ICS 2.3-83 6470247 0001746 3
A-49-23

STANDARDS PUBLICATION/NO. ICS 2.3-1983

nema

Instructions for the Handling, Installation, Operation, and Maintenance of Motor Control Centers

NEMA

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION ■ 2101 L STREET, N.W., WASHINGTON, D.C. 20037

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

TABLE OF CONTENTS

		Page
	FOREWORD	i
	SCOPE	i
Section 1	GENERAL	1
Section 2	HANDLING	2
Section 3	STORAGE	3
Section 4	INSTALLATION OF MOTOR CONTROL CENTER SECTIONS	4
Section 5	INSTALLATION OF CONDUIT AND WIRES	6
Section 6	INSTALLATION OF MOTOR CONTROL CENTER UNITS	6
Section 7	STEPS TO BE TAKEN BEFORE ENERGIZING	7
Section 8	ENERGIZING EQUIPMENT	9
Section 9	PERMISSIBLE LOADING OF MOTOR CONTROL CENTERS	10
Section 10	CARE AND MAINTENANCE	11
Section 11	MAINTENANCE AFTER A FAULT HAS OCCURRED	13

© 1983 by National Electrical Manufacturers Association

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

Foreword

(Approved as Authorized Engineering Information September 15, 1983.)

This publication is a guide to practical information containing instructions for the handling, installation, operation, and maintenance of motor control centers rated 600 volts or less. It is not the intent of these instructions to supersede the manufacturer's instructions. These instructions do not purport to cover all details or variations in equipment, nor to provide for every possible contingency to be met in connection with installation, operation, or maintenance. Should further information be desired or should particular problems arise, which are not covered sufficiently, the matter should be referred to the manufacturer. These recommendations of the Industrial Control and Systems Section of the National Electrical Manufacturers Association will be found useful by architects, electrical engineers, electrical contractors, electricians, maintenance engineers, and others. They will be reviewed periodically by the Section for the purpose of updating them as necessary. Please address any comments or questions you may have on the text to:

Manager, Engineering Department
National Electrical Manufacturers Association
2101 L Street, N.W.
Washington, D.C. 20037

SCOPE

The product scope of the Control Group of the Industrial Control and Systems Section of NEMA which is responsible for the development of this Standards Publication is given below, along with the scope of this publication.

SCOPE OF THE CONTROL GROUP

General purpose mechanical, electromechanical and/or solid state (static) devices and control which are principally used in industrial applications for the control of motors or other power utilization apparatus rated not more than 750 volts dc or 7,200 volts ac. The product scope specifically includes, but is not limited to, devices principally used for the following purposes:

A. To start, stop, protect, accelerate, decelerate, reverse, and/or control the speed of electric motors.

B. To provide some mechanical movement through the action of magnets or solenoids.

SCOPE OF ICS 2.3–1983

These guidelines are provided to facilitate movement, handling, and installation of motor control centers at the job site and to help avoid personal injury and equipment damage during these processes.

Information includes the following:

- Handling
- Storage
- Installation of sections, and units, and of conduit and wires
- Pre-energization and energization
- Permissible loading
- Care and maintenance

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

Section 1

GENERAL

There is a hazard of electric shock whenever working on or near electrical equipment. *Turn off power* supplying this equipment before working inside motor control centers and lockout and/or tag out disconnecting means in accordance with NFPA 70 E, Part II. Where it is not feasible to de-energize the system, the following precautions should be taken:

a. Persons working near exposed parts that are or may be energized should be instructed and should use practices (including appropriate apparel, equipment, and tools) in accordance with NFPA 70 E, Part II.

b. Persons working on exposed parts that are or may be energized should, in addition to (a), be qualified persons who have been trained to work on energized circuits.

The operation of motor control centers is dependent upon handling, installation, operation and maintenance by qualified personnel, as well as upon proper design and manufacture. Failure to follow certain fundamental installation and maintenance requirements could lead to personal injury and the failure and loss of the motor control center, and also damage to other property.

Frequently, a motor control center is split into two or more sections for shipment, with the intent that they will be joined at the point of its permanent location.

References to the *National Electrical Code*—1981 are shown as (NEC) and refer to NFPA Publication No. 70, 1984.

Reference to manufacturer, unless otherwise specified, means the motor control center manufacturer.

Qualified Person

For the purpose of this guide, a qualified person is one who is familiar with the installation, construction, or operation of the equipment and the hazards involved. In addition, he has the following qualifications:

a. *Is trained and authorized* to energize, de-energize, clear, ground, and tag circuits and equipment in accordance with established safety practices.

b. Is trained in the proper care and use of protective equipment such as rubber gloves, hard hat, safety glasses or face shields, flash clothing, etc., in accordance with established safety practices.

c. Is trained in rendering first aid.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

Section 2

HANDLING

The following guidelines are provided to help avoid personal injury and equipment damage during handling, and to facilitate moving the motor control center at the job site.

1. Follow the manufacturer's handling instructions for the specific equipment.

2. Handle the motor control center, with care, to avoid damage to components and to the frame or its finish.

3. Keep the motor control center in an upright position unless otherwise specifically permitted by the manufacturer.

4. Know the capabilities of the moving means available to handle the weight of the motor control center.

5. When the motor control center is received, unpack it sufficiently to inspect for concealed damage and to determine that the shipment is complete and correct.

6. If the motor control center is to be stored for any length of time, prior to installation, restore the packing for protection during that period. Where conditions permit, leave the packing intact until the motor control center or sections are at their final installation position. If the packing is removed, cover the top and openings of the equipment during the construction period to protect them against dust and debris. (See Section 3.)

7. The motor control center should remain secured to the shipping skid to prevent distortion of the frame during moving, and to minimize tipping.

8. Extreme care must be exercised during any movement and placement operations to prevent falling, or unintentional rolling or tipping.

9. Rod or pipe rollers, with the aid of pinch bars, provide a simple method of moving the motor control center on one floor level if there is no significant incline. Steady the load to prevent tipping.

10. A fork-lift truck may offer a more convenient method of handling the motor control center and has the added advantage of permitting it to be hoisted between levels. Motor control centers are normally front heavy and frequently top heavy. Balance the load carefully and steady a motor control center, as necessary, while moving. Use a safety strap when handling with a fork-lift.

11. When it is necessary to move the motor control center between elevations, without a suitable platform elevator, overhead hoisting may be required. Lifting plates and eye bolts (Figure 2-1), or channels, angles or bars with lift holes (Figure 2-2) may be provided as a permanent or removable part of the motor control center.

a. Use spreaders (Figure 2-1) to provide the vertical lift on eye-bolts and lifting slings to avoid eye-bolt failure and/or crushing, or otherwise damaging the motor control center frame or its finish.

b. Select or adjust the rigging lengths to compensate for any unequal weight distribution of load, and to maintain the motor control center in an upright position.

c. In order to reduce the tension on the rigging and the compressive load on the lifting or spanner bars and spreaders, do not allow the angle between the lifting cables and vertical to exceed 45 degrees.

d. Do not pass ropes or cables through the lift holes in bars, angles, or channels. Use slings with safety hooks or shackles.

e. Some motor control center interiors may contain heavy equipment, such as transformers mounted within, that could be adversely affected by tilting.

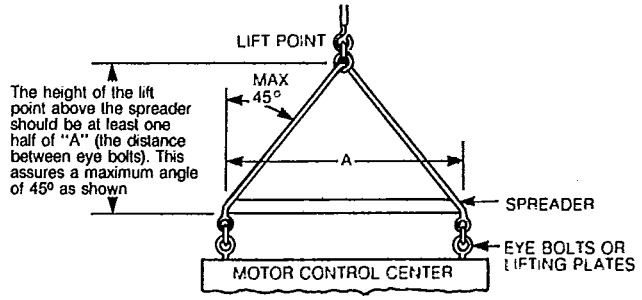


Figure 2-1
LIFTING WITH EYE BOLTS OR LIFTING PLATES

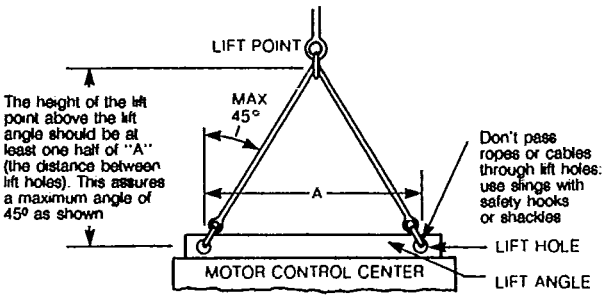


Figure 2-2
LIFTING WITH INTEGRAL LIFT ANGLE

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

Section 3

STORAGE

1. An indoor motor control center or separate unit, which is not installed and energized immediately, should be stored in a clean dry space where a uniform temperature prevents condensation. Preferably, it should be stored in a heated building, with adequate air circulation and protected from dirt and water. Motor control centers and units should be stored where they are not subject to mechanical damage.

2. An indoor motor control center that must be stored outdoors should be securely covered for protection from weather conditions and dirt. Temporary electrical heating should be installed to prevent condensation; approximately 150 watts per section is adequate for the average motor control center's size and environment. All loose packing or flammable materials should be removed before energizing space heaters.

3. An unenergized outdoor motor control center should be kept dry internally by installing temporary heating (see 3.2), or by energizing self-contained space heaters.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS

Not for Resale

Section 4

INSTALLATION OF MOTOR CONTROL CENTER SECTIONS

1. Install the motor control center in a neat and workmanlike manner following the manufacturer's installation instructions, if available.

2. Locate the motor control center in the area shown on the building floor plans. If in a wet location or outside of the building, the motor control center should be protected from moisture or water entering and accumulating within the enclosure. Recommended clearances or working spaces are as follows:

a. Clearance from walls (not rear accessible)—minimum of ½ inch for indoor and 6 inches for outdoor or wet locations.

b. Clearance from front (working space)—minimum of 2½ feet wide for motor control centers without exposed live parts. (See NEC: 116-16(a))

NOTE—The above space should not be used for storage; working spaces should have adequate lighting.

3. Motor control centers should be securely mounted to a level surface.

4. For bottom entry, position the motor control center so that the conduit stubs or floor openings are located in the area specified on the manufacturer's drawing. In the absence of drawings, locate the motor control center over the conduits or floor openings so as to provide cable bending space and clearances to live parts. (See NEC: 373)

5. Install the motor control center in its final position, progressively leveling each section and bolting the frames together if they are separated. If necessary, and allowable by the manufacturer, secure the motor control center to walls or other supporting surfaces. Do not depend for security on wooden plugs driven into holes in masonry, concrete, plaster, or similar materials. (See NEC: 110-13)

6. Connect all horizontal busses at shipping breaks, using the splice busses and hardware supplied with the motor control center. Tighten bolted connections in accordance with the manufacturer's torque specifications, if furnished. If not furnished, use Tables 1, 2, and 3.

7. If a motor control center does not include a ground bus, provide adequate bonding between frames which are joined on the job site.

8. Ground and bond the motor control center as follows:

a. Motor control centers used as service equipment for a grounded system or as a main section for a separately derived system,

i. Run a grounding electrode conductor (ground wire) having a size in accordance with NEC: 250-94 from the grounding electrode to the motor control center ground bus or ground terminal designated by the manufacturer. (See also NEC: 250-91(a) and 250-92(a)).

ii. Unless already done at the factory, install the main bonding jumper from the incoming grounded conductor bus (neutral) to the ground bus or at a location designated by the manufacturer. If a jumper is not furnished, select one having a size in accordance with NEC: 250-79(c).

iii. Steps (i) and (ii) must effectively connect together the grounding electrode, the motor control center frame, all outgoing equipment grounding conductors, and the grounded neutral bus of the system (on the supply side of any disconnecting line).

iv. Do not make any connection to ground on the load side of any neutral disconnecting line or any sensor used for ground fault protection. Do not connect outgoing grounding conductors to the neutral.

v. Where the motor control center or system is dual fed (double-ended) and has ground fault protection, special precautions are necessary to accomplish proper grounding and bonding. Follow the manufacturer's instructions.

b. Motor control centers used as service equipment for an ungrounded system or as a main section for a separately derived system,

i. Run a grounding electrode conductor (ground wire), having a size in accordance with NEC: 250-94, from the grounding electrode to the motor control center ground-bus or ground terminal designated by the manufacturer. (See NEC: 250-91(a) and 250-92(a).

ii. If the system is grounded at any point ahead of the motor control center, the grounded conductor must be run to the motor control center in accordance with NEC: 250-23(b), and connected to the ground bus or to the motor control center frame and equipment grounding terminal designated by the manufacturer.

iii. Steps (i) and (ii) must effectively connect together the grounding electrode, the motor control center frame, all outgoing equipment grounding conductors, and any grounded conductor which runs to the motor control center as described in 8-b-2.

c. Motor control centers *not* used as service equipment or as a main section for a separately derived system, and used on either a grounded or ungrounded system,

i. Ground the motor control center frame and

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS

Not for Resale

any ground bus by means of equipment grounding conductors having a size in accordance with NEC: 250-95 and run with the main supply conductors or by bonding to the raceway enclosing the main supply conductors in accordance with NEC: 250-91(b).

9. Close all unused openings in accordance with the requirements for the motor control center enclosure type.

10. In damp indoor locations, shield the motor control center to prevent moisture and water from entering and accumulating.

11. Unless the motor control center has been designed for unusual service conditions, it should not be located where it will be exposed to ambient temperatures above 40°C (104°F), corrosive or explosive fumes, dust, vapors, dripping or standing water, abnormal vibration, or shock or tilting, or unusual operating conditions.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

Section 5

INSTALLATION OF CONDUIT AND WIRES

1. Conduits should be installed to prevent moisture or water from entering and accumulating within the enclosure. All conduits (including stubs) should be bonded to the motor control center. All conduits should be located in the areas recommended by the manufacturer to avoid cable interference with structural members and live bus.

2. Care should be exercised to make sure that the lugs which have been provided are suitable for use with the type of cables being installed in the motor control center.

3. If crimp lugs are used, crimp with the tools recommended by the lug manufacturers.

4. Care should be exercised in stripping insulation from the conductors to prevent the conductor from nick or ring. For aluminum, clean all oxide from the stripped portion and at once apply inhibiting compound. All screw lugs should be tightened; use the manufacturer's torque values, if furnished. If not furnished, use the torques shown in Tables 1, 2, and 3.

5. Provisions should be made to locate conductors in the motor control center to avoid physical damage and to avoid overheating. The conductors should be secured in order to withstand available short-circuit currents. Follow the manufacturer's instructions for lacing or bracing cables. The largest practical bending radii should be maintained to avoid damaging the insulation and to avoid causing terminals to loosen.

6. All incoming and outgoing control connections should be made in accordance with the motor control center manufacturer's schematic and wiring diagrams.

7. Installation of cables should be done at temperatures above freezing to prevent cable insulation from cracking or splitting due to cold, unless the cable is suitable for installation at temperatures below freezing.

Section 6

INSTALLATION OF MOTOR CONTROL CENTER UNITS

Follow these instructions for field installed *units*.

1. To prevent damage, exercise care in unpacking the units.
2. Check the units for shipping damage and ensure they are the right ones for installation.
3. Check to see that correct doors are used with the units to be installed.
4. To install units and doors in motor control centers, carefully follow the manufacturer's instructions.
5. Make necessary wiring connections in accordance with the wiring diagram and manufacturer's instructions.
6. When units are mounted in the rear, and sections have a common vertical bus, it may be necessary to check that the wires to the motor leads are in proper phase sequence.
7. For unit storage instructions, see 3.1.
8. Follow instructions in Section 7 before energizing.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

Section 7

STEPS TO BE TAKEN BEFORE ENERGIZING

Because of the diversity of components which may be supplied, the manufacturer's instructions should be followed.

1. a. Retighten all accessible electrical connections to the manufacturer's torque specifications, if furnished. If such information is not available, tighten steel hardware parts (except pressure wire connectors and conical spring washers (Belleville) to the values given in Table 7-1 for metal-to-metal connections.

b. Retighten the wire clamping members of all accessible mechanical (pressure wire) type connectors to the torque value (inch-pounds) for the largest wire size the connectors will accept as given in Tables 7-2 and 7-3, unless otherwise noted on the equipment.

c. Retighten conical spring washers (Belleville) until washer is flat.

2. Remove all blocks or other temporary holding means used for shipment from all component devices in the motor control center interior.

3. Check the integrity of all bus mounting means.

4. Check the enclosure to see that it has not been damaged so as to reduce electrical spacings.

5. Compare all circuits for agreement with the wiring diagram which accompany the motor control center.

6. Make certain that field wiring is clear of live busses and, where necessary, physically secured to withstand the effects of fault current.

7. Check to determine that all grounding connections are made properly. If there is no ground bus, make certain that the sections of the motor control center which are shipped separately are connected in such a way as to assure a continuous grounding path.

8. Check all devices for damage. Make all necessary repairs or replacements, prior to energizing.

Table 7-1*

RECOMMENDED TORQUE VALUES FOR METAL-TO-METAL ELECTRICAL CONNECTIONS

Bolt	Diameter	Tightening Torque
#8	(5/32")	15 inch pounds
#10	(3/16")	20 inch pounds
	1/4"	7 foot pounds
	5/16"	12 foot pounds
	3/8"	20 foot pounds
	1/2"	50 foot pounds
	5/8"	95 foot pounds
	3/4"	155 foot pounds

9. Be sure that each motor is connected to its intended starter.

10. Manually exercise all switches, circuit breakers, and other operating mechanisms to make certain that they are properly aligned and operate freely.

11. With all loads disconnected electrically, exercise all electrically operated switches, circuit breakers, and other mechanisms to determine that the devices operate properly. An auxiliary source of control power may be necessary to provide power to the electrical operators.

12. Test the ground fault protection system (if furnished) in accordance with the manufacturer's instructions.

13. Set any adjustable current and voltage trip mechanisms to the proper values. Experience has indicated that damage from faults can be reduced if the devices used for short-circuit and ground fault protection are set to operate instantaneously (that is, without intentional time delay), at 115 percent of the highest value of phase current that is likely to occur as the result of any anticipated motor starting or welding currents.

14. Ensure that overload relays or heater elements are installed and selected and/or adjusted to the full load current shown on the nameplate of each motor and the manufacturer's instructions.

15. Install power circuit fuses in the fusible switches in accordance with the NEC application requirements. Make sure that fuses are completely inserted in the clips. Do not attempt to defeat the rejection feature on the fuse clip, when provided.

16. Remove shorting bars from the secondary of current transformers. Do not operate a current transformer with its secondary circuit open.

17. To prevent possible damage to equipment or injury to personnel, check to insure that all parts and barriers that may have been removed during wiring and installation have been properly reinstalled.

18. Before closing the enclosure, remove all metal chips, scrap wire, and other debris from the motor control center interior. If there is appreciable accumulation of dust or dirt, clean out the motor control center by using a brush, vacuum cleaner or clean, lint-free rags. **Do Not Use Compressed Air Because It Will Redistribute Contaminant On Other Surface.**

19. Conduct an electrical insulation resistance test to make sure that the motor control center and field wiring are free from short circuits and grounds. This should be done phase-to-ground, phase-to-phase, and phase-to-neutral, with the switches or circuit breakers opened.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

Table 7-2*
TORQUE VALUES, INCH-POUNDS
SLOTTED HEAD
SCREW DRIVER
No. 10 AND LARGER SCREWS

Wire Size Installed, AWO or MCM	Slot Width 3/64 and Less Slot Length 1/4 and Less	Slot Width Over 3/64 Slot Length Over 1/4	External Drive Wrench	
			Split Bolt	Other
14	15	25	65	60
12	15	25	65	60
10	15	25	65	60
8	20	30	65	60
6	25	35	135	90
4	. . .	35	135	90
3	. . .	40	225	125
2	. . .	40	225	125
1	. . .	40	225	125
1/0	. . .	40	315	150
2/0	. . .	40	315	150
3/0	. . .	40	400	200
4/0	. . .	40	400	200
250	. . .	. . .	550	250
300	. . .	. . .	550	250
350	. . .	. . .	550	250
400	. . .	. . .	675	250
500	. . .	. . .	675	300
600	. . .	. . .	600	300
700	. . .	. . .	800	300
750	. . .	. . .	800	300
800	. . .	. . .	900	400
900	. . .	. . .	900	400
1000	. . .	. . .	900	400
1250	. . .	. . .	900	500
1500	. . .	. . .	900	500
1750	. . .	. . .	900	500
2000	. . .	. . .	900	500

20. Install covers, close doors, and make certain that no wires are pinched and that all enclosure parts are properly aligned and tightened.

21. Turn all circuit breakers and fusible switches to the OFF position before energizing the bus.

Table 7-3*
HEX SOCKET SCREWS

Socket Size (Across Flats), Inches	Tightening Torque Inch-Pounds
1/8	35
5/32	90
3/16	100
7/32	120
1/4	150
5/16	225
3/8	300
1/2	400
9/16	500

* For motor control centers designed for use under usual service conditions as defined in NEMA Publication ICS 1-108, the torque values in Tables 7-1, 7-2, and 7-3 may be used. For unusual service conditions, consult the manufacturer.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS

Not for Resale

Section 8

ENERGIZING EQUIPMENT

Energizing a motor control center for the first time is potentially dangerous. Therefore, qualified personnel (see Section 1, General, Paragraph 2) should energize the equipment. If faults caused by damage or poor installation practices have not been detected in the checkout procedure described in Section 7, serious damage and/or personal injury can result when the power is turned on.

1. In order to minimize risk of injury or damage, or both, there should be no load on the motor control center when it is energized. Turn off all of the downstream loads, including those such as distribution equipment and other devices which are remote from the motor control center.

2. The equipment should be energized in sequence by starting at the source end of the system and working towards the load end. In other words, energize the main devices, then the feeder devices, and then the branch-circuit devices. With barriers (if applicable) in place, and unit doors closed and latched, turn the devices on with a firm positive motion. Protective devices that are not quick-acting should not be ''teased'' into the closed position.

3. After all disconnect devices have been closed, loads such as lighting circuits, starters, contactors, heaters, and motors, may be turned on.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

Section 9

PERMISSIBLE LOADING OF MOTOR CONTROL CENTERS

1. For motor control centers without main overcurrent protective devices (incoming line lugs), the total continuous load current through the horizontal bus should not exceed the current rating of the motor control center.

2. For motor control centers with a single main overcurrent protective device, the total continuous load current on the protective device should not exceed 80 percent of its ampere rating unless the device is rated to carry 100 percent of its ampere rating.

3. For motor control centers with multiple main overcurrent protective devices, the total continuous current through the horizontal bus should not exceed the current rating of the motor control center.

The total continuous load current on each overcurrent protective device should not exceed 80 percent of its ampere rating unless the device is rated to carry 100 percent of its ampere rating.

4. For a branch-circuit overcurrent protective device in a motor control center, the total continuous load current on the protective device should not exceed 80 percent of its ampere rating unless the device is rated to carry 100 percent of its ampere rating.

5. The maximum Short Circuit Current rating of the entire motor control center should be the smallest of the following:

   a. the rating of the bus structure, or
   b. the lowest rating of the motor control units, or
   c. the lowest rating of the feeder tap units.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS

Not for Resale

Section 10

CARE AND MAINTENANCE

For the equipment to operate properly, a periodic maintenance program should be established. NFPA Publication 70B (Electrical Equipment Maintenance) may be used as a guide for establishing such a program. For unusual service conditions listed in NEMA Part ICS 1-108, or any other unusual service conditions, the user should obtain maintenance instruction from the manufacturer.

1. Because of the diversity of components which may be supplied, the manufacturer's instructions should be consulted for required maintenance, for wear, or degradation of components.

2. Carefully inspect the doors, enclosure sides and deadfront surfaces over all units for evidence of excessive heat. As a general rule, any temperature which the palm of the hand cannot stand for about 3 seconds may indicate trouble.

Disconnect power ahead of the motor control center and lockout and/or tag out circuit and equipment in accordance with NFPA 70 Part II, before performing any of the following operations. Discharge capacitors, if present. Positively ascertain that the equipment is totally de-energized, by using an appropriate instrument, such as a voltmeter. When separate control circuits exist, ascertain that they also are de-energized.

Where it is not feasible to de-energize and lockout and/or tag out circuits or equipment, persons working on or near exposed circuit parts which may or may not be energized, should meet the requirements of Section 1 of this guide.

3. Inspect the motor control center a minimum of once each year, or more often as deemed necessary.

a. Look for any moisture or signs of previous wetness or dripping inside the motor control center. Condensation in conduits or dripping from outside sources is a common cause of motor control center failure.

i. Seal off any conduits that have dripped condensate, and provide an alternative means for the conduit to drain.

ii. Seal off any cracks or openings which have allowed moisture to enter the enclosure. Eliminate the source of any dripping on the enclosure and any other source of moisture.

iii. Replace or thoroughly dry and clean any insulating material which is damp or wet or shows accumulation of deposited material from previous wettings. Conduct an electrical insulation resistance test to verify the dielectric integrity of the affected insulation.

iv. Check devices such as contactors, circuit breakers, disconnect switches, relays, pushbuttons, etc., for wetness, contamination, or corrosion, and replace or clean and dry as required and according to the manufacturer's instructions.

v. *Be sure* that the *cause* of any wetness or contamination has been *identified* and *eliminated*. If the cause is internal condensation, it may be necessary to provide supplementary heating; consult the manufacturer.

b. If there is appreciable accumulation of dust or dirt, clean out the motor control center by using a brush, vacuum cleaner, or clean lint-free rags. **Do not use compressed air because it will only redistribute contaminant on other surfaces.**

c. Carefully inspect all accessible electrical joints and terminals in the bus and wiring systems.

i. Retighten bolts and nuts at bus joints, if there is any sign of overheating or looseness. (See Section 7, Tables 7-1, 7-2, and 7-3, for recommended torque values).

ii. If joints or terminations appear to be badly discolored, corroded or pitted, or show evidence of having been subjected to high temperatures, the parts should be disassembled and replaced or cleaned. It is not recommended that emery paper, sand paper, or a file be used to clean or dress up any portion of the electrical equipment. For unplated copper bus applications requiring a sanding operation use aluminum oxide paper. This will not leave sand or metal particles on contact surface areas. Do not sand aluminum bus under any circumstances.

Do not remove plating on aluminum parts in joints or terminations. Damaged aluminum parts should be replaced.

iii. Examine all wire or cable connections for evidence of looseness or overheating. Retighten, if necessary. If major discoloration of cable insulation or if cable damage is apparent, replace the damaged portion of the cable.

iv. Closely examine fuse clips. If there is any sign of overheating or looseness, check the spring pressure, tightness of clamps, etc. Replace the fuse clips if the spring pressure compares unfavorably with that of other similar fuse clips in the motor control center. Make sure that fuses are completely inserted.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

v. Look for any signs of deterioration of insulating material or melting of the sealing compound. Replace such insulating parts, and assemblies where sealing compound has melted. Make sure that the dielectric integrity of the affected parts has been maintained.

vi. **Be sure that the condition that caused the overheating has been corrected.**

d. Check for the proper operation of all mechanical components.

i. Check all switch operator mechanisms and external operators of circuit breakers. Make sure each operator mechanism quickly and positively throws contacts fully on and fully off.

ii. Check the mechanisms of all electrical and mechanical interlocks and padlocking means. If necessary, adjust according to the manufacturer's instructions.

iii. Check all devices for missing or broken parts, proper spring tension, free movement, rusting or corrosion, dirt, and excessive wear. If necessary, replace, repair, clean, lubricate, and/or adjust according to the manufacturer's instructions.

e. Examine all readily accessible arc chutes and insulating parts for cracks or breakage and for arc splatter, sooty deposits, oil or arc tracking.

i. Clean off arc splatter, oil and sooty deposits, and inspect for burning, charring, or carbon tracking. To measure whether such wear requires replacement, consult the manufacturer's recommended specifications.

ii. Replace insulating parts and arc chutes that are cracked or broken.

4. Operate each switch or circuit breaker, several times, to make sure that all mechanisms are free and in proper working order. If it is desirable to verify the performance of molded case circuit breakers, see NEMA Standards Publication AB 2-1980, *Procedures for Verifying the Performance of Molded Case Circuit Breakers*.

5. Check fuses and circuit breakers to make sure they have the proper ampere rating, type and interrupting rating. Make sure that non-current-limiting fuses are never used as replacements for current-limiting fuses. Never attempt to defeat rejection mechanisms which are provided to prevent the installation of the wrong type of fuses.

6. Inspect to ensure that oil or grease (if used) is applied *only* to surfaces recommended by the manufacturer.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS

Not for Resale

Section 11

MAINTENANCE AFTER A FAULT HAS OCCURRED

The excessive currents occurring during a fault may result in structure, component and/or bus, and conductor damage due to mechanical distortion, thermal damage, metal deposits, or smoke. After a fault, repair the cause of the fault, inspect all equipment per NEMA Standards Publication No. ICS 2-302, *Maintenance of Motor Controllers After a Fault Condition*, and make any necessary repairs or replacements prior to putting the equipment in service again. Be sure that all replacements (if any) are of the proper rating and are suitable for the application. If in doubt, consult the manufacturer. The following procedure is recommended for this inspection.

After a fault has occurred, all equipment must be de-energized, disconnected, and isolated to prevent accidental contact with live parts. Check voltage on all control terminals and on all line and load terminals of circuit breakers, disconnect switches, and starters or contactors before touching or working on equipment. Only qualified personnel should be involved in the inspection and repair procedure and all safety procedures must be observed.

Bus

Retighten all bus connections (see Section 7, Tables 7-1, 7-2, and 7-3 for recommended torque values). Replace damaged or deformed busses and fasteners, or busses with melted, worn, or damaged plating (See Section 10, Paragraph 3,c,2). Replace all insulators showing damage, deterioration, or deposits, and perform an electrical insulation resistance test to verify the electrical integrity. Verify minimum spacings through air and over surface between live parts and grounded metal parts in accordance with NEMA Publication ICS 2-322-60.05.

Plug-in (Stab-on) Assemblies

Inspect stab-on clips for damage. Replace the complete stab-on assembly if there is evidence of arcing, melting, erosion, deformation, or general heat damage.

Enclosure

External evidence of enclosure deformation is usually indicative of damage within. Extensive damage will require replacement of the enclosure parts and the enclosed equipment. The procedure described below may be used to arrive at decisions regarding these replacements.

In addition to inspecting the enclosure and doors for evidence of damage such as deformation, displacement of parts, or burning, ensure that door-mounted equipment and safety. interlock function correctly. Confirm that hinge and latch integrity is maintained.

Disconnecting Means

1. *Circuit Breakers*

Examine the circuit breaker for evidence of possible damage. If there is no apparent evidence of damage, the breaker may be reset and turned "ON" using the external handle. If it is suspected that the circuit breaker has opened several short circuits or if there are signs of possible deterioration, replace the breaker or subject it to the test described in paragraph AB1-2.38, from NEMA Standards Publication, for *Molded Case Circuit Breakers*, before restoring it to service.

2. *Disconnect Switch*

After a fault, the external operating handle must be capable of opening the switch. Replace the switch if the external operating handle fails to open it, or if visual inspection after opening indicates deterioration beyond normal wear, such as overheating, contact blade or jaw pitting, charring, welding or insulation breakage.

3. *Fuse Holders*

Replace fuse holders if the insulating mounts, barriers, or fuse clips show signs of damage, deterioration, heating, distortion or looseness.

4. *Operating Handle*

The disconnection means and external operating handle must be replaced if the operating handle fails to open or close the switch or circuit breaker. The door interlock must be inspected and its proper functions verified prior to restoring the controller to service.

a. Replace insulating parts and arc chutes that are cracked or broken.

5. Operate each switch or circuit breaker several times to make sure that all mechanisms are free and in proper working order. If it is desirable to verify the performances of molded case circuit breakers, see NEMA Standards Publication AB 2-1980, *Procedures for Verifying the Performance of Molded Case Circuit Breakers*.

6. Check fuses and circuit breakers to make sure they have the proper ampere rating, type, and interrupting rating. make sure that non-current-limiting fuses are never used as replacements for current-limiting fuses. Never attempt to defeat rejection mechanisms which are provided to prevent the installation of the wrong type of fuses.

7. Inspect to ensure that oil or grease (if used) is applied *only* to surfaces recommended by the manufacturer.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

Terminals and Internal Conductors

Replace all damaged parts which show evidence of discoloration, melting or arcing damage.

Motor Starter

1. *Contactor*

Replace the contacts and contact springs if the contacts are welded or show heat damage, displacement of metal, evidence of binding in the guides, or wear in excess of wear allowance. If deterioration extends beyond the contacts, replace the contactor or starter. Examples of such deterioration include evidence of arcing on the contactor moldings and insulation damage. Perform an electrical insulation resistance test to verify electrical integrity.

2. *Overload Relays*

a. The complete overload relay or starter must be replaced if burnout of the heater element has occurred. Any indication of an arc striking or burning the overload relay, also requires replacement.

b. If there is no visual indication of damage that would require replacement, contact operation must be verified by electrically or mechanically tripping and resetting the overload relay.

3. *Fuses*

Always replace all three fuses in a three phase circuit, even though only one or two are open circuited, since internal damage suffered by the unreplaced fuses could result in a shut-down later.

4. Before restoring the equipment to service, subject it to the *Steps to be Taken before Energizing* procedures detailed in Section 7 of this manual.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

NEMA STANDARDIZATION

The purpose of NEMA Standards, their classification and status are set forth in certain clauses of the NEMA Bylaws, which are quoted below:

Purpose of Standards

National Electrical Manufacturers Association Standards are adopted in the public interest and are designed to eliminate misunderstandings between the manufacturer and the purchaser and to assist the purchaser in selecting and obtaining the proper product for its particular need. Existence of a National Electrical Manufacturers Association Standard does not in any respect preclude any member or nonmember from manufacturing or selling products not conforming to the standard.

(Bylaw—Art. V, Sec. 1)

Definition of a Standard

A standard of the National Electrical Manufacturers Association defines a product, process or procedure with reference to one or more of the following: nomenclature, composition, construction, dimensions, tolerances, safety, operating characteristics, performance, rating, testing, and the service for which they are designed.

(Bylaw—Art. V, Sec. 2, Subsection A)

Dimensions

Where dimensions are given for interchangeability purposes, alternate dimensions satisfying the other provisions of the standards publication may be capable of otherwise equivalent performance.

(NEMA Policy Memorandum 84-2, dated June 7, 1984)

Classes of Standards

National Electrical Manufacturers Association Standards are of two classes:

1. NEMA Standard, which relates to a product commercially standardized and subject to repetitive manufacture, which standard has been approved by at least 90 percent of the members of the Subdivision eligible to vote thereon;
2. Suggested Standard for Future Design, which may not have been regularly applied to a commercial product, but which suggests a sound engineering approach to future development, which standard has been approved by at least two-thirds of the members of the Subdivision eligible to vote thereon.

(Bylaw—Art. V, Sec. 2, Subsection B)

Authorized Engineering Information

Authorized Engineering Information consists of explanatory data and other engineering information of an informative character not falling within the classification of NEMA Standard or Suggested Standard for Future Design.

(Bylaw—Art. V, Sec. 6, 1st Sentence)

Official Standards Proposal

An Official Standards Proposal is an official draft of a proposed standard which is formally recommended to an outside organization(s) for consideration, comment and/or approval.

(Bylaw—Art. V, Sec. 4, Subsection A)

Identification of Status

Standards in NEMA Standards Publications are identified in the foreword or following each standard as "NEMA Standard" or "Suggested Standard for Future Design." These indicate the status of the standard. These words are followed by a date which indicates when the standard was adopted in its present form by the Association.

The material identified as "Authorized Engineering Information" and "Official Standards Proposal" is designated similarly.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

CONTROL GROUP
OF THE
INDUSTRIAL CONTROL AND SYSTEMS SECTION
OF THE
NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION

MEMBER COMPANIES

Allen-Bradley Company
Milwaukee, WI 53201

ASEA, Inc.
White Plaines, NY 10604

Automatic Switch Company
Florham Park, NJ 07932

Cogenel Inc.-Entrelec Division
Spring Valley, NY 10977

Control Productions Division
Amerace Corporation
Union, NJ 07083

Crouse-Hinds/Arrow Hart
Hartford, CT 06101

Custom Switchgear and Controls, Inc.
Santa Clara, CA 95051

Cutler Hammer Prods, Eaton Corp
Milwaukee, WI 53126

Electro Switch Corporation
Weymouth, MA 02188

Elliott Control Company
Burlingame, CA 94010

Federal Pacific Electric Co.
Raleigh, NC 27607

Furnas Electric Company
Batavia, IL 60510

General Electric Company
Salem, VA 24153

Nelson Electric, A Unit of
General Signal Corporation
Tulsa, OK 74101

Gould Incorporated
Distribution & Controls Division
Westminster, MD 21157

GTE Products Corporation
Lighting Products Group
Danvers, MA 01923

Harnischfeger Corporation
Milwaukee, WI 53201

Harvey Hubell, Incorporated
Hungtington, WV 25778

Industrial Controls Division
Madison, OH 44057
Industrial Solid State Controls Inc.
York, PA 17405

Johnson Controls, Incorporated
Goshen, IN 45526

Klockner Moeller Corporation
Natick, MA 01760

Kohler Company
Kohler, WI 53044

McGill Manufacturing Company, Inc.
Valparaiso, IN 46383

Micko Switch/Div. of Honeywell, Inc.
Freeport, IL 61032

Namco Controls Division
Acme Cleveland Corporation
Mentor, OH 44060

Onan Corporation
Minneapolis, MN 55432

Pass & Seymour, INc.
Syracuse, NY 13221

Russelectric, Inc.
Hingham, MA 02043

Siemens-Allis, Inc.
Wichita Falls, TX 76307

Sprecher & Schuh, INc.
S & S Controls Division
Port Chester, NY 10573

Square D Company
Palatine, IL 60067

Genl Semi-Conductor Industries, Inc.
Tempe, AZ 85281

Telemecanique, Incorporated
Arlington Heights, IL 60005

Texas Instruments, Inc.
Attleboro, MA 02703

Toshiba International Corporation
Houston, TX 77041

Turck Multiprox, Inc.
Plymouth, MN 55441

Ward Leonard Electric Company, Inc
Mt. Vernon, NY 10550

Westinghouse Electric Corporation
Pittsburgh, PA 15222

Zenith Controls, Incorporated
Chicago, IL 50609

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale