

3-Phase Rectifier Input Ratings

In order to determine kVA and AC Line current for Rectifiers, the rectifier circuit design should be considered, along with the turns ratio of the transformer.

-Transformers with 4:1 turns ratio (low voltage plating) or higher turns ratio, will have higher losses vs those with 1:1 ratio (like an e-coat rectifier).

-The circuit configuration used in a rectifier should be known to account for additional losses, although for rough calculations this would be negligible.

-Rectifiers that use SCR and diode devices account for additional losses that effect efficiency, and should be used in the following power consumption calculations.

-Operating any rectifier at maximum voltage and current levels will give you the highest amount of efficiency. This is what is normally stated by manufacturer's in their performance specifications.

-Efficiency is the ratio of Output Power to Input Power.

-Power Factor is the ratio of true power actually consumed, to apparent power (E x I) in an AC circuit.

-Take note of the use of Power factor in the line current formula's. A primary SCR circuit is used in all modular and low voltage plating systems. That means, the SCR phase regulated device feeds a transformer(s) that are inductive in nature. This naturally lowers the PF, and should be included in the power calculations.

-The Series 50 Ecoat rectifier has secondary SCR's and they phase control directly to the L/C filter that may cancel into unity PF, and the load for which we will assume is linear and may also call for unity power factor. Since the PF is unity (one), we will disregard this for the formula.

-Power Factor and Efficiency when used in the following formulas should be expressed as decimals.

Example 1

What is the Line Current and kVA rating of a 0-18volt, 5000 amp plating rectifier?

For the low-voltage plating rectifier, we are using a 6-phase star circuit. This circuit type, along with losses for the transformer, SCR's, diodes, cables, shunt etc account for a total of 14%. So, the overall efficiency will be 86%. The Power Factor, at full output is 90%.

What is the AC input Current?

-Note: Always use lowest line voltage expected. CPC design is Vin nominal +/- 5% (for 460 volt input, use 437 volts)

$$ACamperes = \frac{DCWatts}{Vin \sqrt{3} PF eff}$$

$$So.... \frac{18 \times 5000}{437 \times 1.73 \times .9 \times .86}$$

My line current is approx. 154 AC amperes.

-For general across-the-board calculations, you can use a general PF value of 0.9 and a general efficiency value of 0.8. This would get you in the ballpark, as you will round up to the next value (in increments of 25-50) for feeder service, or add 25-30% margin (See breaker ratings).

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What is the kVA rating?

$$kVA = \frac{V_{in} I_{in} \sqrt{3}}{1000}$$

$$\text{So... } \frac{437 \times 154 \times 1.73}{1000}$$

The kVA rating of the Rectifier is approximately 116.

-Because there are ancillary components in the rectifier, like fans, pilot lights, electronic cards etc. you should always add 1 to 3 kVA additional to cover these items. Assume 119 kVA for example 1

Example 2

I have a Series 50 E-coat Rectifier rated at 0-400 volts and 500 DC amperes.

What is my line current with a 575 volt input?

$$ACamperes = \frac{DCWatts}{V_{in} \sqrt{3} \text{ eff}}$$

$$\text{So... } \frac{400 \times 500}{546 \times 1.73 \times .91}$$

*-Remember to find you lowest practical input voltage that the utility can drop to (Vin nominal minus 5%)
-Remember that the series 50 has secondary SCR's and does not require the PF value, or assume unity (x1).*

My AC line current will be 236 amperes per phase. (Add 2 to 10 amps for Control circuitry).

What is the kVA rating ?

$$ACamperes = \frac{V_{in} I_{in} \sqrt{3}}{1000}$$

$$\text{So... } \frac{546 \times 236 \times 1.73}{1000}$$

My kVA rating is 223 (add 1-3 kVA for Control circuitry)

Use the efficiency matrix on page 3 for your calculations with our rectifier models.

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Useful Formulas

-TO FIND-	Single Phase	Three Phase	Direct Current
Kilowatts	$\frac{I \times E \times PF}{1000}$	$\frac{I \times E \times 1.73 \times PF}{1000}$	$\frac{I \times E}{1000}$
KVA	$\frac{I \times E}{1000}$	$\frac{I \times E \times 1.73}{1000}$	-----
Horsepower (Output)	$\frac{I \times E \times \%EFF \times PF}{746}$	$\frac{I \times E \times 1.73 \times \%EFF \times PF}{746}$	$\frac{I \times E \times \%EFF}{746}$
Amperes when Horsepower is Known	$\frac{HP \times 746}{E \times \%EFF \times PF}$	$\frac{HP \times 746}{1.73 \times E \times \%EFF \times PF}$	$\frac{HP \times 746}{E \times \%EFF}$
Amperes when Kilowatts is Known	$\frac{KW \times 1000}{E \times PF}$	$\frac{KW \times 1000}{1.73 \times E \times PF}$	$\frac{KW \times 1000}{E}$
Amperes when KVA is Known	$\frac{KVA \times 1000}{E}$	$\frac{KVA \times 1000}{1.73 \times E}$	-----

Use Decimal Equivalent for PF (Power Factor) and % EFF (Efficiency)

For 3-phase SCR Rectifiers use chart below for Approximated PF and % EFF.

Note: The Power Factor will change depending on the open circuit voltage of the transformer design (to compensate for losses and low AC line conditions). **Assume an average of .87 for the Power Factor value if it is not known.**

Efficiency Matrix

All Values at Max. Power Output	PF	%EFF
S-1800	.90	.85
S-30	.91	.86
S-50	.93	.91

Quick Calculations for AC Line Current and System kVA for 3-phase Rectifiers

- #1 Find worst case voltage based on low line voltage condition (CPC guarantees output rating with +/-5% input variance)
- #2 Find low voltage ($V_{in} / 1.05 = \underline{\hspace{2cm}}$) (ie..Use 457 for 480 volt input)
- #3 Calculate Divider ($1.73 \times 457 \times \underline{\%EFF}$) (ie.. Use 719 for series 50 model).
- #4 Calculate kW (DC output voltage x DC Output current)
- #5 Divide watt value by divider in # 3
- #6 This is your line current. (Note: Add 2-10 amperes for control circuitry)
- #7 Take line current and multiply it by input voltage (#2) then multiply by 1.73
- #8 Divide answer for # 7 by 1000
- #9 This is your kVA rating. (Note: Add 1-3 kVA for control circuitry)

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CPC Breaker Ratings and Formula

Once the maximum AC line current has been determined, add 25% to find the breaker rating.

Example" 68 AC amperes x 1.25 = 85amps USE 90 AMP BREAKER*
 745 AC Amperes x 1.25 = 931 amps USE 1,000 AMP BREAKER*

* Some lower ratings may be allowed. Contact CPC Engineering for approval.

Standard SQ D Main Circuit Breakers used in CPC Rectifiers:

15	225
20	250
25	300
30	350
35	400
40	450
45	500
50	600
60	700
70	800
80	900
90	1000
100	1200
110	*1400
125	*1600
150	*1800
175	*2000
200	*2500

FAL frame is up to 100 amperes.

KAL frame is from 110 to 250 amperes.

LAL frame is from 300 to 400 amperes.

MAL frame is from 450 to 1200 amperes

*Contact CPC for These and higher ratings

-25% is added to cover the 80% rule-

This is the NEC rule that the circuit breaker device must be rated to carry 80% of the FULL current rating indefinitely without tripping. These breakers are not considered to be in "open air" classification since they are in an enclosure with ambient temperatures higher than the outside temperature.

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