25	334815	3.5	2100	4.1	2630	900	15	5	L	23
	575	3	1.25	334816	2.8	2100	3.3	2630	900	15	4	L	18
3	200	3	1.15	333350	11.5	3130	13.1	3700	900	35	15	K	70
	230	3	1.15	332250	10.0	3130	11.4	3700	900	30	15	K	61
	460	3	1.15	334862	5.0	3130	5.7	3700	900	15	7	K	31
	575	3	1.15	332993	4.0	3130	4.6	3700	900	15	6	K	24
5	200	3	1.15	333381	17.5	5000	20.0	5800	900	50	25	K	120
	230	3	1.15	332251	15.2	5000	17.4	5800	900	45	20	K	104
	460	3	1.15	332903	7.6	5000	8.7	5800	900	25	10	K	52
	575	3	1.15	332994	6.1	5000	7.0	5800	900	20	8	K	42
7-1/2	200	3	1.15	334066	27.0	7700	30.8	9000	900	80	35	J	158
	230	3	1.15	333625	23.5	7700	26.8	9000	900	70	30	J	143
	460	3	1.15	333005	11.7	7700	13.4	9000	900	35	15	J	72
	575	3	1.15	333732	9.3	7700	10.7	9000	900	30	12	J	57
10	460	3	1.15	332992	15.6	10100	17.6	11700	900	45	20	K	108
	575	3	1.15	333734	12.5	10100	14.1	11700	900	40	20	K	86

6-Inch Submersible Water Well Motors
60 Hertz Representative Loading and Performance Data

Rated HP	Volts	PH.	Service Factor	Winding Number	Rated HP Input Amps	Rated HP Input Watts	Maximum Input (S.F. Load) Amps	Maximum Input (S.F. Load) Watts	Max. Thrust Load Pounds	Circ. Brk. or Std. Fuse	Dual Element Fuse	KVA Code	Locked Rotor Amps
5	230	1	1.15	332497	26.0	5070	29.5	5820	1500	80	35	E	99
7-1/2	230	1	1.15	332529	34.5	7300	40.0	8500	1500	100	45	D	145
10	230	1	1.15	334978	45.0	9800	52.0	11500	3500	150	60	F	223
5	200	3	1.15	333394	17.0	4800	19.1	5600	1500	50	25	J	103
	230	3	1.15	332517	14.8	4800	16.6	5600	1500	45	20	J	90
	460	3	1.15	334680	7.2	4800	8.3	5600	1500	25	10	J	45
	575	3	1.15	332679	5.9	4800	6.6	5600	1500	20	8	J	36
7-1/2	200	3	1.15	333395	24.2	7000	27.5	8200	1500	70	30	J	156
	230	3	1.15	332493	21.0	7000	23.9	8200	1500	70	30	J	136
	460	3	1.15	334681	10.5	7000	11.9	8200	1500	30	15	J	68
	575	3	1.15	332649	8.4	7000	9.5	8200	1500	25	12	J	54
10	200	3	1.15	333396	32.1	9600	36.8	11100	3500	100	40	K	235
	230	3	1.15	332475	27.9	9600	32.0	11100	3500	80	35	K	204
	460	3	1.15	334682	13.9	9600	16.0	11100	3500	40	20	K	102
	575	3	1.15	332650	11.1	9600	12.8	11100	3500	35	15	K	82
15	200	3	1.15	333359	47.2	13900	53.6	16100	3500	150	60	J	306
	230	3	1.15	332528	41.0	13900	46.6	16100	3500	125	60	J	266
	460	3	1.15	334683	20.5	13900	23.3	16100	3500	60	30	J	133
	575	3	1.15	332760	16.0	13900	18.6	16100	3500	50	25	J	106
20	200	3	1.15	333397	60.3	18300	70.2	21600	3500	200	80	J	430
	230	3	1.15	333230	52.4	18300	61.0	21600	3500	175	70	J	374
	460	3	1.15	334684	26.2	18300	30.5	21600	3500	80	35	J	187
	575	3	1.15	332790	21.0	18300	24.4	21600	3500	70	30	J	150
25	200	3	1.15	333398	74.8	22600	86.3	26100	3500	225	100	K	598
	230	3	1.15	333595	65.0	22600	75.0	26100	3500	200	90	K	520
	460	3	1.15	334685	32.5	22600	37.5	26100	3500	100	45	K	260
	575	3	1.15	333338	26.0	22600	30.0	26100	3500	80	35	K	208
30	200	3	1.15	333399	92.0	27000	105.8	31500	3500	300	125	J	662
	230	3	1.15	333310	80.0	27000	92.0	31500	3500	250	110	J	576
	460	3	1.15	334686	40.0	27000	46.0	31500	3500	125	50	J	288
	575	3	1.15	333416	32.0	27000	36.8	31500	3500	100	40	J	230
40	460	3	1.15	333183	51.5	36000	60.0	42000	3500	150	70	J	400
	575	3	1.15	333108	41.0	36000	48.0	42000	3500	125	60	J	320
50	460	3	1.15	333594	64.0	44000	75.0	52000	3500	200	90	K	520
	575	3	1.15	333500	53.5	44000	60.0	52000	3500	150	70	K	416

Table 430-150. Full-Load Current* Three-Phase Alternating-Current Motors

HP	Induction Type Squirrel-Cage and Wound-Rotor Amperes					Synchronous Type †Unity Power Factor Amperes			
	115V	230V	460V	575V	2300V	230V	460V	575V	2300V
½	4	2	1	.8					
¾	5.6	2.8	1.4	1.1					
1	7.2	3.6	1.8	1.4					
1½	10.4	5.2	2.6	2.1					
2	13.6	6.8	3.4	2.7					
3		9.6	4.8	3.9					
5		15.2	7.6	6.1					
7½		22	11	9					
10		28	14	11					
15		42	21	17					
20		54	27	22					
25		68	34	27		53	26	21	
30		80	40	32		63	32	26	
40		104	52	41		83	41	33	
50		130	65	52		104	52	42	
60		154	77	62	16	123	61	49	12
75		192	96	77	20	155	78	62	15
100		248	124	99	26	202	101	81	20
125		312	156	125	31	253	126	101	25
150		360	180	144	37	302	151	121	30
200		480	240	192	49	400	201	161	40

For full load currents of 208-volt and 220-volt motors, increase the corresponding 230-volt motor full-load current by 10 and 15 percent, respectively.

* These values of full-load current are for motors running at speeds usual for belted motors and motors with normal torque characteristics. Motors built for especially low speeds or high torques may require more running current, and multispeed motors will have full-load current varying with speed, in which case the nameplate current rating shall be used.

For 90 and 80 percent power factor the above figures shall be multiplied by 1.1 and 1.25 respectively. The voltages listed are rated motor voltages. The currents listed shall be permitted for system voltage ranges of 110 to 120, 220 to 240, 440 to 480, and 550 to 600 volts.

Table 430-148. Full load Currents in Amperes
Single-Phase Alternating- Current Motors

The following values of full-load currents are for motors running at usual speeds and motors with normal torque characteristics. Motors built for especially low speeds or high torques may have higher full-load currents and multispeed motors will have full-load current varying with speed, in which case the nameplate current ratings shall be used.
To obtain full load currents of 208-volt and 200-volt motors, increase corresponding 230-volt motor full-load currents by 10 and 15 percent, respectively.
The voltages listed are rated motor voltages. The currents listed shall be permitted for system voltage ranges of 110 to 120 and 220 to 240.

HP	115V	230V
1/6	4.4	2.2
1/4	5.8	2.9
1/3	7.2	3.6
1/2	9.8	4.9
3/4	13.8	6.9
1	16	8
1½	20	10
2	24	12
3	34	17
5	56	28
7½	80	40
10	100	50