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Generator Sales Application and Technical Information

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Available Markets

- Rental
- Home Standby
- Telecom – Central Office
- Telecom – Cell/mobile
- Telecom – Real Estate/Data centers
- Telecom – Fiber Optic hubs
- Agriculture
- Government/Military
- Export
- Marine
- Bid and Spec – Hospitals, WWTP, Elevators l
- OEM’s
- Ground Support
- Distributed Power to support the grid
- Emergency Vehicle

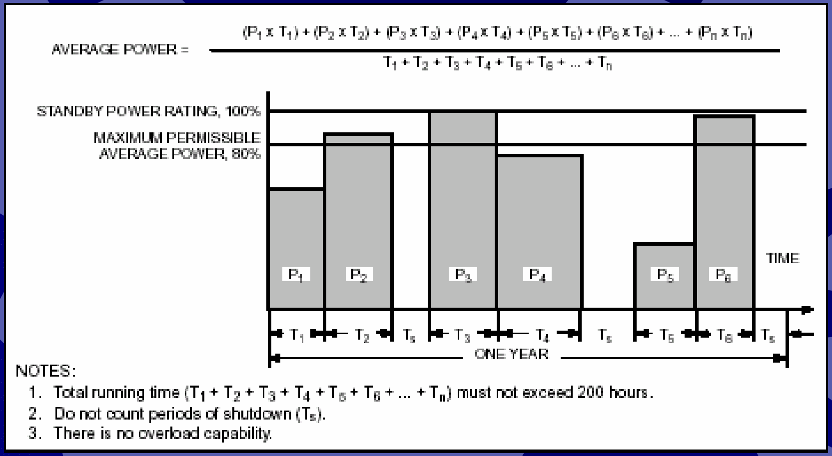
Rating Definitions

Rating Definitions

- Ratings
  - Standby
  - Prime
  - Continuous
- Standards
- Rating Considerations

Standby - Traditional

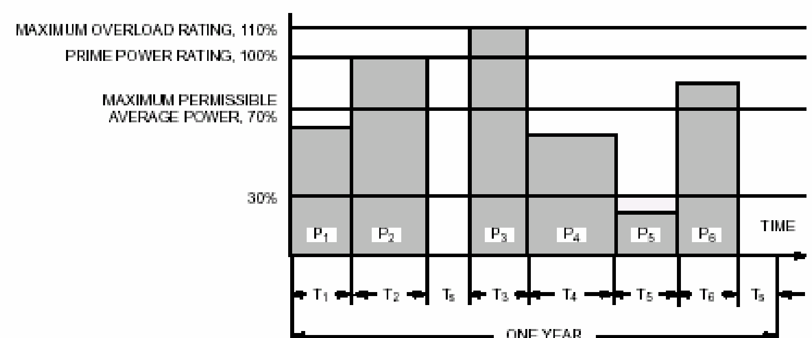
- Emergency Back-up Power
- Less Than 200 hrs/yr.
- Varying (Load Factor 60%-80%)
- No Overload Capacity
- Alternator Should be rated at 150°C



Prime Power - Traditional

- Applicable when supplying electric power in lieu of commercially purchased power.
- Prime Power applications are subject to 500 annual hours of run time, where constant load is present.
- Unlimited run time where a variable load is present. Average load must not exceed 70% of prime power rating.
- Overload capacity is 10% for one hour in every twelve.
- Alternator should be rated at either 105°C or 125°C

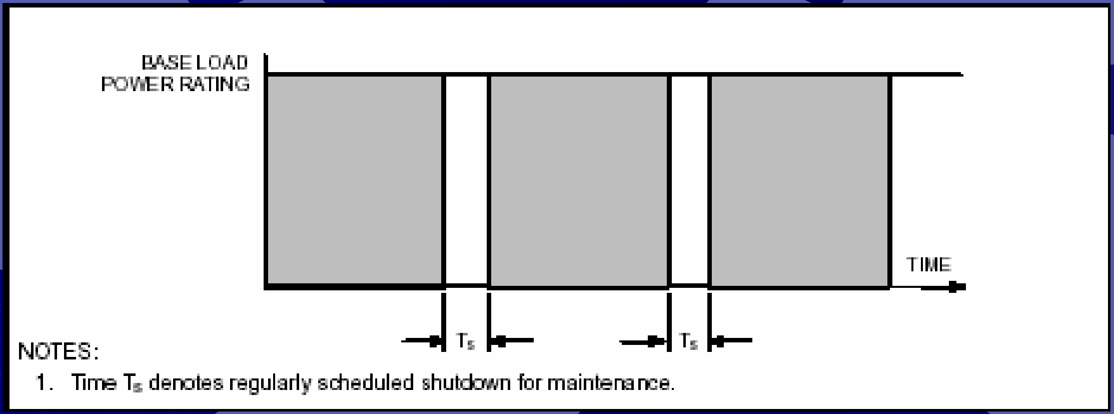
$$\text{AVERAGE POWER} = \frac{(P_1 \times T_1) + (P_2 \times T_2) + (P_3 \times T_3) + (P_4 \times T_4) + (P_5 \times T_5) + (P_6 \times T_6) + \dots + (P_n \times T_n)}{T_1 + T_2 + T_3 + T_4 + T_5 + T_6 + \dots + T_n}$$



NOTES:
1. Count loadings of less than 30 percent as 30 percent (P_5).
2. Do not count periods of shutdown (T_s).
3. A 10 % overload (P_3) is available for 1 hour in 12 for a total annual not to exceed 25 hours.
4. The total number of hours per year at or above the Prime Power Rating (P_2 and P_3) must not exceed 500 hours.

Continuous - Traditional

- The continuous power rating is applicable for supplying power continuously to a load up to 100 percent of the base load engine rating for unlimited hours. (Approx. 8,000/yr.)
- No sustained overload capability is available at this rating.
- In these applications, generator sets are operated in parallel with a utility source and run under constant loads for extended periods of time.



PEAK SHAVING

- * DETERMINE REGIONAL KW COST
- * IDENTIFY FUEL SUPPLY AVAILABLE
- * FACTOR MAINTENANCE AND LOCATION

Fictitious Rating

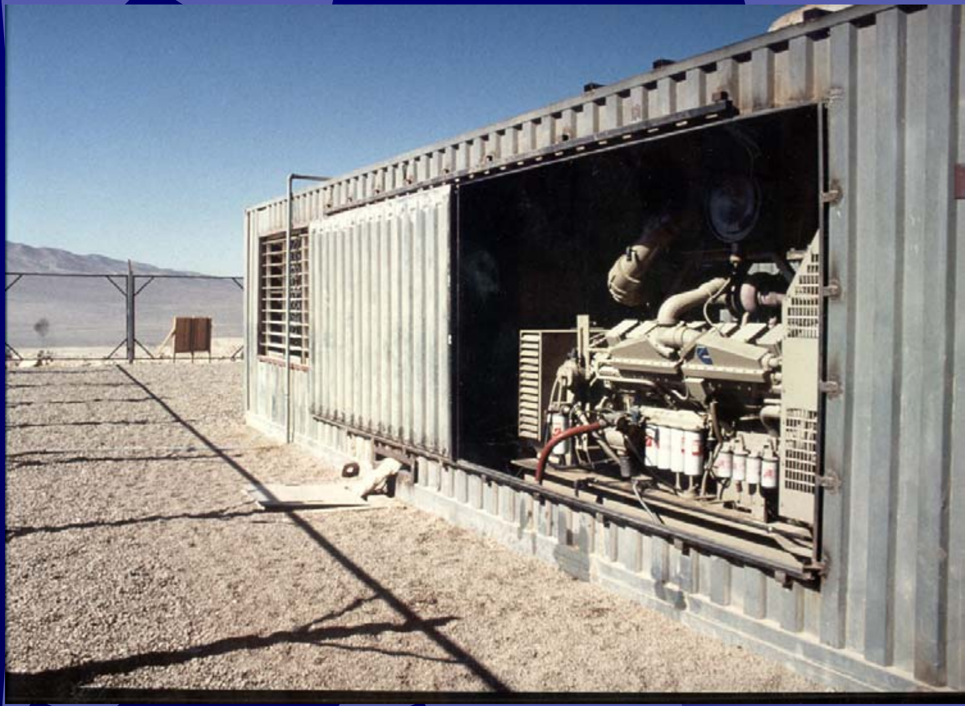
- Continuous Standby
  - THIS RATING DOES NOT EXIST. IT IS MARKETING JARGON PASSED ON THE ENGINEERING FIRMS THAT THEY BOUGHT INTO!

SITE CONSIDERATIONS

- Site Conditions

Site Conditions

- Altitude
- Temperature
- Humidity
- Dust
- Coastal



Performance Considerations

Performance Considerations

- Emissions
- Fuel Consumption

EMISSIONS

- EPA Regulations
- CHANGING IN 2005

EPA Tier 1 Regulations

Power		Effective 01 Jan.	<---------- g/kW hr (g/hp hr) ---------->			
kW	hp		NO_X	HC	CO	Pm
≥130, ≤ 560	≥174.3, ≤ 751	1996	9.2 (6.9)	1.3 (1.0)	11.4 (8.5)	0.54 (0.40)
≥75, <130	≥100.6, <174.3	1997	9.2 (6.9)	NA	NA	NA
≥37, <75	≥49.6, <100.6	1998	9.2 (6.9)	NA	NA	NA
>560	>751	2000	9.2 (6.9)	1.3 (1.0)	11.4 (8.5)	0.54 (0.40)

EPA Tier 1,2 & 3 Regulations

Power		Effective 01 Jan.	<---------- g/kW hr (g/hp hr) ---------->		
kW	hp		NO_X + NMHC	CO	Pm
Tier 1					
≥19, <37	≥25.5, <49.6	1999	9.5 (7.0)	5.5 (4.1)	0.8 (0.60)
≥8, <19	≥10.7, <25.5	2000	9.5 (7.0)	6.6 (4.9)	0.8 (0.60)
<8	<10.7	2000	10.5 (7.8)	8.0 (6.0)	1.0 (0.74)
Tier 2					
≥225, <450	≥301.7, <603.5	2001	6.4 (4.8)	3.5 (2.6)	0.2 (0.15)
≥450, ≤ 560	≥603.5, ≤ 751	2002	6.4 (4.8)	3.5 (2.6)	0.2 (0.15)
≥130, <225	≥174.3, <301.7	2003	6.6 (4.9)	3.5 (2.6)	0.2 (0.15)
≥75, <130	≥100.6, <174.3	2003	6.6 (4.9)	5.0 (3.7)	0.3 (0.22)
≥37, <75	≥49.6, <100.6	2004	7.5 (5.6)	5.0 (3.7)	0.4 (0.30)
≥19, <37	≥25.5, <49.6	2004	7.5 (5.6)	5.5 (4.1)	0.6 (0.44)
≥8, <19	≥10.7, <25.5	2005	7.5 (5.6)	6.6 (4.9)	0.8 (0.60)
<8	<10.7	2005	7.5 (5.6)	8.0 (6.0)	0.8 (0.60)
>560	>751	2006	6.4 (4.8)	3.5 (2.6)	0.2 (0.15)
Tier 3					
≥130, ≤ 560	≥174.3, ≤ 751	2006	4.0 (3.0)	3.5 (2.6)	Tier 2 ?
≥75, <130	≥100.6, <174.3	2007	4.0 (3.0)	5.0 (3.7)	Tier 2 ?
≥37, <75	≥49.6, <100.6	2008	4.7 (3.5)	5.0 (3.7)	Tier 2 ?

Fuel Consumption

- Fuel; Cost (up to 60-80% of the operational cost.)
- Additional Fuel Savings
  - Electric Driven Fan Radiators
  - High Efficiency generator

Load Audits / Sizing

Formulas:

To Obtain:	Single Phase AC	Three Phase AC
kilowatts (kW)	$\frac{Volts\ x\ Amps\ x\ PF}{1000}$	$\frac{Volts\ x\ Amps\ x\ PF\ x\ 1.732}{1000}$
kVA	$\frac{Volts\ x\ Amps}{1000}$	$\frac{Volts\ x\ Amps\ x\ 1.732}{1000}$
Amps (kVA unknown)	$\frac{kW\ x\ 1000}{Volts\ x\ PF}$	$\frac{kW\ x\ 1000}{Volts\ x\ PF\ x\ 1.732}$
Amps (kW unknown)	$\frac{kVA\ x\ 1000}{Volts}$	$\frac{kVA\ x\ 1000}{Volts\ x\ 1.732}$
Reactive Power (kVAR)	$\frac{Volts\ x\ Amps\ x \sqrt{1 - PF^2}}{1000}$	$\frac{Volts\ x\ Amps\ x\ 1.732\ x\ \sqrt{1 - PF^2}}{1000}$
Horsepower required to drive a generator	$\frac{kW}{0.746\ x\ Generator\ Efficiency}$	$\frac{kW}{0.746\ x\ Generator\ Efficiency}$

Sizing

- The comprehensive sizing method relies on the nameplate data of equipment and existing known electrical information.
- We already know that as a minimum the genset must be sized to handle:
  - The maximum starting (surge / inrush) demands.
  - The steady-state running loads of the connected equipment.
- The comprehensive method is designed to obtain values for:
  - Starting kVA(SkVA)
  - Starting kW(SkW)
  - Running kVA(RkVA)
  - Running kW(RkW)
  - Alternator kW(AkW) - Used when calculating non-linear loads.

Sizing

- After the starting and running loads have been calculated it is typical to add a margin factor of up to 20%:
  - For future expansion,
  - To select a generator set of the next largest standard rating.
- From a fuel efficiency stand point the running load should stay within 50% - 80% of the generator sets kW stand-by rating.
- To avoid “wet stacking” the running load should be not less than 30% of the generators stand-by rating.
- It may be necessary to oversize a generator set (or alternator) in applications where non-linear loads are involved:
  - Static Uninterruptible Power Supplies (UPS)
  - Variable Frequency Drives (VFD)
  - Battery Charging Rectifiers (Telecommunications)

Sizing

- First we need to assemble an accurate schedule of loads to be connected to the generator.
- The generator set sizing procedure requires the following steps:
  - Prepare a load schedule
  - Enter the loads in step sequence on the worksheet
  - Enter the individual load characteristics on the worksheet
  - Determine the total step loads
  - Select the generator set

Sizing

- Preparing the Load Schedule
  - We need to document all of the loads to be connected to the generator. List the loads in any order but remember to identify each load as to type, power rating and quantity.

Load Schedule				
Load#	Load Description	Type of Load	Power Rating	Load Qty.
		Examples: Lighting……………………kW Variable Speed Drive……………………HP Static UPS……………………kVA		
1.	Sewage Pump's #1 & #2	Motor, NEMA Code Letter G, Autotransformer Starter (80% Tap)	50HP	2
2.	Sewage Pump #3	Variable Speed Drive Motor	100HP	1
3.	Fluorescent Lighting	Lighting	10kW	1
4.	Electric Heaters	Building Heat	45kW	1

Sizing

- Enter Loads in Step Sequence on the Worksheet
  - Number a worksheet (number block in the upper right-hand corner) for each sequenced load step – Worksheet #1 for Load Step #1, Worksheet #2 for Load Step #2 etc.
  - Enter the individually assigned load numbers (Load Schedule) onto the appropriate Generator Set Sizing Worksheets. That is, all the numbers for Load Step #1 should be entered on Worksheet#1, for Load Step #2 on Worksheet #2, etc.
  - For each load, enter the **Load Qty** marked on the Load Schedule in the column labeled QTY on the worksheet.

Sizing

- Step Sequence Guidelines:
  - Single Step, Simultaneous Starting or Block Load Starting.
    - This commonly used approach is to assume that all connected loads will be started simultaneously in a single step.
    - This assumption will result in the most conservative (largest) generator set selection.
  - Multiple Step Sequence.
    - Sequenced starting of loads will often permit the selection of a smaller generator set.
      - Consider the following when controls or delays are provided to step sequence the loads onto the generator set:
        - Start the largest motor first.
        - Load the UPS last. UPS equipment is typically frequency sensitive, especially to the rate of change of frequency. A pre-loaded generator will be more stable in accepting the UPS load.

Sizing

- Enter Individual Load Characteristics on Worksheets
  - Calculate and enter values for **SkVA**, **SkW**, **RkVA**, and **RkW** for each load on the Worksheets.
  - If **QTY** is one, enter the values for **SkVA**, **SkW**, **RkVA** and **RkW** directly into the columns under the **LOAD STEP TOTALS** heading.
  - If the **QTY** is greater than one, enter the values for **SkVA**, **SkW**, **RkVA** and **RkW** in the columns under the **INDIVIDUAL LOAD CHARACTERISTICS** heading.
    - Then multiply each entry by the number under **QTY** and enter new products under the **LOAD STEP TOTALS** heading **SkVA**, **SkW**, **RkVA** and **RkW**.
  - If non-linear loads are included, calculate a **AkW** value for each non-linear load and enter it under the **AkW** column. Reference the above procedure if **QTY** is greater than one.
  - In order to obtain a total **AkW** in applications that include linear and non-linear loads, enter the values for **RkW** for all the linear loads under **AkW** as well. *(**RkW=AkW** for linear loads only.)*

Sizing

- Find The Load Step Totals
  - At this point all loads on the load schedule should be listed on the Generator Set Sizing Worksheets, all the load characteristics should be calculated and entered on the worksheets, and the worksheets numbered in load step sequence.
    - Starting with Worksheet #1, add the entries in each column under the **Load Step Totals** heading and enter the sums on the **Load Step Totals** line.
    - On worksheet #2, enter the **Load Step Totals** from Worksheet #1 as instructed on the worksheet.
    - Repeat steps 1 and 2 as necessary through all the worksheets.
    - Go back through all the worksheets and highlight the highest **Load Step Total** of **SkVA, SkW, RkVA, RkW** and **AkW.**
    - *Generator set selection will be based on these values.*

Sizing

- The next slide is an example load calculation for a application involving a two-step load starting sequence. Two worksheets are required as shown.

Load Schedule				
Load#	Load Description	Type of Load	Power Rating	Load Qty.
		Examples: Lighting……kW Variable Speed Drive……HP Static UPS……kVA		
1.	Sewage Pump's #1 & #2	Motor, NEMA Code Letter G, Autotransformer Starter (80% Tap)	50HP	2
2.	Sewage Pump #3	Variable Speed Drive Motor	100HP	1
3.	Fluorescent Lighting	Lighting	10kW	1
4.	Electric Heaters	Building Heat	45kW	1

Worksheet #1

Generator Set Sizing Worksheet											Load Step# 1
Load #	Individual Load Characteristics						Load Step Totals				
	SkVA	SkW	RkVA	RkW	AkW	QTY	SkVA	SkW	RkVA	RkW	AkW
	Enter RkW Total From Previous Load Step							-			
	Enter RkVA, RkW and AkW Totals From Previous Step								-	-	-
1.	188.8	67.9	46.5	41.9	41.9	2	*377.6*	*136*	*93*	*83.8*	*83.8*
3.	-	-	-	-	-	1	10.5	10	10.5	10	10
4.	-	-	-	-	-	1	45	45	45	45	45
	Load Step Totals						***433.1***	191	158.5	138.8	138.8

1. (2) 50hp motors, SkVA=HP x NEMA Code Letter Multiplier x Reduced Voltage Multiplier = 50 x 5.9 x .64= 188.8
2. SkW = SkVA x SPF = 188.8 x .36 = 67.9SkW
3. RkW = HP x 0.746 / EFF = 50 x 0.746 / .89 = 41.9RkW
4. RkVA = RkW / RPF = 41.9 / .9 = 46.5
5. An (AkW) total will be required because Load #2 is nonlinear. Therefore, enter values for AkW for the nonlinear loads. AkW = RkW for linear loads.
6. *Load #1, Individual Load Characteristics are doubled because of the (2) motors. The Load Step Total reflects the characteristics doubled or (X x 2).*
7. *For the fluorescent lighting, RkW = SkW, SPF & RPF both = 0.95. (RkVA= 10RkW / .95 = 10.5RkVA) (SkVA= 10SkW / .95)*
8. *Our 45kW of electric heat is purely resistive load at unity power factor, so SkVA=SkW & RkVA=RkW*

Worksheet #2

Generator Set Sizing Worksheet							Load Step# 2				
Load #	Individual Load Characteristics						Load Step Totals				
	SkVA	SkW	RkVA	RkW	AkW	QTY	SkVA	SkW	RkVA	RkW	AkW
	Enter RkW Total From Previous Load Step							138.8			
	Enter RkVA, RkW and AkW Totals From Previous Step								158.5	138.8	138.8
2.						1	89	81.9	89	81.9	163.8
	-	-	-	-	-	-	-	-	-	-	-
Load Step Totals							89	220.7	247.5	220.7	302.6

1. Drive RkW = Drive HP x 0.746/EFF (0.9) — RkW = 100HP x 0.746/.9 = 81.9
2. Drive RkVA = RkW/RPF (0.9) — RkVA = 81.9/0.9 = 89
3. For the 100HP VSD motor: AkW = RkW x generator sizing factor = 81.9 x 2.0= 163.8; SkW = RkW; and SkVA = RkVA

Sizing

	SkVA	SkW	RkVA	RkW	Akw
Totals	433.1	220.7	247.5	220.7	302.6

- Select the Generator Set
  - Establish a minimum size.
    - At this point future load addition should be considered.
      - **RkW** & **RkVA** values that were highlighted should be multiplied by a factor representing your customers best judgment.
    - Referring to the generator set Specification Sheets.
      - Pick the generator set model having a kW/kVA rating that just meets the highest **RkW** and **RkVA** totals that were highlighted.
    - On the Specification Sheet, find the Alternator Performance block of data having the specified frequency and temperature rise (130°C, 105°C and 80°C).
      - The **LRKVA (Locked Rotor kVA)** rating on the specification sheet must be greater than the **SkVA** totals that were highlighted. If not refer to the Specification Sheet for the next larger generator set.

Sizing

	SkVA	SkW	RkVA	RkW	Akw
Totals	433.1	220.7	247.5	220.7	302.6

- Select the Generator Set
  - In applications where it is necessary to limit transient voltage dip to 10 to 20 percent of nominal voltage, multiply the **SkVA** that was highlighted by a factor of at least 1.25. Repeat the selection process.
    - *A transient voltage dip of approximately 20 to 35 percent can be expected when the* ***LRKVA*** *of the generator set selected is only slightly greater than the maximum SkVA. The actual transient voltage dip is a function of several factors and is difficult to determine accurately.*
  - In applications where **AkW** has been determined and where **AkW** is greater than the kW rating of the generator set that has been selected, an alternator (AC generator) must be picked for the set which has a kW rating equal to or greater than **AkW**.
    - Find the Alternator Performance Data block, referenced on the specification sheet for the alternator temperature rise selected (130°C, 105°C and 80°C). Compare the **AkW** to the alternator kW rating at rise.

Sizing

- Select the Generator Set
  - If none of the alternators available for the genset has a kW rating sufficient to meet A**kW,** refer to the Specification Sheet for the next larger size generator set and repeat the selection steps.

	SkVA	SkW	RkVA	RkW	Akw
Totals	433.1	220.7	247.5	220.7	302.6

  - In our application the Baldor IDLC300 will fit this customers specific starting and running load requirements.

Sizing

- Lighting
  - *The following includes <u>all</u> types of lighting loads*
  - **RkW** = The sum of the rated watts of all lamps and ballasts
  - Typical ballast wattages are:

LAMP	*BALLAST*
48" T-12, 40W, Preheat	10W
48" T-12, 40W, Rapid Start	14W
High Output 40W, Fluorescent	25W
Mercury, 100W	18-35W
Mercury, 400W	25-65W

Sizing

- For all types of lighting loads, except high intensity discharge (HID):

  SkW = RkW

- For HID lighting assume the following:

  SkW = 0.75 x RkW

- Unless otherwise known, assume the following starting and running power factors (SPF and RPF, respectively) for the following types of lighting:

Type of Lighting	*SPF*	*RPF*
Fluorescent	0.95	0.95
Incandescent	1.00	1.00
High Intensity Discharge	0.85	0.95

- Note:

$$RkVA = \frac{RkW}{RPF} \qquad SkVA = \frac{SkW}{SPF}$$

Single-Phase Induction Motors

- For single-phase motors, use the **SkVA**, **SkW**, **RkVA** and **RkW** in the table below.

HP	RkW	RkVA	SkVA	SkW
Capacitor Start / Induction Run				
1/6	0.3	0.5	2.6	2.0
1/4	0.4	0.6	3.3	2.6
1/3	0.5	0.7	3.9	3.1
1/2	0.7	0.9	5.3	4.25
3/4	1.0	1.25	7.1	5.7
1	1.2	1.6	9.5	7.6
1-1/2	1.6	2.0	14.25	11.4
2	2.2	2.7	19	15.2
3	3.3	4.1	28.5	22.8
Capacitor Start / Capacitor Run				
1/6	0.3	0.5	2.8	2.3
1/4	0.4	0.6	3.8	3.0
1/3	0.5	0.7	3.6	2.9
1/2	0.7	0.9	5.9	4.7
3/4	1.0	1.25	8.0	6.4
1	1.2	1.6	10.6	12.7
1-1/2	2.2	2.7	21.2	17.0
2	3.3	4.1	31.8	25.5
3	3.3	4.1	31.8	25.5
Split Phase				
1/6	0.3	0.5	1.0	0.8
1/4	0.4	0.6	1.5	1.2
1/3	0.5	0.7	2.0	1.6

Sizing

- Three-Phase Induction Motors
  - Calculate **RkW** as follows:

$$RkW = \frac{\textit{Nameplate}\ \mathrm{HP\ x\ 0.746}}{EFF}$$

    - If EFF (motor running efficiency) is not known, refer to the table provided for three-phase induction motors and use the value corresponding to the motors horsepower.
  - Calculate **RkVA as follows:**

$$RkVA = \frac{RkW}{RPF}$$

    - If RPF (Running Power Factor) is not known, refer to the table provided for three-phase induction motors and use the value corresponding to the motors horsepower.

Sizing

- Three-Phase Induction Motors
  - Calculate **SkVA** as follows:
    - *If you know the NEMA motor code letter:*
      - Refer to the three-phase induction motor table and select the **SkVA** value corresponding to the code letter and the horsepower.
    - *If you know the NEMA motor code letter and motor horsepower:*
      - Refer to the NEMA Code Letter Multiplying Factor Table:

        Multiply the motor horsepower x NEMA multiplying factor.

        SkVA = Motor HP x NEMA Code Multiplier
    - *If you don't know the NEMA motor code letter:*
      - Refer to the three-phase induction motor table and select the **SkVA** value in the shaded area that corresponds to motor horsepower.
        - *The shaded values under the NEMA code letters are typical for standard motors.*

- Three-Phase Induction Motors
  - Calculate **SkVA** as follows:
    - *If reduced voltage motor starting is used,* determine **SkVA** as in the previous three steps.
    - Then multiply the value by the appropriate multiplying factor as shown in the table below.
    - ***SkVA*** *= SkVA x Multiplying Factor*

Reduced Voltage Starting Methods and Their Characteristics					
Starting Method	% Full Voltage Applied (Tap)	% Full Voltage kVA	% Full Voltage Torque	SkVA Multiplying Factor	SPF
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	80 65 50	80 65 50	64 42 25	0.80 0.65 0.50	- - -
Series Resistor	80 65 50	80 65 50	64 42 25	0.80 0.65 0.50	0.60 0.70 0.80
Star Delta	100	33	33	0.33	-
Part Winding (Typical)	100	60	48	0.6	-
Wound Rotor Motor	100	160	100	1.6	-

NEMA Code Letter Multiplying Factor

A = 2 SKVA/HP	L = 9.5 SKVA/HP
B = 3.3 SKVA/HP	M = 10.6 SKVA/HP
C = 3.8 SKVA/HP	N = 11.8 SKVA/HP
D = 4.2 SKVA/HP	P = 13.2 SKVA/HP
E = 4.7 SKVA/HP	R = 15 SKVA/HP
F = 5.3 SKVA/HP	S = 16 SKVA/HP
G = 5.9 SKVA/HP	T = 19 SKVA/HP
H = 6.7 SKVA/HP	U = 21.2 SKVA/HP
J = 7.5 SKVA/HP	V = 23 SKVA/HP
K = 8.5 SKVA/HP	

Three-Phase Induction Motor Table

HP	NEMA MOTOR CODE LETTERS												MOTOR FACTOR		
	A	B	C	D	E	F	G	H	J	K	L	N	SPF	EFF	RPF
1/4	0.5	0.8	0.9	1.0	1.2	1.3	1.5	1.7	1.9	2.1	2.4	2.9	0.82	62.8	0.55
1/2	1.0	1.7	1.9	2.1	2.4	2.6	3.0	3.3	3.8	4.2	4.7	5.9	0.82	62.8	0.55
3/4	1.5	2.5	2.8	3.2	3.6	4.0	4.5	5.0	5.7	6.4	7.1	8.9	0.78	69.3	0.55
1	2	3	4	4	5	5	6	7	8	8	9	12	0.76	73.0	0.70
1.5	3	5	6	6	7	8	9	10	11	13	14	18	0.72	76.9	0.76
2	4	7	8	8	9	11	12	13	15	17	19	24	0.70	79.1	0.79
3	6	10	11	13	14	16	18	20	23	25	28	35	0.66	82.5	0.82
5	10	15	19	21	24	26	30	33	38	42	47	59	0.61	83.8	0.85
7.5	15	25	28	32	36	40	45	50	57	64	71	89	0.56	85.1	0.87
10	20	33	38	42	47	53	59	67	75	85	95	118	0.53	85.9	0.87
15	30	50	57	64	71	79	89	100	113	127	142	177	0.49	86.9	0.88
20	40	67	75	85	95	106	119	134	151	170	190	236	0.46	87.6	0.89
25	50	84	94	106	119	132	149	167	189	212	237	295	0.44	88.0	0.89
30	60	100	113	127	142	159	178	201	226	255	285	354	0.42	88.4	0.89
40	80	134	151	170	190	212	238	268	302	340	380	475	0.39	88.9	0.90
50	100	167	189	212	237	265	297	335	377	425	475	590	0.36	89.6	0.90
60	120	201	226	255	285	318	357	402	453	510	570	708	0.36	89.6	0.90
75	150	251	283	318	356	397	446	502	566	637	712	885	0.34	90.0	0.90
100	200	335	377	425	475	530	595	670	755	849	949	1180	0.31	90.5	0.91
125	250	418	471	531	593	662	743	837	943	1062	1187	1475	0.29	90.9	0.91
150	300	502	566	637	712	794	892	1004	1132	1274	1424	1770	0.28	91.2	0.91
200	400	669	754	849	949	1059	1189	1339	1509	1699	1899	2360	0.25	91.7	0.91
250	500	836	943	1061	1186	1324	1486	1674	1886	2124	2374	2950	0.24	92.0	0.91
300	600	1004	1131	1274	1424	1589	1784	2009	2264	2549	2849	3540	0.22	92.3	0.92
350	700	1171	1320	1486	1661	1853	2081	2343	2641	2973	3323	4130	0.19	93.1	0.92
400	800	1338	1508	1698	1898	2118	2378	2678	3018	3398	3798	4720	0.19	93.1	0.92
500	1000	1673	1885	2123	2373	2648	2973	3348	3773	4248	4748	5900	0.17	93.8	0.92

Sizing

- Variable Frequency Drives
  - Variable Frequency Drives are a non-linear load.
  - We will calculate **AkW** in addition to **RkW**, **RkVA**, **SkW** and **SkVA.**

Sizing

- Calculate **RkW** as follows:

$$RkW = \frac{\textit{Drive}\ \text{Output HP x 0.746}}{\text{EFF}}$$

  - Assume 0.9 for EFF (drive running efficiency) unless otherwise known

- Calculate **RkVA** as follows:

$$RkVA = \frac{RkW}{RPF}$$

  - Assume 0.9 for RPF (Running Power Factor) unless otherwise known

Sizing

- Variable Frequency Drives
  - Since Variable Frequency Drives are current limiting:
    - **SkW** = RkW
    - **SkVA** = RkVA
  - Calculate **AkW** as follows, assume a **sizing factor of 2** unless otherwise known:
    - **AkW** = 2.0 x RkW
  - Assume a **sizing factor of 1.4** for a Pulse Width Modulated (PWM) drive.
    - Contact the drive manufacturer to verify that the drive limits harmonic current to less than 10% THD on a high impedance load, eg. a generator set.
    - Baldor IDLC generator set models are offered with several AC generator sizes. Many times a larger alternator can be selected to meet the calculated AkW rather than a larger generator set.
    - Using these factors for AkW results in selecting a generator reactance low enough to limit voltage distortion caused by non-linear loads to approx. 10 – 15 percent.

Sizing

- Static UPS
  - Uninterruptible Power Supplies are non-linear loads.
  - We will calculate **AkW** in addition to **RkW**, **RkVA**, **SkW** and **SkVA.**

Sizing

- Static UPS
- Calculate **RkW** as follows:

$$RkW = \frac{(\text{Output kVA} + \text{Battery Charging kVA}) \text{ x RPF}}{\text{EFF}}$$

  - *In the equation above:*
    - *Output kVA is the nameplate kVA of the UPS.*
    - *Battery charging kVA is that required for battery charging, and can range from 0 – 50% of the UPS kVA rating.*
    - *Assume 0.9 RPF (Running Power Factor) for the UPS, unless otherwise known.*
    - *Assume 0.85EFF (Running Efficiency) for the UPS, unless otherwise know.*

Sizing

- Static UPS
  - Unless otherwise known:

    SkW = RkW

    SPF = RPF

$$\mathrm{RkVA} = \frac{\mathrm{RkW}}{\mathrm{RPF}}$$

$$\mathrm{SkVA} = \frac{\mathrm{SkW}}{\mathrm{SPF}}$$

Sizing

- Calculate **AkW** as follows:
  - For a 3 Pulse UPS: AkW= 2.50 x RkW
  - For a 6 Pulse UPS: AkW= 1.40 x RkW
  - For a 12 Pulse UPS: AkW= 1.15 x RkW
    - Baldor IDLC generator set models are offered with several AC generator sizes. Many times a larger alternator can be selected to meet the calculated AkW rather than a larger generator set.
    - Using these factors for AkW results in selecting an alternator reactance low enough to limit voltage distortion caused by non-linear loads to approx. 10 – 15 percent.

Environmental Considerations

Environmental Considerations

Typical Maximum Allowable Noise Levels

Noise Zones	Peak Daytime db(A)	Peak Nighttime db(A)	Continuous Daytime dB(A)	Continuous Nighttime dB(A)
Urban - Residential	62	52	57	47
Suburban - Residential	57	47	52	42
Very Quiet Suburban or Rural Residential	52	42	47	37
Urban - Nearby Industry	67	57	62	52
Heavy Industry	72	62	67	57

Environmental Considerations

- Effects of distance on sound
  - Sound decreases as distance increases
  - Sound Pressure can be determined as follows:

$$SPL_2 = SPL_1 - 20\,x\log_{10}\left(\frac{d_2}{d_1}\right)$$

$$SPL_1 = \text{Sound Pressure Level (Source)}$$

$$SPL_2 = \text{Sound Pressure Level (Result)}$$

$$D_1 = \text{Distance of } SPL_1$$

$$D_2 = \text{Distance of } SPL_2$$

Environmental Considerations

- Mufflers / Silencers
  - Critical grade mufflers are recommended whenever noise control is a present or future concern.
    - Typical noise attenuating rating deductions of mufflers are as follows:
      - Industrial: 12-18 dB(A)
      - Residential: 18-25 dB(A)
      - Critical: 25-35 dB(A)

        Based off of engine exhaust noise only.

Environmental Considerations

- Fuel Storage Regulations
  - Fuel tank design and installation design are controlled by regulations that are written for two purposes:
    - Fire protection
    - Environmental protection
  - Because the regulations vary from place to place, ensure the applicable codes are checked prior to design and installation.

Electrical Distribution

Electrical Distribution

- Transfer Switches
  - Manual, Open Transition
    - Manually operated by a person.
    - Has a mechanical interlock to prevent the contactor from simultaneously closing the normal and emergency sources.
  - Automatic, Open Transition
    - Operates automatically with voltage relays and monitors the utility source for a power outage. Retransfers the load when utility is reestablished.
    - Has a mechanical interlock to prevent the contactor from simultaneously closing the normal and emergency sources.

Electrical Distribution

- Transfer Switches
  - By-Pass Isolation, Open Transition
    - The by-pass portion of the ATS serves as a manual transfer switch, providing the ability, by throwing one of two handles, to conduct power around the automatic transfer switch, energizing the load from either the normal or emergency source.
      - Think of the By-Pass switch as two contactors in parallel with each other.
      - One contactor operates automatically the other contactor operates manually.
    - Isolating the the automatic portion can be done in three modes:
    - Connected, Test and Withdrawn

Electrical Distribution

- Transfer Switches
  - By-Pass Isolation, Open Transition
    - Connected – Where the automatic contactor is connected to the normal or emergency load.
    - Test – Where the automatic contactor is disconnected from the load but its control circuitry is energized.
      - This allows testing and maintenance to be performed without disturbing the customers load.
    - Drawn-Out – In this position the transfer switch is totally disconnected from any source of power and can be physically removed from the switchgear for other maintenance or replacement.

Electrical Distribution

- Transfer Switches
  - Automatic Transfer Closed Transition
    - Similar in automatic operation to a standard ATS except:
      - The closed transition switch does not have a mechanical interlock.
      - This switch allows the utility to parallel to the generator for a time period not to exceed 100ms.

        Most utilities will require a 32R device or reverse power relay prior to connection to the utility.

Electrical Distribution

- Transfer Switches
  - When the normal voltage relay notices a utility dip or loss it causes the start contacts to close.
    - This contact closure is what generally gives the generator a signal to crank and run.
  - After the generator voltage and frequency buildup satisfies the Emergency Voltage Relay the ATS will change the transfer switch contactor position to emergency.
  - The generator is now supplying the load.

Electrical Distribution

- Transfer Switches
  - When utility (normal service) is again sensed by the normal voltage relay the transfer switch will retransfer the load back to utility.
    - There is generally a time delay on retransfer to ensure that the utility is indeed reestablished and connected.
    - A time delay setting of 15min. is standard.
  - After the ATS has retransferred to the utility the genset will shut down.
    - There is generally a time delay cool down, the genset may run for 5 – 10 min. additionally unloaded.

Electrical Distribution

- Transfer Switches
  - Five Steps in selecting a Transfer Switch
    1. Determine the phase to phase voltage, frequency and number of poles.
    2. Determine the current rating by totaling all lighting, motor and other loads. Motor loads are evaluated on the basis of full load running current only.
    3. Considering the system voltage select the appropriate amperage rating of the switch that is equal to or larger than the total in step 2.

Electrical Distribution

- Transfer Switches
    - Note: Remember that the emergency and normal sources are fed through the transfer switch and the switch must be sized for the larger source.

  4. Determine the operating environment.
    - Indoors, Outdoors, Wet, Dusty etc. This determines NEMA 1, 3R, 4X, 12 etc.

  5. Check for conformance to the available withstand, closing and interrupt ratings that the switch must be able to handle during a possible short circuit.
    - Withstand and interrupt ratings are generally available on the transfer switch manufacturers specification sheet.

Electrical Distribution

- Transfer Switches
  - In most cases transfer switches are provided with:
    - Full phase voltage sensing on the normal (utility) source.
    - Single phase sensing on the emergency source.
  - Normal Voltage Relay Settings are:
    - Normal Voltage Relay 70% - 80% Dropout
    - Normal Voltage Relay 90% - 95% Pickup

Electrical Distribution

- Transfer Switches
  - Emergency Voltage Relay Settings are:
    - Emergency Voltage Relay 50% - 60% Pickup
    - Emergency Frequency 40% - 60% Pickup

GENERATOR OPTIONS

Governor Definition

- A governor is a device on the engine which controls fuel to maintain a constant engine speed under various load conditions. The governor must have provision for adjusting speed (generator frequency) and speed droop (no load to full load).
  - Electronic Governor
    - Electronic governors allow generator sets to recover faster from transient load steps than mechanical governors. Electronic governors should always be used when the loads include UPS equipment.
  - Mechanical Governor
    - Mechanical governors are suitable for applications where the five percent frequency droop inherent in the design is not a problem for the loads being served.

Alternator Requirements

- Temperature Rise ______________________
- Required Voltage Dip____________________
- Minimum Starting KVA Required__________
- Permanent Magnet Generator (PMG)
- Exciter Field Breaker
- Condensation Heater / Specify Voltage__________
- Drip Shield

Alternator Definitions

- Temperature Rise
  - Stand-by: 150°C Rise/40° Ambient
  - Prime: 125°C Rise/40° Ambient
  - Continuous: 80°C or 105°C Rise/40° Ambient
- Voltage Dip (Default 30% unless specified)
  - Voltage dip is the dip in voltage that results when a load is added, occurring before the regulator can correct it, or resulting from the functioning of the voltage regulator to unload an overloaded engine-generator.

Cooling System Options

- Unit Mounted Radiator Std. 40 ° C / 104°F
- High Ambient 50 °C / 122°F
- Duct Flange Adapter (Indoor Units)
- Block Heater________Watts, ________Voltage

Cooling System Options

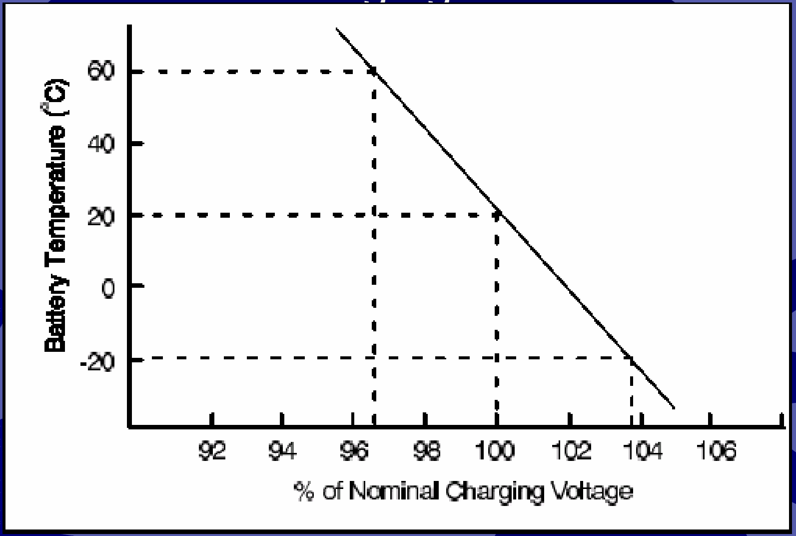
- City Water Cooling (Verify Engine requirements)
  - Unit Mounted Heat exchanger
  - Thermostatic Flow Valve
  - Raw water Solenoid Valve
  - Flexible connections

Battery Charger Definition

- Automatic Float
  - The battery chargers output voltage automatically adjusts to changing input, load, battery and ambient conditions. The result is fast battery charging without overcharging and the consequent loss of battery electrolyte.

Battery Charger Definition

- Automatic Temperature Compensation
  - The battery charger compensates for battery temperature using a negative temperature coefficient. The battery charger provides temperature compensation of –2mv/°C per cell over the ambient temperature range of -40°C up to 60°C. The temperature compensation automatically adjusts the float and equalize voltage setting to prevent the battery from overcharging at high ambient temperatures and undercharging at low ambient temperatures.



Weather Protective Enclosures

- Standard Weather Protective Enclosure
- Sound Attenuated Enclosure (15 dba Reduction at 3 meters)
- Sound Attenuated Enclosure (25 dba Reduction at 3 meters)
- Sound Attenuated Enclosure (35 dba Reduction at 3 meters)
- Sound Attenuated Enclosure (____dba reduction at 3 meters)
- Standard Color (Almond)
  - Special Color ___________Spec Number ___________
  - Steel –14 gauge Construction (Standard)
  - Aluminum Construction
  - Walk-In Design (diamond plate floor materials)
  - Fixed Blade Louvers (Standard)

Exhaust Systems

System Includes Silencer, Flex, Elbow and Rain Cap (Installed only on Enclosed Units)

- Industrial Grade Silencer
- Residential Grade silencer
- Critical Grade Silencer
- Super Critical (Hospital) Grade Silencer
    - Exhaust Insulation Wrap
    - Dual Flange Kit (shipped loose for installation)

Diesel Fuel System

- Sub-base Fuel Tank (Matching Generator Foot Print)
- Single Wall Tank _____________Hours / Gallons
- Double Wall UL-142 Listed ______Hour / Gallons
  - Secondary Containment (basin with atmospheric vent)
  - Closed Top Dike (std vent and emergency vent equipped)
  - 5 Gallon Fill / Spill Box
  - Alarms (high , low, and leak alarm)
  - Remote Alarm Fill station   w/ NEMA 3R Box
  - ***Check local codes city/state and notify factory.***

Gaseous Fuel Systems

- Natural gas / L.P. Fuel System Accessories
  - Fuel Strainer (Shipped loose)
  - Remote Mounted Vaporizer (Outdoor L.P. Liquid system only)
  - Flex Fuel Line (Vapor System Only / Shipped Loose)

Control Systems

- **Solid-state Control w/ LED Indication**

(Standard LED's display - Overcrank, Overspeed, Low Oil Pressure, High Water Temperature)

  - Analog A.C. Meters – (Voltmeter, Ammeter, Frequency Meter)
  - Watt Meter (Analog)
  - Phase Selector Switch
  - Engine Gauges – (Oil Pressure, Water Temperature, DC Voltmeter)
  - Hour meter Alarm Horn w/ Silencing Option
  - Pre-Alarm Senders - Specify Pre Alarms
  - Pre Low Oil Pressure
  - Pre High Engine Temperature
  - Low Fuel (Level or Pressure)
  - Fuel in Basin alarm
  - Low Coolant Level Shutdown
  - Switch "Not in Auto"

Control System Definitions

- Analog A.C. Meters (Voltmeter, Ammeter, Frequency Meter)
  - 2.5” metes that indicate the respective values
- Watt Meter (Analog)
  - 2.5” meter that indicates the number of kW being produced. Requires additional PT’s.
- Phase Selector Switch
  - Allows the user to look at voltage and amperage on L1, L2 or L3
- Engine Gauges – (Oil Pressure, Water Temperature, DC Voltmeter)
- Hour meter Alarm Horn w/ Silencing Option
- Pre-Alarm Senders - Specify Pre Alarms
  - Engine mounted senders that allow for impending failure warnings (Pre-low Oil Pressure, Pre-High Engine Temperature)
- Low Fuel (Level or Pressure)
  - Alarm that indicates impending fuel level or pressure failure
- Fuel in Basin alarm
  - Alarm that indicates fuel in the rupture vessel of the fuel tank
- Low Coolant Level Shutdown
  - Allows for engine shutdown prior to complete loss of coolant
- Switch “Not in Auto”
  - Used for maintenance purposes, notifies technician that the “Run, Off, Auto” Switch is in the off position

Control System Definitions

- Tachometer
  - Shows engine speed in RPM
- Exhaust Pyrometer
  - Shows Exhaust Gas Temperature
- Emergency Stop Switch (Local)
- Emergency Stop Switch (Remote)
- Common Failure Relay 1SPDT
  - 1SPDT Form “C” Contact that changes position on a overspeed, overcrank, high engine temp., low oil pressure shut down
- Dry Contacts *Specify Qty. Required (____)*
- Run Relay 1SPDT
  - 1SPDT Form “C” contact that changes position when the the runs. Used primarily as a pilot relay.
- Panel mtd. Remote speed Adjust
- Voltage Adjust Rheostat ±5%
- Condensation Strip Heater 120/240vac, 100Watts
- Battery Charger Failure Light
- Low Battery Voltage Light
- High Battery Voltage Light

Control Systems

- **Digital w/LCD Display or Vacuum Fluorescent Display**
  - Emergency Stop Switch Remote
  - Common Failure Relay
  - Engine Run Contacts
  - RS232 Communication links
  - Modem
  - Dry Contacts *Specify Qty. Required (____)*
- Remote Alarm Annuniciator (to match control panel selected)
  - Surface Mount
  - Flush Mount

Circuit Breakers & Options

- Breakers / Unit Mounted
  - UL Listed 80% Rated
  - UL Listed 100 % Rated
  - IEC List (Export Market Only)
    - Breaker __________AMP __________ Pole
    - Breaker __________AMP __________ Pole
  - Shunt trip
  - Auxiliary Contacts
  - Ground Fault Indication
  - Bus Bar Connection / load side of breaker

Circuit Breaker & Options Definition

- UL Listed 80% Rated (Std. unless specified)
  - The thermal-magnetic molded case circuit breaker (MCCB) is the most often used resettable type of overcurrent device. For a given rating, it is more economical and smaller in size than other types of circuit breakers. A standard rated 80 percent MCCB breaker has been type tested in open air (no enclosure) to verify its continuous ampere rating while a 100 percent rated MCCB breaker has been type tested in a specific enclosure. Accordingly, when installed in an enclosure, the standard rated MCCB breaker is permitted to carry a continuous current of 80 percent of its nameplate rating.
- UL Listed 100 % Rated
  - When selecting molded case circuit breakers for overcurrent protection of cable and bus, the system designer may choose between standard 80 percent rated or 100 percent rated circuit breakers. Provided the protection is equivalent, economics and future load growth factors drive the decision. A standard rated 80 percent MCCB breaker has been type tested in open air (no enclosure) to verify its continuous ampere rating while a 100 percent rated MCCB breaker has been type tested in a specific enclosure. Accordingly, when installed in an enclosure, the standard rated MCCB breaker is permitted to carry a continuous current of 80 percent of its nameplate rating. The 100 percent circuit breaker is allowed to carry 100 percent of its rating when installed in an enclosure of minimum dimensions and using 90° C cable sized for 75° C ampacity.

Circuit Breaker & Options Definition

- IEC List (Export Market Only)
- Shunt trip
  - Shunt coil trips breaker open during engine failure shutdown
- Auxiliary Contacts
  - Used to show breaker position
- Ground Fault Indication
  - _The electrical code requires an indication of a ground fault on emergency (life safety) generators that are solidly grounded, operating at more than 150 volts to ground, and with main overcurrent devices rated 1000 amperes or more. If required, standard practice in emergency/standby applications is to provide a latching indication only of a ground fault, and not to trip a circuit breaker. Although ground fault protection of equipment that opens the faulted circuit may be provided, it is not required by code nor recommended on critical life safety circuits.
- Bus Bar Connection / load side of breaker

Vibration Isolators

- Elastomer Type
- Pad Type
- Spring Type
- Seismic Type (Specify Zone) ______

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- COMPONENT REACTION (IE UPS…)
- LOCATION (AESTHETICS)

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  - Williams Texas Gas Pipeline
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  - New York Yankees
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  - Port Authority of NY.NJ
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  - Capital University
  - Water Treatment Facilities Dayton OH., Evansville IN., Pittsburgh PA.


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QUESTIONS ?