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## APPLICATION NOTE

### Drive Applications Support Library

Application Note	AN-P2-070
Title	Mounting Drives in Control Panels
Related Products	P2 Series AC Drives
Level: <b>2</b>	1 - Fundamental - No previous experience necessary. 2 - Basic - Some basic drives knowledge recommended. 3 - Advanced - Some basic drives knowledge required. 4 - Expert - Good experience in topic of subject matter recommended.

### Overview:

All Bardac AC drives are designed to be easily mounted into control panels when required, allowing easy installation into typical industrial environments and end user sites. The P2 series is available in three basic enclosure types, dependent on the power rating, as follows:

Enclosure Type	Power Ratings	Notes
IP20	1 – 15HP / 0.75 – 11kW	These drives must be mounted into a control cabinet, to provide protection against dust and moisture, and also to prevent the risk of accidental electric shock.
NEMA 12 / IP55	15 – 250HP / 11 – 160kW	These drives are protected against dust and moisture ingress, and may be mounted directly in a typical production environment. They can also be optionally mounted into control cabinets if desired.
NEMA 4X / IP66	1 – 10HP / 0.75 – 7.5kW	These drives are protected against high levels of dust and direct moisture ingress, and may be mounted directly in typical production environments, including wash down areas. They can also be optionally mounted into control cabinets if desired.

## Planning the Installation:

In order to ensure correct installation of the drive into a control cabinet, it is important to consider the following points :

- **Control Cabinet Size**

- The cabinet must be large enough to accommodate the required drives and any additional equipment, whilst maintaining correct air flow clearances around them to allow sufficient airflow through the drives heatsink.

- **Control Cabinet Ventilation**

- It is important to ensure adequate airflow through the panel to prevent the internal panel temperature exceeding the maximum ratings of any components mounted within. In some instances, this may require air conditioning equipment to be fitted.
- Where IP20 drives are mounted in control panels, all ventilation must be filtered to prevent dust entering and damaging the drives.
- The ventilation layout must ensure that hot spots do not develop in the panel, e.g. allowing hot air to exit above the drives, and fresh cool air to enter below.

- **Control Cabinet IP Rating**

- The panel design must be suitable for the environment where the panel will be mounted, and provide protection against dust and moisture as necessary.

- **EMC Considerations**

- The EMC of all components mounted inside the panel must be considered.
- Cable routing within the panel must be carefully planned to provide correct segregation of control and power cables and prevent unwanted noise transfer.
- All equipment should be correctly connected to Earth (Ground) to ensure correct EMC performance and safety.

## Control Cabinet Sizing Guidelines:

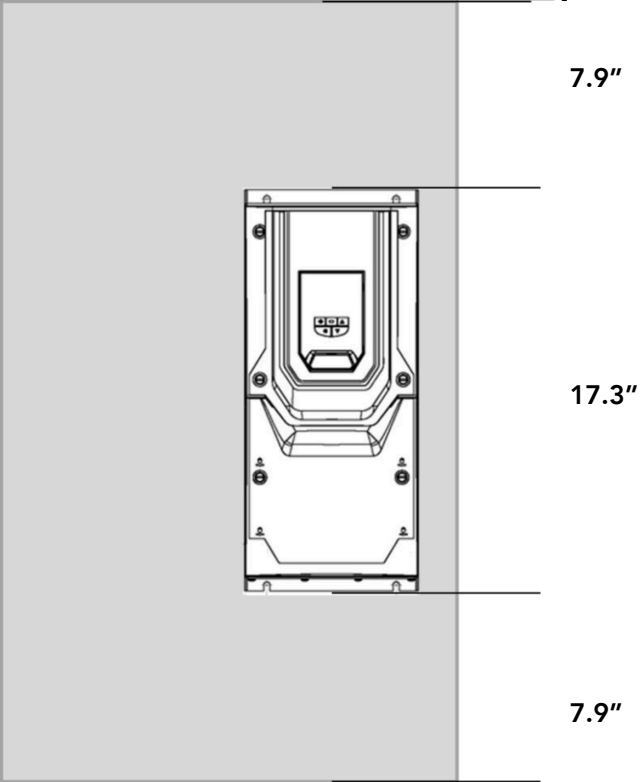
When selecting a control cabinet in which to mount drives, always ensure that the height of the panel can accommodate the largest drive to be mounted, whilst meeting the minimum required cooling air gaps, as shown in the product User Guide. These are as follows:

Drive Frame Size	Drive Enclosure Type	Drive Dimensions			Cooling Air Clearance Required		
		Height	Width	Depth	Above	Below	Sides
2	IP20	8.7"	4.4"	7.3"	3.0"	3.0"	0"
	NEMA 4X / IP66	10.2"	7.4"	9.5"	6.0"	6.0"	0"
3	IP20	10.3"	5.2"	8.1"	4.0"	4.0"	0"
	NEMA 4X / IP66	12.2"	8.3"	10.5"	6.0"	6.0"	0"
4	NEMA 12 / IP55	17.3"	6.8"	10.0"	7.9"	7.9"	0"
5	NEMA 12 / IP55	21.3"	9.3"	10.7"	7.9"	7.9"	0"
6	NEMA 12 / IP55	34.1"	13.0"	13.0"	7.9"	7.9"	0"
7	NEMA 12 / IP55	50.4"	13.0"	14.2"	7.9"	7.9"	0"

This means, for example, that for a Frame Size 4 Drive mounted in a control cabinet, the cabinet height must be a minimum of

Drive Height + Top Air Clearance + Bottom Air Clearance

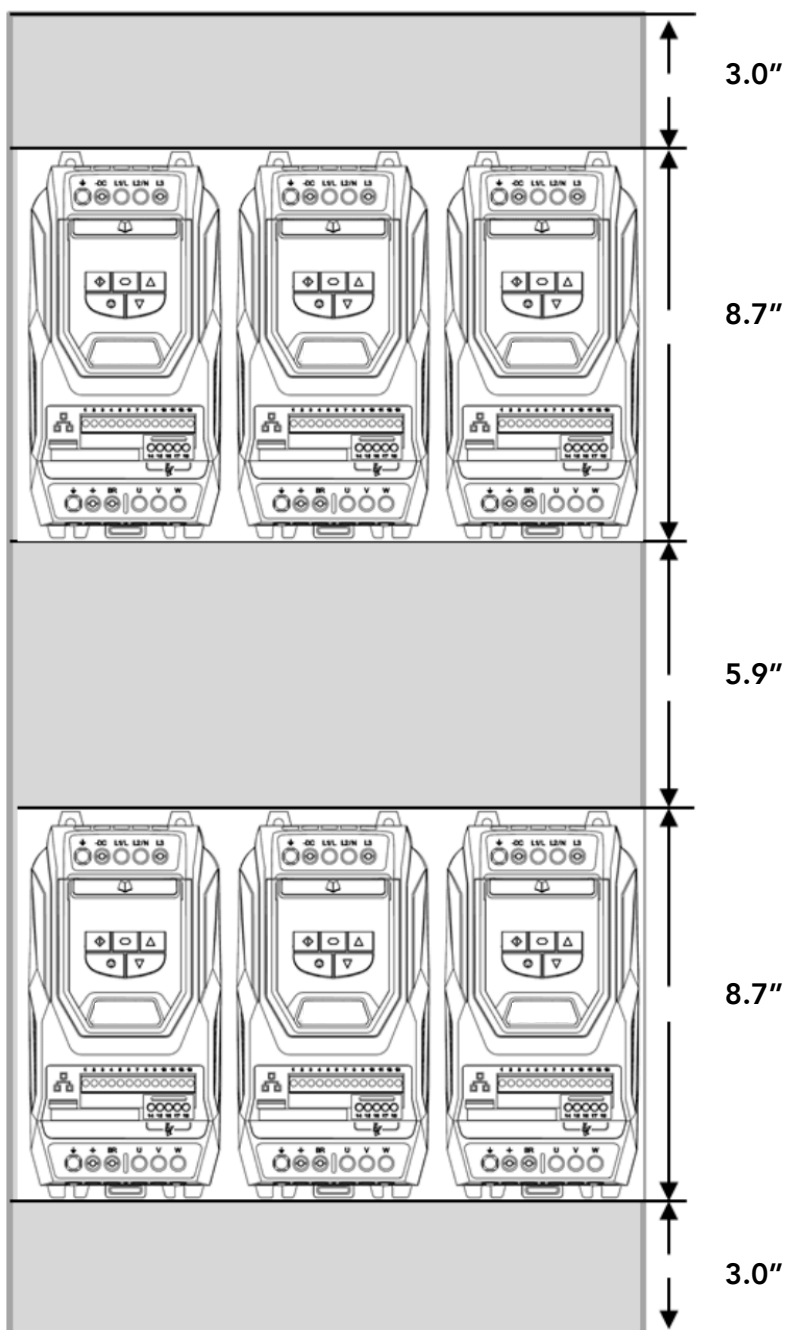
The panel depths and width must be sufficient to accommodate the drive depths and width, plus any additional equipment to be mounted inside the control cabinet.



When multiple drives are to be mounted into the same control cabinet, they can be mounted above each other provided that the air gap clearance is maintained. In this case, to ensure that as little hot air as possible is drawn from the drives below into the drives above, the clearance between the drives must be

Top Air gap clearance + Bottom Air Gap Clearance

E.g. if a number of Frame Size 2 Drives are located in the same control cabinet, they can be arranged as follows:



In both the above examples, the gray shaded areas above and below the drives are to be left free to allow air to easily enter and exit the drive cooling channel. No equipment may be mounted in these areas that would in any way restrict the flow of air into and out of the drive heatsink.

## Control Cabinet Cooling:

Any electrical equipment mounted inside a control cabinet will likely generate heat, and it is important to ensure that the control cabinet is correctly designed to maintain all the enclosed electrical components at or below their maximum operating temperature during operation. The following steps can be followed to ensure correct cooling:

- Determine the maximum internal temperature which may be allowed inside the control cabinet. This can be done by checking each of the components to be mounted, and determining its maximum operating temperature. The component with the lowest maximum operating temperature will determine the maximum limit.
  - With all Bardac AC drives, the following maximum temperature limits apply:
    - IP20 Drives: 50°C Maximum Continuous without derating, up to 60°C with derating
    - NEMA 12 / IP55 Drives : 40°C Maximum Continuous without derating, derate the maximum available output current by 1.5% per degree C above 40°C up to a maximum of 50°C
    - NEMA 4X / IP66 Drives : 40°C Maximum Continuous without derating, derate the maximum available output current by 2.5% per degree C above 40°C up to a maximum of 50°C
- Determine the heat losses generated by all components mounted inside the panel. This can easily be found by summing together the total of the losses for each component.
  - As a simple method for calculation purposes, it is easiest to assume that each drive will dissipate around 3% of rated power as heat losses when operated at full load.
  - Items such as input and output chokes will normally dissipate around 2% of the rated load power, however this can be determined by checking their line impedance % vs. the connected load.
  - For all other equipment, refer to the manufacturers data sheet.

- When the total heat losses are known, the required panel surface area or cooling airflow can be calculated.
  - If the panel is to be completely sealed, with no external ventilation, the external surface area which is free to radiate heat to the environment must be great enough to dissipate the heat generated inside the panel. The required panel surface area can be calculated according to the following:
    - $A = P / k * (T_{MAX} - T_{AMB})$ 
      - A = Control Panel Surface Area in square meters which is free to radiate heat to the air (e.g. areas mounted against the wall or floor are excluded)
      - P = Total power dissipated in panel
      - K = Thermal constant, typically 5.5 for painted mild steel
      - $T_{MAX}$  = Maximum temperature allowed in the panel
      - $T_{AMB}$  = Maximum ambient temperature around the panel
  - If the panel is to be ventilated using cooling fans and filters, the required airflow can be determined as follows:
    - $F = 0.053 * P / (T_{MAX} - T_{AMB})$ 
      - F = Airflow in Cubic meters per minute
      - P = Total power dissipated in panel
      - $T_{MAX}$  = Maximum temperature allowed in the panel
      - $T_{AMB}$  = Maximum ambient temperature around the panel

## Example Calculations:

### **Example 1**

- 0.75kW, IP20 Drive
- Mounted in a Sealed, Painted Mild Steel enclosure
- 35°C Maximum Ambient Temperature

Assuming that the drive is the only component mounted in the panel producing heat,

$$P = 0.75\text{kW} \times 3\% = 22.5 \text{ Watts}$$

Control Panel is made of painted mild steel, hence  $k = 5.5$

The drive is IP20, no derating is applied, and hence maximum internal temperature of the panel is  $50^{\circ}\text{C}$

$$A = 22.5 / 5.5 * (50 - 35) = 0.273 \text{ Square meters is required}$$

The drive itself is 221mm high, and requires 75mm clearance above and below, hence the minimum panel height is:

$$75 + 75 + 221 = 371\text{mm}$$

The drive is 185mm deep; hence the minimum panel internal depth would be 185mm

From this, we can determine a control panel size, e.g. 400H x 400W x 200Dp

Assuming the panel is to be wall mounted, there will be five surfaces free to radiate heat to the environment,

- Top –  $0.2 \times 0.4 = 0.08$  Square Meters
- Bottom –  $0.2 \times 0.4 = 0.08$  Square Meters
- Front –  $0.4 \times 0.4 = 0.16$  Square Meters
- Left Side –  $0.2 \times 0.4 = 0.08$  Square Meters
- Right Side –  $0.2 \times 0.4 = 0.08$  Square Meters
- (The rear cannot radiate heat, as it is mounted against the wall)

Therefore the total surface area is  $0.08 + 0.08 + 0.16 + 0.08 + 0.08 = 0.48$  Square Meters, which is suitable

### **Example 2**

- 10 x 400Volt, 3 Phase, 5.5kW IP20 Drives
- Mounted in a Ventilated Enclosure

- 25°C Maximum Ambient Temperature
- Additional heat losses within the panel total 100 Watts

Heat losses from the drives =  $3\% \times 10 \times 5.5\text{kW} = 1650 \text{ Watts} + 100 \text{ Watts}$  Additional other heat losses

The drive may be mounted in two rows of 5, with one row above the other. The drives are Frame Size 3, therefore...

- Drive Height: 261mm
- Clearance Required Above & Below : 100mm

This requires a minimum panel height of  $100 + 261 + 100 + 100 + 261 + 100 = 962\text{mm}$

Drive depth is 205mm, hence a minimum internal panel depths of 205mm is required.

Drive width is 131mm; hence the minimum panel width is  $131 \times 5 = 655\text{mm}$

In practice, the additional components to be mounted in the panel will also require space; hence the panel is likely to be a minimum of 1000 – 1200mm high, and 800 – 1000mm Wide, 300mm Deep.

Calculate the required airflow as follows:

$F = 0.053 \times P / (T_{\text{MAX}} - T_{\text{AMB}}) = 0.053 \times 1750 / (50 - 25) = 3.71$  cubic meters per minute of airflow is required

### **Example 3**

- 2 x 30kW NEMA 12 Drives operating as Duty / Standby (Motor Current 57Amps)
- Mounted in a ventilated, mild steel enclosure
- Maximum Ambient Temperature 45°C

In this case, as the drives operate in Duty / Standby configuration, only one drive will operate at any given time, hence the cooling airflow calculation can be based on only one drive operating.

Heat Loss for one drive =  $3\% \times 30\text{kW} = 900 \text{ Watts}$

The ambient temperature exceeds the continuous rating of the drive, hence it will be necessary to use a higher power rated drive and derate. In this case, we can select a 37kW drive (72Amps rated), and derate to the required motor current. The derating factor for IP55 drives is 1.5% per degree C, hence at 50°C ambient, the drive can still output  $72\text{A} - 15\% = 61.2\text{Amps}$



The cooling airflow calculation can then be based on 50°C operation of the drive.

Control panel minimum height = 540 + 200 + 200 = 940mm

Required airflow =  $0.053 \times 900 / (50 - 45) = 9.54$  cubic meters per minute.

## Correct Installation for best EMC Performance:

When installing drives in control cabinets, it is important to be certain that the final cabinet design ensures that all equipment operates correctly, and does not create unnecessary interference. The diagram below highlights particular areas of importance when installing to pay special attention to.

### Notes

- The drive **MUST** be earthed.
- Any additional EMC filters used with the drive must be mounted to the control cabinet back plate, ensuring good metal to metal contact over as much of the available surface area as possible.
- The motor cable must be of a shielded type, with the shield bonded to earth at BOTH ends. Bonding to earth at the control cabinet can be easily achieved using a motor shield clamp to the panel backplate.
- Control and power cables must be routed separately within the panel, to avoid noise from the power cables passing to signal cables. Where it is necessary for cables to cross, they should cross at right angles only.
- The complete control cabinet frame should be bonded to earth, to prevent any noise generated inside the cabinet from being radiated outside. For best results, each panel side, or door should be bonded to the main panel chassis using flat, braided earth straps, which provide better high frequency performance than typical earth wires.

[ see graphic on next page ]

