



Recommended Practice for
Installing and Maintaining

Motor Control Centers

NEIS[®]



Published by
National Electrical
Contractors Association



NECA 402–2000
Recommended Practice for
Installing and Maintaining
Motor Control Centers



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(This foreword is not a part of the standard)

Foreword

National Electrical Installation Standards™ are designed to improve communication among specifiers, purchasers, and suppliers of electrical construction services. They define a minimum baseline of quality and workmanship for installing electrical products and systems. *NEIS™* are intended to be referenced in contract documents for electrical construction projects. The following language is recommended:

Motor Control Centers shall be installed and maintained in accordance with NECA 402, *Recommended Practice for Installing and Maintaining Motor Control Centers*.

Use of *NEIS™* is voluntary, and the National Electrical Contractors Association assumes no obligation or liability to users of this publication. Existence of a standard shall not preclude any member or nonmember of NECA from specifying or using alternate construction methods permitted by applicable regulations.

The installation and maintenance practices recommended by this publication are intended to comply with the edition of the National Electrical Code® (NEC) in effect at the time of publication. *NEIS™* are not intended to duplicate NEC requirements nor to establish regulatory requirements for electrical construction. It is the responsibility of users of this standard to comply with state and local electrical codes when installing electrical products and systems.

Suggestions for revisions and improvements to

this standard are welcome. They should be addressed to:

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1. Scope

This recommended practice describes installation procedures for motor control centers rated 600 volts or less. It also covers periodic routine maintenance procedures for motor control centers and special procedures to be used after adverse circumstances such as a short-circuit, ground-fault or immersion in water.

All information in this publication is intended to conform to the National Electrical Code® (ANSI/NFPA Standard 70). Installers should always follow the NEC, applicable state and local codes, and manufacturer's instructions when installing and maintaining motor control centers.

Only qualified persons familiar with the construction and operation of motor control centers should perform the work described in this publication.

2. Motor Control Center Receiving, Handling and Storing

2.1 Receiving the Motor Control Center

a) *Equipment needed:* Prior to receiving the motor control center, obtain the shipping weight and the type of truck that will make the delivery. This allows you to have the proper handling equipment for receiving the shipment.

b) *Forklifts:* Use forklifts or other loading equipment only for palletized shipments.

c) *Unloading:* Unload the motor control carefully. Observe all packing label warnings.

d) *Inspection:* Open the motor control center carefully. Inspect completely for shipping damage, and to assure that the shipment is complete. Leave protective coverings in place as much as possible during the inspection.

e) *Electrical ratings:* Verify that the motor control center's electrical ratings (voltage, current, short-circuit) match the plans and specifications, and what is actually available at the installation site. Advise the general contractor or other proper party of any discrepancies or problems.

f) *Enclosure type:* Verify that the environmental rating of the enclosure (Type 3R, Type 12, etc.). Match the plans and specifications, and conditions at the installation site. If the motor control center is to be installed in an area protected by sprinklers, a Type 3R rating may be required. Check with the authority having jurisdiction. Advise the general contractor or other proper party of any discrepancies or problems.

g) *Replace protective coverings:* Unless installation is immediate, undamaged material should be carefully re-packed for transporting it to the installation site.

2.2 Handling the Motor Control Center

To avoid injury to personnel and damage to equipment, motor control centers must be handled properly. Follow all handling instructions provided by the manufacturer. Unless otherwise specified, keep the motor control center in an upright position.

Motor control centers are typically large, bulky pieces of equipment, weighing several hundred pounds or more. The packing list will provide the actual weight of each item. Verify that the lifting capacity of the handling equipment is more than the weight to be moved. Delivery to the job site on an open truck is recommended. However suitable protection against the weather, dust and debris must be provided during delivery.

There are two primary ways of lifting the equipment: with, or without, lifting straps. Using lifting straps is the preferable method when these are supplied by the manufacturer.

2.2.1 Handling with lifting straps

When lifting straps are provided by the manufacturer, follow all lifting warning labels on the motor control center. It is important to provide vertical lift on the straps, in order to stabilize

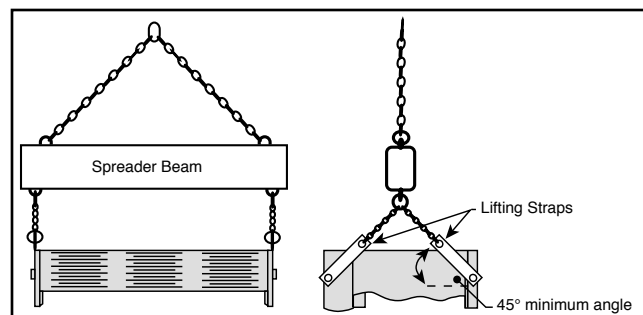


Figure 1

the load and avoid damage to the frame or finish. The angle of the lifting straps must be a minimum of 45 degrees (see Figure 1). Secure the lifting straps to a spreader beam, or spanner beam, to ensure that the lifting straps are at a suitable vertical angle for accomplishing the lift safely.

2.2.2 Handling without lifting straps

Lifting straps are not provided if the weight of the section(s) is too heavy for the recommended capacity of the straps, if the use of straps would cause stress on the motor control equipment, or if the design of the equipment does not permit. In such cases, the equipment can be handled by slings, forklifts, rollers, or a combination of these means. Typically, a handling warning is provided on those motor control sections for which the manufacturer does not supply lifting straps.

a) *Slings*: A sling can be used when lifting the motor control equipment with a crane, hoist or similar lifting device. Construct the sling of either chain or wire cable, rated of sufficient strength to handle the weight of the equipment. Rig the sling completely around the equipment and its shipping stringers. Wooden blocks should also be used, as needed, to keep the sling from digging into the sides of the equipment and damaging it during lifting (see Figure 2). Pass the sling underneath the equipment, by using either a forklift or jacks to lift the equipment off the floor. Attach the sling to a

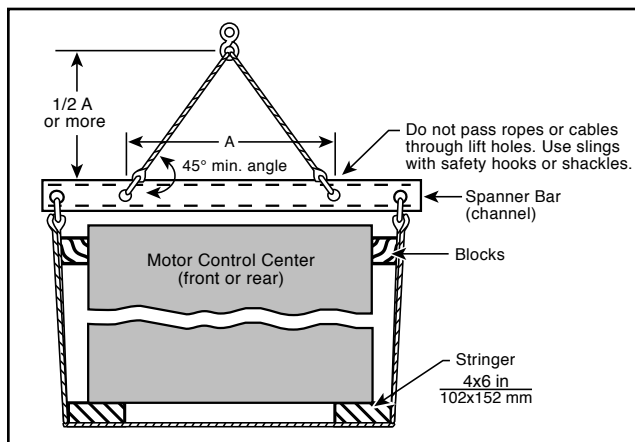


Figure 2

spanner bar with safety hooks and shackles. Do not pass any ropes or cables through the spanner bar's lift holes because sharp edges of the holes could cause them to be cut.

b) *Forklifts*: An alternative means of lifting motor control centers is to use a forklift with a capacity that exceeds the weight of the load to be lifted. To prevent tipping, or loss of the load, always use a safety strap to secure the load to the forklift. Make sure that the forks extend under the entire load and beyond the opposite side (see Figure 3). Also extend the forks to the furthest possible left and right positions for maximum stability.

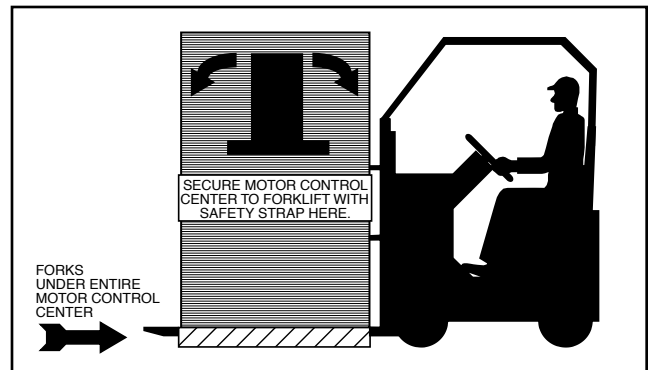


Figure 3

c) *Rollers*: Where conditions do not permit using a hoist or a crane to lift the motor control center into the desired position, use rod or pipe rollers suitable for the purpose. Rollers work best for moving equipment on a level surface. The rollers should be positioned approximately 18 inches apart and be at least as wide as the equipment to be moved. For lifting the equipment on to the rollers, and for positioning it properly, a forklift or jacks can be used, use extreme care to steady the load when using rollers. Pinch bars are useful in controlling movement of the load. When it is necessary to travel on an incline, use a winch or a chainfall to prevent “runaway.”

2.3 Storing the Motor Control Center

a) *Indoors*: When possible, store the motor control center indoors in a heated, dry space.

Cover it with a tarp or plastic to protect against harmful dust, moisture and corrosion. Make sure that the storage location does not subject the motor control center to any potential sources of mechanical damage.

b) *Outdoors:* If outdoor storage of the motor control center is necessary, make sure that the tarp or plastic protective cover is strong enough to keep from tearing during wind gusts and severe weather conditions. The cover should be

water-tight to protect against rain, snow and condensation.

c) *Heat source:* Provide a reliable heat source to keep the motor control center internally dry if stored outdoors, or for storage in an unheated indoor location. At least 250 watts of heat should be provided for each vertical section of the motor control center. Before applying the heat, remove all loose packing or other materials that could catch fire.

3. Installation

Proper installation is essential to the proper operation of all motor control center components. Advance preparation and planning for installation is advisable. Request that the manufacturer send instruction manuals, literature and drawings before the motor control center is delivered. Study this instructional material thoroughly before undertaking the installation.

3.1 Location

a) *Plans*: When installing motor control centers outdoors, consult the site plan to determine the area for installation. When installing indoors, consult the floor plan of the building or structure to determine where the equipment will be located.

b) *Accessibility*: Accessibility to the motor control center is of primary importance. Depending upon the manufacturer, points of access may be from the front, rear, top or bottom. Make sure that sufficient clearances are maintained around the motor control center to allow necessary access (e.g., a rear access motor control center should not be placed against a wall). In calculating headroom above the equipment, take the height of foundation into account, as well as the height of the motor control center.

c) *Working space*: The location should comply with all applicable building codes, as well as working space requirements of the National Electrical Code, Section 110-26. (*NOTE: Working space clearances greater than NEC minimums may be required for temporary ramps or hoists used during installation.*)

d) *Moisture*: When installation is in a damp or wet location, appropriate measures must be

taken to prevent moisture and water from entering and accumulating. Water may seriously damage the motor control center and its components. Where a sump pump is required, the pump should be working properly, and connected to a standby power source, before the motor control center is installed.

e) *Ambient*: The motor control center should not be exposed to ambient temperatures exceeding 104°F (40°C), unless the design allows operation under unusual conditions. In cool or damp areas it may be necessary to provide an appropriate supplemental heat source, either inside each motor control unit or outside the motor control center.

3.2 Foundation Preparation

a) *Concrete*: The floor or foundation on which the motor control center will be installed needs to be strong enough to support the weight of the motor control center without bowing or sagging. A concrete surface is preferred.

b) *Seismic*: In special instances where earthquakes may occur, 4000 psi concrete should be used along with specific anchoring means such as stud anchors, sleeves anchors or concrete anchor bolts (anchoring hardware is not supplied as a standard item with most motor control centers). Performance of the motor control center under earthquake conditions is directly related to the foundation preparation. (*NOTE: Local building codes may have seismic requirements that affect motor control center installation. Installers should consult these codes or coordinate with the general contractor prior to installing motor control centers.*) Also see 3.6.1 and 3.10.2(g).

c) *Level:* A level mounting pad raised 4 inches (102 mm) above the general floor level is typical with the surrounding floor area gently sloping toward a drain. To ensure correct bus bar alignment within the motor control center, and to enable bolting vertical sections together, it is critical that the mounting pad or floor be smooth and level. (*NOTE: Provisions for temporary ramps or installation hoists may require working clearances greater than NEC minimums.*)

d) *Channels:* If floor channels are embedded in the concrete pad, they should be level over the entire length of the motor control center in order to avoid distortion of the motor control center structure.

e) *Conduit layout:* Before pouring the concrete for the pad, install all conduits including future conduits required for bottom entry into the motor control center. Consult the bottom-view drawing of the motor control center to verify that the conduit layout matches the available conduit entry area into the motor control center.

f) *Embedded conduits:* Embedded conduits typically project above the finished pad approximately 2 inches (51 mm). If the embedded conduits project more than 2 inches (51 mm) above the concrete pad, it may be necessary to lift each shipping section vertically into place using a crane, timbers, jacks or forklift. After the sections are installed, and appropriate extension sleeves added to the conduits, the maximum projection should be 3 inches; NEC Section 384-10 prohibits projections greater than 3 inches (76 mm) for motor control centers and similar enclosures.

3.3 General Installation Instructions

a) *Clean:* Clean dirt and debris from the pad and the surrounding area where the motor control center will be located before moving the switchboard into its final position.

b) *Remove skids:* Remove the shipping skids before installing the motor control center on the pad.

c) *Remove bottom plates:* If the motor control center units are equipped with bottom closure plates, temporarily remove these plates and set them aside. Cut holes for the conduits entering the bottom of each enclosure in the bottom plates (if supplied) based on that section's conduits. Once the vertical sections of the motor control center have been installed, reinstall the bottom closure plates.

d) *Block openings:* Block the opening of each conduit with material that rodents will not be able to gnaw through, squeeze through or push out of the way. Bottom closure plates will not keep out rodents that come in through the conduits.

3.4 Installing Vertical Sections

3.4.1 Initial placement

a) If the motor control center has incoming cables or busway near or in its center, start with that vertical section first and work outward on each side.

b) If the motor control center is left-feed, start from the left. If right-feed, start from the right.

c) If the motor control center is close-coupled to a transformer, start at the transformer and work away from the transformer.

3.4.2 Positioning

Position each unit carefully, following the instructions in 2.2 *Handling the Motor Control Center*. Level with shims if necessary and align each unit with the previous unit. Proper alignment will make joining the structures and through-bus easier. (*NOTE: Improper alignment of the through-bus may result in death, serious injury or property loss.*)

3.4.3 Lifting straps

Remove lifting straps or slings so that vertical sections of the motor control center can be joined flush. Leave lifting straps or hardware on the sections if their removal is not required to join adjacent sections flush together.

3.5 Joining Motor Control Center Sections

a) Open all doors or remove all panels that provide access for bolting the adjacent sections together.

b) Bolt sections together based on manufacturer's instructions. *(NOTE: The authority having jurisdiction may require that all bolts connecting bus sections be inspected for proper torque prior to closing up the motor control center.)*

3.6 Anchoring the Motor Control Center

Motor control center sections are free-standing structures. Hard bumps or shifting movements can damage interior components, conduit hubs and cable/busway connections. Therefore, each vertical section of the switchboard is anchored to the floor. Some manufacturers provide formed base channels that run the entire length of the motor control center, mounting holes in the structure base, or both (see Figure 4).

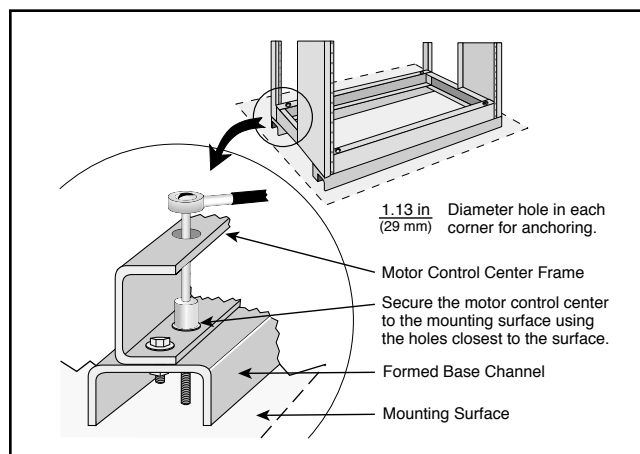


Figure 4

3.6.1 Seismic considerations

Carefully follow the plans and specifications when anchoring a motor control center for seismic conditions since the top of the motor control center can move as much as 3 inches in any direction. *(NOTE: Local building codes may have seismic requirements that affect motor control center installation. Installers should consult these codes or coordinate with the general contractor prior to installing motor control centers.)*

3.7 Installing Interconnections Between Motor Control Center Sections

Vertical sections of motor control centers are electrically linked together using either through-bus or cables.

3.7.1 Through-bus splice connections

Through-bus splice connections are extremely important to the performance of the motor control center, since these connections are expected to carry the full current intended for their operation. Failure to properly make through-bus splice connections may result in property damage, death or serious injury.

a) Through-bus splice kits are provided by the motor control center manufacturer when more than one section is required to be electrically connected together by through-bus.

b) The splice kits provided by the manufacturer may come in separate boxes, or be shipped inside the sections to be spliced, or be installed on the through-bus of one or more vertical sections.

c) Follow the proper sequence of hardware installation, as specified in the manufacturer's installation instructions. Conical washers should be installed with the convex or "top" side against the nut (see Figure 5).

d) Torque each splice bolt to the values recommended by the manufacturer. Mark each torqued connection with a permanent marker.

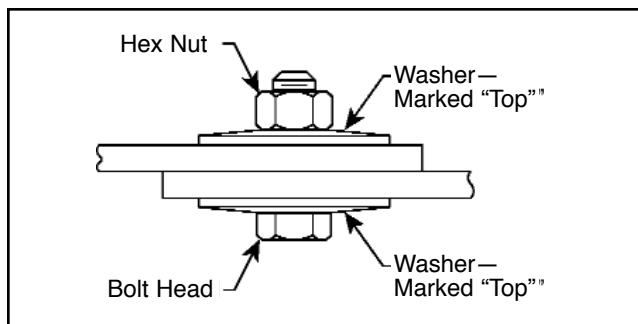


Figure 5

e) The through-bus of some motor control centers is covered with an insulating material. Follow the manufacturer's instructions for installing insulation on each through-bus splice connection.

3.7.2 Cable interconnections

Install the interconnection cables (which may or may not be supplied by the manufacturer) between sections as shown on manufacturer's drawings. Torque all connections to the manufacturer's recommended values.

3.8 Ground Bus Splice Connections

Ground bus splice connections are provided by the manufacturer when more than one section of the motor control center is required to be electrically connected (see Figure 6). Proper installation of ground bus splice connections is essential to providing a low-impedance path to ground for temporary currents resulting from phase-to-ground short circuits.

- a) Splice kits may come in separate boxes, be installed on the ground bus of one or more sections, or be stored inside the motor control center sections.
- b) Follow the proper sequence of hardware installation, as specified in the manufacturer's installation instructions. Install conical washers such that their convex side is against the nut.
- c) Torque the splice bolts to the recommended

value. Mark each torqued connection with a permanent marker.

3.9 Grounding and Bonding

3.9.1 Grounded systems — motor control centers used on a grounded system, or on a grounded separately-derived system

NEC Section 250-30(a) describes grounding requirements for grounded separately-derived systems.

- a) Run a grounding electrode conductor from the grounding electrode at the installation site to the grounding electrode conductor connection, commonly called a ground lug, located on the motor control center ground bus (see Figure 7).
- b) Refer to NEC Section 250-64 for requirements for grounding electrode conductor material, installation and size.
- c) Torque the ground lug binding screw based on the manufacturer's recommendations or crimp in accordance with the crimp tool's instructions.
- d) For service entrance equipment, or a motor control center used on a separately derived system, install the main bonding jumper between the neutral bus and the ground bus. A label on the front of the motor control center will identify the section(s) that incorporate the main bonding jumper(s).
- e) Torque the hardware of the main bonding jumper in accordance with the manufacturer's recommendations, or else in accordance with the recommendations shown in Section 9.
- f) Equipment ground-fault protection will be rendered inoperative if the system is grounded downstream from the ground fault sensor.
- g) For motor control centers with multiple sources of power, there will be two or more main bonding jumpers to install.

3.9.2 Ungrounded systems — motor control centers on ungrounded systems, or on separately derived, ungrounded systems

NEC Section 250-30(b) describes grounding requirements for ungrounded separately derived systems. To assure proper grounding and bonding, the following steps should be implemented:

- a) Proper materials for grounding the electrode conductor, and proper installation, are specified in NEC Section 250-64.
- b) Proper sizing of the grounding electrode conductor for alternating current systems is specified in NEC Section 250-66.
- c) Run a grounding electrode conductor that connects the ground lug of motor control center to the main grounding electrode at the service entrance of the installation site.
- d) Torque the ground lug binding screw of the motor control center in accordance with the manufacturer's recommendations, or crimp in accordance with crimp tool instructions.

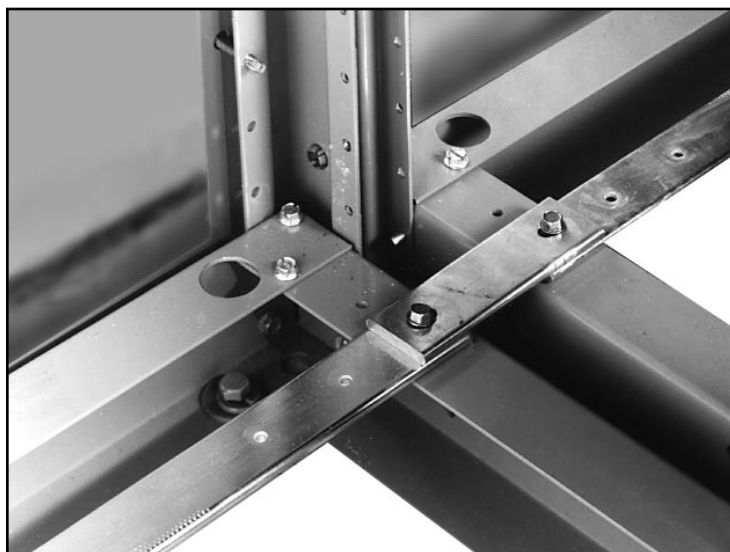


Figure 6

3.10 Cable, Conduit, and Wire Installation

3.10.1 Preparing for wiring installation

- a) *Bottom plate:* If a bottom plate without holes is furnished for conduit and cable entry, remove that plate before cutting holes. Reinstall the plates after the holes are made. Saw kerfs between conduit holes in bottom plate for installations where individual conductors are run in individual conduits, such as duct bank risers. This will distribute phase conductors uniformly, so that eddy currents are not generated in the steel between the conduits.
- b) *Cable lugs:* Verify from the motor control center cable schedule that the lugs are suitable for the cables being terminated. If the lugs furnished are not compatible with wire size, type, and stranding, either change the wire or the lugs accordingly.
- c) *Order of connections:* Before pulling the cables into the motor control center, choose which overcurrent device to cable first. This is particularly important for group-mounted constructions.
- d) *Ambient:* Plan to install conductors at ambient temperatures above freezing, to prevent cracking or freezing of the insulation.



Figure 7

3.10.2 Installing cables and conduits

Motor control centers are arranged to provide clearance and wire bending space for both line and load cables. Route external circuit cables to their designated connection terminals in accordance with conduit entry drawings provided by the manufacturer. This should be done for each section of the motor control center to prevent the cables from interfering with a live bus or structural members.

a) *Conductors grouped together:* Pass all phase and grounded conductors of the same circuit through the same metal opening together, as required by NEC Section 300-20(a). Failure to do this can create induction and cause overheating within the motor control center.

b) *Lubricants:* Be sure that cable pulling lubricants do not drip or come into contact with overcurrent devices or plating of the bus bars. Before energizing the motor control center, remove all pulling compounds from the interior.

c) *Conductor positioning:* Position all conductors in the motor control center so they are not subject to physical damage or overheating. If any conductors are in contact with structural members, place suitable protective material at the contact point to protect the cable insulation.

d) *Approved connectors:* Install all cables with approved hubs and ring connectors to prevent moisture from entering the conduits or the motor control center enclosure.

e) *Supports:* Install cables and conduits with independent supports, so that their weight is not supported by motor control center. Where required, brace or lace the conductors in accordance with the manufacturer's instructions or consulting engineer's specifications. Cable ties can be used on both vertical and horizontal wireways to support the load and interconnection wires. Since incoming power lines tend to

separate under short-circuit conditions, secure these in a manner that will prevent or minimize separation.

f) *Low-voltage signals:* Protect very low-voltage signals (such as those transmitted from a programmable controller, or a computer) by using a shielded communications cable inside a flexible metal conduit.

g) *Sag:* As a general rule, eliminate sag in the conductors. It may be necessary, however, to leave slack in some cable connections, in order to permit future maintenance on the motor control center. Check manufacturer's instructions to determine which connections require slack.

h) *Seismic:* In geographic areas where seismic conditions apply, cables entering the top of the motor control center should have at least 3 inches of slack to accommodate any motion of the motor control center caused by a seismic event. If the floor of the motor control center is designed for movement during a seismic event, cables entering the bottom of the motor control center should also have enough slack to accommodate this motion.

i) *Bonding:* Bond all conduits, stubs and ring connectors to the enclosure, following the manufacturer's recommendations.

3.10.3 Cable Terminations

Terminating and tightening cable connections to the manufacturer's recommended torque is imperative for a satisfactory connection. Follow these steps when terminating conductors at the motor control center:

a) *Stripping:* Strip a sufficient length of insulation from the cable end to fit it into the full length of the lug barrel. Use a proper insulation stripping tool to avoid nicking conductor strands. Stripping cable too long should be avoided since the through-air clearance could

be reduced below the minimums required by the NEC.

b) *Torqued lugs*: Mechanical lugs (set-screw type) are the most common type of connector furnished with motor control centers. Torque these lugs in accordance with the manufacturer's recommendations to avoid stripping threads or cracking the lug body.

c) *Crimped lugs*: If the installation calls for using crimp lugs, use the crimp tools recommended by the lug manufacturer.

d) *Aluminum conductors*: When compression lugs are used to terminate aluminum conductors, remove oxides from the conductors and apply an anti-oxidant compound to the aluminum conductor before inserting into the lug body. Oxides on aluminum conductors are poor conductors and will cause abnormal heating at the connection.

3.11 Busway Connections

Power is often distributed to motor control center units using busway (also called bus duct). Busway is provided in different configurations by different manufacturers; one typical configuration is shown in *Figure 8*.

a) When connecting busway, install conical washers such that the convex side of the washer is against the nut.

b) Confirm proper phasing of the busway before energizing the busway run.

c) Do not use the motor control center to support the weight of the busway. Support the busway independently of the motor control center.

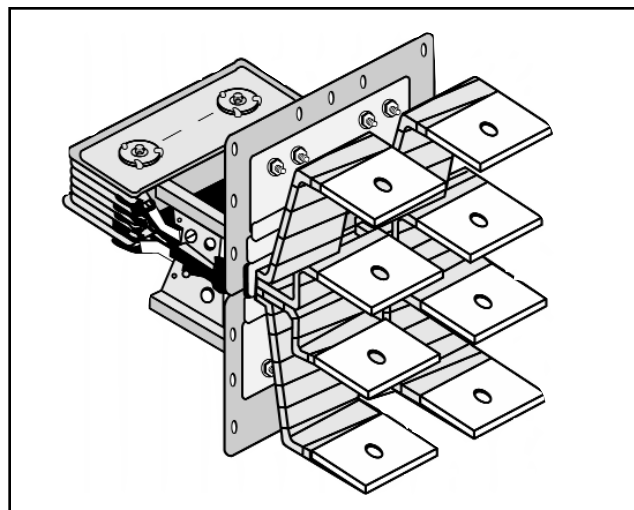


Figure 8

4. Pre-Energizing Checkout Procedure

4.1 General

Before energizing the motor control center, conduct a complete inspection of all its components to ensure that they function properly.

- a) Check all field-installed bus bar connections for correct torque value.
- b) Check all accessible connections for tightness, including circuit breaker and switch terminals, contactor and relay terminals, and terminal blocks.
- c) Check all field installed lug terminations for the correct torque value. Also check factory installed lug terminations, since they can sometimes be loosened by vibrations during shipping.
- d) Visually check the bussing insulators for cracks, and check supports for damage.
- e) Check to ensure that dents or other damage to the enclosure have not resulted in clearances that violate NEC requirements.
- f) Check all relays, meters and instrumentation device wiring and terminations.
- g) Compare all circuits with the manufacturer's wiring diagrams, to assure that they are installed in accordance with the diagrams.
- h) Be sure that each motor is connected to its intended starter.
- i) Make certain that field wiring does not contact live busses, and that the wiring is properly

secured to withstand the effects of fault currents.

- j) Check to assure that the proper overload relay heater elements are installed in accordance with the full-load current shown on the nameplate of each motor.

- k) Install all power circuit fuses in the fusible switches, making sure that they are firmly inserted in the clips provided. If the fuse clips provided have a rejection feature, do not attempt to defeat this feature. Check to be sure that the fuses selected comply with NEC requirements.

4.2 Clean-up

- a) Remove any remaining packing material, including foam blocks and temporary cushioning, from the motor control center enclosures. Remove all foreign objects such as tools, scraps of wire and other debris.
- b) Vacuum to remove all dust and debris. Do not use compressed air, since this may contain moisture, or cause dust to settle inside devices and impair their ability to function.

4.3 Insulation Test

- a) Perform a dc insulation resistance test to assure that the motor control center and field wiring are free from short circuits and grounds. Make sure that the switches or circuit breakers are opened when performing the tests, and remove control power fuses and any other equipment that should not be subject to this level of potential. Perform the test phase-to-phase, phase-to-ground, and neutral-to-ground.

b) Record the values for future maintenance tests on the insulation resistance chart shown in Section 9. Values less than 1 megohm are typically unacceptable.

4.4 Circuit Breakers and Fusible Switches

a) Manually open and close all circuit breakers and fusible switches to ensure proper operation.

b) Adjust the magnetic trip on thermal magnetic circuit breakers to their proper setting based on the system study or motor control center schedule. A setting too low for a load that has a high-peak inrush current will trip the circuit breaker on start-up.

c) Electronic circuit breakers have functions such as instantaneous, short-time, long-time and ground fault, that require initial adjustment. Settings typically are provided in a coordination study prepared by the consulting engineer, or by other persons responsible for the motor control center set-up. *(NOTE: These values typically are not found on the drawings supplied by the motor control center manufacturer.)* If values are not provided, consult the manufacturer's circuit-breaker instruction manual for values that will set the electronic circuit-breaker functions to emulate thermal magnetic circuit-breaker characteristics.

4.5 Ground-Fault Protection

a) Test any ground-fault protection systems that are provided with the motor control center. Make sure that a written record of all tests

is available to the authority having jurisdiction.

b) Some ground-fault protection systems require field connections at the job site. Consult the manufacturer's interconnection wiring diagram for details.

c) Check the ground-fault circuitry to establish that there are no grounds on the neutral downstream from the service entrance point of the installation.

d) The NEC requires that the ground-fault protection system be performance tested when first installed. A testing group with experience in motor-control center ground-fault testing should perform the test.

4.6 Interconnections

Verify that all interconnecting wiring between sections of the motor control center has been connected.

4.7 Power Fuses and Control Power Disconnects

Replace all control power fuses removed in the Insulation Test (see 4.3a) and turn on all control power disconnects.

4.8 Close-up

Before closing up the motor control center, check again for any foreign objects, dust or debris. Clean again, if necessary. Replace all covers. Check for any pinched wires. Close all doors. Make sure that the enclosure parts are properly aligned and fastened securely.

5. Energizing the Motor Control Center

Hazards exist in energizing a motor control center. Energizing should be performed only by qualified electrical personnel.

If a short-circuit or ground-fault condition exists, caused by damage or poor installation practices, which is not found and corrected during the checkout procedures, serious personal injury and/or damage can result when the motor control center is first energized. Safety glasses and gloves should be worn during initial energization. Before proceeding to energize the motor control center, read and follow all steps below:

Step 1 Turn all fusible switches and circuit breakers to the **OFF** position before energizing the bus.

Step 2 Make sure that there is no load on the motor control center when it is energized. This minimizes the risk of damage or injury. Turn off all downstream loads, including contactors, heaters, motors, etc., including those that are remote from the motor control center.

Step 3 Prior to energizing any circuit that supplies rotating machinery, verify that the phase sequence is correct. If this is not done, serious damage can result to motors and similar equipment that rotates in the wrong direction.

Step 4 Energize the equipment beginning at the source end of the motor control center and works toward the load end. The following sequence should be used:

1. Main devices
2. Feeder devices
3. Branch circuit devices

Step 5 One by one, close each circuit breaker or fusible switch in the motor control center. Use a firm, decisive motion when operating the handles of the disconnecting devices.

Step 6 Proceed to energize (turn on) the downstream loads, such as contactors, heaters, starters and motors, one at a time.

6. Motor Control Center Maintenance

Periodic maintenance of motor control centers extends their service life and increases their reliability. Maintenance typically includes visual checks, cleaning, lubrication and exercising of component parts. Establish a periodic maintenance schedule.

The maximum interval recommended for motor control center inspections is one year. More frequent inspections may be needed, however, depending upon the usage of the equipment and environmental conditions such as ambient temperature in the motor control center room.

The first inspection should take place within six months of the original installation, or even sooner under heavy usage or severe operating conditions. The motor control center also should be inspected whenever an overcurrent device opens, or a phase-to-phase short circuit or ground fault occurs (*see section 7.1*).

6.1 General Inspection

a) Maintenance of a motor control center should be performed by a qualified person who is trained to energize and de-energize electrical equipment in accordance with established safety practices. The proper safety equipment and clothing, such as a face shield, rubber gloves, hard hat, flash clothing, etc., should be used by the person performing the maintenance.

b) Consult the manufacturer's maintenance instructions for any recommendations that may be specific to your particular motor control center or its component parts.

c) Before de-energizing the motor control center, check doors and surfaces of the units, both

visually and manually, to see if excessive heat is being generated, which could indicate a problem. Discoloration of the surface finish could indicate a heat problem. Carefully touch the doors, enclosure sides and surfaces of all units. If a temperature is too hot for the palm to stand for several seconds, it may indicate trouble. Also, perform an infrared scan of all accessible terminations and active components that generate heat.

d) De-energize the motor control center by disconnecting power ahead of the equipment. If feasible, lock out or tag out circuits and equipment in accordance with the requirements of NFPA 70E, Part II. Use a voltmeter, or other appropriate instrument, to verify that no voltage exists, and that an alternate source of power is not involved. Discharge any capacitors that the unit may contain.

e) After it is verified that the motor control center has been completely de-energized, maintenance work may begin on the interior of the units.

f) Vacuum the inside of the switchboard to remove any debris, dirt, or dust. Note any unusual conditions such as signs of insects or rodents. If possible, take corrective action to prevent the condition from recurring. Wipe the bus bars, insulators, conductors and other parts with a clean, dry lint-free cloth. Do not use chemicals or petroleum-based solvents on plastics or insulating materials, since these may degrade the plastics or insulating materials.

g) Visually check the inside of the motor control center for moisture, condensation build-up

or signs of previous wetness. Moisture causes insulation failures and rapid oxidation of current carrying parts. Pay particular attention to conduit entrances and leaks at the top of the motor control center between sections. Remove any moisture present inside the motor control center and seal off all leaks.

h) Visually inspect the motor control center for signs of overheating, such as discoloration and flaking of insulation or metal parts. Correct conditions that caused the overheating, and replace the affected parts before re-energizing the motor control center.

i) Carefully inspect all motor control center devices for any worn-out, cracked or missing parts. Exercise the devices several times, checking for free movement, proper spring tension, rust and corrosion. Many circuit breakers have a test feature that trips, exercises and lubricates the mechanism. This method should be used if available; otherwise operate circuit breakers manually. Any defective devices should be adjusted, repaired or replaced, in accordance with the manufacturer's instructions. Also clean and lubricate parts, as necessary.

j) Verify that all key interlocks and door interlocking provisions are working properly.

6.2 Bus Bar Joints

a) Consult the manufacturer's recommendations concerning bus bar joints and re-torque where required. *(NOTE: Some motor control center manufacturers indicate that their joints are maintenance-free and that additional torquing after installation may degrade the connection.)*

b) Indications of pitting, corrosion, discoloration and annealing due to heat require that the affected part of the bus assembly must be replaced. Use of abrasive materials to correct the problem is not recommended since joints are one of the most critical parts of the bussing system. Use hardware and washers of a grade identical to or better than the hardware replaced.

6.3 Field Testing Molded-Case Circuit Breakers and Motor Circuit Protectors

- a) Consult the manufacturer's instructions.
- b) Exercise the operating mechanism during the periodic inspection.
- c) If the circuit breaker uses solid-state circuitry or a microprocessor, run the self-diagnostics feature if available.
- d) For electronic circuit breakers, use the test set to run trip unit tests automatically with user prompts.

6.4 Field Testing Fusible Switches

- a) Consult the manufacturer's instructions.
- b) Exercise the operating mechanism during the periodic inspection.
- c) Check the cover interlock with the switch **ON**. The cover should not open using normal hand force.
- d) Inspect the switch interior for any broken parts. Replace as necessary.
- e) Check the fuse mounting clips or bolted contacts area for corrosion or discoloration indicating overheating. Replace the parts as required.

6.5 Fuse Replacement

It is important to turn off the power before replacing fuses. Always check the line and load ends of fuses for the presence of voltage before starting fuse replacement procedures.

- a) Look for indications that the motor control center may be fed from multiple sources.
- b) Turn the fusible switch **OFF** before opening the door. Do not defeat the cover interlock to gain access to the fuses.

c) Visually check the position of the switch blades to confirm that all switch blades have disconnected from their line connection. If all switch blades are not in the correct position, consult the manufacturer's recommendation for this abnormality.

6.6 Ground-Fault Protection Systems

a) Check the terminal connections on the ground-fault protection system at least once a year for tightness and corrosion. Replace any components physically or electrically damaged. Depending on the system, ground-fault testing may be conducted with or without tripping main or branch overcurrent protective devices. Testing, by actually tripping the device(s) is preferable since it ensures the whole system is functioning.

b) If the ground-fault protection system does

not operate properly, and additional equipment has been connected to the installation since the last maintenance check, de-energize the entire system, disconnect the main bonding jumper, and check for continuity between the neutral and ground on the load-side of the main bonding jumper. If grounds are found, remove them and test again. If no grounds are now detected and the ground-fault protection system is still not functioning properly, contact the motor control center manufacturer.

c) If the ground-fault protection system does not operate properly, and no additional equipment has been connected to the installation since the last maintenance test or check, then check the devices for physical or electrical damage and replace accordingly. Check wiring for damage or loose connections and correct any problems found.

7. Adverse Circumstances

Special procedures are necessary to determine if a motor control center can remain safely in service following a short-circuit, ground-fault, or exposure to water.

7.1 Inspection Following a Short-Circuit or Ground-Fault Condition

Do not attempt to re-energize a motor control center following a short-circuit or ground-fault condition within the motor control center. Do not re-energize a feeder or branch overcurrent device in the motor control center that has opened due to a short circuit or ground-fault until the problem downstream has been corrected.

Following a short-circuit or ground-fault within a motor control center, inspect the equipment thoroughly as described in 7.1 to verify that damage has not occurred to conductors or insulators within the switchboard. *(NOTE: The insulating properties of some organic insulating materials may deteriorate during an electrical arc. Replacement of the damaged insulating material is the only remedy.)*

7.1.1 Short-circuits develop high mechanical stresses that can damage conductors and insulation.

Improper and loosened connections may result in conductors pulling out of their terminations on subsequent short-circuits; for this reason all connections should be inspected and re-evaluated. Great care must be taken in evaluating the cause of the short-circuit. Do not replace any fuses, or turn the overcurrent protective devices back on, or reset the circuit breakers, without first determining whether it is safe to

energize the circuit. Phase-to-phase short circuits that originate on bus bars can travel the length of the bussing system through the motor control center, and the greatest damage may not occur where the arcing condition originated. Conduct an insulation test to determine the integrity of the insulation prior to re-energizing the motor control center.

7.1.2 Ground-faults are unintentional current paths between a phase conductor and ground.

Depending upon the magnitude of the ground-fault and its duration, carbon build-up and metallic splatter may need to be removed, insulators cleaned or replaced, and bus bar material or connections replaced. Perform phase-to-phase and phase-to-ground insulation tests with a minimum reading of 1 megohm, prior to turning the motor control center power back on.

7.2 Replacing a Motor Control Center Submerged or Soaked by Water

- a) Do not work on energized electrical equipment while standing in water.
- b) Do not energize a motor control center that is wet.
- c) Any motor control center that is submerged or soaked in water will likely need to be replaced, rather than attempting to clean and repair it. Current-carrying parts, insulation systems, and electrical or electronic components may be damaged beyond repair through becoming soaked, or through contamination from chemicals, river or creek water, dirt, sewage and other pollutants. In this event, replace the motor control center, instead of attempting repairs.

7.3 Inspecting and Re-Energizing a Motor Control Center Sprayed or Splashed with Clean Water

If a motor control center has become wet, though not soaked, with clean water, it may be possible to make it safely operational again after thoroughly drying it and testing it. Apply heat (a minimum of 250 watts per section) to the motor control to dry it out until visible signs of dampness cannot be seen. Before applying heat, remove any materials that could catch fire. Consult the manufacturer's recommendations for specific guidelines on how to ensure that it is safe to re-energize the motor control center, or follow this procedure:

7.3.1 Preliminary Inspection

Follow the steps in 7.3.2 (below) to re-energize the switchboard only if a preliminary inspection verifies that the following conditions are satisfied:

- a) There are no signs of physical damage to the equipment.
- b) The motor control center has not been soaked or submerged in water.
- c) The water that has been in contact with the motor control center was not contaminated with sewage, chemicals or other substances.
- d) Water has not entered any area of the motor control center enclosures that contain wiring, and has not come into contact with any live part. Look for water entering through conduits.

If all of the conditions listed above are satisfied, proceed as follows:

7.3.2 Cleaning, testing, and re-energizing a motor control center

Step 1 Completely de-energize and electrically isolate the motor control center.

Step 2 Wipe off all moisture from bus bars, insulators and insulating materials with a clean, dry, lint-free cloth. Never use cleaning agents or sprays unless specifically recommended by the motor control center manufacturer.

Step 3 Prepare for an insulation resistance test by disconnecting all line-side supply conductors and all load-side conductors to isolate the motor control center from the wiring system. Turn all circuit breakers or fusible switches to the **ON** position. Voltage cannot be present on the motor control center during the insulation resistance test.

Step 4 Use a dc insulation resistance tester with a capacity of 500-1000 volts dc to perform phase-to-ground and phase-to-phase insulation tests. (*NOTE: Use of an AC dielectric tester is not recommended.*)

- Measure each phase (A, B, C) to ground with the circuit breakers or fusible switches **ON**.
- Measure each phase to another phase with the circuit breakers or fusible switches **ON**. Record the values of the insulation resistance on the insulation resistance chart shown in Section 10.

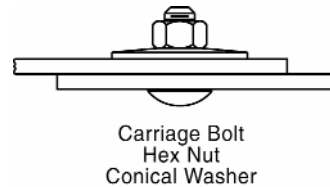
Step 5 Do not re-energize the equipment if any of the resistance measurements are less than 0.5 megohm (500,000 ohms). If moisture is the cause of the low resistance readings, the moisture can be removed from the motor control center by providing a minimum of 250 watts of heat per vertical section.

Step 6 If the resistance measurements are greater than 0.5 megohm, the equipment can be re-energized.

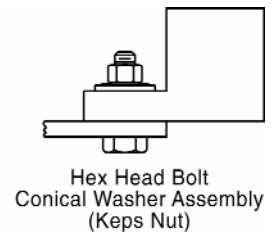
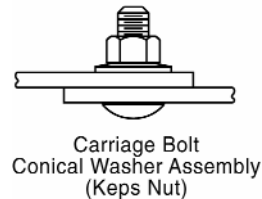
8. Recommended Torque Values

If the motor control center manufacturer does not provide specific torque recommendations, use the following as a guide.

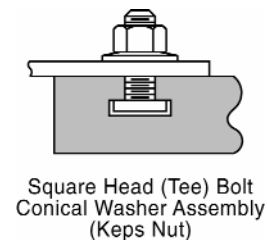
Hardware Description	Torque Value
1/2 inch	780-900 lb-in (88-102 N*m)



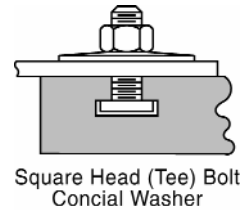
Hardware Description	Torque Value
1/4 inch	50-75 lb-in (6-8 N*m)
5/16 inch	80-125 lb-in (9-14 N*m)
3/8 inch	175-225 lb-in (20-25 N*m)
1/2 inch	250-350 lb-in (28-40 N*m)



Hardware Description	Torque Value
3/8 inch	175-225 lb-in (20-25 N*m)
1/2 inch	250-350 lb-in (28-40 N*m)

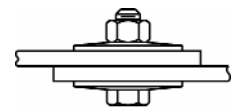


Hardware Description	Torque Value	
	Conical Washer OD	Square Head (Tee) Bolt Conical Washer
3/8 inch	0.87 inches (22 mm)	250-280 lb-in (28-32 N*m)
	1 inch (25 mm)	130-150 lb-in (15-17 N*m)
1/2 inch	1.25 inches (32 mm) 2.25 inches (57 mm)	450-550 lb-in (51-62 N*m)



Square Head (Tee) Bolt
Conical Washer

Hardware Description	Torque Value	
	Conical Washer OD	Hex Head Bolt (2) Conical Washers
5/16 inch	0.90 inches (23 mm)	145-260 lb-in (16-29 N*m)
3/8 inch	0.87 inches (22 mm)	250-280 lb-in (28-32 N*m)
	1 inch (25 mm)	130-150 lb-in (15-17 N*m)
1/2 inch	1.25 inches (32 mm) 2.25 inches (57 mm) 3.00 inches (76 mm)	780-900 lb-in (88-102 N*m)



Hex Head Bolt
(2) Conical Washers

9. Motor Control Center Insulation Resistance Chart

NOTE: The use of a AC dielectric tester for testing the motor control center is not recommended. Use an insulation resistance tester with a capacity of 500-1000 Vdc.

	Phase-to-Phase			Phase-to-Ground			Neutral-to-Ground
Date	All Disconnects Open						
	A-B	B-C	C-A	A-GND	B-GND	C-GND	N-GND
	Phase-to-Phase			Phase-to-Ground			Neutral-to-Ground
Date	All Disconnects Closed						
	A-B	B-C	C-A	A-GND	B-GND	C-GND	N-GND

10. Operations and Maintenance Documents

All manufacturer's packing label warnings, instruction manuals, literature, as-built drawings, recorded test values, and set values of adjustable trip devices should be assembled and delivered to the owner of the facility at the completion of the installation.

(This appendix is not part of the standard)

Annex A: Reference Standards

This publication, when used in conjunction with the National Electrical Code and manufacturers' literature, provides sufficient information to install exterior lighting systems.

National Fire Protection Association
1 Batterymarch Park
P.O. Box 9101
Quincy, Massachusetts 02269-9101
(617) 770-3000 tel
(617) 770-3500 fax
www.nfpa.org

NFPA 70-1999, *National Electrical Code* (ANSI)

Other *National Electrical Installation Standards™* Published by NECA

National Electrical Contractors Association
3 Bethesda Metro Center, Suite 1100
Bethesda, MD 20814
(301) 215-4504 tel
(301) 215-4500 fax
orderdesk@necanet.org

NECA 100-1999, *Symbols for Electrical Construction Drawings* (ANSI)

NECA/FOA 301-1997, *Standard for Installing and Testing Fiber Optic Cables*

NECA 400-1998, *Recommended Practice for Installing and Maintaining Switchboards* (ANSI)

NECA/EGSA 404-2000, *Recommended Practice for Installing Generator Sets* (ANSI)

NECA/IESNA 500-1998, *Recommended Practice for Installing Indoor Commercial Lighting Systems* (ANSI)

NECA/IESNA 502-1999, *Recommended Practice for Installing Industrial Lighting Systems* (ANSI)

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10K/4-00

