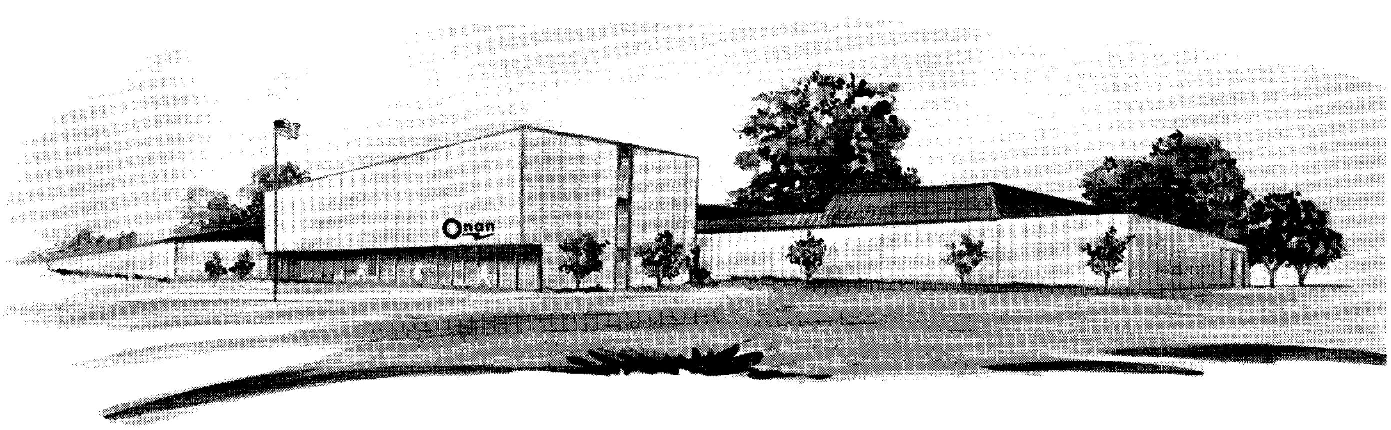
T-009

technical bulletin

SELECTING ONAN ELECTRIC GENERATING SETS FOR ELECTRIC MOTOR LOADS



ONAN 1400 73RD AVENUE N.E. • MINNEAPOLIS, MINNESOTA 55432

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INTRODUCTION

Due to initial cost of generator sets, the installation, and other equipment involved, it is extremely important to initially select the correct generator set. The information in this bulletin should simplify generator set selection and eliminate common errors in selection. The practical and theoretical information combined with practical experience of Onan distributors and dealers will enable the best selection of an Onan generator set for your application.

The information in this bulletin was compiled and is based on Onan designed generator sets only. Although the information may apply to other manufacturers' generator sets, we assume no responsibility for their application using the data in this bulletin.

When determining generator set size, consider the fact that electrical usage has a growth which doubles about every ten years. Select a generator set of adequate size for your anticipated future needs.

All information, illustrations and specifications contained in this manual are based on the latest product information available at the time of publication. Onan reserves the right to make changes at any time without notice.

Part I of the bulletin covers the detailed listing of motors, their power factor, starting and running kW's and kVA's, and Onan generator set ratings. Tables, sample selection problems, and a form for compiling data for the actual generator set selection are included.

Part II covers load applications when considering generator set selection. Phase unbalance and reduced voltage motor starting are just some of the subjects discussed.

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PART I

SELECTION OF GENERATOR SET

DESCRIPTION OF ONAN MOTOR STARTING FORM

MOTOR STARTING FORM

	MOTOR INFORMATION FROM MOTOR NAMEPLATE				REDUCED VOLTAGE MOTOR STARTING		MOTOR STARTING LOAD (Locked Rotor)			MOTOR RUNNING LOAD		ACCUMULATED LOAD PLUS NEXT MOTOR STARTED		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.	LRkVA		LRkW	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																
2																
3																

The following numbered paragraphs explain each of the first nine columns on the motor starting form above (above is reduced from actual form).

1. **MOTOR HORSEPOWER (HP)**
   The National Electrical Manufacturers Association (NEMA) lists standard horsepower ratings for induction motors. Except for certain motors, a standard horsepower rating found on the motor's nameplate will correspond with the data on Page 4.

2. **MOTOR CODE LETTER (CODE)**
   A code letter can be found on the nameplate of most alternating current motors. The letter is a code for starting kVA per horsepower. Starting kVA per horsepower has been compiled in Table 2 (next page).

   Don't confuse the code letter with the design letter. See CODE LETTER AND DESIGN LETTER in PART II.

3. **PHASE (Ø)**
   Both single phase and three phase motors are available in ratings up to 10 horsepower. However, motors 7-1/2 horsepower and larger are usually three phase.

4. **VOLTAGE**
   When listing the voltage, list the motor nameplate voltage and not the generator voltage.

5. **REDUCED VOLTAGE MOTOR STARTING**
   List the amount of voltage reduction in percent (%) tap. Use a 1.0 when across the line starting is used. An explanation of reduced voltage motor starting and examples are given in Part II of this bulletin.

6. **kVA STARTING (LRkVA)**
   Starting kVA required by a motor is found in Table 2 under the appropriate code letter column. For any motor of given horsepower and code letter, the locked rotor kVA draw is the same regardless of the phase, speed and voltage rating on the motor nameplate.

7. **kW STARTING (LRkW)**
   Locked rotor kW is determined by multiplying the locked rotor kVA by the motor locked rotor power factor (PF). The typical power factor for motors is listed in Table 2.

8. **MOTOR RUNNING (kVA)**
   The kVA for a running motor is the apparent power required by the motor at rated speed and load (Table 2).

9. **MOTOR RUNNING (kW)**
   The kW for a running motor is the real power required by the motor at rated speed and load (Table 2).

TABLE 1. REDUCED VOLTAGE MOTOR STARTING

STARTING METHOD	TAP	MULTIPLIER
Full Voltage	100	1.0
Autotransformer	80 65 50	0.64 0.42 0.25
Series Reactor or Resistor	80 65 50	0.80 0.65 0.50
Star Delta	33*	0.33*
Part Winding	66*	0.66*
Wound Rotor	**	**

* No standard values of kVA and torque are available. These are typical values and can be used only if the motor will reach run speed before transfer to run windings. Pleast contact motor supplier for information.

** See *Wound Rotor Motor* of *TYPICAL MOTOR STARTING SYSTEMS* in Part II.

STEP-BY-STEP PROCEDURE USING EXAMPLE PROBLEMS

The following step-by-step procedure shows how to fill out the motor starting form.

1. On the first line under "ACCUMULATED LOAD" (columns 12 and 13), list all the lighting and heater loads which are on the circuit before the motors are started. If no lighting or heater loads are on the circuit, list on line "1" the first motor started (as shown in Step 3).
2. List all other loads in the order they will be applied to the generator set. For the smallest generator set, the larger motors should be started first whenever possible. In automatic start applications, list the larger motors last.
3. In columns 1, 2, 3 and 4, enter the horsepower, code letter, phase and voltage of each motor. List the motors in the sequence they are started—use a separate line for each motor.
4. Decide on the generator set voltage needed (480-volt generator sets are used in samples). The different voltage combinations, the standard motor voltages, and generator set voltages are listed in Table 2A and 2B.

   Obtain the locked rotor kVA under the proper code letter for each motor. Enter this value in column 6 if across-line starting (examples 1, 2 and 5). When starting blocks of motors, total all in block and enter on a single line. See example 4.

   (287 LRkVA + 860 LRkVA = 1147 LRkVA)
5. For a motor utilizing a reduced voltage starter, enter the tap and multiplier in column 5. Enter the product of locked rotor kVA (from Table 2) times the multiplier in column 6. See example 3.

   (860 LRkVA x 0.42 = 361.2 LRkVA)
6. Multiply the locked rotor kVA (column 6) times the locked rotor power factor (PF) and enter this value in column 7—for examples 1, 2 and 3 only. For an application as example 4, multiply the locked rotor kVA times the locked rotor power factor for each motor. Add these two figures and enter in column 7. (287 LRkVA x 0.36 PF) + (860 LRkVA x 0.28 PF) = 103 LRkW + 241 LRkW = 344 LRkW (enter in column 7).
7. Obtain the running kVA and running kW for each motor from Table 2 when the actual value is unknown, and enter these values in columns 8 and 9 (examples 1, 2, 3 and 5). For example 4, add the running kVA and running kW of each motor and enter the totals in columns 8 and 9: 49 kVA + 140 kVA = 189 kVA, enter in column 8; 41 kW + 123 kW = 164 kW, enter in column 9.

DETERMINING MAXIMUM AND CONTINUOUS LOAD

The generator set selected must have the capability of supplying the maximum load during the starting for each motor and continuous load when the motors are running. Progressive totals of the accumulated load and the incoming motor's starting load will show the maximum kVA and kW demand during the time each motor is starting. Progressive totals of the accumulated load and the incoming motor's running load will show the continuous kVA and kW demand after each motor is running.

8. Start with the first motor; add the kVA from column 6 to the kVA from column 12 of the line above. Enter this total in column 10 (example 1, 860 kVA + 12 kVA = 872 kVA).
9. Start with the first motor; add the kW from column 7 to the kW from column 13 of the line above. Enter this total in column 11 (example 1, 241 kW + 12 kW = 253 kW).
10. Add the kVA from column 8 to the kVA from column 12 of the line above. Enter this total in column 12 (example 1, 140 kVA + 12 kVA = 152 kVA).
11. Add the kW from column 9 to the kW from column 13 of the line above. Enter this total in column 13 (example 1, 123 kW + 12 kW = 135 kW).
12. Repeat Steps 8 through 11 for each motor in turn. This completes the calculations.
13. Refer to Tables 4, 5, 6, 7, or 8. Select the table describing units of the phase and frequency used in the calculation. In the table, the columns which give the generator set ratings are numbered to correspond with the column number in the motor starting form. Circle the number which is the limiting factor in reducing the generator size. Select the smallest generator set which has the maximum kVA and kW capabilities, and continuous kVA and kW ratings equal to or greater than the circled numbers on the compilation form.

Consider additional capacity for future requirements when making the selection.

EXAMPLES

#1. Largest Motor First.
#2. Largest Motor Last.
#3. Reduced Voltage Motor Starting.
#4. Simultaneous Starting of all Motors.
#5. Sewage Lift Pump (low inertia).

Examples demonstrate how different applications with same HP motors can vary generator set selection.

Circle the value which prevents reducing the generator set to the next size.

CAUTION **A time delay, approximately 10 seconds minimum, is required between starting large motors.**

		MOTOR INFORMATION FROM MOTOR NAMEPLATE				REDUCED VOLTAGE MOTOR STARTING		MOTOR STARTING LOAD (Locked Rotor)			MOTOR RUNNING LOAD		ACCUMULATED LOAD PLUS NEXT MOTOR STARTED		ACCUMULATED LOAD		NOTES: NAME OF LOAD, VOLTAGE DIP, ETC.
		1	2	3	4	5		6		7	8	9	10	11	12	13	
		HP	Code	ϕ	Volts	Tap	Mult.	LRkVA	PF	LRkW	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														12*	12*	Largest motor first,
# 1	2	150	F	3	460		1	860	0.28	241	140	123	872	253	152	135	use only when on
	3	50	F	3	460		1	287	0.36	103	49	41	439	238	201	176	a manual starting
	4				Recommend 250.0 DFM								864	270	312	250	system.
	5																
	6																
	7														12*	12*	Largest motor last—
# 2	8	50	F	3	460		1	287	0.36	103	49	41	299	115	61	53	use on automatic
	9	150	F	3	460		1	860	0.28	241	140	123	921	294	201	176	demand systems.
	10				Recommend 300.0 DFS								950	310	375	300	Must have 10 sec.
	11																time delay between
	12																start.
	13														12*	12*	
# 3	14	50	F	3	460		1.0	287	0.36	103	49	41	299	115	61	53	Reduced voltage
	15	150	F	3	460	0.65	0.42	860×0.42 361.2	0.28	101	140	123	422	154	201	176	starting,
	16				Recommend 180.0 DFE								570	183	225	180	autotransformer.

* Resistive (lighting) loads.

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CUSTOMER ______________________ RECOMMENDED UNIT ______________________

ADDRESS ______________________ VOLTAGE ____________ PHASE ____________

CITY ____________ STATE ____________ ZIP ________ kW ________ kVA ________ PF ________

DATE ____________ 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 (Locked Rotor)			MOTOR RUNNING LOAD		ACCUMULATED LOAD PLUS NEXT MOTOR STARTED		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.	LRkVA		LRkW	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														12*	12*	All motors start
# 4	2	50	F	3	460		1	1147		344	189	164	1159	356	201	176	at same time. Add
	3	150	F	3	460		1										all LRkVA and all
	4				Recommend 450.0DFW								1200	485	562	450	LRkW.
	5																
	6																
	7																
	8														12*	12*	Sewage lift appli-
# 5	9	150	F	3	460		1	860	–	–	140	123	872	–	152	135	cation. Low inertia
	10	150	F	3	460		1	860	–	–	140	123	1012	–	292	258	motors. Disregard
	11				Recommend 400.0DFV								104[illegible]		500	400	max. kW columns
	12																7 and 11.
	13																
	14																
	15																
	16																

8B0 63

** Voltage dip is often measured using peak reading (light beam) instruments or average reading (pen recorder) instruments, neither of which gives actual RMS voltage values. The RMS voltage dip, which is the only meaningful value, must be derived from test data by complex calculations. If the actual RMS voltage dip must be precisely known, your Onan distributor will be glad to help.

TABLE 2. LOCKED ROTOR STARTING AND RUNNING MOTOR POWER REQUIREMENTS (AVERAGE VALUES)

HP	TYPICAL RUNNING AT 100% OF LOAD		PWR. FAC STARTING		LOCKED ROTOR (STARTING) KVA - 1φ OR 3φ. 50 OR 60 HERTZ — CODE LETTER															TYPICAL RUN AT 75% LOAD	
	KVA	KW	1φ	3φ	A	B	C	D	E	F	G	H	J	K	L	M	N	P	R	KVA	KW
.12	.40	.25	.80	.68	.38	.44	.49	.55	.62	.69	.77	.87	.98	1.10	1.23	1.38	1.54	1.72	1.95		
.25	.65	.40	.80	.68	.80	.91	1.02	1.15	1.30	1.43	1.61	1.82	2.05	2.30	2.57	2.87	3.20	3.53	4.06		
.33	.72	.45	.80	.68	1.05	1.20	1.35	1.52	1.70	1.90	2.13	2.40	2.70	3.04	3.40	3.78	4.23	4.73	5.36		
.50	.97	.60	.80	.68	1.60	1.81	2.04	2.30	2.60	2.87	3.22	3.63	4.08	4.60	5.14	5.73	6.41	7.17	8.11	.797	.46
.75	1.37	.85	.85	.68	2.39	2.72	3.06	3.45	3.85	4.30	4.83	5.44	6.12	6.90	7.70	8.60	9.62	10.74	12.17	.95	.55
1	1.6	.99	.80	.68	3.2	3.6	4.1	4.6	5.1	5.7	6.4	7.2	8.2	9.2	10.3	11.5	12.8	14.3	16.2	1.43	.76
1.5	2.2	1.45	.80	.68	4.8	5.5	6	6.9	7.7	8.6	9.7	10.9	12	14	15	17.3	19	22	24	1.9	1.1
2	2.6	1.8	.90	.68	6.4	7.3	8.2	9.3	10.3	11.5	13	14.6	16.4	18.5	21	23	26	29	33	2.3	1.4
3	3.7	2.8	.90	.60	9.6	10.9	12	13.9	15.5	17	19.4	21.9	24.6	27.7	31	34.6	38	43	49	3.6	2.2
5	5.4	4.8	.90	.60	16.0	18	20.4	23	25.8	28.8	32.4	36.5	41	46	52	57.7	64	72	82	4.2	3.4
7.5	8.4	6.5	.90	.55	24.0	27.5	30.5	34.5	39	43.5	48.5	55	61.5	69.5	77	86	97	108	122	6.9	5.0
10	10.7	8.7		.48	32	36	41	46	52	58	65	73	82	92	103	116	129	144	164	8.5	6.3
15	15.5	12.2		.47	48	55	61	69	78	87	97	110	123	138	155	173	194	217	245	12.2	9.0
20	19.9	16.6		.47	64	73	82	93	104	116	130	146	163	184	206	229	256	287	325	15.9	13.0
25	24.5	21		.42	80	92	102	116	130	145	162	183	205	230	257	287	320	358	409	20.5	15.4
30	29.5	26		.42	96	110	123	139	155	173	194	219	245	276	308	344	385	430	491	25.0	20.0
40	39.8	33		.40	128	145	164	186	208	232	258	290	327	368	411	459	513	573	653	32.0	24.6
50	49.4	41		.36	160	181	204	230	257	287	322	362	408	460	514	574	641	717	817	39.4	30.9
60	59	48		.35	191	217	246	276	308	344	386	435	490	552	617	688	770	860	982	47.3	37.3
75	73	62		.33	240	272	305	345	385	430	483	544	612	690	770	860	962	1075	1225	58.7	46.3
100	96	80.5		.30	319	362	409	460	514	573	644	725	817	920	1028	1147	1281	1433	1635	74.4	61.3
125	120	105		.29	400	452	510	575	642	717	805	905	1021	1150	1285	1433	1602	1790	2045	90.8	78.7
150	140	123		.28	479	543	613	690	771	860	966	1087	1225	1380	1540	1720	1922	2150	2450	105	90.8
200	183	164		.25	638	725	817	920	1030	1145	1287	1450	1633	1840	2055	2293	2563	2865	3270	141	122.7
250	223	202		.23	798	906	1021	1150	1285	1435	1610	1810	2042	2300	2568	2866	3205	3585	4055	170	151
300	280	246		.22	957	1086	1225	1380	1540	1720	1930	2175	2450	2760	3085	3440	3845	4300	4870	210	182
350	323	287		.21	1116	1268	1430	1610	1800	2010	2255	2535	2860	3220	3600	4015	4485	5015	5680	246	214
400	366	328		.20	1276	1449	1633	1840	2055	2300	2575	2900	3265	3680	4110	4585	5130	5735	6490	282	245
450	406	366		.19	1436	1630	1837	2070	2310	2585	2900	3260	3675	4140	4625	5160	5770	6450	7300	312	274
500	446	404		.18	1595	1812	2042	2300	2570	2870	3220	3625	4085	4600	5140	5735	6410	7165	8115	341	302

TYPICAL 1φ MOTOR, CAPACITOR-START

TYPICAL 3φ PROTECTED MOTOR 1800 RPM AND 3600 RPM

TYPICAL 3φ TOTALLY ENCLOSED 3600 AND 1800 RPM MOTORS OR MOTORS WOUND WITH ALUMINUM WIRE

STANDARD VOLTAGES FOR GENERATORS DIFFER FROM THE CORRESPONDING STANDARD VOLTAGES FOR MOTORS. THE TWO NEMA STANDARDS MG1-10.30 AND MG1-22.13 LIST MOTOR AND GENERATOR VOLTAGES AS SHOWN IN TABLE 2A. FOR THESE CORRESPONDING "STANDARD" VOLTAGES USE THE STARTING kVA AS SPECIFIED IN TABLE 2. IF CORRESPONDING VOLTAGES ARE "NON-STANDARD," MODIFY THE STARTING kVA BY THE MULTIPLICATION FACTOR GIVEN IN TABLE 2B.

TABLE 2A.

STANDARD VOLTAGES	
GENERATOR NAMEPLATE VOLTAGE	MOTOR NAMEPLATE VOLTAGE STAMPING
120	115
120 200 OR 208	200
240	230*
480	460
600	575

*PREVIOUS STANDARD VOLTAGE WAS 220 VOLTS SHOULD BE OPERATED ON 240 VOLTS WHENEVER POSSIBLE.

TABLE 2B.

FOR VOLTAGES OTHER THAN STANDARD		
FOR VOLTAGES OTHER THAN NORMAL		
GEN. VOLTS NAMEPLATE	MOTOR VOLTS NAMEPLATE	MULTIPLY TABLE 2 STARTING KVA BY
MOTOR VOLTAGE SAME AS GEN VOLT		0.9246
208 416	220 440	0.8939
240 480	220 440	1.1187

TABLE 3. MOTOR STARTING CAPABILITIES OF ONAN BRUSHLESS, REVOLVING FIELD GENERATOR SETS

DIESEL ENGINES, 3Ø, 60 HZ

GENERATOR SERIES	MODEL	MAXIMUM KVA COL. 10				MAXIMUM KW* COL. 11		RATED KVA COL. 12	RATED KW* COL. 13	MAX. KVA WHEN PURCHASED WITH A FULL POWER 1φ OPTION. COL. 10			
		3φ 120/208 240/416 120/2400 (YD)	3φ 127/220 254/440	3φ 139/240 277/480 347/600 120/2400 ΔUR & YB	1φ 120/240 (3φ GEN CONNECTED FOR 1φ)	STD (SEE T-017)	CITY WATER COOLED			3φ 120/208 240/416 120/2400 (YD)	3φ 127/220 254/440 120/2400 (UR)	3φ 139/240 277/480 347/600	1φ 120 240 (3φ GEN CONNECTED FOR 1φ)
YD	AIR COOLED												
YD	6.0 DJB	26	27	28	18	6.7		7.5	6.0	32	33	34	22
YD	12.0 DJC	43	44	45	32	13.4		15.6	12.5	48	50	52	37
YD	LIQUID COOLED												
YD	7.5 MDJE	32	33	34	22			9.4	7.5	38	39	40	27
YD	12.0 MDJC	43	44	45	32			15.6	12.5	48	50	52	37
YD	15.0 RDJC	48	50	52	37	15.7		18.7	15.0	54	55	56	42
YD	15.0 MDJF	48	50	52	37			18.7	15.0	54	55	56	42
YD	17.5 RDJF	54	55	56	42	17.5		21.8	17.5				
UR	30 DEH(MDEH)	90	102	115	75	33		37.5	30	162	178	189	125
UR	30 DDA					35							
UR	45 DEF	162	178	189	125	50		56	45	230	240	251	165
UR	45 DYJ					45							
UR	50 DEG(MDEG)	162	178	189	125	55		62.5	50	263	277	286	190
UR	50 DDB					55							
UR	60 DYA	230	240	251	165	66	67	75	60	336	347	357	235
UR	75 DYC	283	277	286	190	106	109	94	75	380	391	400	266
UR	90 DYC	297	309	318	210	106	109	112.5	90	432	440	450	300
UR	100 DYC	336	347	357	235	106	109	125	100	481	490	498	330
UR	125 DYD	432	440	450	300	141	144	156	125	520	526	530	350
UR	150 DYG	485	495	505	330	207	215	187	150				
UR	155 DFE	485	495	505	330	240	246	193	155				
UR	175 DYG	550	560	570	350	207	215	218	175				
UR	180 DFE	550	560	570	350	240	246	225	180				
YB	200 DFP	578	620	631	420	240	246	250	200				
YB	200 DYG					202	212						
YB	230 DFP	730	758	800	530	240	246	287	230				
YB	250 DYH	815	840	864	576	257	267	312	250				
YB	250 DFM					267	275						
YB	300 DFS	900	928	950	633	310	321	375	300				
YB	350 DFN	912	942	972	650	376	388	437	350				
YB	350 DHB					388	399						
UV	400.0 DFV	980	-	1040		461	475	500	400				
UV	450.0 DFW	1065	-	1200		461	475	562	450				
UV	500.0 DFY	1176	-	1370		521	534	625	500				
UV	600.0 DFX	1677	-	1780		625	-	750	600				
UV	750.0 DFZ	1960	-	2080		785	807	937	750				

*USE FOR MOTOR STARTING CALCULATION ONLY. THESE VALUES USUALLY MUST BE DERATED ABOVE 1000 FEET AND 80°F, SEE T-017

TABLE 4. MOTOR STARTING CAPABILITIES OF ONAN BRUSHLESS, REVOLVING FIELD GENERATOR SETS

DIESEL ENGINES, 1Ø AND 3Ø, 50HZ

GENERATOR SERIES	MODEL	MAXIMUM KVA COL. 10							OVERLOAD 2		CONTINUOUS 1	
		3φ	3φ	3φ	3φ	1φ	1φ	1φ				
						3φ GENERATOR CONNECTED 1φ						
	(YD) UR	110/190 Y 220/380 Y 110/220 Δ	115/200 Y 230/400 Y 115/230 Δ 110/220 Δ	120/208 Y 220/416 Y 120/240 Δ 115/230 Δ	127/220 Y 254/440 Y 120/240 Δ	110/220 ΔΔ 110 Δ 110/220 1φ	115/230 ΔΔ 115 Δ 115/230 1φ	120/240 ΔΔ 120 Δ 120/240 1φ	RATED KVA	RATED KW COL 11	RATED KVA COL 12	RATED KW COL 13
YD	AIR COOLED											
YD	4.5DJB-53CR	-	-	-	-	11	12	13	4.5	4.5	4.5	4.5
YD	4.5DJB-51BR	22	23	24	25	14	15	-	4.5	4.5	5.6	4.5
YD	9.0DJC-53CR	-	-	-	-	25	26	27	9.0	9.0	9.0	9.0
YD	9.0DJC-51BR	36	39	38	39	24	25	-	11.2	9.0	11.2	9.0
YD	LIQUID COOLED											
YD	6.0MDJE-53CR	-	-	-	-	14	15	16	6.0	6.0	6.0	6.0
YD	6.0MDJE-51BR	27	28	29	30	18	19	-	7.5	6.0	7.5	6.0
YD	10.0MDJC-53CR	-	-	-	-	25	26	27	10.0	10.0	10.0	10.0
YD	10.0MDJC-51BR	36	37	38	39	24	25	-	12.5	10.0	12.5	10.0
YD	12.5RDJC-53CR	-	-	-	-	30	31	32	12.5	12.5	12.5	12.5
YD	12.5RDJC-51BR	40	41	42	43	27	28	-	15.6	12.5	15.6	12.5
YD	12.0MDJF-53CR	-	-	-	-	30	31	32	12.0	12.0	12.0	12.0
YD	12.0MDJF-51BR	40	41	42	43	27	28	-	15.0	12.0	15.0	12.0
YD	14.5RDJF-53CR	-	-	-	-	33	34	35	14.5	14.5	14.5	14.5
YD	14.5RDJF-51BR	45	46	47	48	33	34	-	18.1	14.5	18.1	14.5
UR	25.0DEH(MDEH)	55	62	70	80	46	53		36.5	29.0	32.5	26.0
UR	25.0DDA	55	62	70	80	46	53		36.5	29.0	32.5	26.0
UR	37.5DEF	102	112	123	131	82	87		51.0	41.0	46.0	37.0
UR	37.5DYJ	102	112	123	131	82	87		51.0	41.0	46.0	37.0
UR	40.0DEG(MDEG)	102	112	123	131	82	87		55.0	44.0	50.0	40.0
UR	40.0DDB	102	112	123	131	82	87		54.0	43.0	49.0	39.0
UR	50.0DYA	153	160	167	173	111	115		66.0	53.0	60.0	48.0
UR	62.5DYC	174	183	192	200	126	132		86.0	69.0	79.0	63.0
UR	75.0DYC	200	206	214	220	140	146		100.0	80.0	91.0	73.0
UR	80.0DYD	226	233	240	248	160	165		118.0	94.0	106.0	85.0
UR	100.0DYD	295	300	305	312	203	208		138.0	110.0	125.0	100.0
UR	125.0DYG	328	336	344	351	229	234		173.0	138.0	158.0	126.0
UR	130.0DFE	328	336	344	351	229	234		179.0	143.0	163.0	130.0
UR	145.0DYG	375	382	389	396	259	264		173.0	138.0	158.0	126.0
UR	150.0DFE	375	382	389	396	259	264		206.0	165.0	188.0	150.0
YB	153.0DYG	374	401	430	436				211	169	191	153
YB	165.0DFP	374	401	430	439				228.0	182.0	206.0	165.0
YB	190.0DFP	487	506	526	555				245.0	196.0	223.0	178.0
YB	210.0DFM	550	566	583	600				275.0	220.0	250.0	200.0
YB	210.0DYB	550	566	583	600				248.0	198.0	225.0	180.0
YB	250.0DFS	606	625	644	660				338.0	270.0	306.0	245.0
YB	290.0DFN	612	633	654	675				398.0	318.0	360.0	288.0
YB	290.0DHB	612	633	654	675				336.0	269.0	305.0	244.0
UV	330.0DFV	722	760	785	810				458.0	366.0	416.0	333.0
UV	400.0DFW	833	876	905	934				503.0	402.0	456.0	365.0
UV	500.0DFX	1236	1300	1340	1380				650.0	520.0	591.0	473.0
UV	625.0DFZ	1444	1520	1570	1610				810.0	648.0	736.0	589.0

1) a. THE POWER LISTED FOR SETS UTILIZING THE UR, YB, UV SERIES GENERATORS IS THE POWER AVAILABLE FOR CONTINUOUS USE AT BRITISH STANDARD (B.S.) 649:1958 AND DEUTSCHES INSTITUT FOR NORMUNG (DIN) "CONTINUOUS OUTPUT A" 6270 STANDARD CONDITIONS. ALTHOUGH THESE STANDARD CONDITIONS ARE NUMERICALLY DIFFERENT, THEIR OVERALL EFFECT IS VIRTUALLY EQUIVALENT.

b. GENERATORS ARE APPLIED AT MAXIMUM CONTINUOUS RATING (MCR) OF B.S. 2613:1970 AND INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC) PUBLICATION 34-1. IEC PUBLICATION 34-1 IS EQUIVALENT TO VERBAND DEUTSCHER ELEKTROTECHNIKER (VDE) 0530 TEIL 1/11.72.

2) a. THE POWER LISTED FOR SETS UTILIZING THE UR, YB, UV SERIES GENERATORS IS THE POWER AVAILABLE FOR 1 HOUR IN 12 HOURS AT B.S. 649:1958 AND DIN 6270 STANDARD CONDITIONS. THIS RATING IS AT LEAST 110% OF THE CONTINUOUS RATING.

TABLE 5. MOTOR STARTING CAPABILITIES OF ONAN BRUSHLESS, REVOLVING FIELD GENERATOR SETS

GASOLINE OR GASEOUS FUELED ENGINES, 3∅, 60HZ

GENERATOR SERIES	MODEL	MAXIMUM KVA COL. 10				MAXIMUM KW* COL. 11				RATED KVA COL. 12	RATED KW* COL. 13	MAX KVA (WHEN PURCHASED WITH FULL POWER 1φ OPT) COL. 10			
		3φ 120/208 240/416 [120/2400 (YD)]	3φ 127/220 254/440 [120/2400 (UR)(YB)]	3φ 139/240 277/480 347/600	1φ 120/240 WHEN 3φ GEN CONNECTED FOR 1φ	GASOLINE	PROPANE —— SEE T-017 ——	NAT. GAS	CITY WATER COOLING ADD THIS KW			3φ 120/208 240/416 [120/2400 (YD)]	3φ 127/220 254/440 [120/2400 (UR)(YB)]	3φ 139/240 277/480 347/600	1φ 120/240 WHEN 3φ GEN CONNECTED FOR 1φ
	AIR COOLED														
	7.5JB	32	33	34	22	8.0	7.8	7.5	-	9.4	7.5	38	39	40	27
	12.5JC	43	44	45	32	17.0	16.0	13.5	-	15.6	12.5	48	50	52	37
	15.0JC	48	50	52	37	17.0	16.0	13.5**	-	18.7	15.0	54	55	56	42
	LIQUID COOLED														
YD	10.0MJC	38	39	40	27	17	NA	NA		12.5	10.0	43	44	45	32
YD	12.5RJC	43	44	45	32	17	16.5	16	-	15.6	12.5	48	50	52	37
YD	15.0MJC	48	50	52	37	17	NA	NA		18.7	15.0	54	55	56	42
YD	15.0RJC	48	50	52	37	17	16.5	16	-	18.7	15.0	54	55	56	42
YD	30 SK	100	112	125	75	37.0	33.5	26.8	-	37.5	30.0	150	168	187	110
UR	30 EK	90	102	115	75	33	31	28	-	37.5	30.0	162	178	189	125
UR	45 EM	162	178	190	125	48	45	39	-	56.0	45.0	230	240	251	165
UR	55 EN	195	210	220	146	78	65	55	3.0	68.0	55.0	297	309	318	212
UR	55 KB	195	210	220	146	65	58	52	3.0	68.0	55.0	297	309	318	212
UR	65 KB	230	240	250	165	65	NA	NA	3.0	81.0	65.0	336	347	357	235
UR	70 EN	263	277	286	190	78	NA	NA		87.0	70.0	380	391	400	266
UR	85 KR	297	309	318	210	93	85	77**		106.0	85.0	432	440	450	300
UR	115 WA	380	391	400	266	120	119	118	3.0	143.0	115.0	520	526	530	350
UR	170 WB	520	526	530	350	185	180	174**	10	212.0	170.0				
UV→YB	250 FT	815	840	846	576	NA	NA	260	10	312.0	250.0				
UV→YB	350 WF	912	942	972	650	NA	NA	390	20	437.0	350.0				
UV→YB	400 WK	980	-	1040		NA	NA	480	20	500.0	400				

* USE FOR MOTOR STARTING CALCULATIONS ONLY. SEE T-017 FOR ALTITUDES ABOVE 1000 FEET AND FUEL DERATINGS.

** HIGH COMPRESSION HEAD WILL INCREASE THIS VALUE SEE T-017.

TABLE 6. MOTOR STARTING CAPABILITIES OF ONAN BRUSH-TYPE, REVOLVING ARMATURE GENERATOR SETS (1Ø & 3Ø, 50 & 60HZ)

6A. SPARK IGNITION ENGINES (60 Hz)

	MODEL	PHASE	MAXIMUM KVA COL. 10	MAXIMUM KW GASO COL. 11	MAXIMUM KW PROPANE - SEE T-017 - COL. 11	MAXIMUM KW NAT'L GAS COL. 11	RATED KVA COL. 12	RATED KW COL. 13
AJ	AIR COOLED							
	1.0AJ	1	2.3	1.1	-	-	1.0	1.0
	1.5AK	1	2.6	1.6	-	-	1.5	1.5
	2.5AJ	1	4.4	2.5	-	-	2.5	2.5
	2.5AJ*	1	6.0	2.5	2.4	2.3	2.5	2.5
	2.7AJ	1	5.8	2.7	-	-	2.7	2.7
UN	2.5LK	1	5.8	2.6	2.5	2.1	2.5	2.5
	4.0CCK	1	8.0	4.8	4.7	4.3	4.0	4.0
	4.0CCK	3	9.6	4.8	4.7	4.3	4.0	4.0
	5.0CCK	1	12.5	5.2	5.0	4.6	5.0	5.0
	5.0CCK	3	14.0	5.2	5.0	4.6	5.0	5.0
	6.5NH	1	14.0	6.8	5.8	4.8	6.5	6.5
	6.5NH	3	16.0	6.8	5.8	4.8	6.5	6.5
CCKB	10.0CCKB	1	16.0	10.2	9.5	8.0	10.0	10.0
	10.0CCKB	3	16.0	10.2	9.5	8.0	10.0	10.0
UN/AJ	LIQUID COOLED				NOT AVAILABLE			
	3.0MAJ	1	6.0	3.0			3.0	3.0
	4.0MCCK	1	9.6	5.0			4.0	4.0
	6.5MCCK	1	12.5	6.5			6.5	6.5
YCB	AIR COOLED							
	1.2TM	1			SEE TABLE 7		1.2	1.2
	1.7TN	1					1.7	1.7
	2.0TP	1					2.0	2.0
	3.0TR	1					3.0	3.0
	4.5TS	1					4.5	4.5
	5.5TT	1					5.5	5.5

* Electric Start Model.

6B. SPARK IGNITION ENGINES (50 Hz)

	MODEL	PHASE	MAX KVA COL. 10	MAX KW COL. 11	RATED KVA COL. 12	RATED KW COL. 13
AJ	AIR COOLED					
	1.2AR	1	2.1	1.2	1.2	1.2
	2.0AJ	1	3.7	2.0	2.0	2.0
	2.0AJ*	1	5.0	2.0	2.0	2.0
	1.7LK	1	4.0	1.7	1.7	1.7
	3.5CCK	1	6.0	3.5	3.5	3.5
UN	4.2CCK	1	8.0	4.2	4.2	4.2
	4.2CCK	3	9.0	4.2	4.2	4.2
	5.5NH	1	11.0	5.5	5.5	5.5
	5.5NH	3	13.0	5.5	5.5	5.5
UN	LIQUID COOLED					
	3.5MCCK		6.0	3.5	3.5	3.5
	5.5MCCK		9.0	5.5	5.5	5.5
YCB	AIR COOLED					
	1.0TM	1	1.6	1.0	1.0	1.2
	1.4TN	1	2.8	1.4	1.4	1.4
	1.6TP	1	2.9	1.6	1.6	1.6
	2.5TR	1	4.6	2.5	2.5	2.5
	3.7TS	1	6.8	3.7	3.7	3.7
	4.5TT	1	10.0	4.5	4.5	4.5

6C. DIESEL ENGINES

	MODEL	HZ	PHASE	MAXIMUM KVA COL. 10	MAXIMUM KW COL. 11	RATED KVA COL. 12	RATED KW COL. 13
CCK	AIR COOLED						
	2.5DJA	50	1	5.0	2.5	2.5	2.5
	3.0DJA	60	1	6.0	3.0	3.0	3.0
	LIQUID COOLED						
	2.5MDJA	50	1	5.0	2.7	2.5	2.5
	3.0MDJA	60	1	6.0	3.2	3.0	3.0

CAUTION On revolving armature generator sets, maximum kVA in column 10 is not a true value but an equivalent we use to permit standardization on unit selection procedures. It is what the generator set would appear to produce if it could maintain rated voltage under motor starting conditions. Actually, the voltage will dip to about 70 percent of rated value resulting in about 50 percent reduction of kVA during motor starting. Similar to reduced voltage starters, this permits starting relatively larger motors. Remember, the starting torque of the motor is proportional to the kVA input and reducing it by 50 percent will cut the stalled torque in half. This may cause some problems if the motor must start while it is heavily loaded (compressors, piston pumps, conveyors, etc.). For such cases, it may be necessary to select the next size larger generator set.

TABLE 7. DETERMINING SET SIZE WHEN LOADS ARE SMALL SINGLE-PHASE MOTORS*

MOTOR HP RATING	APPROXIMATE RUNNING WATTS	MINIMUM WATTAGE RATING OF GENERATOR SET REQUIRED**			
		UNIVERSAL MOTOR	REPULSION INDUCTION MOTOR	CAPACITOR MOTOR	SPLIT PHASE MOTOR
1/6	275	400	600	600	1000
1/4	400	500	850	800	1500
1/3	500	600	950	1200	2000
1/2	700	750	1300	1500	2500
3/4	950	1000	1900	2100	
1	1200	1200	2300	2500	
1-1/2	1600	1750	3200	3200	
2	2200	2300	3900	3500	
3	3200		5200	4200	

* Use next size larger generator set for **hard-starting loads such as compressors, residential air conditioners,** freezers, etc.

** For applications with only one motor load, this would equal minimum generator set size.

NOTE: Do not use this table for mobile type air conditioners. Contact the factory or distributor.

Calculation

Lighting Load	+	Approx. Watts of Motors Running	+	Minimum Starting Watts of Last Motor Started	=	Minimum Size Continuous Rating of Generator Set

Sample

1000 Watts (Lights)	+	700 Running Watts (½ HP Fan Motor)	+	2100 Starting Watts (¾ HP Capacitor Start Motor)	=	3800 Watts Total Load	⇨	Recommended Minimum Size Generator Set *4000 Watts*

TABLE 8. ONAN PTO ALTERNATOR (60 Hz, 1∅ AND 3∅) MOTOR STARTING CAPABILITIES

MODEL	MAXIMUM kVA Col. 10	MAXIMUM* kW Col. 11	RUN kVA Col. 12	RUN* kW Col. 13	Minimum HP Input for Proper Performance	PTO RPM	PHASE	VOLTAGE	POWER FACTOR	AMPERE at 240 V
15.0 UF-3S/	22.5§	15.0	15.0	15.0	30	540	1	120/240	1.0	62.5
15.0 YD-3G/	37.5	15.0	15.0	15.0	30	540	1	120/240	1.0	62.5
20.0 YD-3G	52.0	20.0	20.0	20.0	37	540	1	120/240	1.0	83.3
20.0 YD-5DG	57.5	20.0	25.0	20.0	37	540	3	120/240D	0.8	60.0
25.0 UT-3S/	37.5	25.0	25.0	25.0	45	540	1	120/240	1.0	104.0
25.0 UT-5DS/	37.5	25.0	31.2	25.0	45	540	3	120/240D	0.8	75.0
25.0 YD-3G/	62.5	25.0	25.0	25.0	45	540	1	120/240	1.0	104.0
25.0 YD-5DG/	70.0	25.0	31.2	25.0	45	540	3	120/240D	0.8	75.0
30.0 YD-3G	80.0	30.0	30.0	30.0	55	540	1	120/240	1.0	125.0
30.0YD-5DG	95.0	30.0	37.5	30.0	55	540	3	120/240D	0.8	90.0
45.0 UR-3G/	120.0	45.0	45.0	45.0	82	1000	1	120/240	1.0	187.5
45.0 UR-5DG/	165.0	45.0	56.2	45.0	82	1000	3	120/240D	0.8	135.5
65.0 UR-3G/	163.0	65.0	65.0	65.0	120	1000	1	120/240	1.0	271.0
65.0 UR-5DG/	208.0	65.0	81.2	65.0	120	1000	3	120/240D	0.8	195.5
80.0 UR-5DG	300.0	80.0	100.0	80.0	145	1000	3	120/240D	0.8	241.0

* This value will be lower (or higher) if tractor HP is less (or more) than value in minimum HP column.

§ With boost field, value is 25.4 kVA.

PART II

THEORY AND PROBLEMS ASSOCIATED WITH COMMON LOAD APPLICATIONS

CODE LETTER AND DESIGN LETTER

All standard motors which meet NEMA (National Electrical Manufacturers Association) MG1-10.36 specifications have the locked rotor kVA printed on the nameplate in the form of a code letter. For example, a 15 HP motor with 105 locked rotor amperes at 460 volts and 210 locked rotor amperes at 230 volts would have a code letter "F" in both cases.

The NEMA letter designations for locked rotor kVA/HP as measured at full voltage and rated frequency are as shown below.

CAUTION **Do not confuse the code letter with the design letter. A design letter is the NEMA designation denoting the torque versus speed characteristics (Figure 1). The design letter is not associated with the locked rotor kVA.**

Letter Designation	kVA per Horsepower	*Average kVA/HP
A	0- 3.15	2.95
B	3.15- 3.55	3.35
C	3.55- 4.0	3.77
D	4.0 - 4.5	4.25
E	4.5 - 5.0	4.75
F	5.0 - 5.6	5.30
G	5.6 - 6.3	5.95
H	6.3 - 7.1	6.70
J	7.1 - 8.0	7.55
K	8.0 - 9.0	8.50
L	9.0 -10.0	9.50
M	10.0 -11.2	10.60
N	11.2 -12.5	11.85
P	12.5 -14.0	13.25
R	14.0 -16.0	15.00
S	16.0 -18.0	17.00
T	18.0 -20.0	19.00
U	20.0 -22.4	21.20
V	22.4 and up	

* Average of NEMA values is used by Onan as basis for values used in Table 2. The above chart, however, is based upon generator voltage being equal to motor voltage. Therefore, a 0.9246 factor is utilized (per Table 2B) to arrive at values for Table 2.

TYPICAL MOTOR STARTING SYSTEMS*

FULL VOLTAGE MOTOR STARTING

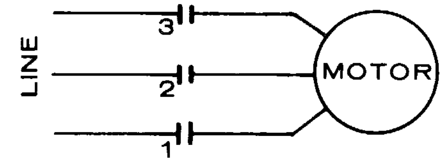
STARTING

Full voltage starting should always be used unless limited capacity of the generator set makes reduced kVA starting necessary or reduced voltage dip is required during motor starting. There is no limit to the HP, size, voltage rating or type of motor.

APPLICATION NOTES

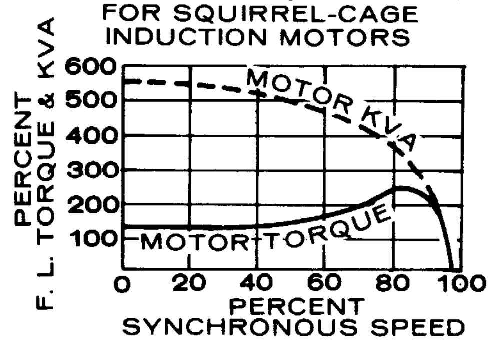
Across-the-line, full voltage starting most commonly used due to simplicity, reliability, and initial low cost. Note on kVA and torque curves that starting kVA remains fairly constant until motor almost reaches full speed.

STARTING DIAGRAM PRIMARY CONNECTIONS



START: CLOSE 1-2-3
RUN: NO CHANGE

TYPICAL KVA AND TORQUE CURVES FOR SQUIRREL-CAGE INDUCTION MOTORS



AUTOTRANSFORMER MOTOR STARTING, OPEN TRANSITION

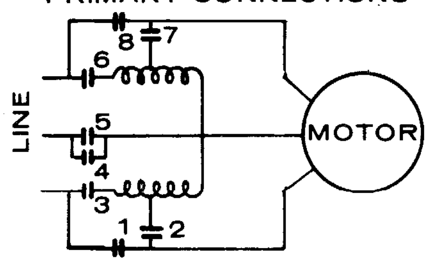
STARTING

Only in the circuit during starting, the autotransformer reduces voltage to the motor. Opening of the circuit during transition permits the possibility of relatively severe transients and could cause nuisance tripping of circuit breakers.

APPLICATION NOTES

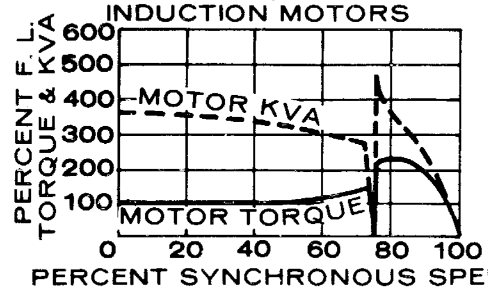
Open transition types of reduced voltage starters should be avoided for generator set applications particularly when the motor is not up to full speed at time of transition. When the switch opens for transition, the motor slows down so that when the switch closes on the run winding, the motor is not synchronized. The resulting transients are similar to paralleling generators out of phase. The kVA drawn immediately after switching to the line could exceed starting kVA. Autotransformers lower power factor during starting.

STARTING DIAGRAM PRIMARY CONNECTIONS



START:CLOSE 2-3-5-6-7
RUN: OPEN 2-3-5-6-7 CLOSE 1-4-8

TYPICAL KVA AND TORQUE CURVES FOR SQUIRREL-CAGE INDUCTION MOTORS



* **Typical curves are shown for descriptions of motor starting methods only. Do not use curves for calculations.**

AUTOTRANSFORMER MOTOR STARTING, CLOSED TRANSITION

STARTING

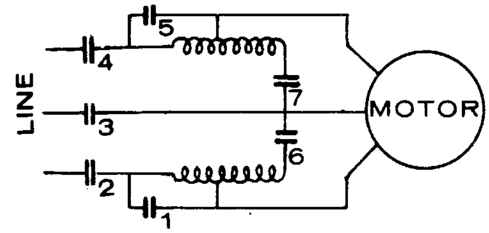
Circuit is not interrupted during starting. On transfer, part of autotransformer winding remains in the circuit as a series reactor with the stator winding.

APPLICATION NOTES

Preferred to open type because it minimizes the electrical disturbance, but more expensive and more complex due to three switching elements.

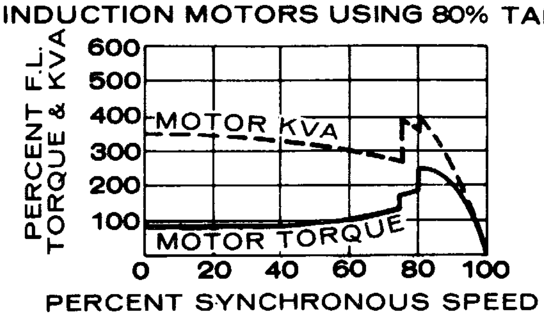
Can have automatic or remote operation. Most commonly used of reduced voltage starting types, principally for large motors with low-load torque requirements such as M-G sets, sewage lift pumps, and chillers. Principle advantage is more torque per current than other types of reduced voltage starters. Lowers power factor during starting.

STARTING DIAGRAM
PRIMARY CONNECTIONS



START: CLOSE 6-7 AND 2-3-4
TRANSFER: OPEN 6-7 RUN: CLOSE 1-5

TYPICAL KVA AND TORQUE CURVES FOR SQUIRREL-CAGE INDUCTION MOTORS USING 80% TAP



REACTOR MOTOR STARTING, CLOSED TRANSITION

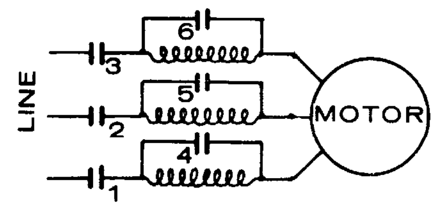
STARTING

Reactor starting, used for large motors, has advantage of simplicity and closed transition, but gives lower starting torque per kVA drawn from the line than with autotransformer starting. Relative torque does improve, however, as the motor accelerates.

APPLICATION NOTES

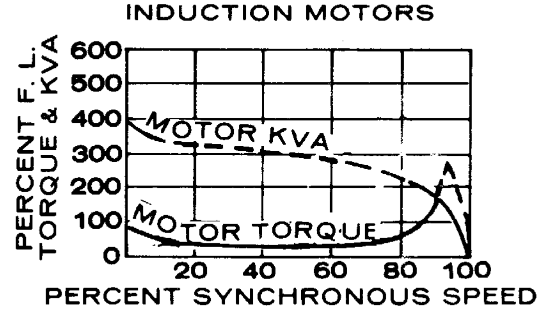
Generally not used except in high voltage or high current installations. Exceptional low power factor. Generally, reactor starting costs more for small motors than autotransformer starting, but it is usually simpler and less expensive for large motors. The basic problem is the reactor must be sized for each HP and voltage, and so usually are not as readily available. Reactor starting has a rising characteristic and allows a smooth start with almost no observable disturbance on transition. Suits well for applications such as centrifugal pumps or fans.

STARTING DIAGRAM
PRIMARY CONNECTIONS



START: CLOSE 1-2-3
RUN: CLOSE 4-5-6

TYPICAL KVA AND TORQUE CURVES FOR SQUIRREL-CAGE INDUCTION MOTORS



RESISTOR MOTOR STARTING, CLOSED TRANSITION

STARTING

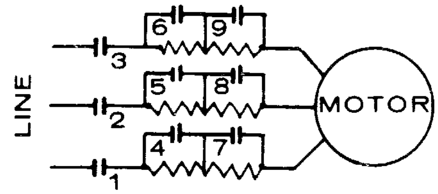
Resistor starting is occasionally used for smaller motors where several steps of starting are required and no opening of motor circuit between steps is allowed.

APPLICATION NOTES

Also available as a stepless transition starter which provides a smoother start. Resistor starting is usually the least expensive with small motors. Has a higher starting power factor. When actual power factor isn't known, use table. Accelerates loads faster because the voltage increases with a decrease in current.

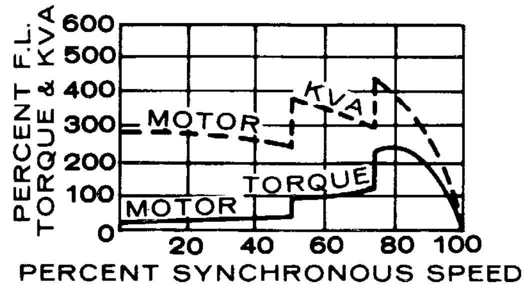
TAP	USE P.F.
80%	0.6
65%	0.7
50%	0.8

STARTING DIAGRAM
PRIMARY CONNECTIONS



START: CLOSE 1-2-3
SECOND STEP: CLOSE: 4-5-6
THIRD STEP: CLOSE 7-8-9

TYPICAL KVA AND TORQUE CURVES
FOR SQUIRREL-CAGE
INDUCTION MOTORS USING 50% TAP



STAR-DELTA MOTOR STARTING, OPEN TRANSITION

STARTING

Star-delta starting requires no autotransformer, reactor or resistor. The motor starts as a star-connected motor and runs delta connected.

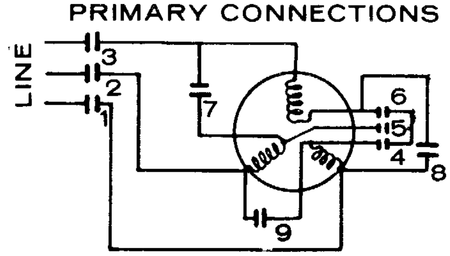
APPLICATION NOTES

This starting method is becoming more popular where low starting torques are accepted. Has the following disadvantages:

1. Open transition; closed transition available at extra cost.
2. Low torque.
3. No advantage when motor is powered by generator set unless motor reaches synchronous speed before switching to run winding.

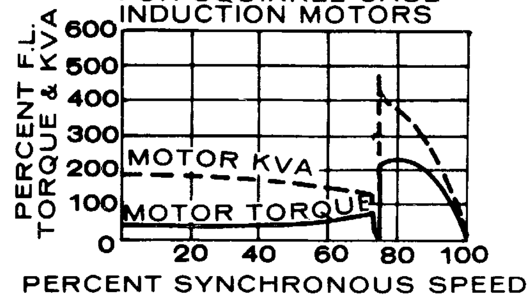
   In applications where motor does not reach synchronous speed before switching to run winding, generator set must be sized to meet surge.

STARTING DIAGRAM
PRIMARY CONNECTIONS



START: CLOSE 1-2-3-4-5-6
RUN: OPEN 4-5-6
CLOSE 7-8-9

TYPICAL
KVA AND TORQUE CURVES
FOR SQUIRREL-CAGE
INDUCTION MOTORS



PART WINDING MOTOR STARTING, CLOSED TRANSITION

STARTING

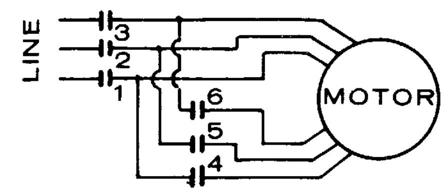
Part winding starting is less expensive because it requires no autotransformer, reactor or resistor and uses simple switching. Available in two or more starting steps depending on size, speed and voltage of motor.

APPLICATION NOTES

Automatically provides closed transition. First, one winding is connected to the line; after a time interval, the second winding is paralleled with the first. Starting torque is low and is fixed by the motor manufacturer. The purpose of part winding is not to reduce starting current but to provide starting current in smaller increments.

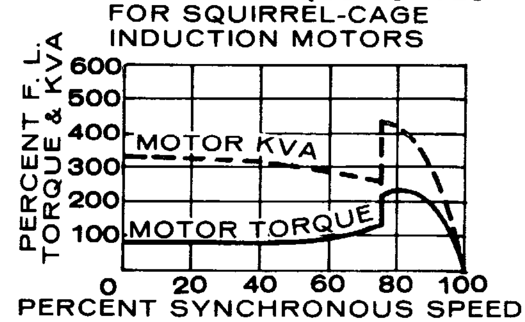
No advantage when motor is powered by a generator set unless the motor can reach synchronous speed before transition to the line.

STARTING DIAGRAM
PRIMARY CONNECTIONS



START: CLOSE 1-2-3
RUN: CLOSE 4-5-6

TYPICAL
KVA AND TORQUE CURVES
FOR SQUIRREL-CAGE
INDUCTION MOTORS



WOUND ROTOR MOTOR STARTING

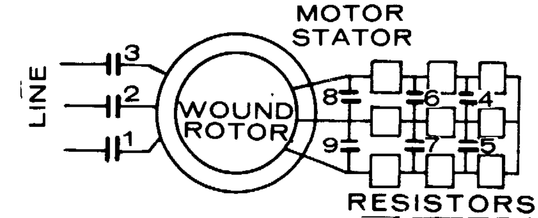
STARTING

A wound rotor motor can have the same starting torque as a squirrel cage motor but with less current. Differs from squirrel cage motors only in the rotor. Squirrel cage motor has short circuit bars, wound rotor motor has windings, usually three phase.

APPLICATION NOTES

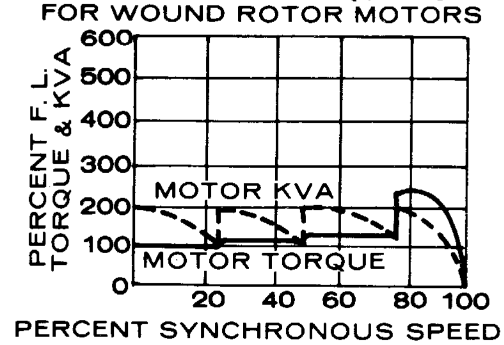
Starting current, torque and speed characteristics can be changed by connecting the proper amount of external resistance into the rotor. Usually the wound rotor motors are adjusted so that the starting kVA is about 1.5 times the running kVA. This is the easiest type of motor for a generator set to start. If wound rotor motors are used for variable speed applications, contact your distributor for information.

STARTING DIAGRAM
PRIMARY CONNECTIONS



START: CLOSE 1-2-3
FIRST STEP: CLOSE 4-5
SECOND STEP: CLOSE 6-7
RUN: CLOSE 8-9

TYPICAL KVA AND TORQUE CURVES
FOR WOUND ROTOR MOTORS



SYNCHRONOUS MOTORS

STARTING	APPLICATION NOTES
Synchronous motors can use most of the starting methods as previously listed. Synchronous motors 20 HP and larger have starting characteristics similar to the wound rotor motors.	Synchronous motors are in a class by themselves. There are no standards of performance, frame sizes, or connections for these motors. Synchronous motors 30 horsepower and smaller have high lock rotor current. Use in applications where power factor correction is desired. (Use the standard code letter when the actual letter is unknown.)

REDUCED VOLTAGE MOTOR STARTING

Although voltage dip often causes various problems, a controlled reduction in voltage can be beneficial when used to reduce the starting kVA of a motor. Whenever the starting kVA is reduced, the size of the generator set required is smaller, voltage dip is less and the motor load has a softer start. Reduced voltage starters can be used whenever the reduction of the motor's torque will not hinder the application.

CAUTION **Before adding reduced voltage motor starters to equipment, consult the manufacturer of the equipment. The torque of the motor may be reduced to the point the motor can't start or accelerate the load. Motor damage could result.**

Table 9 compares different types of reduced voltage motor starting methods with their associated reduction in kVA and torque. Variations of these types of reduced voltage motor starters may be available from local suppliers.

Application Note: If the reduced voltage motor starter has a time or rate adjustment, adjust the settings to about two seconds between taps. This allows shaft speed to approach synchronous speed and reduce the peak kVA at the time of switching. A reduced voltage starter set in minimum position is not much of an improvement over full voltage starting as shown in Figure 2.

In some applications, the inrush current is so low, the motor shaft will not turn on the first and often the second tap. For this type of application, there is little reduction of starting kVA from the standpoint of the generator set.

TABLE 9. REDUCED VOLTAGE STARTING METHODS WITH CHARACTERISTICS

STARTING METHOD	% VOLTS APPLIED (TAP)	% F.V. kVA	% F.V. TORQUE	MULTIPLYING FACTOR
Full Voltage	100	100	100	1.0
Reduced Voltage Autotransformer	80 65 50	64 42 25	64 42 25	0.64 0.42 0.25
Series Reactor or Resistor	80 65 50	80 65 50	64 42 25	0.80 0.65 0.50
Star Delta	100	33	33	0.33
Part Winding (Typical)	100	60	48	0.6
Wound Rotor Motor	100	160*	100*	1.6 *

* Of running current. Depends on value of series resistance added to the rotor. (See section on Wound Rotor Motors, p. 19.)

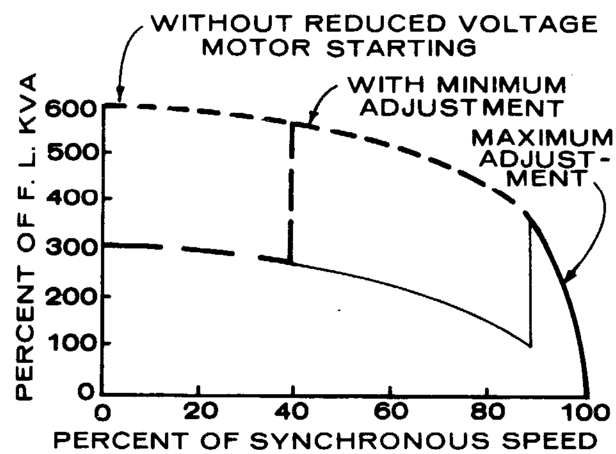


FIGURE 2. REDUCED VOLTAGE MOTOR STARTING EFFECTS

A SAMPLE MOTOR STARTING PROBLEM IS LOCATED ON NEXT PAGE.

Following is a sample motor starting problem using reduced voltage starting. The motor is 50 horsepower, 460 volts, code F, has a starting kVA of 287 and a 0.36 starting PF. The generator set output is 480 volts. See Table 10.

TABLE 10. SAMPLE MOTOR STARTING PROBLEM

	TYPE OF STARTER		
	AUTOTRANSFORMER	**RESISTOR**	**FULL VOLTAGE**
% of applied volts (tap)	65	50	100
% of full voltage (multiplier)	0.42	0.50	1.0
Starting kVA with reduced voltage motor starter	287 x 0.42 = 120.5	287 x 0.50 = 143.5	287 x 1.0 = 287
Starting kW with starter (kVA x PF)	120.5 x 0.36 = 43.4	143.5 x 0.8 PF* = 114.8	287 x 0.36 PF = 103.3
Run kVA	49.4	49.4	49.4
Run kW	41	41	41
†Generator set (gasoline)	45.0EM	115.0WA	115.0WA
†Generator set (diesel)	45.0DEF	100.0DYD	100.0DYD

* - See description of resistor motor starting, closed transition.
† - From Tables 4 and 6 of Part I.

Conclusion: Autotransformer starting and wound rotor motor starting require the least motor starting capacity from the generator set, and allow the smallest capacity generator set to be purchased. Resistor starting and part winding motors have little effect on reducing the capacity requirement of the generator set.

X-RAY APPLICATIONS

X-ray applications are somewhat difficult due to the limited information available from the X-ray equipment manufacturers. The essential information needed to properly size a generator set is the peak kVA load (kVP x ma) and the allowable voltage dip.

For all X-ray applications, two important factors must be understood:

1. The operator must realize when the X-ray equipment is powered by the generator set, the picture may be different than when powered by the commercial utility line. Figure 3 shows the stability of the power line during the X-ray, but the generator set has a greater voltage dip and also attempts to regulate during the X-ray.

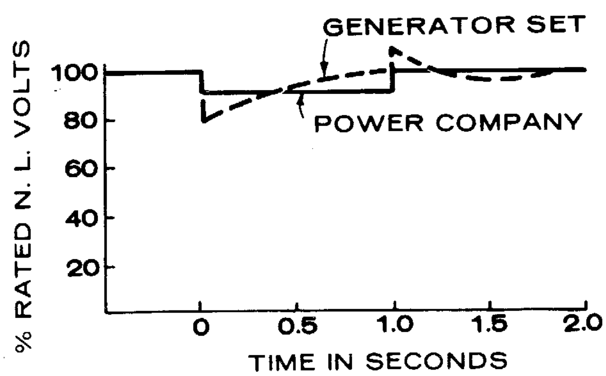


FIGURE 3. VOLTAGE DIP OF GENERATOR SET AND UTILITY POWER

2. Between the time the operator makes the adjustment for the X-ray and takes the X-ray, no large load changes should take place from elevators or air conditioning switching on or off. This is of particular concern in mobile applications where there are usually two large loads, the X-ray equipment and the air conditioner. For these applications, it is recommended the air conditioning be left on continuously and the temperature be controlled by changing the ratio of outside air to cooled air with a small motorized control.

The X-ray machine is designed to operate from the power line. Most have a line voltage compensator, some of which are installer adjustable and others are adjustable by the operator. In applications where the generator set is the only power source, the line voltage compensator can be adjusted for the generator set's voltage dip. For X-ray equipment having been adjusted for power line operation, the generator set must duplicate the voltage dip of the utility power line as close as possible. X-ray engine and generator requirements are shown in Table 11.

TABLE 11. X-RAY MINIMUM ENGINE AND GENERATOR REQUIREMENTS

X-RAY RATING		PEAK LOAD (KVP x ma x PF**) MIN. ENGINE kW	MIN. kVA RATING* MIN. GENERATOR kVA
ma	kVP		
15	100	1.5	3.8
20	85	1.7	4.3
40	125	5.0	12.5
50	125	6.3	15.8
100	125	12.5	31.3
200	125	25.0	62.5
300	125	37.5	93.8
300	150	45.0	112.0
500	125	62.5	156.0
500	150	75.0	187.0
700	110	77.0	192.0
1200	90	108.0	270.0

* Minimum Generator kVA = $\frac{\text{PEAK LOAD}}{0.4}$

** If power factor is unknown, use 1.0.

Past experience shows whenever the X-ray unit's peak load is approximately 40 percent of the generator's continuous kVA rating, the X-ray pictures will be satisfactory. This results in approximately 6 percent voltage dip on most Onan units. Higher current and voltage settings on the X-ray machine may not be usable if the voltage dip approaches 10 percent.

Sample X-ray problem: The X-ray loads can be calculated by multiplying the kVP by the ma. With 200 ma X-ray, 125 kVP, 0.95 PF, we find:

0.2 amps x 125,000 volts = 25 kVA.
kW = kVA x 0.95 PF = 23.8 kW.

To find the minimum size continuous kVA generator for this application, divide

$$\frac{25\text{ kVA}}{40\%\text{ or }0.4} = 62.5\text{ kVA}.$$

Generator set selection results in two model choices.

Choice 1: 55.0 EN, full output, single phase.
Allows a miscellaneous load of 31.2 kW (55 kW - 23.8 kW = 31.2 kW).

Choice 2: 55.0KB, full output single phase.
Allows for a 31.2 kW miscellaneous load (55 kW - 23.8 kW = 31.2 kW).

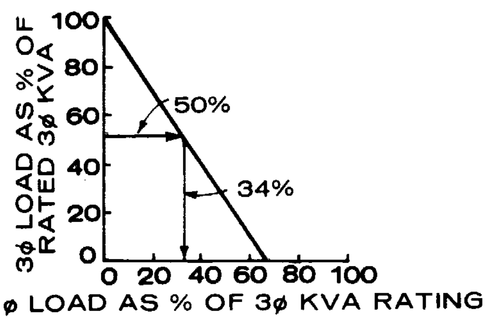
ALLOWABLE SINGLE AND THREE PHASE UNBALANCE

Loads often consist of both three phase and single phase equipment. An easy rule to remember with Onan generator sets is that any combination of single phase and three phase loads is permissible as long as the nameplate line current rating is not exceeded. This rule limits the maximum single-phase load to 58 percent of the generator three-phase rating, but the generator can be loaded to 66 percent of the three-phase rating because the unused winding will dissipate the heat. For allowable combinations of unbalanced loads, see Figure 4.

Example: Determine the single phase load possible for a generator set with a 125 kVA, 100 kW rating and has a 62 kVA, three-phase load. Then calculate:

$$\frac{\text{kVA LOAD}}{\text{kVA GENERATOR RATING}} = \%;$$

$$\frac{\text{62 kVA LOAD}}{\text{125 kVA GENERATOR RATING}} = 50\%.$$



CAUTION This curve applies only to wye or delta connected three-phase generators when loaded with combinations of symmetrical three phase and line-to-line, single-phase loads.

FIGURE 5. DETERMINING MAXIMUM SINGLE PHASE LOAD WITH A THREE PHASE LOAD

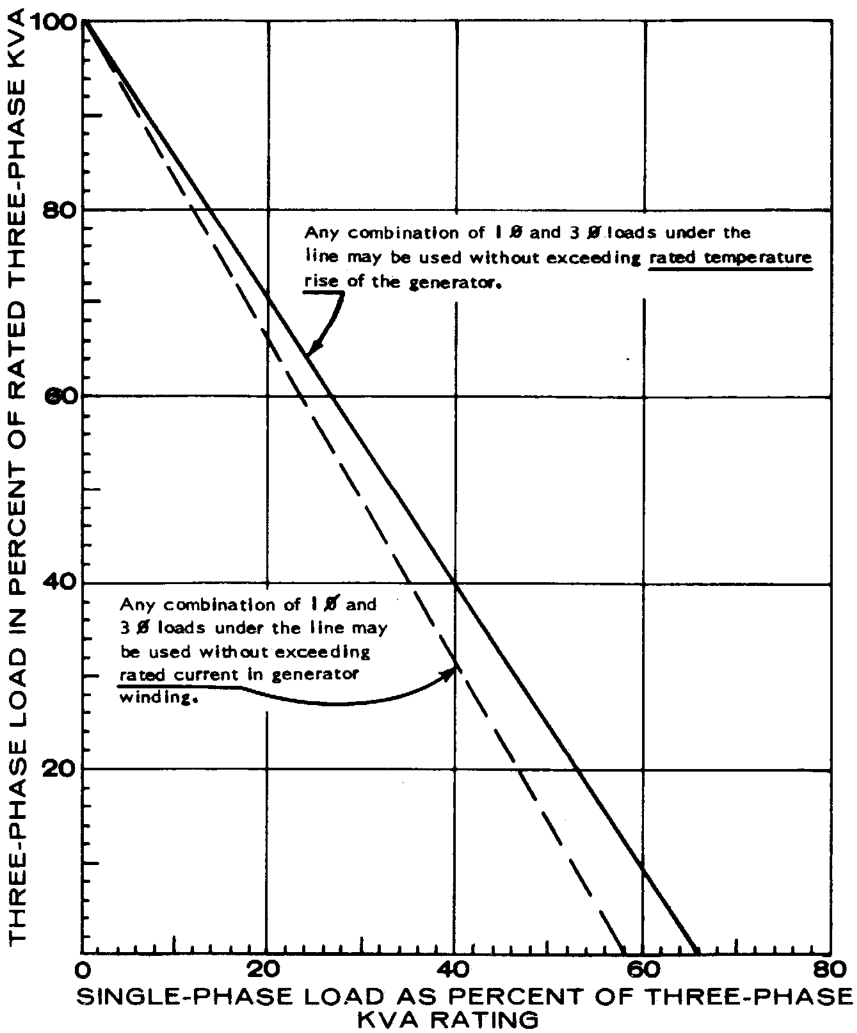


FIGURE 4. ALLOWABLE COMBINATIONS OF UNBALANCED LOADS

The maximum single-phase load allowed according to Figures 4 and 5 is approximately 34 percent of the three phase rating (125 kVA x 34 percent = 42.5 kVA).

The total kVA, 62 kVA + 42.5 kVA = 104.5 kVA, is less than the 125 kVA rating of the generator set. If the single-phase load could be split into three equal loads, the full rating of the generator set could be used.

CAUTION **When unbalanced loads are connected to a three-phase generator, the phase voltages are no longer balanced. The amount of unbalanced voltage can be greater than 10 percent between phases, depending upon the amount of unbalanced load connected to the generator. Therefore, place any critical load on the same phase as the voltage reference circuit. (L1-L2 as defined in generator set schematic).**