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NEMA STANDARDS PUBLICATION NO. ICS 1.3

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Preventive Maintenance of Industrial Control and Systems Equipment

NEMA

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

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PREVENTIVE MAINTENANCE OF INDUSTRIAL CONTROL AND SYSTEMS EQUIPMENT

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(This NEMA Standards Publication is classified as Authorized Engineering Information.)

Foreword

The purpose of this Standards Publication is to assist those responsible for maintenance and repair of Industrial Control and Systems Equipment.

Effective preventive maintenance is essential to the satisfactory and safe operation of electrical and electronic equipment, and to the minimization of down-time associated with unscheduled corrective maintenance.

This publication covers maintenance practices that are common to most Industrial Control and Systems Equipment. It is intended to supplement more specific maintenance instructions which may be provided for particular product lines and specific products in other NEMA Standards and manufacturers' publications. It also covers general safety precautions for preventive maintenance activities.

In the preparation of this standards publication input of users and other interested parties has been sought and evaluated. Inquiries, comments, and proposed or recommended revisions should be sent to:

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Scope

This Standards Publication covers fundamental principles, safety precautions, and common guidelines for preventive maintenance of equipment within the scope of the NEMA Industrial Control and Systems Section. The products of the Industrial Control and Systems Section are identified in NEMA Standards Publication Nos. ICS 2, ICS 3, ICS 4, and ICS 6.[1]

This publication is intended as a guideline only, and cannot cover all possible variations and combinations of specific equipment. Manufacturer's instructions take precedence in the event that they conflict with these guidelines. ANSI/NFPA Publications 70B and 70E[1] should also be used as applicable. For additional information, refer to the individual NEMA product standards listed above.

A preventive maintenance program is not intended to cover reconditioning or major repair, but should be designed to reveal, if possible, the need for such actions in time to prevent malfunctions or unsafe conditions during operation.

[1]See Section 1, REFERENCED STANDARDS, for more detailed information.

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PREVENTIVE MAINTENANCE OF INDUSTRIAL CONTROL AND SYSTEMS EQUIPMENT

Section 1

REFERENCED STANDARDS

The following publications are adopted, in whole or in part as indicated, by reference in this standards publication and are available from the organizations and addresses shown below.

National Electrical Manufacturers Association
2101 L Street, N.W.
Washington, DC 20037

NEMA ICS 1.1-1984 (R1988)	*Safety Guidelines for the Application, Installation and Maintenance of Solid State Control*
ANSI/NEMA ICS 2-1988	*Industrial Control Devices, Controllers and Assemblies*
ANSI/NEMA ICS 3-1988	*Industrial Systems*
ANSI/NEMA ICS 4-1983 (R1988)	*Terminal Blocks for Industrial Use*
ANSI/NEMA ICS 6-1988	*Enclosures for Industrial Control and Systems*

American National Standards Institute
11 West 42nd Street
New York, NY 10036

ANSI/NFPA 70-1990	*National Electrical Code*
ANSI/NFPA 70B-1987	*Electrical Equipment Maintenance*
ANSI/NFPA 70E-1988	*Electrical Safety Requirements for Employee Workplaces*

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Section 2
FUNDAMENTALS

2.1 PLANNING

A well-planned and executed preventive maintenance program is essential to the satisfactory operation of electrical and electronic equipment. A program should be established at the time the equipment is installed. At that time, any manufacturer's instructional literature should be reviewed and retained in a location readily accessible for reference during maintenance of the equipment.

2.2 SCHEDULING

A schedule should be established for routine preventive maintenance of the equipment at intervals selected on the basis of severity of duty and environment. The schedule should be adjusted if later experience indicates the need.

2.3 DOCUMENTATION

A specific checklist of routine preventive maintenance requirements for each equipment item is recommended, as well as a logbook to record the maintenance history.

2.4 RENEWAL PARTS

A supply of renewal parts recommended by the equipment manufacturer should be kept available.

Section 3
SAFETY PRECAUTIONS

3.1 WORK PRACTICES

For the safety of maintenance personnel as well as others who might be exposed to hazards associated with maintenance activities, the safety related work practices of ANSI/NFPA 70E, Part II,[1] should always be followed when working on electrical equipment. Maintenance personnel should be trained in the safety practices, procedures, and requirements that pertain to their respective job assignments.

3.2 DEENERGIZATION

Circuit parts and equipment that can endanger personnel should be deenergized and locked out or tagged out in accordance with the requirements of ANSI/NFPA 70E, Part II. If more than one incoming power source exists (e.g., a separate control circuit), make sure that all sources are deenergized. Solid state electronic equipment may contain elements that exhibit potentially hazardous leakage current in the "off" state. Such equipment should be isolated from the source of power by conventional disconnection means rather than by simply "turning off" the solid state device.

3.3 WORK ON ENERGIZED EQUIPMENT

Persons should not be permitted to work on electric circuit parts or equipment that have not been deenergized and locked out or tagged out unless they are qualified and trained to use all appropriate safe work practices, procedures, and protective equipment in accordance with the requirements specified in ANSI/NFPA 70E, Part II. No work should be permitted on energized electrical equipment in any hazardous location as defined in the *National Electrical Code* (ANSI/NFPA 70).[1]

3.4 HAZARDS OF CONTROLLED EQUIPMENT

Maintenance activities, particularly shut-down and return to service of equipment or processes, must be coordinated with operations management to avoid hazardous conditions. Access to any machinery or process equipment that is controlled by the electrical equipment undergoing maintenance should be prohibited unless all means of activating the machinery or process have been locked out or blocked; including release or restraint of all stored energy, such as the electrical charge in capacitors, pressure in fluid or gas systems and stored mechanical energy in springs and elevated parts.

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[1]See Section 1, REFERENCED STANDARDS, for more information.

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Section 4
GENERAL GUIDELINES

4.1 CLEANLINESS

4.1.1 Opening Enclosures

Control equipment should be kept clean and dry. Before opening the door or cover of a cabinet or enclosure, comply with Section 3, "Safety Precautions." Foreign material, dirt, hardware, or debris should be removed from the outside top surfaces to avoid the risk of anything falling onto the equipment. Methods used in cleaning the outside of cabinets or enclosures should be chosen with consideration for the enclosure's type designations (see NEMA Standards Publication No. ICS 6),[1] to avoid risk of contaminating the enclosed equipment.

4.1.2 Inspection

Upon opening the cabinet or enclosure, control equipment should be inspected for any dust, dirt, moisture or evidence of moisture, or other contamination. If any is found, the cause must be eliminated. This could indicate an incorrectly selected, deteriorated, or damaged enclosure; unsealed enclosure openings; internal condensation; condensate from an unsealed conduit; or improper operating procedures (e.g., operating with enclosure door or cover open).

4.1.3 Operating Conditions

Enclosure doors, access plates, and covers are intended to remain closed during normal operation. Evidence that equipment has been operated with the enclosure door open or cover removed is usually an indication of a problem that should be diagnosed and corrected.

4.1.4 Cleaning

Corroded or damaged parts should be replaced. Dirty, wet, or contaminated parts of control equipment should also be replaced unless they can be cleaned effectively by vacuuming or wiping with dry cloth or soft brush. Use care to avoid damaging delicate parts. Compressed air is not recommended for cleaning because it may displace dirt, dust, or debris into other parts or equipment, or damage delicate parts. Liquid cleaners, including spray cleaners, are not recommended unless specified by the equipment manufacturer, because of the risk of residues causing damage or interfering with electrical or mechanical functions. The inside bottom of the cabinet or enclosure should also be cleaned, including removal of any hardware or debris, so that any new or unusual wear or loss of parts occurring after the inspection may be more readily detected during subsequent maintenance.

4.2 MECHANICAL INTEGRITY

4.2.1 Inspection

A general inspection of mechanical integrity should be made, i.e., loose, broken, missing, or badly worn parts. The intended movement of mechanical parts, such as armature and contacts or electromechanical contactors, disconnector, or circuit breaker operator mechanism and mechanical interlocks should be checked for freedom of motion and functional operation. For example, does a mechanical interlock actually provide the intended function?

4.2.2 Servicing

Any broken, deformed, or badly worn parts or assemblies should be replaced with manufacturer-recommended renewal parts. Any loose fasteners should be retightened securely (to manufacturer recommended torque if specified). Lubricate mechanisms only if recommended by the manufacturer, using only the recommended type and amount of lubricant. Remove any surplus lubricant to avoid risk of establishing a tracking path across insulating surfaces, and of excess lubricant migrating into areas that should not be lubricated.

4.3 TEMPERATURE CONTROL

4.3.1 Inspection

Ventilation passages should be kept open. If equipment depends on auxiliary cooling or heating, the temperature control system should be checked and repaired if necessary to assure proper functioning. Filters should be cleaned or replaced if necessary, based on inspection or the time interval recommended by the manufacturer.

4.3.2 Servicing

If dust or dirt has accumulated on heat sinks and/or components which generate heat, it should be removed carefully by vacuuming, wiping or brushing, since such accumulation can reduce heat dissipation capability and lead to premature failures (see 4.1.4).

4.4 DIAGNOSIS

Maintenance should always aim to determine and correct the cause of any problems, not just the symptoms.

[1] See Section 1, REFERENCED STANDARDS, for more information.

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4.5 REPAIR

If the equipment condition indicates need for adjustment, repair, or replacement, the manufacturer's instruction manual should be followed carefully. Diagnostic information within such a manual should be used to identify the probable source of the problem and to formulate a repair plan. The level of field repair recommended by the manufacturer should be followed; if more extensive repair is needed, the item should be replaced and/or returned to the manufacturer.

4.6 REPLACEMENT PARTS

Some apparently equivalent replacement parts from sources other than the original equipment manufacturer may not be suitable because the original equipment manufacturer may have required the original part to meet unique specifications, performance or test requirements (e.g., burn-in). Therefore, replacement parts meeting the specifications of the original equipment manufacturer should be used. Care should be taken to avoid the use of parts which are no longer compatible with changes in the equipment; revision levels should be verified. All parts contained in a replacement kit should be changed. Do not use parts that have deteriorated in storage.

4.7 DISPOSAL OF PARTS

Government regulations and/or safe practice dictate that some types of parts which may be removed during maintenance require special handling and disposal. Examples are lithium storage batteries, and capacitors or transformers filled with polychlorinated biphenyl (PCB) electrolyte. Follow manufacturer's instructions and any applicable government regulations.

4.8 FAULT CONDITIONS

Fault conditions can cause extensive damage to control equipment. Opening of a short circuit protective device (such as a fuse or circuit breaker) indicates a fault condition in excess of operating overload. Where evidence of a fault is found, before restoring power any damaged item(s) should be repaired or replaced. Refer to Part 302 of NEMA Standards Publication No. ICS 2[1] for further information.

4.9 FUNCTIONAL CHECK

4.9.1 Tests

After inspection, maintenance, or repair operations the equipment should be tested for proper functioning before it is returned to service. During such tests, personnel should be protected against hazards in the event of a malfunction.

4.9.2 Indications

A change in magnitude or frequency of vibration or noise indicates a need for attention; for example, a noisy AC magnet solenoid (see 5.4).

4.10 DOCUMENTATION

An entry should be made into the log each time preventive maintenance is performed. The entry should indicate the date maintenance was performed; observations; description of any repairs or modifications and reasons for them; and identity of person(s) who performed the maintenance.

[1]See *Section* 1, REFERENCED STANDARDS, for more information.

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Section 5

SPECIFIC GUIDELINES

Refer to individual product standards (NEMA Standards Publication Nos. ICS 2, ICS 3, ICS 4, and ICS 6)[1] for additional details.

5.1 ASSEMBLY/REASSEMBLY

If partial disassembly of a mechanism is necessary, the manufacturer's instructions should be followed for disassembly, reassembly, and any required adjustment or lubrication. Upon reassembly, the mechanism should be checked for freedom of motion and functional operation. Alignment should be checked by operating the mechanism (at a reduced speed if an operating means for this purpose has been supplied by the manufacturer).

5.2 TERMINALS AND CONNECTIONS

Loose electrical connections can cause overheating that can lead to equipment malfunction or failure. Loose bonding or grounding can compromise safety and/or function. Terminal screws, lugs, bus connections, bonding and grounding connections should be checked for tightness and retightened securely (to manufacturer's specifications) as required. Fuse clips should be checked for signs of overheating, looseness or inadequate spring pressure, and replaced if necessary. Any parts or wiring found to be damaged by overheating should be replaced, using parts supplied or recommended by the manufacturer. Evidence of overheating may include discolored conductors, terminals or parts; or melted, charred or burned insulation.

CAUTION: Do not remove plating on aluminum parts in joints or terminations.

5.3 CONDUCTORS

Examine insulation on conductors for overheating or chafing against metal edges that could progress into an insulation failure. Any damaged conductors should be replaced. Replacement conductors should be re-routed, braced or shielded if needed to avoid similar damage in future operation. Temporary wiring should be removed or replaced by permanent wiring.

5.4 CONTACTS AND ARC CHUTES

5.4.1 Inspection

Contacts and arc chutes of electromechanical contactors should be checked for excessive burning, beads of molten material, and unusual erosion of the contact faces. Do not file or dress contacts unless recommended by the manufacturer.

5.4.2 Servicing

Replace excessively worn or pitted contacts with manufacturer recommended renewal parts, or replace the contactor. All contacts of multi-pole devices should be replaced simultaneously to avoid misalignment and uneven contact pressure. Arc chutes and arc hoods should be replaced if they are broken or deeply eroded. Easily dislodged dust or granules should be removed by vacuuming, wiping or light brushing. Insulating surfaces should not be scraped, sandpapered or filed.

5.5 AC MAGNET SOLENOIDS

A noisy solenoid in a relay or contactor indicates failure to seat properly or a broken or loose shading coil. The cause should be determined and corrected to avoid overheating and coil damage. If a coil exhibits evidence of overheating (cracked, melted or burned insulation), it must be replaced, after the cause of overheating has been detected and corrected. This could include the AC magnet symptoms described above, or any binding that keeps the magnet from seating properly when energized, or overvoltage or undervoltage conditions. If melted coil insulation has flowed onto other parts, they should be cleaned or replaced.

[1] See Section 1, REFERENCED STANDARDS, for more information.

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5.6 SOLID-STATE DEVICES

5.6.1 Inspection

Solid-state devices require periodic visual inspection. Printed circuit boards should be inspected to determine that they are fully inserted into the edge board connectors. Board locking tabs should also be engaged. Unplugging and replugging of connectors to verify seating is not recommended as this will shorten the useful life of most types of connectors used with solid-state devices.

5.6.2 Cleaning

Dust or dirt, if found, should be cleaned from boards and components as recommended in 4.1.4. Solvents should not be used on printed circuit boards.

5.6.3 Servicing

Necessary replacements should be made only at the printed circuit board or plug-in component level unless otherwise recommended by the equipment manufacturer. Special care is needed to avoid damage when servicing equipment which contains electrostatic-sensitive components. Manufacturer's recommendations should be followed for removal, handling, packaging, shipping and/or replacement of such components or modules.

5.6.4 Testing

Use only test equipment and test instructions specified by the manufacturer of the solid-state equipment to avoid damage to the solid-state equipment or the test equipment, or unintended actuation of other equipment controlled by the solid-state equipment. Refer to NEMA Standards Publication No. ICS 1.1[1] for further information.

5.7 PROTECTIVE DEVICES

The rating and setting of protective devices for each particular application, such as fuses, circuit breakers, and overload relays, should be checked to verify that they are proper. Adjustment, repair or replacement should be performed as necessary, in accordance with any applicable instructions of the manufacturer. For replacement purposes, use only fuse types and ratings specified by the equipment manufacturer. Never attempt to defeat rejection mechanisms which are provided to guard against installation of the wrong type of fuses.

5.8 INDICATING DEVICES

All indicating lamps, mechanical flags, and similar auxiliaries should be checked and repaired or replaced if required.

5.9 LABELS AND NAMEPLATES

Labels and nameplates should be checked to verify that they are securely attached and legible. Clean or replace any that are damaged, loose, missing, or deteriorated to the extent that legibility is compromised.

[1]See Section 1, REFERENCED STANDARDS, for more information.

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NEMA STANDARDIZATION

The purpose of NEMA Standards, their classification and status are set forth in certain clauses of the NEMA *Standardization Policies and Procedures* manual and are referenced 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 their particular needs. 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.

(Standardization Policies and Procedures, p. 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.

(Standardization Policies and Procedures, p. 2)

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.

(Standardization Policies and Procedures, p. 8)

Categories of Standards

National Electrical Manufacturers Association Standards are of three classes:

1. NEMA Standard, which relates to a product, process or procedure 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.
3. Adoptive Standard, which is adopted in whole or in part from the standards of another organization, either domestic, regional, or international.

(Standardization Policies and Procedures, pp 7 & 16)

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, which standard has been approved by at least two-thirds of the members of the Subdivision eligible to vote on the standard.

(Standardization Policies and Procedures, pp. 7 & 16)

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, and which has been approved by at least 90 percent of the members of the Subdivision eligible to vote thereon. *(Standardization Policies and Procedures, pp 7 & 16)*

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.

July 17, 1990

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INDUSTRIAL CONTROL AND SYSTEMS SECTION OF THE NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION

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