

## Sizing Enclosures for SCR Power Controllers

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### INTRODUCTION

Most applications for SCR Power Controllers require some type of enclosure. This application note is intended to assist you in properly selecting an enclosure, taking into consideration

1. The environment and
2. The type of SCR Power Control.

### SELECTION CRITERIA

The first step in selecting an enclosure is to evaluate the environment. Answers to the following eight questions are essential before a selection can be made properly.

1. What is the maximum ambient temperature where the enclosure will be mounted?
2. Will the enclosure see any reflected heat from any nearby sources?
3. Is there dust, water, oil or other contaminants that may affect the overall operation of the equipment?
4. Is the user installing any additional equipment in the enclosure?
5. Will both sides, top, bottom, front and back be exposed to the air for heat sinking purposes?
6. Are there any objections to forced-air cooling?
7. Is cooling water available if a sealed enclosure is required?
8. Are there any size restrictions?

### TYPES OF ENCLOSURES

Once the above questions are answered, you can select an enclosure type from the following list.

**NEMA 1** General Purpose – used indoors as a safeguard for personal safety, normally where special conditions do not exist. NEMA 1 enclosures may be ventilated.

**NEMA 2** Drip Proof – used indoors where falling, non-corrosive liquids and falling dirt may damage electrical/electronic components.

**NEMA 3** Dust Tight – for outdoor use where protection from wind-blown dust and water is required.

**NEMA 3R** Rain Tight – same as NEMA 3, except NEMA 3R enclosures provide equipment protection from rain. They are not dust tight or sleet-resistant.

**NEMA 4** Watertight and Dust Tight – for indoor or outdoor use where splashing or seeping water, falling or hose-directed water and severe external condensation are threats to the electrical/electronic components.

**NEMA 12** Industrial Use, Dust Tight and Drip Tight – used indoors for protection from fibers, dust and dirt, light splashing, seepage, dripping and external condensation of non-corrosive liquids.

Note: There are many other types of NEMA enclosures for very special applications but beyond the scope of this paper.

## SIZING THE ENCLOSURE

After selecting the enclosure, you can size it. This requires knowing: 1) the ambient temperature at the installation site; 2) the SCR Power Control dimensions; 3) whether additional equipment will be installed and 4) the maximum allowable equipment operating temperature. Space is always at a premium, so initially select the smallest enclosure that will hold the equipment while allowing proper clearance for mechanical, electrical and thermal considerations.

### Calculating Power Loss

The next step is to calculate the power losses into the enclosure for each piece of equipment mounted. If there is more than one of the same type, multiply the losses by the quantity. When calculating power losses for any HDR power controller, a conservative estimate is given by this formula:

$$\text{Power Loss} = \text{Maximum Current} \times 1.5 \times \text{Number of Controlled Legs}$$

### Enclosure Heat Sinking Capabilities

After calculating the power losses, determine the heat sinking capability of the enclosure. Find the square inches of surface area required for the maximum temperature rise allowed in Table 1. Subtract the maximum ambient temperature from the equipment maximum allowable temperature rating to find the maximum temperature rise allowed. The surface area required is the product of the total losses in watts multiplied by the surface area required per watt from Table 1.

Now you know the type of enclosure, the estimated size and the surface area. Next, you need to verify the thermal size.

In the following example, assumptions are:

1. Only one Power Controller will be mounted in the enclosure (an HDR ZF1-480-120)
2. The external ambient conditions will be 30°C or less
3. There are no restrictions on enclosure size
4. The enclosure will be mounted on a wall, which allows the top, bottom, two sides and the front for heat dissipation
5. A dust-tight and drip-tight enclosure is desired and
6. The actual full load current is 110 amperes.

#### Example #1

Based on the above assumptions, the procedure for selecting the appropriate enclosure is as follows.

1. Select the enclosure type from the list.

*The correct enclosure is NEMA 12.*

2. Select the physical dimensions of the enclosure.

*The AMETEK HDR Power Control has dimensions of 15"H x 11"W x 10"D. Based on experience, the first pick for an enclosure size will be 30"H x 24"W x 12"D. This allows 7.5" clearance top and bottom, and 6.5" clearance on each side. This is ample room for the power controller to fit and leaves plenty of room for wiring.*

3. Calculate the power losses.

$$\begin{aligned} \text{Loss} &= 110 \times 1.5 \times 1 \\ \text{Loss} &= 165 \text{ watts} \end{aligned}$$

4. Calculate the required surface area.

*The maximum ambient temperature is 30°C and the power controller's maximum operating temperature is 50°C; therefore, you can allow for a 20°C temperature rise. From Table 1, 9.2 sq. in. of surface area are needed to dissipate each watt of power.*

$$\begin{aligned} \text{Required Surface Area} &= 9.2 \times 165 \\ \text{Required Surface Area} &= 1518 \text{ square inches} \end{aligned}$$

MAXIMUM ALLOWABLE TEMPERATURE RISE	MAXIMUM WATTS SQ. IN.	SURFACE AREA REQUIRED SQ. IN. / WATT
10°C	0.054	18.4
20°C	0.108	9.2
30°C	0.103	6.1
40°C	0.218	4.6
50°C	0.260	3.8

**TABLE 1 – ENCLOSURE HEAT SINK VARIABLES**

5. Calculate the available enclosure surface area using the top, bottom, both sides and the front for heat dissipation

$$\begin{aligned} \text{Front:} & \quad 30 \times 24 = & \quad 720 \\ \text{Top:} & \quad 24 \times 12 = & \quad 288 \\ \text{Bottom:} & \quad 24 \times 12 = & \quad 288 \\ \text{Two Sides:} & \quad 30 \times 12 \times 2 = & \quad 720 \\ \text{Total =} & & \quad 2016 \text{ square inches available} \end{aligned}$$

*Since 2016 sq. in. are available and 1518 sq. inches are required, the calculations show that the available surface area is greater than the required surface area. This situation indicates a good thermal design and the power controller will operate at 100% duty cycle at full current.*

## Fan Cooling

If the enclosure had not been large enough, the next size enclosure would be selected and the calculations reworked. If the application had required a smaller enclosure and allowed forced-air cooling, you would perform all of the previous calculations plus determine the air flow (CFM) requirements using chart 1. If a fan is required, and the enclosure size is already determined, calculate the heat dissipation of the enclosure based on Table 1 using the "Maximum Watts/Sq. In." column. Simply determine the surface area of the enclosure and multiply by the watts/sq. in. number based on the maximum allowable temperature rise.

Next calculate the maximum power generated by the power controller and subtract the enclosure power dissipation from the power controller dissipation. This is the total watts that must be removed by the fan. Refer to chart 1 to determine the fan size. Sample calculations for this procedure are shown in example #2.

### Example #2

In this second example, the assumptions are: 1) One power controller will be mounted in the enclosure (an HDR ZF2-480-225), 2) All other conditions are the same as the previous example except the actual full load is 215A. Under these conditions, selecting the proper enclosure is as follows.

1. Select the type of enclosure.

*Once again the proper choice is a NEMA 12.*

2. Determine enclosure dimensions.

*The power controls dimensions are 15"H x 14"W x 10"D. Using the previous NEMA 12 sized 30"H x 24"W x 12"D allows about 7.5" clearance top and bottom and 5" on the sides for mechanical and electrical considerations.*

3. Calculate the power losses.

$$\begin{aligned} \text{Loss} &= 215 \times 1.5 \times 2 \\ \text{Loss} &= 645 \text{ watts} \end{aligned}$$

4. Calculate the required surface area.

$$\begin{aligned} \text{Required Surface Area} &= 9.2 \times 645 \\ \text{Required Surface Area} &= 5934 \text{ square inches} \end{aligned}$$

5. Calculate the enclosure's surface area.

*The calculations are the same as the previous example - 2016 square inches. Since 2016 square inches are available but 5934 square inches are required, a fan is required!*

6. Determine the watts the enclosure will dissipate (use table 1).

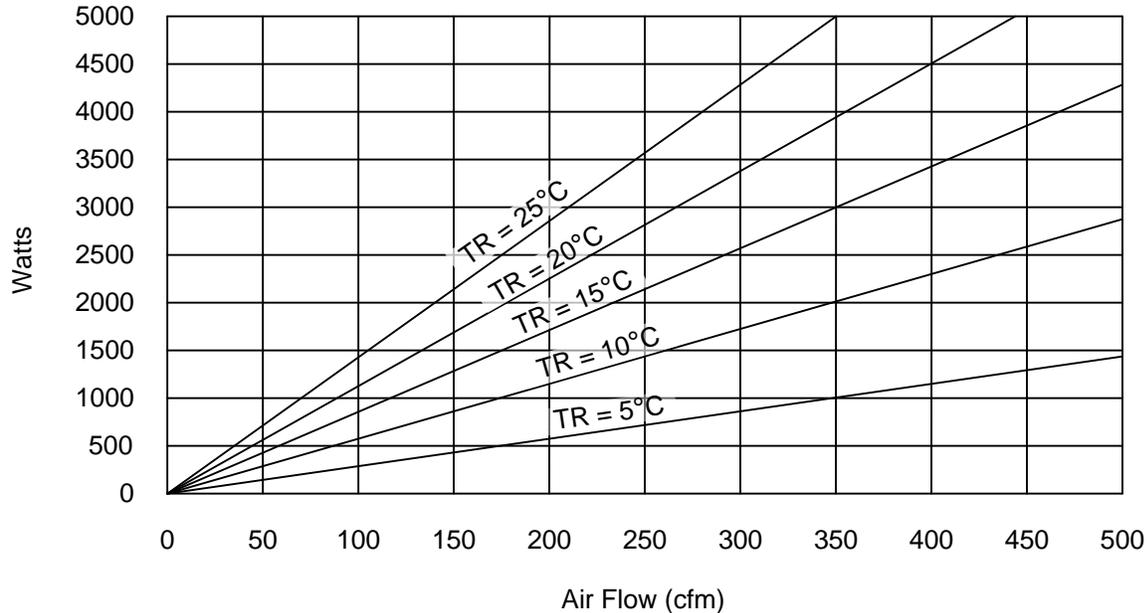
$$\begin{aligned} \text{Enclosure Dissipation} &= 2016 \times .108 \\ \text{Enclosure Dissipation} &= 218 \text{ watts} \end{aligned}$$

7. Calculate the watts the fan must remove.

$$\begin{aligned} \text{Remaining Watts} &= 645 - 218 \\ \text{Remaining Watts} &= 427 \text{ watts} \end{aligned}$$

8. Select the fan.

Using the fan requirement chart, note that removing 427 watts requires a 40 cfm fan. To extend the applicability of this chart if the power dissipation is higher than the range shown, multiply both the vertical and horizontal numbers by the same factor.



**CHART 1 – Fan Requirements**

There are many other ways to cool electrical equipment enclosures. Included are air-to-air heat exchangers, direct water cooling, air-to-water heat exchangers and venturi tubes just to name a few. These are usually used on equipment installed in dirty installations where it is extremely important to keep the enclosure sealed such as in a steel foundry.

*Note: this application note originally appeared in the May 1991 issue of Industrial Heating magazine*