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# Overview of AC Drives in Motor Control Centers (MCCs)

## Class 8998

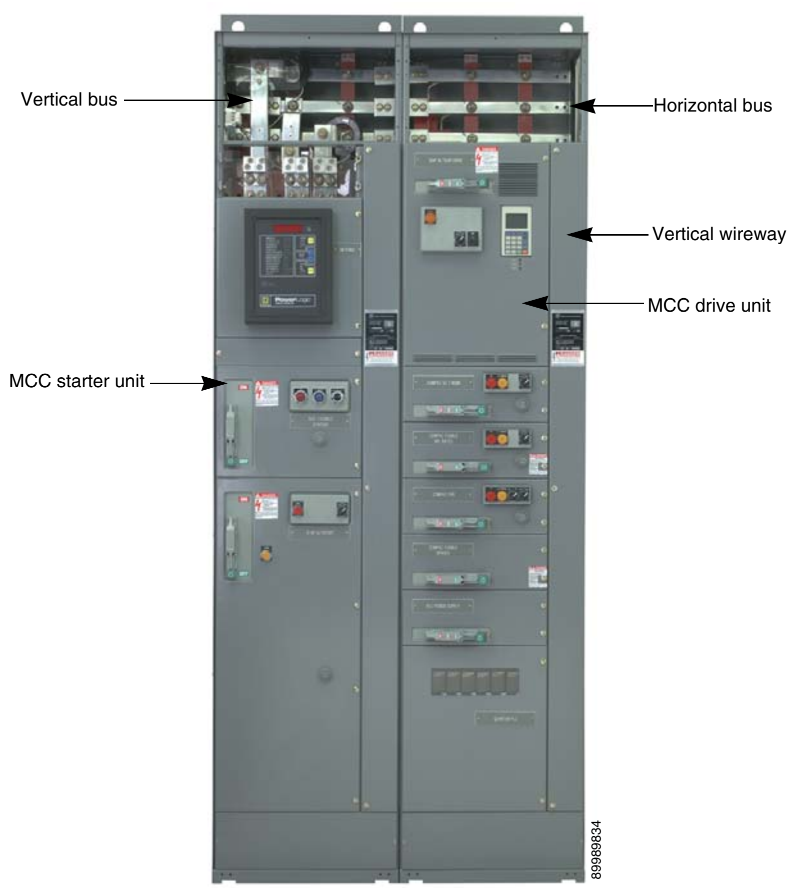
## Introduction

For decades, many facilities have chosen motor control centers (MCCs) to provide convenient, economical mounting solutions for ac drives. This document provides an overview of MCCs, as well as some key benefits of installing drives in MCCs.

## MCC Structure Characteristics

Various types of motor controllers and branch disconnects can be consolidated in an MCC enclosure. Figure 1 illustrates a typical MCC arrangement. This section describes the basic characteristics of an MCC that impact drive and packaging design.

**Figure 1: MCC Structure**



## Bus Structures

MCCs feature horizontal and vertical 3-phase power bus mounted inside the enclosure. This preconfigured power bus provides:

- Convenient expansion. Sections are spliced, not cabled, together.
- Easy installation and removal of units. Instead of fixed mounting, units are mounted in plug-in drawers (also called buckets).

## Pre-Defined Wireways

Metal wireway areas in the top, bottom, and side of the MCC sections are designed for routing, shielding, and protecting wiring. Sensitive control wiring can be separated from power wires within the wireway. Cables can enter or exit the MCC via the top or the bottom wireway.

## Standard Dimensions

MCCs are typically standardized cabinets, with fixed widths and depths. Typical MCC dimensions are 20 in. wide x 15 or 20 in. deep x 90 in. high (508 mm wide x 381 or 508 mm deep x 2286 mm high). Units within the structure are mounted in removable buckets that have a range of possible heights (6–72 in.), but a fixed width and depth. Figure 2 shows a typical MCC unit.

**Figure 2: Typical MCC Unit**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## Continuous Interconnected Structures

Continuous power bus and structures create a consolidated package that is physically and electrically bolted together.

## Front Access and Heat Dissipation

Units are maintained and removed from the front of the MCC structure. Depending on the installation, the side and rear surfaces of the MCC structure may not be able to dissipate the heat generated by internal devices. See “Improved Thermal Management” on page 6 for more information about thermal management.

## Protection from the Environment

Whether initially or over a long period of time, some applications can introduce high temperatures or excessive contaminants to electrical equipment. To protect against these environments, Schneider Electric offers MCCs with varying degrees of protection, such as NEMA 12 dust-tight and drip-tight industrial use enclosures or NEMA 3R rainproof and sleet-resistant outdoor-rated enclosures.

## MCC Features

### Compact and Modular

Most MCC units are designed as drawers that slide in and out of the MCC structure. This plug-in construction allows flexibility in layout and enhances maintenance. Users can arrange the units in any order or location before, during, and after installation to consolidate process controls or accommodate future expansions. Because units are built for simple removal from the MCC, they are relatively compact and easy to handle.

### Flexible

Motor control centers are used in nearly all operations in which an ac drive is installed. Drive units in MCCs are flexible in their design so that they can handle various load types, including variable and constant torque.

### Modifiable

Customers often want to modify their MCCs, either by adding more control units or by making internal modifications. To expand an MCC, customers can:

- Plug additional drive units into a section, or
- Add more MCC sections by making simple splice bar connections, instead of running more incoming feeders.

Customers can easily modify a drive for an upgraded process by adding input/output or serial communications cards to the drives.

### Easy to Maintain and Replace

MCC unit arrangements allow for convenient, hands-on maintenance and replacement of motor control components. If a drive must be replaced, a user can plug a spare unit into the space, and then connect motor and control leads. Since there is no need to touch incoming power wires or disconnect rigid conduits, work in tight spaces, or remove mounting bolts or wiring on the drive, downtime is minimal.

### Freestanding

Square D® brand MCCs are often used in applications in which there is little or no wall space nearby. MCCs can stand away from walls, wherever it is convenient to monitor and operate the motors.

### Rugged

During installation and periodic maintenance, customers often move or remove MCC drive units several times. Schneider Electric designs and builds robust MCC drive units that can withstand the rigors of installation, service, and frequent handling.

### User-Friendly

The wide experience range of installers, operators, and maintenance personnel impacts MCC features. Schneider Electric designs MCCs that are user-friendly, suitable for various plant disciplines, and eliminate the need for special instructions and tooling.

### Isolated

In an MCC, individual doors and internal steel barriers physically separate the units. These barriers enhance electrical fault containment and maintainability. Additionally, the barriers make it possible for some units to be absent from the MCC while other units operate.

# Advantages of Installing Drives in MCCs

## Installation Savings

When drives are mounted individually, individual feeders must be pulled to each drive (see Figure 4). The dashed lines in Figures 3 and 4 represent the incoming feeder(s) that are necessary to provide electricity to the drives.

These multiple feeders add cost and complexity to the installation. However, when drives are mounted in an MCC, only one incoming feeder supplies power to the entire MCC (see Figure 3). Additionally, installation of future drives costs significantly less because the main power feed is already in place, and the MCC structure is ready to accept plug-in units.

In general, when four or more drives will be installed near each other, it is more cost-effective to mount the drives in an MCC. Reductions in wiring, conduit, and labor offset any additional cost of the MCC structure.

**Figure 3: Typical MCC Drive Installation**

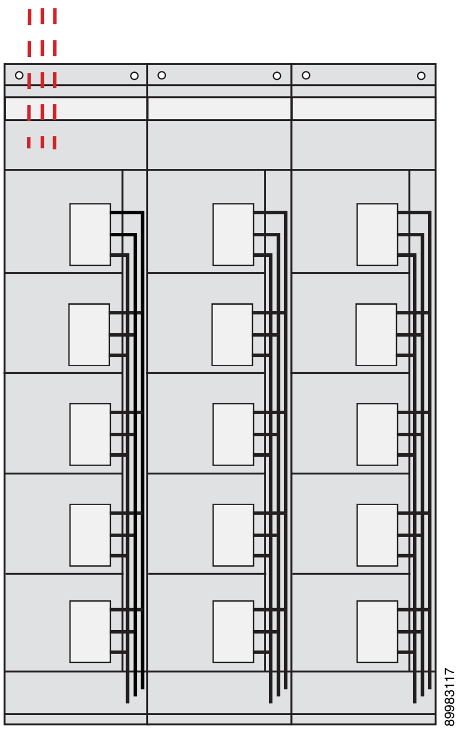
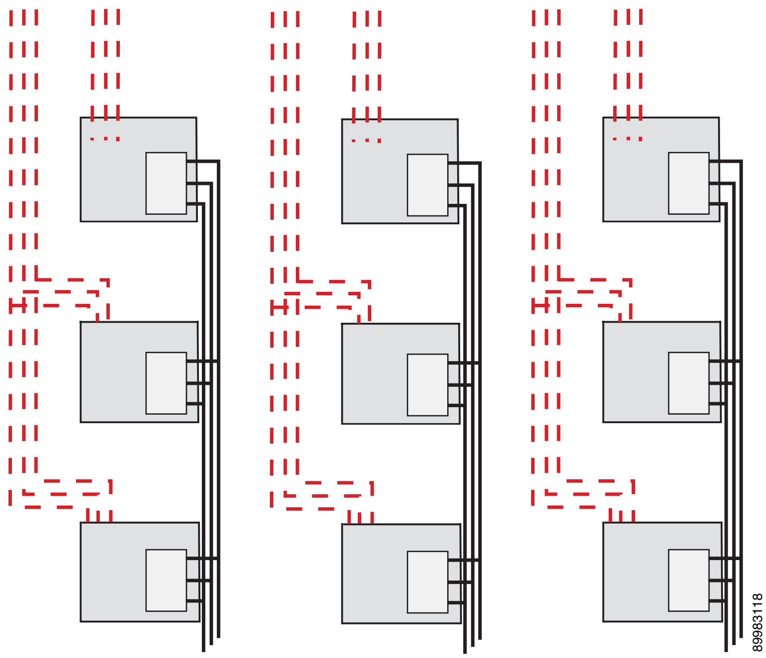



**Figure 4: Typical Individually-Mounted Drive Installation**

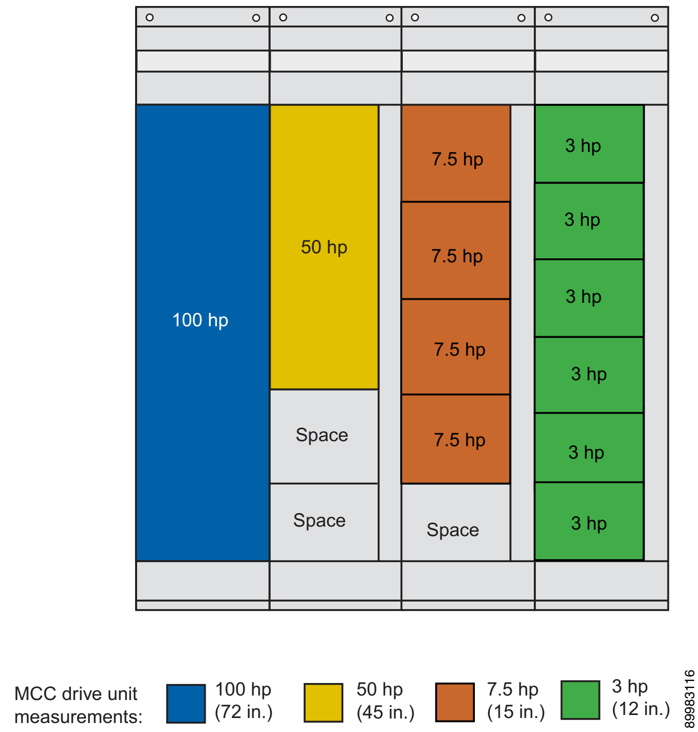



## Space Savings

Today, many plants and buildings have increasingly less room for electrical equipment. Tight budgets and higher costs demand efficient use of available space.

Square D® brand MCCs provide a dense consolidation of motor controls (see Figure 3). A bank of individual drives (see Figure 4) typically requires more wall and floor space than an MCC lineup, due to installation codes, wire/conduit bending space, and minimum workspace requirements. A single wall-mounted drive with conduits requires several feet of width. However, as many as six 3 hp drives can fit in one 20-in. wide MCC section (see Figure 5 on page 5).

**Figure 5: MCC Drive Unit Measurements**




## Improved Short Circuit Ratings

MCCs typically meet extended short circuit ratings above those provided by individual drives. Underwriters Laboratories® (UL®) 508C, the UL Standard for Safety for Power Conversion Equipment, requires that open type 1.5–50 hp drives are tested to 5,000 A. However, it is common for MCC units to be rated for 100,000 A.

To meet these higher levels, Schneider Electric takes additional steps to improve MCC unit integrity during high electrical short circuit currents by using the latest technology in quick acting, high fault rated circuit breakers. Fuses and the necessary exposure to live units when changing fuses have been eliminated in most drive units.

Customers should always verify that MCC drive units are evaluated as part of the MCC enclosure. A UL label on the structure and bussing does not necessarily mean that evaluation and testing have been performed on the combination of the drive unit and MCC structure. It is also good to verify that the individual MCC drive units carry a UL label and have been qualified to UL 845 (the UL Standard for Motor Control Centers). Table 1 shows typical short circuit current ratings of open drives and drives mounted in an MCC.

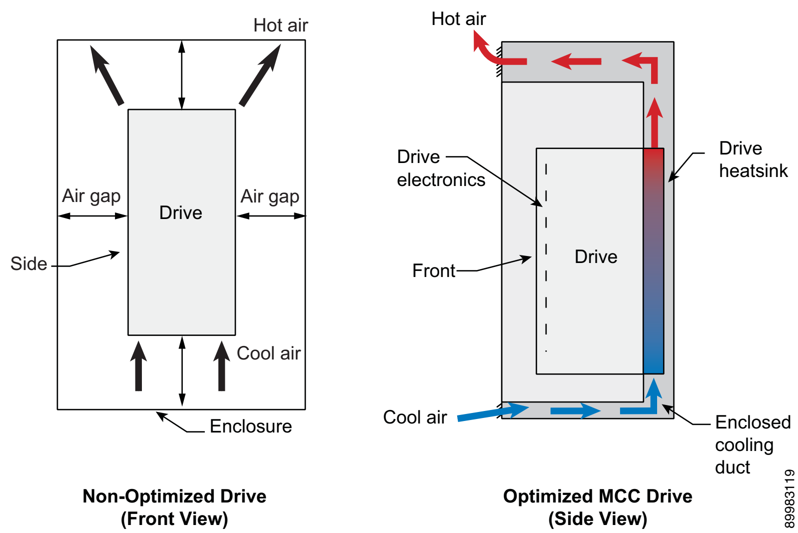
**Table 1: Typical Short Circuit Current Ratings**

| Drive HP | Open Drive Rating | MCC Drive Rating |
|---|---|---|
| 1.5–50 | 5,000 A | 100,000 A |
| 51–200 | 10,000 A | 100,000 A |
| 201–400 | 18,000 A | 100,000 A |

## Improved Thermal Management

Drives produce much more heat than other motor controllers; for example, the wattage loss from a drive can be five times higher than that for an equally rated electromechanical starter. Thus, drive enclosures must provide some way to effectively dissipate heat from the drive to avoid temperature shutdown or drive damage.

**Figure 6: Drive Heat Dissipation**




## Method 1: Non-Optimized

One simple, effective way to keep an open drive cool is to keep the ambient air temperature around the drive below the manufacturer's rated maximum. However, this method typically requires several inches of airflow space around all sides of the drive. It also requires correctly placed vents and/or fans to create a method of air movement in the enclosure. Additionally, placement of the drive requires consideration of other heat-producing items, such as reactors and transformers. The final result is a non-optimized package that requires a relatively large amount of space for the enclosure.

## Method 2: Optimized

Consider the following when designing a heat management system for drives in MCCs:

- Heat can only be removed from the front of the MCC, because other sections are usually beside the section containing the drive unit, and the MCC itself is often against a back wall.
- Internal power bus and other units can both contribute to and be affected by the heat around the drive.

Modern thermal analysis software tools can optimize cooling and create a reliable drive solution. Segregating the heatsink area and focusing cool airflow into, through, and out of the drive unit removes most of the heat before it can impact other areas (see Figure 6). This design removes the heat at the drive's metal heatsink, where 80% of the drive losses are emitted. The air flow for cooling the drive heatsink is directed away from the drive's electronics, keeping them clear of dust and moisture.

Most MCCs are installed in separate air-conditioned electrical rooms along with switchboards and other electrical gear. Still, not all electrical rooms are ideal, since they have high ambient temperatures as well as contaminants. For these areas, Schneider Electric can provide a NEMA 12 MCC drive unit. The NEMA 12 construction includes sealed chimneys or air ducts within the unit to keep contaminants out of the drive's electronics area.

The drive package provider should confirm the design, ensuring that all hotspot temperature limits are not exceeded within the drive or other components in the MCC or enclosure. The user should always request that any MCC or enclosed drive package is UL listed, in order to meet standardized guidelines for the drive temperatures and the expected environment.

### Noise Immunity

In today's highly electronic control systems, any installation with drives must include provisions to reduce Electromagnetic Interference (EMI) and Radio Frequency Interference (RFI). Major nuisance problems can occur if electrical noise is introduced on control lines, electronic devices, or power feeders.

Since drives and other electronics produce harmonics and other high frequency noise, the drive feeders and enclosures can be a cause of noise problems. Grounded metal shielding is recommended to reduce the spread of electrical noise. The modular metal unit in the MCC creates a shield between drives, as well as between drives and other devices. Also, consolidating noisy devices in one metallic enclosure reduces electrical noise in the factory.

To reduce the risk of noise problems, drive manufacturers recommend separating power conductors from low voltage control wires. Each MCC vertical wireway has adequate room to separate wires.

## Special Applications

### Long Motor Leads

The power switching frequency used on modern drives exposes the connected motor to high voltage transients that can damage motor insulation. These transients are present when motor leads are so long that there is a voltage reflection. For drives with switching frequencies below 10 kHz, voltage reflection becomes an issue at approximately 100 feet (30 m). For drives with switching frequencies of 10 kHz and above, this critical lead length is shorter.

To avoid motor damage from voltage reflections, use one of the following solutions:

- Specify motors rated per NEMA MG-1, Part 31 with 1600 V insulation. These motors are designed to withstand higher transients.
- Move the MCC or enclosure closer to the motor. Since it is freestanding, the MCC can be located near the motor to reduce the length of motor cables.
- Add reactors or filters between the drive and the motor. These devices reduce the voltage transient so that the motor insulation is not overstressed. These devices are typically offered in vented NEMA 1 enclosures to dissipate the heat they generate. Mount the enclosure on top of an MCC and wire it between the drive and motor. Or, mount it inside NEMA 1 MCCs with adequate ventilation openings on the MCC door. Schneider Electric can implement this solution at the factory.

### Line-Side Harmonics

Some users and specifiers want to limit system propagations of line-side harmonics produced by drives. Many drive manufacturers offer harmonic calculation software to check whether harmonic reduction devices are required to comply with the IEEE 519 standard. The devices available to reduce harmonics are:

- **Line Reactors**

  These 3-phase devices add impedance to the system to limit harmonic currents injected into the power line ahead of the drive. An added benefit of line reactors is that they help protect the drive from the effects of line overvoltage transients.

Schneider Electric can install, wire, and UL certify a 3 or 5% reactor in the MCC enclosure, so the customer does not have to provide an additional enclosure, wire it, or worry about sizing the reactor. If reactors are not ordered with the drive MCC package, space can be set aside in the MCC in case reactors are needed in the future.

- **Harmonic Tuned Passive Filters**

  These 3-phase power filters are shunt-connected onto the power system ahead of the drive. The filter is “tuned” to redirect some of the harmonics produced on the line side of the drives away from the rest of the power system. Harmonic filters consist of heat-producing components, including reactors, capacitors, and in some cases, resistors. As with line reactors, heat must be kept away from the drives. Off-the-shelf units are available, but changes in the power system can affect performance. The MCC manufacturer should install harmonic tuned passive filters in MCCs, or direct their integration.

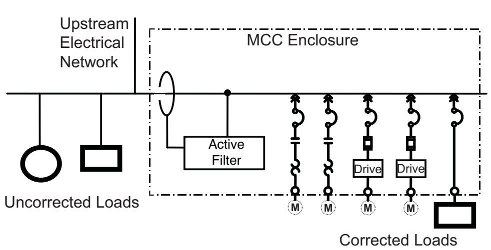
- **Broadband Harmonic Filters**

  These 3-phase power filters are series-connected onto the power system. They introduce impedance **and** redirect the harmonic currents produced on the line side of the drives. Broadband filters are very effective and simple to apply, but they can be expensive and require large amounts of floor space and cooling. An MCC standard section can integrate the filter components of the broadband filter, up to approximately 100 hp, but the MCC manufacturer should be consulted.

- **Multi-Pulse Drives**

  These drives (sometimes referred to as 12-pulse or 18-pulse drives) are variations of standard drives that reduce harmonic currents generated from the drive. Multi-pulse drives require additional transformer components and reduce harmonics by phase shifting the drive-generated harmonic currents causing some cancellation of harmonics. They are physically larger and produce more losses than standard drives. They are generally effective at meeting IEEE 519 limits for harmonic levels. However the size and cost are not always justified unless the application is above 100 hp. Some MCC manufacturers offer 18-pulse drive products in oversized MCC cabinets.

**Figure 7: Typical MCC Active Filter Installation**




- **Active Harmonic Filter**

  The active harmonic filter cancels harmonics by dynamically injecting out-of-phase harmonic currents back into the power system. The filter can be applied at the system level and can correct harmonics created by other sources besides just drives. The active filter senses the harmonic currents flowing in a system and reacts very quickly through electronic power devices to cancel a wide spectrum of harmonic currents and meet the IEEE 519 harmonic limits. The filter is a separate device connected onto the system and can compensate for multiple drives. This can become very economical where multiple drives are bussed together such as in an MCC application. The relatively low losses and capacity sharing make this ideal for groups of drives. Some MCC manufacturers offer the active harmonic filter as a package for splicing to new or existing MCCs.

## Outdoor Installations (NEMA 3R)

Generally, an enclosure exposed to outside air and direct sunlight needs additional cooling, whereas an indoor installation does not. Some MCC drive manufacturers, including Schneider Electric, have developed special ventilation and forced-cooling packages, compliant with the NEMA 3R rainproof and sleet-resistant requirements. Generally these special NEMA 3R MCCs have limits on the horsepower range for the drives. In larger horsepower applications, special cooling provisions, such as air-conditioning, can be added to the MCC to provide drive unit cooling. These are applied on a case-by-case basis.

## Coordination

MCCs are specified with most other electrical gear in Division 16 of project specifications. In the past, drives were mechanical devices with a physical relationship to the motor. Since drives are now electrical devices, they must be properly coordinated with the rest of the electrical system. An electrical contractor must be involved to connect drive electrical interfaces and run conduits. Performing system start-up in conjunction with the mechanical and/or control contractor also requires close coordination.

The electrical contractor must understand all electrical connections for the drive, and install them before system start-up. Most changes to horsepower or contact sequence will have electrical implications. Drives should also be specified in Division 16 of the specification, so that the system designer ensures that the drive supplier and electrical contractor are kept aware of system revisions.

Changes in the horsepower of traditional NEMA type electromechanical starters are not as challenging as changes with drives, since NEMA type starters are designed to fit a wide range of motor sizes. The enclosure size can be affected by each horsepower change on a drive. The wall-mounted enclosure or MCC may need modification to fit the new drive. In MCCs, this change in space requirements can be accommodated by moving plug-in units to extend unit spaces, or by reducing unit size. If the drive is in a wall-mounted enclosure, a new enclosure must be installed in the former space. In each of these scenarios, the later a change is requested, the greater the impact on delivery. Some enclosed and MCC drive vendors have standardized their products so that changing rating before shipment will result in only a few days' delay, if any.

The current trend is to automate and communicate with drives via PLCs, building automations systems, or Supervisory Control and Data Acquisition (SCADA) systems. Control and monitoring of the drive is performed remotely, so the drive itself has few controls on it. Today's "smart" MCCs use a networked approach to drives and starters, providing extended benefits for automated installations. In this serial communication environment, it is beneficial to have a coordinated system approach for the drive, the mounting package, and the control system. By design, MCC manufacturers are packaging a system with every lineup they sell. An MCC ties together various controls and device types to create an integral system.

## Recommendations

To determine the best package for ac drives, consider the following questions:

- Is the MCC package installation more economical than individual drives mounted on a wall?

  *This is generally true for four or more drives.*

- How high is the available short circuit requirement?

  *MCC drives are typically offered with high short circuit withstand ratings.*

- Am I looking for a factory tested system?

  *MCC vendors can factory test many options offered with the drive.*

- Do I have limited space for drives?

  *MCCs offer significant space savings due to efficient group mounting.*

- What type of environment will surround the drive enclosure?

  *Investigate both the temperature and contaminants in the ambient air. Enclosure ratings and a cooling method should be available to meet the installation's needs.*

- What type of power quality devices do I need?

  *Cost, mounting method, physical size, and heat may make a particular solution impractical for the chosen package.*

- How much electrical/mechanical coordination is required?

  *A clear definition of responsibility should be documented, regardless of whether the drive is in Division 15 or 16 of the specification.*

Schneider Electric USA
1990 Sandifer Blvd.
Seneca, SC 29678 USA
1-888-SquareD (1-888-778-2733)
www.us.SquareD.com