NEMA STANDARDS PUBLICATION NO. ICS 8

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Industrial Control and Systems Crane and Hoist Controllers

NEMA

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

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NEMA Standards Publication No. ICS 8-1993

INDUSTRIAL CONTROL AND SYSTEMS
CRANE AND HOIST CONTROLLERS

Published by

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FOREWORD

This Standards Publication was prepared by a technical committee of the NEMA Industrial Control and Systems Section. It was approved in accordance with the bylaws of NEMA and supersedes the indicated NEMA Standards.

Replacement: Part ICS 3-441, DC Magnetic Controllers for Metal Mills, has been rescinded. Those parts of ICS3-1988 relating to Adjustable Speed Drives have been replaced by ICS 7-1993. The seven parts of ICS 8-1993 supersede the following remaining parts of ICS 3-1988:

Part 1 supersedes Part ICS 3-442

Parts 2–5 supersede Part ICS 3-443

Part 6 supersedes Part ICS 3-445

Part 7 supersedes Part ICS 3-446

In 1988, unrevised portions of all NEMA Standards Publications for Industrial Controls and Systems (the ICS series) were reaffirmed.

This Standards Publication provides practical information concerning ratings, construction, test, performance and manufacture of industrial control equipment. These standards are used by the electrical industry to provide guidelines for the manufacture and proper application of reliable products and equipment and to promote the benefits of repetitive manufacturing and widespread product availability.

NEMA Standards represent the result of many years of research, investigation and experience by the members of NEMA, its predecessors, its Sections and Committees. They have been developed through continuing consultation among manufacturers, users and national engineering societies and have resulted in improved serviceability of electrical products with economies to manufacturers and users.

One of the primary purposes of this Standards Publication is to encourage the production of reliable control equipment which, in itself, functions in accordance with these accepted standards. Some portions of these standards, such as electrical spacings and interrupting ratings, have a direct bearing on safety; almost all of the items in this publication, when applied properly, contribute to safety in one way or another.

Properly constructed industrial control equipment is, however, only one factor in minimizing the hazards which may be associated with the use of electricity. The reduction of hazard involves the joint efforts of the various equipment manufacturers, the system designer, the installer and the user. Information is provided herein to assist users and others in the proper selection of control equipment.

The industrial control manufacturer has limited or no control over the following factors which are vital to a safe installation:

a. Environmental conditions
b. System design
c. Equipment selection and application
d. Installation
e. Operating practices
f. Maintenance

This publication is not intended to instruct the user of control equipment with regard to these factors except insofar as suitable equipment to meet needs can be recognized in this publication and some application guidance is given.

This Standards Publication is necessarily confined to defining the construction requirements for industrial control equipment and to providing recommendations for proper selection for use under normal or certain specific conditions. Since any piece of industrial control equipment can be installed, operated and maintained in such a manner that hazardous conditions may result, conformance with this publication does not by itself assure a safe installation. When, however, equipment conforming with these standards is properly selected and is installed in accordance with the National Electrical Code and properly maintained, the hazards to persons and property will be reduced.

To continue to serve the best interests of users of Industrial Control and Systems equipment, the Industrial Control and Systems Section is actively cooperating with other standardization organizations in the development of simple and more universal metrology practices. In this publication, the U.S. cus-

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tomary units are gradually being supplemented by those of the modernized metric system known as the International Systems of Units (SI). This transition involves no changes in standard dimensions, tolerances, or performance specifications.

NEMA Standards Publications are subject to periodic review. They are revised frequently to reflect user input and to meet changing conditions and technical progress. Users should secure the latest editions. See the postal return card attached to the front cover of the Standards Publication for the proper procedure to obtain revision service for your copy of the publication.

Proposed revisions to this Standards Publication should be submitted:

Vice President, Engineering Department
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INTRODUCTION

The standards pertaining to crane and hoist controller in NEMA Standards Publication ICS 8 are subdivided into the following clauses:

1 General
  Referenced Standards
  Scope
  Normative Standards
  General Requirements
2 Definitions
  Terms which supplement the IEEE Standard Dictionary of Electrical and Electronics Terms (Std 100) or assist in clarifying the product standard.
3 Classification
  Product classifications where they have been established.
4 Characteristics and Ratings
  Descriptions of the kinds of ratings applicable to the product and tables of standard ratings for the product where they have been established.
5 Product Marking, Installation and Maintenance Information
  Product information to be provided to assist the user in the installation, use and maintenance of the devices.
6 Service and Storage Conditions
  A description of service and storage conditions for which the devices are intended.
7 Construction
  Marking, color coding and similar production requirements to be incorporated into the product as manufactured, as well as production test requirements where they have been established, i.e., the rules that the manufacturer follows in producing the product.
8 Performance Requirements and Tests
  The performance required to pass each design test specified for the product.

NEMA Standards Title
Publication No.

ICS 1-1993 Industrial Control and Systems
General Requirements

ICS 2-1993 Industrial Control and Systems
Controllers, Contactors, and Overload Relays, Rated Not More Than 2000 Volts AC or 750 Volts DC.

Part 1: *General Standards for Manual and Magnetic Controllers*
Part 2: *AC Noncombination Magnetic Motor Controllers, Rated 600 Volts*
Part 3: *Nonmagnetic Motor Controllers*

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Part 4: *Overload Relays*
Part 5: *DC General-Purpose Constant-Voltage Controllers*
Part 6: *AC Combination Motor Controllers*
Part 7: *Magnetic Lighting Contactors*

ICS 3-1993 Industrial Control and Systems
Factory-built Assemblies

Part 1: *Motor Control Centers Rated Not More Than 600 Volts AC*
Part 2: *Medium Voltage Controllers Rated 2001 to 7200 Volts AC*
Part 3: *AC General-Purpose Controllers for Synchronous Motors*

ICS 4-1993 Industrial Control and Systems
Terminal Blocks

ICS 5-1993 Industrial Control and Systems
Control Circuit and Pilot Devices

Part 1: *General Standards for Control Circuit and Pilot Devices*
Part 2: *Industrial Control Relays*
Part 3: *Industrial Control Input Devices Actuated by Force, Temperature and Pressure*
Part 4: *Proximity Switches*
Part 5: *Pushbuttons, Selector Switches, Indicating Lights and Pushbutton Stations*

ICS 6-1993 Industrial Control and Systems
Enclosures

ICS 7-1993 Industrial Control and Systems
Adjustable Speed Drives

Part 1: *General Standards for Drive Converters, Drives, and Drive Systems*
Part 2: *Loop Position and Tension Control Drive Systems*
Part 3: *Wind and Unwind Drive Systems*
Part 4: *Variable-Frequency, Three-Phase Controllers, Rated Not More Than 600 Volts*
Part 5: *Adjustable-Voltage Packaged-Drive Systems (Where DC Armature Power Is Obtained from AC Lines Using Controlled Semiconductor Rectifiers)*
Part 6: *Variable-Frequency Drive Systems Rated Not More Than 600 Volts Using Semiconductor Power Conversion*
Part 7: *Variable-Frequency. Three-Phase Drives, Rated 601 to 7,200 Volts*

ICS 8-1993 Industrial Control and Systems
Crane and Hoist Controllers

Part 1: *General Standards for Crane Controllers Rated 600 Volts or Less AC and DC*
Part 2: *Constant-Voltage DC Magnetic Controllers for Motors on Cranes*
Part 3: *Adjustable-Voltage DC Controllers for Motors on Cranes*
Part 4: *Magnetic Controllers for AC Wound-Rotor Motors on Cranes*
Part 5: *Static Controllers for AC Wound-Rotor Motors on Cranes*
Part 6: *Crane and Hoist Power-Circuit Limit Switches*
Part 7: *Heavy-Duty DC Magnetic Contactors Rated 600 Volts*

ICS 9-1993 Industrial Control and Systems
Power-Circuit Accessories

Part 1: *Electromagnetic Brakes*
Part 2: *Resistors and Rheostats*
Part 3: *Autotransformers and Reactors*

ICS 10-1993 Industrial Control and Systems
AC Transfer Switch Equipment

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Part 1
GENERAL STANDARDS FOR CRANE CONTROLLERS RATED 600 VOLTS OR LESS, AC AND DC

1 General

1.1 Referenced Standards

In this NEMA Standards Publication reference is made to the standards listed below. Copies are available from the indicated sources.

National Electrical Manufacturers Association
2101 L Street, NW
Washington, DC 20037

ICS 1-1993	*Industrial Control and Systems General Requirements*
ICS 1.3-1986 (R1991)	*Preventive Maintenance of Industrial Control and Systems Equipment*
ICS 5-1993	*Industrial Control and Systems Control Circuit and Pilot Devices*
ICS 6-1993	*Industrial Control and Systems Enclosures*

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

ANSI/ASME B30.2	*Overhead and Gantry Cranes*
ANSI/ASME B30.3	*Hammerhead Tower Cranes*
ANSI/ASME B30.4	*Portal, Tower and Pillar Cranes*
ANSI/IEEE 100-1992	*Standard Dictionary of Electrical and Electronics Terms*

Crane Manufacturers Association of America
8720 Red Oak Blvd. Suite 201
Charlotte, NC 28217

Publication No. 70	*Specifications for Electric Overhead Traveling Cranes*

National Fire Protection Association
Batterymarch Park
Quincy, MA 02269

NFPA 70	*National Electrical Code*

1.2 Scope

The standards in this section apply to controllers for crane service as applied to DC and wound-rotor AC motors, rated 600 volts or less. The types of cranes to which these standards are applicable are defined in the following American National Standards Institute Publications:

a. ANSI/ASME B30.2
b. ANSI/ASME B30.3
c. ANSI/ASME B30.4

1.3 Normative References

Crane Manufacturers Association of America (CMAA) Publication No. 70, defines the crane service classes referred to in this section.

The definitions and standards of ICS 1 apply to this section unless otherwise stated.

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2 Definitions

For the purposes of this section the following definitions apply.

(* indicates definition from ANSI/IEEE Standard 100.)

deadman's handle:* A handle of a controller for a master switch that is designed to cause the controller to assume a preassigned operating condition if the force of the operator's hand on the handle is released.

master switch:* A switch that dominates the operation of contactors, relays, or other remotely operated devices.

3 Classifications

3.1 General

The crane controller class (I or II) should be specified by the controller purchaser.

3.2 Class I Controllers

Class I crane controllers are intended for use with CMAA crane service Classes C, D, E, and F (except floor operated Class C cranes), all rated less than 31 horsepower.

3.3 Class II Controllers

Class II crane controllers are intended for use with CMAA crane services Classes A and B, plus floor-operated Class C cranes up to and including 30 horsepower.

4 Characteristics and Ratings

4.1 General Provisions for DC and AC Controllers

4.1.1 Controls

Each crane controller shall provide means for starting, stopping, speed control and reversing the motor.

4.1.2 Braking

Electric-braking means shall be provided for hoists which are not equipped with mechanical load brakes.

4.1.3 Protection

Undervoltage and overload protection shall be provided for each motor. The devices necessary to provide this protection shall be integral with the panels for the individual motions in accordance with the appropriate tables in Parts 2 through 5 unless grouped protection is specified. When grouped protection is specified, common undervoltage protection and individual motor running overload protection shall be grouped in accordance with the appropriate tables in Parts 2 through 5.

4.1.4 Controllers with Semiconductor Devices

Controllers employing semiconductor power devices shall be rated on a continuous duty with overload considerations. Extrapolations for intermittent duty are subject to analysis by the manufacturer with regard to ambient, enclosure, duty cycle, and ventilation.

4.2 Electrically-Operated Disconnecting Means

An electrically-operated disconnecting means for cranes shall be capable of operating in conjunction with a pilot device having contacts with a Contact Rating Designation "B" for AC or "P" for DC control, in accordance with ICS 5, Part 1.

4.3 Current Rating of the Disconnecting Means for Cranes

The disconnecting means for cranes shall have a continuous current- rating equal to or greater than the larger of:

a. Fifty percent of the combined intermittent-duty current ratings of all the motors on the crane, plus the rated current of auxiliary loads (other than crane motions) on the load side of the disconnecting means.

b. Seventy-five percent of the sum of intermittent-duty current ratings of all motors required for the crane motion having the largest horsepower plus the rated current of all auxiliary loads (other than crane motions) on the load side of the disconnecting means.

For systems with power conversion equipment on the crane, the motor current shall be considered as the input current to the power conversion equipment.

4.4 Maximum Control Voltage

The voltage at pendent or portable control stations for cranes shall not exceed 150 volts AC or 300 volts DC.

4.5 Power Circuit Resistor Ratings

Power circuit resistors shall be selected from Table 2-3-2 or 2-3-3 in ICS 9, Section 2. Resistors for CMAA Class D, E, or F cranes shall have a rating not less than Class 160, unless otherwise specified.

Where the application requires continuous duty, speed-regulating resistors shall be selected in accordance with note (c) of Table 2-3-4 in ICS 9, Section 2.

4.6 Electrically-Operated Brakes

Electrically-operated brakes should meet the applicable requirements of ANSI/ASME B30.2, B30.3, or B30.4, and ICS 9, Part 1.

4.7 Control Circuit Device Ratings

Ratings of control circuit contacts in pushbuttons, master switches, limit switches, and auxiliary contacts which operate directly in contactor operating coil circuits of crane controls shall be in accordance with ICS 5, Part 1. Special purpose devices shall be applied in accordance with their published ratings.

5 Product Marking, Installation and Maintenance Information

See NEMA Standards Publication ICS 1.3 for preventive maintenance instructions.

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6 Service and Storage Conditions

See ICS 1, Clause 6.

7 Construction

7.1 Disconnecting Means

Unless the installation is covered by the exception stated in Article 610 of NFPA 70 (NEC) a motor circuit switch or circuit breaker with provision for locking in the open position shall be provided in the leads from the runway contact conductors on all cranes. Where this disconnecting means is not readily accessible from the crane operating station, means shall be provided at the crane operating station to open the common power circuit to the crane motors.

Exception: Where a monorail hoist or hand-propelled crane bridge installation meets all the following, the disconnecting means shall be permitted to be omitted.

a. The unit is floor controlled.
b. The unit is within view of the power supply disconnecting means.
c. No fixed work platform has been provided for servicing the unit.

7.2 Branch Circuit Protection

The branch circuit protection required by Article 610 of NFPA 70 (NEC) may be achieved by devices on the controllers for each motion when specified, or by separately mounted devices.

7.3 Power-Circuit Resistors

All power-circuit resistors shall be provided with terminals and shall be mounted in substantial end frames.

7.4 Terminations for Power Cables

Incoming line leads shall terminate directly at the line side of the controller. Terminals shall be provided in the controller for load-side cables and they shall have the same wire range as the line side. See Table 7-7-1.

7.5 Operator Controls

7.5.1 Steps of Hand Control

Where the speed range is covered in steps, the master switch or control station shall provide for the following steps of control:

a. For all crane motions, a minimum of three hand-controlled speed points in each direction except that:
   1. For Class I cab-operated hoist controllers with three or more accelerating contactors, a minimum of five hand-controlled speed points in each direction shall be provided.
   2. For AC Class II controllers rated less than 8 horsepower, a minimum of two hand-controlled speed points in each direction shall be provided.
   3. For floor-operated bridge and trolley motions, a minimum of one hand-controlled point in each direction shall be provided.
b. Where specified, a drift point (no power, no brake) shall be included as a hand-controlled speed point in addition to the above minimum requirements for bridge and trolley motions.

7.5.2 Direction of Operation of Master Switch Levers

The direction of operation of master switch levers shall be as shown in Figure 1-7-1.

7.5.3 Suspended Pendent or Wired Portable Master Control Stations

Suspended control stations shall include the following devices in addition to those required for each crane motion:

a. A momentary-contact pushbutton or switch or a maintained-contact pushbutton arranged to open one side of the control circuit which feeds the motor control panels and the protective devices. This pushbutton shall be marked in red, POWER OFF.
b. A momentary-contact pushbutton arranged to reset the control circuit undervoltage protective device and labeled POWER ON.
c. A terminal for grounding exposed metal parts.

The hoist, bridge and trolley switches shall return to the OFF position when the operating handle, arm or button is released. This is a spring-return type of switch, commonly known as a "deadman's handle" control.

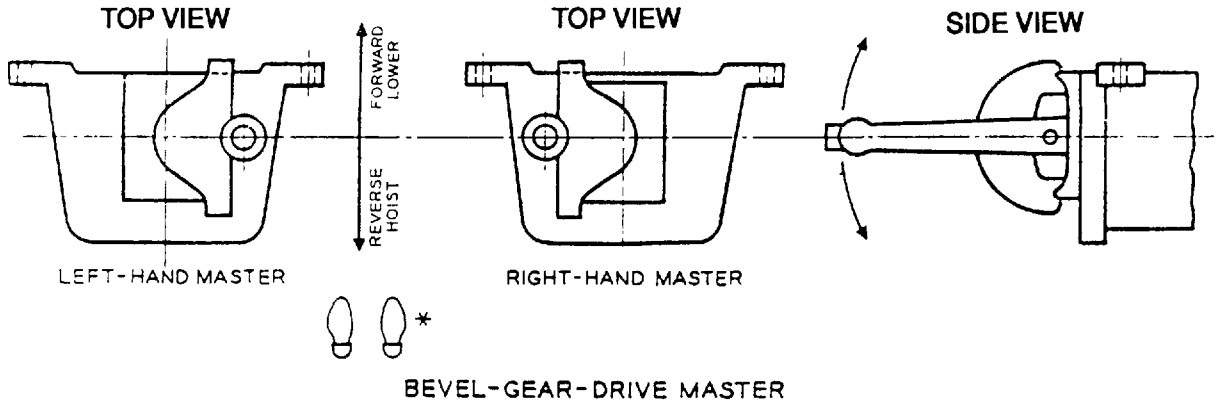
7.5.4 Direction of Controlled Motion

The direction of the motion which on the master switch station shall be indicated in accordance with ANSI B30.2.

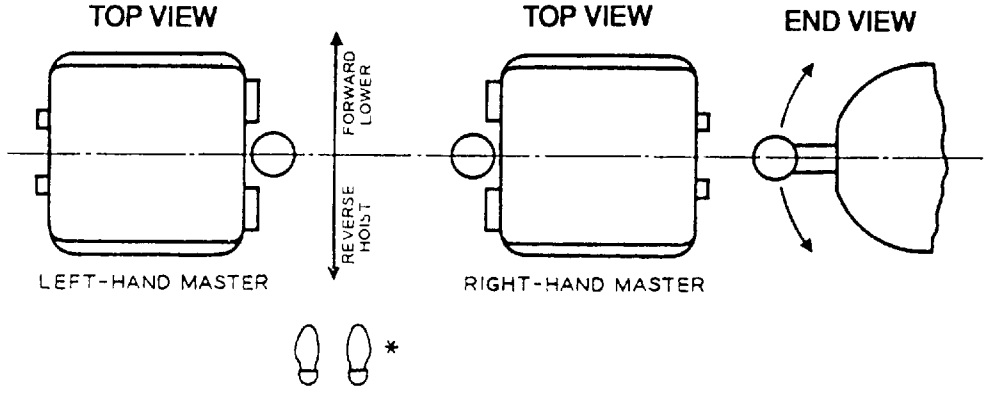
8 Performance and Tests

Applicable performance and test requirements appear in the parts of this publication that are product specific.

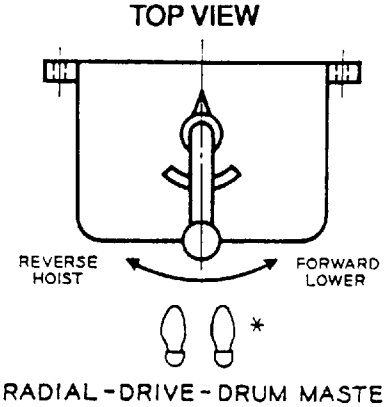
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BEVEL-GEAR-DRIVE MASTER



MILL-TYPE MASTER



RADIAL-DRIVE-DRUM MASTER

* Position of operator with respect to switch.
NOTE I—Levers operate in the direction of the arrows.
NOTE II—These sketches are illustrative only of the handle throw. Location of handle on the master switch may be different from that shown.

Figure 1-7-1
DIRECTION OF OPERATION OF MASTER SWITCH LEVERS

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9 Application

9.1 Pushbuttons

See ICS 5, Part 5.

9.2 Limit Switches

See ICS 5, Part 3.

9.3 Auxiliary Contacts

See ICS 5, Parts 2 and 3.

9.4 Master Switches

The make and break ratings and test values shown in ICS 5, Tables 1-4-1 and 1-4-2 shall not be used as application ratings where the total number of operations is expected to exceed by three to four times the number specified in the test conditions described in ICS 5, Part 1.

Where the load is an AC electromagnetically-operated mechanical device whose coil current may be interrupted occasionally before completion of its stroke, such as in jogging, the break current of the load shall be considered to be 50 percent of the make current of the load.

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Part 2
CONSTANT-VOLTAGE DC MAGNETIC CONTROLLERS FOR MOTORS ON CRANES

1 General

1.1 Scope

The standards in this part apply to constant-voltage DC controllers for DC motors used with cranes.

1.2 Normative References

The definitions and standards of NEMA Standards Publication ICS 1 and ICS 8, Part 1, and ICS 1.3-1991 apply to this part unless otherwise stated.

2 Definitions

There are no definitions unique to this section.

3 Classifications

See Parts 1 and 7.

4 Characteristics and Ratings

4.1 Controller Contactors

4.1.1 Contactor Interrupting Ability

Controller contactors shall have a load-current interrupting ability in accordance with Part 7.

4.1.2 Ratings of Line and Directional Contactors at 230 to 250 Volts.

The intermittent-duty horsepower and current ratings of contactors used in the power circuits of DC controllers at 230 to 250 volts shall be both:

a. In accordance with Table 2-4-1
b. Not less than the intermittent-duty horsepower and current ratings of the motors used for cranes.

4.1.3 Ratings of Line and Directional Contactors at Voltages Other Than 230 to 250 Volts

The ratings of line and directional contactors at 500 or 550 volts shall be in accordance with Table 2-4-2. A straight line interpolation shall be used for voltages between 250 and 500 volts.

4.1.4 Ratings of Accelerating, Plugging and Low-Torque Contactors

Accelerating, plugging and low-torque contactors up to and including Size 6 shall have the same rating as line or directional contactors. Contactors larger than Size 6 that do not carry all of the motor current shall be permitted to have a lesser rating than the line or directional contactors.

4.1.5 Ratings of Common-Line Contactors Used For Grouped Protection

The size of contactors used for grouped protection (responding to overload or undervoltage relays) shall be shown in Table 2-4-1 for 230 to 250 volts and in Table 4-2 for 500 to 550 volts. At voltages between 250 and 500 volts, a straight-line interpolation shall be used to determine the intermittent-duty rating of the power circuit contactors used for grouped protection. In no case shall the rating of contactors used for grouped protection be less than the rating of the largest contactor used on any of the protected controllers. The 8-hour open rating of the power circuit contactors used for grouped protection shall be not less than that which meets the more severe of the following requirements.

a. Fifty percent of the sum of the full-load currents of all of the intermittent-duty motors

Table 2-4-1
RATINGS AT 230 TO 250 VOLTS OF DC CONTACTORS FOR CONSTANT-VOLTAGE CONTROLLERS

Size Contactor	8-Hour Open Rating, Amperes	Maximum Intermittent-Duty Rating, Amperes	Ratings for Controller Maximum Horsepower	Ratings for Grouped Protection	
				Maximum Total Motor Horsepower	Maximum Horsepower for any Motion
1	25	30	7-1/2	10	7-1/2
2	50	67	15	22	15
3	100	133	35	55	35
4	150	200	55	80	55
5	300	400	110	160	110
6	600	800	225	320	225
7	900	1200	330	480	330
8	1350	1800	500	725	500
9	2500	3330	1000	---	---

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Table 2-4-2
RATINGS AT 500 OR 550 VOLTS OF DC CONTACTORS FOR CONSTANT-VOLTAGE CONTROLLERS

Size Contactor	Rating for Controller Maximum Horsepower	Ratings for Grouped Protection	
		Maximum Total Motor Horsepower	Maximum Horsepower for any Motion
1	10	15	10
2	25	35	25
3	55	80	55
4	80	120	80
5	165	140	165
6	330	480	330

b. Seventy-five percent of the full-load current of the intermittent-duty motor or motors required for the crane motion having the highest horsepower.

4.2 Rating of Controller Power-Circuit Disconnecting Means

Each controller power-circuit disconnecting means shall have a current rating not less than the 8-hour open ampere rating of the line contactor of the circuit which it isolates.

5 Product Marking, Installation and Maintenance Information

See NEMA Standards Publication No. ICS 1.3 for preventive maintenance instructions.

6 Service and Storage Conditions

Clause 6 of ICS 1 applies.

7 Construction

7.1 Quantity of Accelerating Contactors

The number of accelerating contactors per motion for magnetic controllers is exclusive of the plugging or low-torque contactor and shall be not less than that shown in Table 2-7-1.

7.2 Equipment Required

Magnetic controllers shall have the number of accelerating contactors specified in Table 2-7-1, the equipment listed in Table 2-7-2 and, if group protection is specified, the equipment listed in Table 2-7-3.

8 Performance and Test

There are no performance requirements or tests unique to this part.

9 Application

See Parts 1 and 7.

Table 2-7-1
NUMBER OF ACCELERATING CONTACTORS

Maximum Horsepower		Minimum Number of Accelerating Contactors per Motion for DC Controllers	
At 250 Volts	At 550 Volts	Class I Controller	Class II Controller
7-1/2	10	2	2
15	25	3	2
35	55	3	3
55	80	3	3
110	165	3	...
225	330	4	...
330	...	4	...
500	...	4	...
1000	...	4	...

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Table 2-7-2
MINIMUM EQUIPMENT FOR MAGNETIC CONTROLLERS FOR DC MOTORS

	Class I Controller		Class II Controller	
	Bridge or Trolley	Hoist	Bridge or Trolley	Hoist
1. Multipole power circuit isolating switch or circuit breaker with provision for locking in the open position for each motor or for each pair of motors in the case of duplex controllers *	X	X	X	X
2. Multipole control-circuit switch and fuses, circuit breaker, or fuse pullout *	X	X	X	X
3. Inverse-time trip overload protection in an ungrounded line for each motor *	X	X	X	X
4. Instantaneous trip overload protection in an ungrounded line for each motor circuit or in an ungrounded line for a pair of motors unless equivalent protection is provided in the power circuit isolating means *	X	X	X	X
5. Undervoltage relay to provide undervoltage protection for each motor *	X	X	X	X
6. Line (power circuit) contactor for each motor *†	X	X	...	...
7. Set of mechanically interlocked reversing contactors (four normally open poles per set) per motor†	X	...	X	...
8. Plugging contactor for each motor with means for automatically preventing its closing unless the motor is operating at approximately zero speed †	X	...	X	...
9. Set of accelerating contactors. See Table 2-7-1.†	X	X	X	X
a. Delay means for each step	X	...	...	...
b. Delay means for the last accelerating contactor	...	...	X	X
c. Delay means for at least two steps in the hoisting direction. For duplex hoists, delay means is common to both motors.	...	X	...	...
10. Low-torque contactor or means for slow-speed hoisting with light load	...	X	...	...
11. Set of switches to permit emergency operation of one or more motors on multimotor drives when required by the particular application	X	X	...	...
12. Set of devices to provide dynamic braking control in the lowering direction with or without line voltage and with the master switch in the OFF position ‡	...	X	...	X
13. Set of mechanically interlocked hoisting and lowering contactors	...	X	...	X
14. Brake relay when required by the particular application	X	X	X	X
15. Protection against motor shunt field loss	X	X	X	X

* These items may be omitted if panels are ordered for use with grouped protection and if grouped protection equipment is provided in accordance with Table 2-7-3.

† Where two motors are operated in parallel (duplex), each contactor may be a two-pole device.

‡ Not required when mechanical load braking is used.

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Table 2-7-3
MINIMUM EQUIPMENT FOR MAGNETIC CONTROLLERS PROVIDING GROUPED PROTECTION FOR AC MOTORS

	Class I Controller	Class II Controller
1. Multipole control-circuit isolating switch and fuses, circuit breaker, or fuse pull-out, common to all motions *	X	X
2. Inverse-time trip running overload protection in an ungrounded line for each motor *	X	X
3. Instantaneous trip overload protection in an ungrounded common line. The protection shall respond to the total current in the crane system, unless equivalent protection is provided by fuses or circuit breaker. *	X	X
4. Line (power circuit) contactor(s) to open both sides of the line to all motions, to provide undervoltage protection, to open the control supply to all motions, and to open the dynamic lowering loop of dynamic lowering controllers using series brakes *	X	...
5. Line (power circuit) contactor(s) to open an ungrounded line common to all motions, to provide undervoltage protection, to open the control supply to all motions, and to open the dynamic lowering loop of dynamic lowering controllers using series brakes *	...	X
6. On a cab-operated crane, a pushbutton station to provide three-wire control of the line (power circuit) contactor(s). The pushbutton for removing power shall be marked in red and labeled "Power Off." On a floor-operated crane, those pushbuttons required by Clause 7.5.3 of Part 1	X	X

* These devices shall be assembled on a separate panel or on the panel(s) for some crane motion(s) as specified.

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Part 3
ADJUSTABLE-VOLTAGE DC CONTROLLERS FOR MOTORS ON CRANES

1 General

1.1 Scope

The standards in this part apply to adjustable voltage controllers for DC motors used with cranes.

1.2 Normative References

The definitions and standards of ICS 1, ICS 1.3-1991, and ICS 8, Parts 1 and 7 apply to this part unless otherwise stated.

2 Definitions

There are no additional definitions unique to this part.

3 Classifications

See Parts 1 and 7.

4 Characteristics and Ratings

4.1 Controller Contactors

4.1.1 Contactor Interrupting Ability

Each contactor handling DC power shall be a NEMA Class B controller with load-current interrupting ability in accordance with Part 7 Clause 3. The contactor shall be selected so that the horsepower rating and the 8-hour or intermittent-duty current rating in Table 3-4-1 are not less than the current and time ratings of the associated motor.

4.1.2 Ratings of Loop or Line Contactors

The loop or line contactor shall have a continuous current rating not less than 75 percent of the full-load current used to determine the intermittent-duty rating of the motor(s). If installed ahead of the power conversion equipment, the intermittent current shall be equivalent to the input current.

5 Product Marking, Installation and Maintenance Information

See ICS 1.3 for preventive maintenance instructions.

6 Service and Storage Conditions

ICS 1, Clause 6 applies.

7 Construction

Equipment Required

DC adjustable-voltage controllers shall have the equipment listed in Table 3-7-1.

8 Performance and Test

There are no additional performance requirements or tests unique to this part.

9 Application

See Parts 1 and 7.

Table 3-4-1
RATINGS OF DC CONTACTORS FOR ADJUSTABLE-VOLTAGE CONTROLLERS

Size Contactor	8-Hour Open Rating, Amperes	Maximum Intermittent-Duty Rating, Amperes	Maximum Horsepower at 230 Volts*
1	25	30	7-1/2
2	50	67	15
3	100	133	35
4	150	200	55
5	300	400	110
6	600	800	225
7	900	1200	330
8	1350	1800	500
9	2500	3330	1000

* For other voltages, the horsepower is directly proportional to the voltage up to a maximum of 600 volts.

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Table 3-7-1
MINIMUM EQUIPMENT FOR CLASS I AND II ADJUSTABLE-VOLTAGE CONTROLLERS FOR DC MOTORS

	Bridge or Trolley	Hoist
1. Multipole main circuit isolating switch or circuit breaker with provisions for locking in the new position *	X	X
2. Control circuit fuse(s), switch and fuse(s), circuit breaker or fuse pullout *	X	X
3. Inverse-time trip running overload protection, one for each motor circuit or, when specified, an integral motor thermal sensing device	X	X
4. Instantaneous trip overload protection for each motor circuit or, in a common line, for a pair of motors	X	X
5. Undervoltage protection for each motor	X	X
6. If alternating-current to direct-current static conversion equipment is used, short-circuit protection	X	X
7. Set(s) of static reversing devices or mechanically interlocked reversing contactors	X	X
8. Adjustable means to provide a limit on acceleration or torque	X	X
9. Set(s) of devices to provide speed control in lowering overhauling loads	...	X
10. Protection against motor shunt field loss	X	X
11. If alternating-current to direct-current static conversion equipment is used, a direct-current loop contactor or a line contactor	X	X
12. If motor-generator equipment is used, a direct-current loop contactor or its equivalent	X	X
13. Set of switches to permit emergency operation of one or more motors on multi motor drives when required by the particular application	X	X
14. Brake relay when required by the particular application	X	X
15. Motor and/or generator shunt field discharge means when required	X	X

* This item may be common to all motors and may be assembled on a separate panel.

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Part 4
MAGNETIC CONTROLLERS FOR AC WOUND-ROTOR MOTORS ON CRANES

1 General

1.1 Scope

The standards in this part apply to controllers for AC wound-rotor motors used with electric powered cranes.

1.2 Normative References

The definitions and standards of ICS 1, ICS 1.3-1991, ICS 2, and ICS 8, Part 1 apply to this part unless otherwise stated.

2 Definitions

There are no definitions unique to this part.

3 Classifications

See Part 1.

4 Characteristics and Ratings

4.1 Controller Contactors

4.1.1 Contactor Interrupting Ability

Contactors which serve as magnetic controllers for AC wound-rotor motors shall have Class A load current interrupting ability. Class A controllers are AC air-break, vacuum-break and oil-immersed manual or magnetic controllers for service on 600 volts or less. They are capable of interrupting operating overloads but not short circuits or faults beyond operating overloads. See ICS 2 for standards applying to these controllers.

4.1.2 Ratings of Line and Directional Contactors

The horsepower and intermittent-duty current ratings of contactors used in the power circuits of AC controllers shall be not less than the corresponding ratings of the intermittent-duty motors used for cranes. Contactor current and horsepower ratings shall be as shown in Table 4-4-1.

4.1.3 Ratings of Line and Directional Contactors at Voltages Less Than 460 Volts

For voltages not listed in Table 4-4-1 but less than 460 volts, the intermittent-duty current rating of the contactors shall be in accordance with 4.1.2 and not less than the full-load current used to determine the intermittent rating of the motor.

4.1.4 Ratings of Accelerating, Plugging and Low-Torque Contactors

Accelerating, plugging and low-torque contactors shall have an intermittent-duty current rating not less than the full-load secondary current of the motor. When used for motor secondary control, the intermittent-duty ampere rating of a three-pole AC contactor, with its poles connected in delta, shall be 1.5 times the intermittent-duty current rating shown in Table 4-4-1.

4.1.5 Rating of Line Contactors Used for Grouped Protection

The size of contactors used for grouped protection (responding to overload or undervoltage relays) shall be shown in Table 4-4-1 but not less than the rating of the largest primary contactor used on any of the protected controllers.

Table 4-4-1
AC CONTACTOR RATINGS

Size Contactor	8-Hour Open Rating, Duty Rating, Amperes	Maximum Intermittent 460 and Amperes*	Rating for Controller Maximum Horsepower		Maximum Total Motor Horsepower		Maximum Horsepower for any Motion	
			230 Volts	460 and 575 Volts	230 Volts	460 and 575 Volts	230 Volts	460 and 575 Volts
0	20	20	3	5	6	6	3	5
1	30	30	7-1/2	10	10	20	7-1/2	10
2	50	67	20	40	30	60	20	40
3	100	133	40	80	63	125	40	80
4	150	200	63	125	110	225	63	125
5	300	400	150	300	225	450	150	300
6	600	800	300	600	450	900	300	600
7	900	1200	450	900	675	1350	450	900
8	1350	1800	600	1200	900	1800	600	1200

*The ultimate trip current of overload (overcurrent) relays or other motor protective devices used shall not exceed 115 percent of these values or 125 percent of the motor full-load current, whichever is smaller.

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4.2 Rating of Controller Power-Circuit Isolating Means

Each controller power-circuit isolating means shall have a current rating not less than the 8-hour open ampere rating of the line contactor of the circuit which it isolates.

5 Product Marking, Installation and Maintenance Information

See ICS 1.3 for preventive maintenance instructions.

6 Service and Storage Conditions

ICS 1, Clause 6 applies.

7 Construction

7.1 Quantity of Accelerating Contactors

The number of accelerating contactors per motion for AC magnetic controllers is exclusive of plugging or low-torque contactors and shall be no less than that shown in Table 4-7-1.

7.2 Equipment Required

Magnetic controllers shall have the number of accelerating contactors specified in Table 4-7-1, the equipment listed in Table 4-7-2 and, if grouped protection is specified, the equipment listed in Table 4-7-3.

8 Performance and Tests

There are no performance requirements or tests unique to this part.

9 Application

There are no application guidelines unique to this part.

Table 4-7-1
MINIMUM EQUIPMENT (ACCELERATING CONTACTORS) FOR AC MOTORS

Motor Horsepower	Minimum Number of Accelerating Contactors Per Motion for AC Hoist, Bridge and Trolley Controllers	
	Class I	Class II
Less than 8	2	1*
8 thru 15	2	2
16 thru 30	3	2*
31 thru 75	3	3
76 thru 125	4	3*
126 thru 200	4	- - -
greater than 200	5	- - -

*A 10 percent permanent slip resistance shall be provided on bridge and trolley drives.

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Table 4-7-2
MINIMUM EQUIPMENT FOR MAGNETIC CONTROLLERS FOR AC MOTORS

	Class I Controller		Class II Controller	
	Bridge or Trolley	Hoist	Bridge or Trolley	Hoist
1. Multipole power circuit isolating switch or circuit breaker with provision for locking in the open position*	X	X	X	X
2. Multipole control circuit switch and fuses, circuit breaker, or fuse pullout*	X	X	X	X
3. Inverse time trip running overload protection in each phase for each motor* or, when specified, an integral motor thermal sensing device	X	X	X	X
4. Undervoltage relay to provide undervoltage protection for each motor*	X	X	X	X
5. Set of mechanically and electrically interlocked reversing contactors to open all lines	X	X	X	X
6. Plugging contactor for each motor with means for automatically preventing its closing unless the motor is operating at approximately zero speed	X	...	X	...
7. Set of accelerating contactors in the motor secondary. See Table 4-7-1	X	X	X	X
a. Delay means for each accelerating contactor required by Table 4-7-1	X	X	...	...
b. Delay means for all but the first of the accelerating contactors required by Table 4-7-1, but not less than one	...	...	X	X
8. Low torque contactor or means for slow-speed hoisting with light load	...	X	...	...
9. Brake relay when required by the particular application	X	X	X	X
10. Set of devices to provide counter-torque or other forms of electrical braking when mechanical load braking is not provided	...	X	...	X

* These items may be omitted if panels are ordered for use with grouped protection and if grouped protection equipment is provided in accordance with Table 4-7-3.

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Table 4-7-3
MINIMUM EQUIPMENT FOR MAGNETIC CONTROLLERS PROVIDING GROUPED PROTECTION FOR AC MOTORS

	Class I Controller	Class II Controller
1. Multipole control-circuit isolating switch and fuses, circuit breaker, or fuse pullout,common to all motions *	X	X
2. Inverse-time running overload protection in each phase for each motor or, when specified, an integral motor thermal sensing device *	X	X
3. Line (power circuit) contactor(s) to open all power lines to all motions and to provide undervoltage protection *	X	X
4. On a cab-operated crane, a pushbutton station to provide three-wire control of the line (power circuit) contactor(s). The pushbutton for removing power shall be marked in red. On a floor-operated crane, those pushbuttons required by Clause 7.5.3 of Part 1.	X	X

* These devices shall be assembled on a separate panel, or the main hoist panel, or the panel for some other motion as specified.

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Part 5
STATIC CONTROLLERS FOR AC WOUND-ROTOR MOTORS ON CRANES

1 General

1.1 Scope

The standards in this part apply to static controllers for AC wound-rotor motors used with cranes.

1.2 Normative References

The definitions and standards of ICS 1, Part 1, ICS 1.3-1991, and some portions of Part 4 apply to this part unless otherwise specified.

2 Definitions

For the purposes of this section, the following definition applies.

static controller (converter): A controller that employs static rectifier devices such as semiconductor rectifiers or controlled rectifiers (thyristors), transistors or electron tubes to change AC power to DC power or vice-versa.

3 Classifications

See Part 1.

4 Characteristics and Ratings

4.1 Controller Contactors

4.1.1 Contactor Interrupting Ability

Contactors which serve as a magnetic disconnect means in AC static controllers shall have Class A load current interrupting ability. Class A controllers are AC air-break, vacuum-break and oil-immersed manual or magnetic controllers for service on 600 volts or less. They are capable of interrupting operating overloads but not short circuits or faults beyond operating overloads. See ICS 2 for standards applying to these controllers.

4.1.2 Ratings of Line and Directional Contactors

Contactor current and horsepower ratings shall be as shown in Table 4-4-1 except that the intermittent-duty rating of the contactor shall not be less than the line current when the drive is running at rated motor torque and the maximum speed provided at that torque.

4.1.3 Ratings of Line and Directional Contactors at Voltages Less Than 460 Volts

For voltages not listed in Table 4-4-1 but less than 460 volts, the intermittent-duty current rating of the contactors shall be in accordance with 4.1.2.

4.1.4 Ratings of Accelerating Contactors

Accelerating contactors shall have an intermittent-duty current rating not less than the secondary current of the motor when the drive is running at rated motor torque and maximum speed provided at that torque. When used for motor secondary control, the intermittent-duty ampere rating of a three-pole AC contactor, with its poles connected in delta, shall be 1.5 times the intermittent-duty current rating shown in Table 4-4-1.

4.2 Rating of Controller Power-Circuit Isolating Means

Each controller power-circuit isolating means shall have a current rating not less than the 8-hour open ampere rating of the line contactor of the circuit which it isolates.

5 Product Marking, Installation and Maintenance Information

See ICS 1.3 for preventive maintenance instructions.

6 Service and Storage Conditions

ICS 1, Clause 6 applies.

7 Construction

7.1 Equipment Required

Static crane controllers shall have the equipment listed in Table 5-7-1.

8 Performance and Tests

There are no additional performance requirements or tests unique to this part.

9 Application

There are no additional application guidelines unique to this part.

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Table 5-7-1
MINIMUM EQUIPMENT FOR CLASS I AND II STATIC CONTROLLERS FOR AC MOTORS

	Bridge or Trolley	Hoist
1. Multipole main circuit isolating switch or circuit breaker with provision for locking in the open position *	X	X
2. Multipole control circuit switch and fuses, circuit breaker, or fuse pullout *	X	X
3. Inverse time trip running overload protection in each phase for each motor or, when specified, an integral motor thermal sensing device *	X	X
4. Undervoltage protection *	X	X
5. Set of static reversing devices or mechanically interlocked reversing contactors	X	X
6. Adjustable means to provide a limit on acceleration or torque	X	X
7. Means for regulating motor speed hoisting and lowering	...	X
8. Brake relay when required by the particular application	X	X
9. Line contactor when primary static reversing is used	X	X

* These items may be omitted if panels are ordered for use with grouped protection and if grouped protection equipment is provided in accordance with Table 4-7-3.

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Part 6
CRANE AND HOIST POWER-CIRCUIT LIMIT SWITCHES

1 General

1.1 Scope

The standards in this part apply to limit switches used in the power-circuit of motors applied to cranes and hoists.

1.2 Normative References

The definitions and standards of ICS 1, ICS 1.3-1991, ICS 6 and some portions of ICS 5 apply to this part unless otherwise stated.

2 Definitions

For the purposes of this section, the definitions of ICS 5, Part 3 and the following definitions apply.

crane and hoist power-circuit limit switch: A snap-acting switch which interrupts motor current and, directly or indirectly, initiates braking action when the load block or other mechanism causes the switch to operate.

form C contacts: A contact arrangement which has single-pole double-throw contacts with three terminals; a normally open, a normally closed, and a common.

3 Classifications

3.1 Direction of Operation

Crane and hoist power-circuit limit switches shall be specified to be right-hand or left-hand operated as shown in Figure 6-3-1.

3.2 Reset Operating Means

A crane and hoist power-circuit limit switch is either suspended-weight operated or lever operated.

3.2.1 Suspended-Weight Type

A weight (reset weight), suspended by a cable from the operating lever of a switch. This weight overcomes the torque of the operating arm counterweight, thereby maintaining the power contacts in the normal position. When the load block or other portion of the hoist mechanism is raised to the point where the reset weight contacts the load block or other mechanism, the reset weight is also raised. This allows the counterweight on the switch operating lever to cause the contacts to change state. The switch resets automatically when the hoist mechanism is lowered allowing the reset weight to again be suspended.

3.2.2 Lever Type

A weighted or spring-biased operating lever maintains the power contacts in the normal position. When the load block or other traveling mechanism is moved beyond the point where it contacts the operating lever, the load block or other mechanism supplies the force to permit the contacts to change state. The switch resets automatically when the operating lever is allowed to return to its normal position.

4 Characteristics and Ratings

4.1 Current and Horsepower Ratings

Crane and hoist power-circuit limit switches shall be rated in accordance with Table 6-4-1.

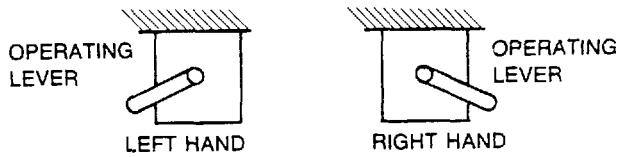
Table 6-4-1
CURRENT AND HORSEPOWER RATINGS OF CRANE AND HOIST POWER CIRCUIT LIMIT SWITCHES

NEMA Size	Continuous Current Rating		Direct Current Horsepower Rating*		Three Phase Alternating Current Horsepower Rating*		
	AC	DC	230-250 Volts	550-600 Volts	220-240 Volts	440-480 Volts	550-600 Volts
1	27	22½	5	5	7½	10	10
2	45	45	10	10	15	25	25
3	90	90	25	25	25	50	50
4	135	135	50	50	50	100	100
5	270	270	100	100	100	200	200
6	540	540	200	200	200	400	400
7	810	810	300	300	300	600	600
8	1215	1215	450	450	450	900	900

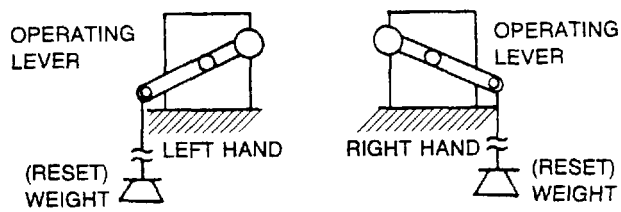
* Based on an intermittent rating at a 50% or less duty cycle with an ON time not to exceed 10 minutes. (See 9.8.)

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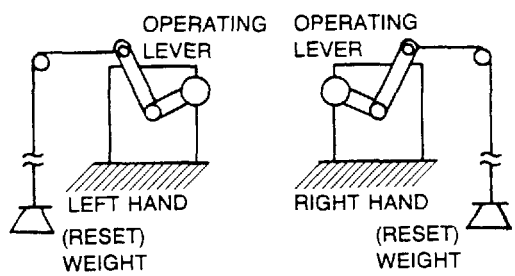
(LEVER OPERATED SWITCH)*



STRAIGHT OPERATING LEVER
(SUSPENDED WEIGHT SWITCH)*



90° OPERATING LEVER
(SUSPENDED WEIGHT SWITCH)*



* All switches shown in normal contact (running) position

Figure 6-3-1
MECHANICAL CONFIGURATIONS

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4.2 Voltage Ratings

Crane and hoist power-circuit limit switches shall be rated at 250 or 600 volts DC; 240, 480, or 600 volts AC, 50 or 60 hertz, or any combination of these ratings.

4.3 Auxiliary Contacts

Where crane and hoist power-circuit limit switches contain auxiliary control-circuit contacts, in addition to the power-circuit contacts, the ratings for these control-circuit contacts shall be in accordance with ICS 5, Part 1.

5 Product Marking, Installation and Maintenance Information

5.1 Marking

5.1.1 Device Marking

Each crane and hoist power-circuit limit switch shall be marked with the following data:

a. Rated voltage
b. Horsepower at rated voltage
c. Manufacturer's name or identifying mark
d. Device identification number
e. NEMA size
f. 3-phase AC, DC, or DC and 3-phase AC
g. Rated Frequency (AC only)

5.1.2 Terminal Markings

Each crane and hoist power-circuit limit switch shall have terminal markings as shown in Figure 6-5-1.

5.2 Maintenance

A maintenance program and schedule should be established to meet the needs of each particular installation and to assure minimum downtime. As an example the program should include:

a. Tightening connections
b. Inspecting for evidence of overheating
c. Removing dust and dirt
d. Confirming freedom of reset weight and cable movement
e. Replacing contacts when worn to a level which might impair the operation of the equipment

Also see ICS 1.3.

6 Service and Storage Conditions

ICS 1, Clause 6 applies.

7 Construction

Power-circuit limit switches shall be constructed so as to work properly with the reset weights and cable lengths specified in Table 6-8-3 and meet the performance requirements of Clause 8. ICS 1, Clause 7 also applies.

8 Performance and Tests

8.1 Performance Requirements

Power-circuit limit switches shall meet the applicable requirements of ANSI/ASME B30.2.

8.2 Tests

8.2.1 Design Test Concept

Design tests of crane and hoist power-circuit limit switches are performed on one or more representative new samples of apparatus to demonstrate the conformance of the product design with these standards. Design tests are not intended to be production tests.

8.2.2 Temperature Rise of Current Carrying Parts

Tests and temperature rise limits described in ICS 1, Clause 8 apply. AC tests shall be made at 60 hertz.

8.2.3 Make and Break Capacity

Crane and hoist power-circuit limit switches shall be capable of making and breaking current at the specified voltage and load conditions in accordance with Table 6-8-1. Verification tests for make and break capacities shall be in accordance with 8.2.4.

8.2.4 Make and Break (Operating Overload) Test

The purpose of the test for the making and breaking capacities is to verify that the switch is capable of making and breaking the operating overload currents stated in Table 6-8-1 and not intended to verify contact wear or erosion over long periods of operation.

8.2.4.1 Test Conditions

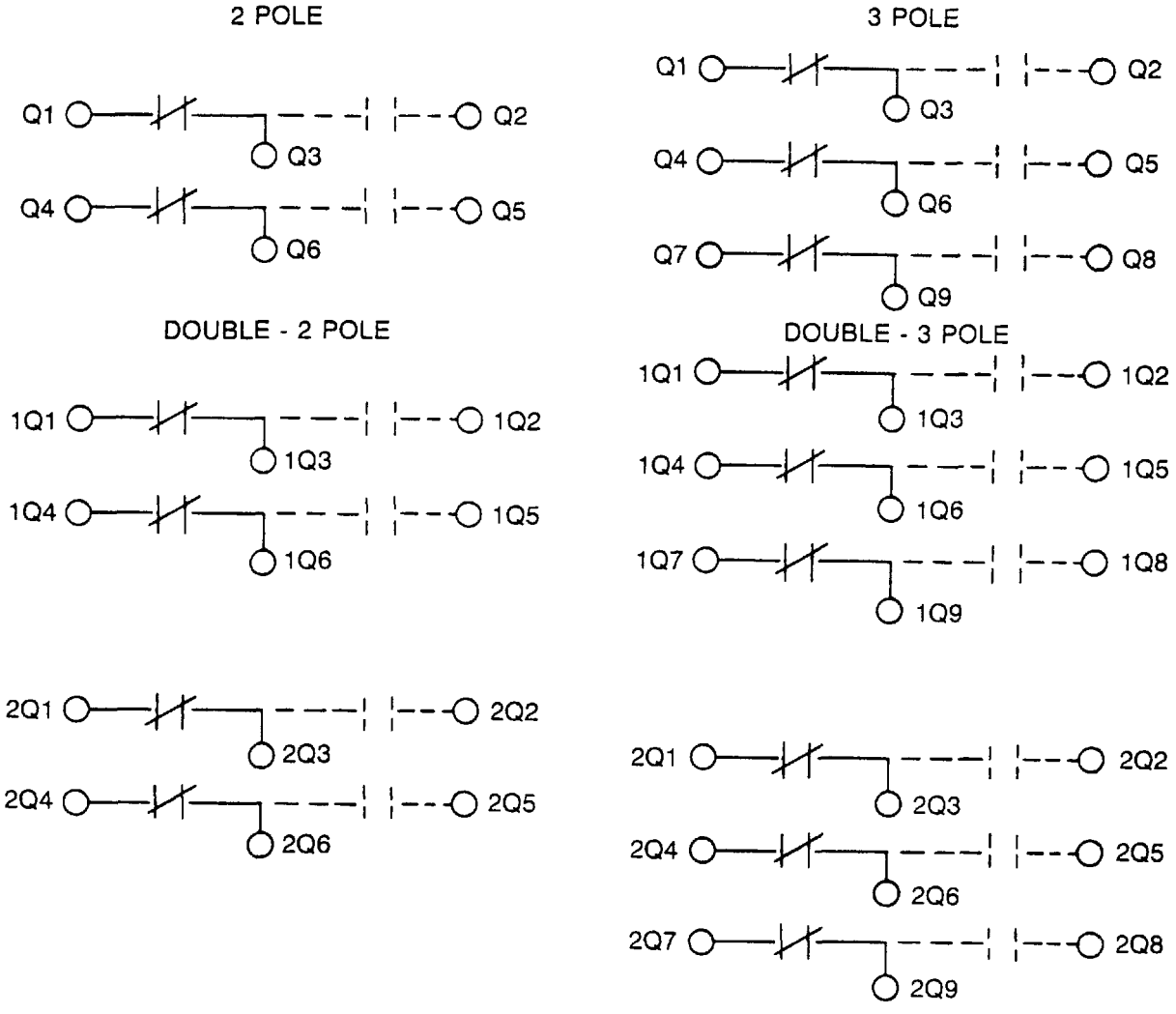
The switch shall be connected as shown in the test circuit, Figure 6-8-1. The switch shall be tested with its cover installed. The enclosure cover shall be removed after one-half of the total operations required for the test to exhaust the ionized gases. The cover is then replaced for the remainder of the test operations. The switch enclosure shall be connected as shown in Figure 6-8-1 to a 30-ampere nontime-delay cartridge fuse for the detection of fault current. The switch shall be exercised with the make time sufficiently long for the current to reach a steady state value but not less than 100 milliseconds. The current ON period shall be less than 5 seconds. The time for one make/break cycle shall not exceed 1 minute. This test shall be run with either a new or refurbished switch. AC tests shall be made at 60 hertz.

For switches equipped with Form C contacts, the test shall be conducted using normally-open contacts and then repeated using the normally closed contacts.

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LIMIT SWITCHES SHOWN IN NORMAL CONTACT (RUNNING) POSITION



DOTTED LINES INDICATE FORM C VERSIONS

Figure 6-5-1
TERMINAL MARKINGS

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Table 6-8-1
MAKE/BREAK (OPERATING OVERLOAD) TEST LEVELS

	Make and Break			
	I/Ie	V/Ve	Power Factor	L/R* (ms)
AC**	6	1.1	40% - 50%	...
DC	4	1.1	...	2.5

where: I = test current

V = test voltage (apply the provisions of UL 508-Section 42.8)

Ve = highest rated voltage (refer to 4.2)

$$\text{for AC} \quad \begin{cases} Ie = \text{continuous current for } Ve \leq 480 \\ Ie = \text{continuous current for } Ve > 480 \times \dfrac{480}{Ve} \end{cases}$$

$$\text{for DC} \quad \begin{cases} Ie = \text{continuous current for } Ve \leq 250 \\ Ie = \text{continuous current for } Ve > 250 \times \dfrac{250}{Ve} \end{cases}$$

*Tolerance ± 15%

**The tabulated values are expressed as rms steady-state values. The transient values may be different. However, the steady state values define the making and breaking capacity

8.2.4.2 Test Criteria

An AC switch shall successfully make and break for 20 operations the current specified in Table 6-8-1.

A DC switch shall successfully make and break the current specified in Table 6-8-1 ten operations with the enclosure fuse connected to the negative power pole, and then ten operations with the fuse connected to the positive power pole.

There shall be no permanent arcing, no flashover between poles, no opening of the fuse, and no welding of the contacts during the test. The switch shall successfully withstand dielectric testing as specified in 8.2.6 before and after the make and break test.

Where Form C contacts are employed, it is permissible to have an arcing overlap during switch operation. See 9.9.

8.2.5 Mechanical and Electrical Endurance Tests

The purpose of these tests is to verify the minimum mechanical and electrical endurance of a power-circuit limit switch. Such a switch functions to interrupt motor current and, thereby directly or indirectly, to limit the final travel of the load block or other traveling mechanism.

8.2.5.1 Endurance Test Conditions

These tests shall be run with either a new or refurbished switch.

8.2.5.1.1 Mechanical Test Conditions

A lever-operated switch shall be tested from its free position to at least 75 percent of its total overtravel. A suspended-weight limit switch shall be tested from stop to stop of the operating lever, with a maximum reset weight (as shown in Table 6-8-3) installed.

8.2.5.1.2 Electrical Test Conditions

The switch shall be tested with its cover removed to prevent a buildup of excessive amounts of ionized gas and shall be connected and exercised as in the make and break test. Actuation of the switch shall be as in the mechanical test. AC electrical tests shall be made at 60 hertz.

8.2.5.2 Test Criteria

8.2.5.2.1 Mechanical Test Criteria

The minimum mechanical endurance requirement for a power-circuit limit switch shall be 100,000 cycles.

8.2.5.2.2 Electrical Test Criteria

An AC switch shall successfully make and break the current specified in Table 6-8-1 6,000 times.

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Table 6-8-2
ELECTRICAL ENDURANCE TEST LEVELS

	Make and Break			
	I/Ie	V/Ve	Power Factor	L/R* (ms)
AC**	2.0	1	40% - 50%	...
DC	2.0	1	...	2

where: I = test current

V = test voltage (apply the provisions of UL 508-Section 42.8)

Ve = highest rated voltage (refer to 4.2)

$$\text{for AC} \quad \begin{cases} \text{Ie = continuous current for Ve} \leq 480 \\ \text{Ie = continuous current for Ve} > 480 \times \dfrac{480}{\text{Ve}} \end{cases}$$

$$\text{for DC} \quad \begin{cases} \text{Ie = continuous current for Ve} \leq 250 \\ \text{Ie = continuous current for Ve} > 250 \times \dfrac{250}{\text{Ve}} \end{cases}$$

*Tolerance ± 15%

**The tabulated values are expressed as rms steady-state values. The transient values may be different. However, the steady state values define the making and breaking capacity

A DC switch shall successfully make and break the current specified in Table 6-8-1 3,000 times, with the enclosure fuse connected to the negative power pole, immediately followed by 3,000 times with the enclosure fuse connected to the positive power pole.

There shall be no repairing or replacing of switch parts, including contact tips, for the duration of the test.

There shall be no permanent arching, no flashover between poles, no opening of the fuse, and no welding of contacts during the test. The switch shall successfully withstand dielectric testing before and after the endurance test as specified in 8.2.6.

8.2.6 Dielectric Test

Tests and limits described in ICS 1, Clause 8 apply. All tests shall be run at 60 hertz. Tests shall be run after exhausting the ionized gases, with the cover installed, both before and after the make and break test and the electrical endurance test.

9 Application

9.1 Intended Function

The function of a crane and hoist power-circuit limit switch is to interrupt motor current and, thereby directly or indirectly, limit the final travel of a load block or other mechanism. This type of switch is not intended to function as an operational limit switch that is actuated on each lift. It is customary to test-operate a power-circuit limit switch once every eight-hour shift to ensure its operating ability. See ANSI/ASME B30.2.

9.2 Cable Sheaves

The design of the reset-weight cable sheave(s) for crane and hoist power-circuit limit switches should be the subject of special analysis in each application. The use of multiple sheaves for reset weights is discouraged because of excessive mechanical losses. The cable sheave should be of a diameter at least as large as that recommended by the manufacturer of the power-circuit limit switch. The design and maintenance of the cable, sheave and guard system should ensure free running operation for the life of the limit switch. Particular attention should be paid to possible cable sag conditions.

Where it is necessary to use a sheaved system, the vector sum of the forces from the cable, sheave(s) and guard system (excluding the reset weight) tangent to the lever motion, should not exceed the weight of the maximum length of cable as shown in Table 6-8-3.

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Table 6-8-3
RESET WEIGHTS AND CABLE LENGTHS

NEMA Size	Type	Cable Size	Maximum Permissible Length*		User Supplied Reset Weight Minimum**		Maximum	
		inches	feet	meters	pounds	kilograms	pounds	kilograms
3	Single	1/4	15	4.6	35	15	50	25
4	Single	3/8	20	6.1	55	25	80	35
4	Double	3/8	30	9.2	100	45	150	70
5	Single	3/8	20	6.1	100	45	150	70
5	Double	3/8	30	9.2	135	60	200	90
6	Single	3/8	20	6.1	135	60	200	90
6	Double	3/8	40	12.2	235	110	350	160
7	Single	1/2	40	12.2	265	120	400	180
7	Double	1/2	50	15.2	500	230	750	340
8	Single	1/2	40	12.2	265	120	400	180
8	Double	1/2	50	15.2	500	230	750	340

*Lengths based: 1/4" – .11 lbs./foot
3/8" – .22 lbs./foot
1/2" – .42 lbs./foot

**Refer to 6-9.4

9.3 Cable Length

The length of the cable supporting the suspended reset weight should include adequate allowances for hook-block travel, after the actuation and trip of the crane and hoist power-circuit limit switch. Cables (of the size shown) should not exceed the maximum lengths shown in Table 6-8-3.

9.4 Reset Weights

Crane and hoist power-circuit limit switches should operate to the normal contact position when a weight is used that is equal to or exceeds the value of the minimum reset weight shown in Table 6-8-3. Specific switches may operate with less weight and may be furnished by the manufacturer with this lesser weight, providing the weight operates the specific switch to the normal contact position.

The reset weight should not exceed the values of the maximum reset weights shown in Table 6-8-3. The crane and hoist power-circuit limit switch manufacturer should be consulted when reset weights outside the limits shown in Table 6-8-3 are to be used.

9.5 Lever-Operated Switch Overtravel

Load blocks or other traveling mechanisms used to actuate lever- operated crane and hoist power-circuit limit switches should be applied so as to have them stop prior to reaching the overtravel limit position of the switch.

9.6 Frequency of Operation

When a crane and hoist power-circuit limit switch is not operated while under load at least once in any given 8-hour period, the switch should be provided with power contacts suitable for continuous operation in the closed position. The 8-hour period is the elapsed time that the contacts, while carrying current, are at thermal equilibrium.

9.7 Low Current DC Operation

Where it is anticipated that any pole of a DC crane and hoist power-circuit limit switch will be required to interrupt currents at very low levels compared to its rating, the manufacturer should be consulted.

9.8 Intermittent Rating Applications

For applications exceeding a 50 percent duty cycle, both the computed rms current and the rated horsepower at the applied voltage must be less than or equal to the continuous-current and horsepower ratings given in Table 6-4-1.

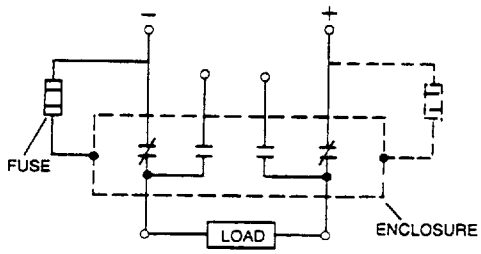
For ON times exceeding 10 minutes, either the motor current should be less than or equal to the continuous-current ratings given in Table 6-4-1 or the manufacturer should be consulted.

9.9 Reversing or Plugging

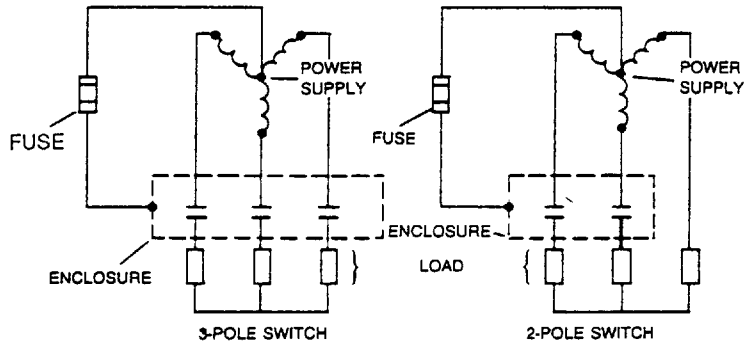
Crane and hoist power-circuit limit switches, employing Form C contacts, are not intended for direct reversing or plugging of motors because of the possibility of developing a short circuit though an arcing overlap between the normally-open and the normally-closed contacts. For reversing or plugging applications, consult the manufacturer.

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DC TEST CIRCUIT



AC TEST CIRCUIT

Figure 6-8-1
MAKE AND BREAK (OPERATING OVERLOAD) TEST CIRCUITS

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Part 7
HEAVY-DUTY DC MAGNETIC CONTACTORS RATED 600 VOLTS

1 General

1.1 Scope

The standards in this part apply to the contactor portion of Class B controllers and the crane and hoist controllers covered by other parts of this NEMA Standards Publication.

1.2 Normative References

The definitions and standards of ICS 1, ICS 1.3-1991, ICS 2, and ICS 5 apply to this part unless otherwise stated.

2 Definitions

For the purposes of this section, the following definitions apply.

eight-hour rating: Duty in which the main (power circuit) contacts of a contactor remain closed while carrying a steady current long enough to reach thermal equilibrium, but not for more than 8 hours without interruption.

The eight-hour duty rating is the basis for determining the rated thermal current of the apparatus. To interrupt means to break the current by operation of the contactor.

form C contacts: A contact arrangement which has single-pole double-throw contacts with three terminals; one for normally open, one for normally closed, and one common. The function of this arrangement is to transfer a circuit when actuated.

3 Classifications

Class B Controllers: Class B controllers are DC air-break manual or magnetic controllers for service on 600 volts or less. They are capable of interrupting DC operating overloads but not short circuits or faults beyond operating overloads. For standards applying to these controllers, see ICS 2.

4 Characteristics and Ratings

4.1 Contact Forms

4.1.1 Power-Circuit Contact Forms

DC contactors are single-pole or multipole devices designed to control DC. Poles have contacts that are normally open, normally closed or both.

4.1.2 Auxiliary Contact Forms

Auxiliary contacts, when provided, shall be rated in accordance with ICS 5, Part 1.

4.2 Voltage Ratings

The insulation voltage rating of Class B DC contactors shall be 600 volts. Utilization voltage ratings shall be 115, 230 and 550 volts.

4.3 Current Ratings of DC Contactors

The current ratings of DC contactors shall be in accordance with Table 7-4-1.

The intermittent-duty current ratings, open or enclosed, for DC contactors for crane and hoist duty, shall be as given in Table 3-4-1 of Part 3.

Table 7-4-1
CURRENT RATINGS OF DC CONTACTORS
(Ratings shown are on a per pole basis.)

Size of Contactor	8-Hour Rating-Amperes	
	Enclosed*	Open
1	22.5	25
2	45	50
3	90	100
4	135	150
5	270	300
6	540	600
7	810	900
8	1215	1350
9	2250	2500

* Contactor temperature rise shall be at least 10°C below those temperatures specified in Clause 8 of ICS 1 when tested in open air to the rated enclosed current. (See 9.2 for enclosed applications.)

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4.4 Horsepower Ratings of DC Contactors

The horsepower ratings of full-voltage magnetic DC contactors shall be in accordance with Table 7-4-2.

5 Product Marking, Installation and Maintenance Information

5.1 Device Marking

DC contactors shall be marked with the following minimum data:

a. Rated voltage with the designation DC
b. Rated current and basis of rating (e.g. open, 8-hour)
c. Manufacturer's name or identifying mark
d. Device identification number
e. NEMA size designation
f. Coil operating voltage

5.2 Maintenance

A maintenance program and schedule should be established to meet the needs of each particular installation. The program should include, for example, tightening connections, inspecting for evidence of overheating, removing dust and dirt, confirming freedom of reset weight and cable, and replacing contacts when worn or when the contact follow-up and pressure have been reduced to a level which might impair the operation of the device. Also see ICS 1.

6 Service and Storage Conditions

See ICS 1, Clause 6.

7 Construction

7.1 Mechanical Interlocking

Contactors shall be supplied with provision for the addition of mechanical interlocking to prevent simultaneous closing of two normally-open contactors.

7.2 Terminal Sizes

Service connections of DC contactors shall be capable of accepting conductor sizes in accordance with Table 7-7-1.

8 Performance and Test

8.1 Temperature Rise Tests

The temperature rise of the coils and current-carrying parts of contactors shall be measured simultaneously when tested in accordance with their ratings. The values shall not exceed those given in ICS 1, Clause 8.

8.2 General

The following tests shall be run on one contactor without refurbishing, and in the following order: dielectric, make and break (operating overload), electrical endurance and a repeat of the dielectric test.

A test voltage between 600 and 660 volts DC is acceptable for these tests, except that for a contactor rated more than 100 amperes, the open-circuit voltage shall be adjusted as much above 600 volts as the closed-circuit voltage is below that value, unless such adjustment results in the open-circuit voltage being more than 660 volts in which case the test may be conducted at whatever closed-circuit voltage is obtained when the open-circuit voltage is 660 volts.

8.3 Make and Break (Operating Overload) Design Test

The tests for making and breaking capacities are to verify that the contactor is capable of making and breaking the (operating overload) currents stated in Table 7-8-1 and not to verify the contactor's electrical and mechanical endurance. Tests shall be run both open and enclosed to also determine the minimum arcing clearances and minimum enclosure volume.

8.3.1 Test Conditions

The contactor shall be mounted on a panel with steel plates in front of and above the contactor at distances corresponding to the manufacturer's published minimum arcing clearances for the open test and mounted in its intended enclosure for the enclosed test. The contactor shall be connected as shown in the test circuit Figure 7-8-1. The contactor enclosure or plates shall be connected to a 30-ampere nontime-delay cartridge fuse for the detection of fault current. The contactor shall be exercised by energizing the operating coil with rated coil voltage with the make time sufficiently long for the operating overload current to reach a steady-state value, but not less than 100 milliseconds. The operating overload current flow period shall be less than 5 seconds. The time for one make/break cycle shall not exceed 1 minute.

All the poles of a multipole device shall be tested simultaneously.

Table 7-4-2
HORSEPOWER RATINGS OF FULL-VOLTAGE MAGNETIC DC CONTACTORS

Size of Controller, Volts	8-Hour Open Rating, Amperes	Horsepower at 115 Volts	Horsepower at 230 Volts
0	15	1	1
1	25	1-1/2	2

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Table 7-7-1
TERMINALS

Size of Controller	Minimum Range of Wire Sizes* For Wire Insulation Rated 60°C	For Wire Insulation Rated 75°C
00	14 AWG	14 AWG
0	14-10 AWG	14-10 AWG
1	14-8 AWG	14-8 AWG
1P	8-6 AWG	10-8 AWG
2	10-4 AWG	10-6 AWG
3	8-0 AWG	10-1 AWG
4		4-3/0 AWG
5		2/0 AWG-500 kcmil
6		Two 2/0 AWG-Two 500 kcmil
7		Three 2/0 AWG-Three 500 kcmil
8		Four 2/0 AWG-Four 500 kcmil
9**		

*For contactors Size 5 and larger, a combination of parallel conductors that provide ampacity equivalent to the wire sizes shown shall be permitted.
**Busbar or cable-connected, as specified between control manufacturer and user.

For contactors with Form C power contacts, tests shall be conducted using normally-open contacts and then repeated on the same device using normally-closed contacts.

8.3.2 Test Criteria

The contactor shall successfully make and break the current specified in Table 7-8-1 25 times in succession with power supply polarity as shown in Figure 7-8-1, immediately followed by 25 times with the power supply polarity reversed.

There shall be no permanent arcing, no flashover between poles, no opening of the fuse and no welding of the contacts during the test.

8.4 Short-Time Capabilities

8.4.1 Short-Time Operating Capability

Short-time operating capability of a contactor is the ability to withstand the thermal stresses due to starting and accelerating a motor to normal speed and those due to an operating overload.

8.4.2 Short-Time Surge Capability

Short-time surge capability of a contactor (with contacts closed) is the ability to withstand the thermal and mechanical stress due to current surges, such as might result from restoration of power to the load following a momentary loss of power.

The I^2t value (Joule Integral) calculated from the surge capability test should not be used to estimate the performance of the contactor under short-circuit conditions.

8.4.3 Short-time Capability Test

Separate tests shall be conducted to establish short-time operating capability and short-time surge capability. The test current shall be passed through the closed contacts for the specified period of time, and must be supplied at a voltage sufficient to maintain the current. At the end of the tests:

a. The motor controller must be capable of withstanding the dielectric tests described in ICS 1, Clause 8.
b. The contacts must be capable of being opened by normal operation.

In the tests covered in 8.4 a separate source of power may be supplied to the coil.

8.5 Mechanical and Electrical Endurance Tests

The purpose of these tests is to verify the minimum mechanical and electrical endurance of a DC magnetic contactor. Such a contactor functions to initiate and interrupt motor current and thereby directly or indirectly control the starting and stopping of various mechanisms. The endurance values specified do not represent the ultimate life of the contactor.

8.6 Mechanical Endurance Test

The mechanical endurance of DC contactors shall not be less than 3,000,000 no-load cycles when tested as specified below.

The mechanical endurance of DC contactors relates to specified environmental and application conditions. Hence the number of no-load cycles will be affected accordingly.

8.6.1 Test Conditions—Mechanical

The contactor shall be mounted in its intended mounting arrangement. The contactor shall be exercised by energizing the operating coil with rated coil voltage for a period of time sufficient to ensure complete sealing of the contac-

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Table 7-8-1
MAKE/BREAK (OPERATING OVERLOAD) TEST LEVELS

Test Parameters		
I/I_e	V/V_e	L/R*
4	1.1	7.5

*Tolerance ± 15%
Where:
I = Test Current
I_e=Rated Current (open) per Table 7-4-1
V = Test Voltage (See 8.2.)
Ve =600 Volts
L/R =Time Constant of the Load in Milliseconds

tor armature and removal of coil voltage for a period of time sufficient to enable a stabilized change of contactor state. The time for one close/open cycle shall not exceed 5 seconds. Maintenance shall be restricted to cleaning or lubricating without dismantling, and replacing contacts according to the manufacturer's recommendation.

8.6.2 Test Analysis—Mechanical

The following mechanical life tests are chosen on the basis of a 90 percent confidence level. Either of the following two test methods may be used:

a. Single 8 Test—Eight contactors are tested up to the assigned mechanical endurance. If the number of failures does not exceed two, the test is considered passed.
b. Double 3 Test—Three contactors are tested up to the assigned mechanical endurance. The test is considered passed if there is no failure, and failed if there is more than one failure. Should there be one failure, then three additional contactors are tested up to the assigned mechanical endurance. Providing there is no additional failure, the test is considered passed. The test is failed if, at any time, there is a total of two or more failures.

8.6.3 Test Criteria—Mechanical

The contactor shall successfully complete the no-load cycles specified before it is necessary to replace parts affecting proper contactor operation, other than contacts.

8.7 Electrical Endurance Test

The electrical endurance of DC contactors shall not be less than the on-load cycles indicated in Table 7-8-2 when tested as specified below.

The electrical endurance of DC contactors relates to specific application conditions. Hence the number of on-load cycles will be affected accordingly.

8.7.1 Test Conditions—Electrical

The contactor shall be mounted in its intended mounting arrangement in the open. The contactor shall be exercised by energizing the coil with rated coil voltage with the make time sufficiently long for the load current to reach a steady-state value, but not less than 100 milliseconds. The load current on period shall be less than 2 seconds. The test cycle shall be repeated every 10 seconds.

8.7.2 Test Criteria—Electrical

The contactor shall successfully meet load and endurance criteria specified in Table 7-8-2 before repairing or replacing contactor parts affecting proper contactor operation, including contacts.

8.8 Operating Voltage Test

8.8.1 Overvoltage

A DC contactor operating coil shall withstand 110 percent of its rated voltage until thermal equilibrium is established, in an ambient of 40°C, without apparent damage. The temperature rise at 110 percent of rated voltage may exceed that specified in ICS 1, Table 8-2.

8.8.2 Undervoltage

The contactor shall close successfully at 80 percent of its rated operating coil voltage after reaching a stabilized temperature at 100 percent of its rated operating coil voltage in an ambient temperature of 40°C. When tested at a lower ambient temperature, external resistance shall be added to the operating coil circuit to simulate the above condition.

9 Application

9.1 Application Guide

The following load characteristics should be considered when selecting contactors:

a. Maximum circuit-closing inrush current and duration
b. Maximum circuit interrupting current, voltage, and inductance
c. Frequency of operation and duration of ON time
d. Rms current for periodic loads (see ICS 1, Clause 8)

Because of the endless variety of application conditions in terms of electrical loads, duty cycles, voltage fluctuations, mechanical vibration, environmental conditions, etc., contact life will vary. Manufacturer's recommendations should be obtained regarding specific applications.

Where it is anticipated that a contactor will be required to interrupt currents at 10 percent or less of its open current rating, the manufacturer should be consulted.

Where a contactor operates under load for more than eight hours without opening the power circuit contacts, the

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Table 7-8-2
ELECTRICAL ENDURANCE

Test Parameters			
I/I_e	V/V_e	L/R*	Number of On-Load Cycles
2.5	1	3.5	6,000

*Tolerance ± 15%
Where:
I_e = Rated Current (open) per Table 7-4-1
V_e = 600 Volts

I =Test Current
V=Test Voltage (See 8-2)
L/R=Time Constant of the Load in Milliseconds

contactor should be provided with power-circuit contacts suitable for continuous operation in the closed position.

9.2 Application of Enclosed Contactors

DC contactors may be used at their enclosed ratings in enclosed locations where the interior temperature rise does not exceed 10°C above a maximum outside ambient of 40°C.

For interior temperature rises exceeding 10°C or external ambients exceeding 40°C, the manufacturer should be consulted regarding ratings, clearances, and ventilation.

9.3 Arc Clearance Test Data

Minimum arcing clearances and minimum enclosure volume determined by the make and break (operating overload) design test (8.3) shall be provided to the user when required.

The manufacturer should be consulted for reduced minimum arc clearances and minimum enclosure volume when the contactor is operated at lower than rated voltage or in multiple-break circuits.

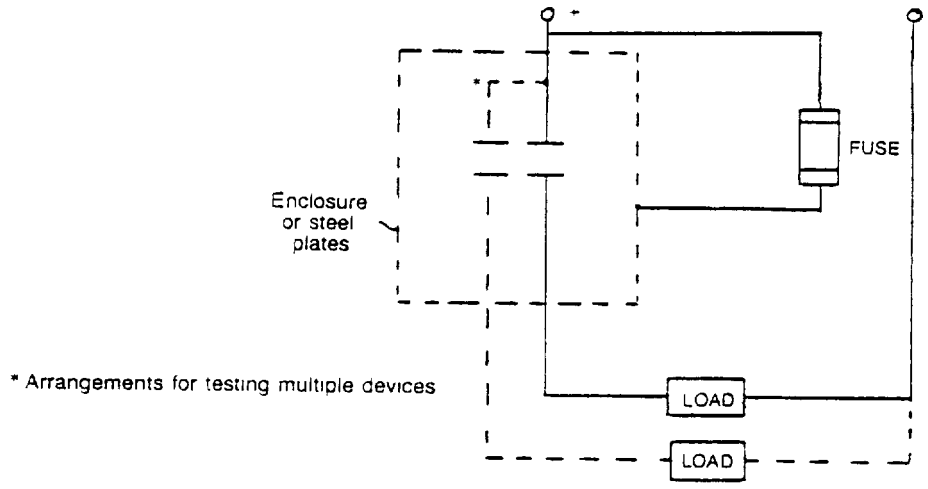


Figure 7-8-1
MAKE AND BREAK (OPERATING OVERLOAD) TEST CIRCUITS

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Supplement 1
SCOPE OF THE INDUSTRIAL CONTROL AND SYSTEMS SECTION

The NEMA Standards Publications for Industrial Control and Systems cover the requirements for all industrial control apparatus except as modified below. These standards cover all devices, whether electric, magnetic, mechanical, or electronic (except those devices intended specifically for marine auxiliaries and propulsion control apparatus, mine locomotive control apparatus, and railway and railroad locomotion) which, individually or grouped, serve to govern in some predetermined manner the electric power delivered to the apparatus to which they are connected, and which are intended to function on commercial voltages of 750 volts or less, direct current and 7200 volts or less, alternating current.

Industrial Control and Systems Section equipment comprises, but is not limited to, mechanical, electromechanical and solid state devices, components, and controls.

The equipment is principally used in industrial applications for the control, or regulation, or both, of power utilization apparatus, including motors. Such equipment is rated not more than 750 volts DC or 7,200 volts AC.

These devices, components, and controls may be arranged to include one or more feedback loops. Functional elements in such arrangements include, sensors, programmable controllers, operational amplifiers, encoders, tape readers, gauging equipment and computer elements. Computer elements for the readout, logging, processing, and programming input and monitoring output of data may or may not be in the feedback loop. Devices, components and controls so arranged are used in functions such as:

a. Computer control of machines
b. Industrial process regulation
c. Integrated mill control
d. Energy management
e. Emergency and standby power control
f. Control of the cogeneration of electric power

The Industrial Control and Systems Section scope specifically includes, but is not limited to, products principally used to:

a. Start, stop, protect, accelerate, decelerate, reverse, or control the speed of electric motors
b. Automatically disconnect, connect, or transfer all classes of loads fed by primary or alternate power sources
c. Provide some mechanical movement through the action of magnets or solenoids
d. Start, stop and control AC or DC adjustable speed drives, whether unregulated, regulated automatically regulated, including semiconductor power converters and invertors for adjustable speed drives, and providing such functions as: regulating speed, tension, current, frequency and voltage
e. Start, stop and control the function and operation of machine tools, including feedback control and speed, position and torque
f. Start, stop and control the operation of automatic warehouses, including control of conveyors, stackers, and the like
g. Start, stop and control the operation of cranes and hoists
h. Start, stop and control the operation of AC motors applied to fans, pumps, and blowers, including provision for feedback control of speed by sensors such as for temperature, flow, and pressure
i. Control the management of energy under normal and emergency conditions including peak load shaving
j. Control generator equipment used in dispersed power generation systems for cogeneration, emergency, or stand-by electric power

Also included, but not limited to, are:

a. Motor controllers
b. Motor control centers
c. Medium-voltage controllers
d. Programs and related documentation making up the software that is furnished with programmable devices for industrial control and systems equipment
e. Register and synchronizing controls
f. Digital display devices
g. Analog-digital convertors and transducers
h. Programmable controllers
i. Functional elements of systems, such as:
    1. Operational amplifiers
    2. Computer elements
    3. Encoders

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4. Tape readers
5. Sensors
6. Man-machine interface devices
7. Gaging equipment

j. Renewal parts for Industrial Control and System products

Examples of Industrial Control and System products are:

a. Manual, magnetic and solid-state (static) starters and controllers
b. Relays and contactors
c. Automatic transfer switches and controllers, and associated by-pass isolation switches
d. Drum switches
e. Overload devices intended primarily for the starting and running protection of electric motors, including inherent overload protective devices
f. Rheostats and resistors
g. Autotransformers and reactors of the type principally used in reduced-voltage starters
h. Control-circuit and pilot devices including, but not limited to, timers, pushbuttons, indicating (pilot) lights, solenoids, photoelectric relays, and plugging switches, speed switches, domestic water pump pressure switches
i. Limit, pressure, vacuum, temperature and liquid-level switches
j. AC and DC brakes, clutches, and electrical operators
k. Resistance dimmers, autotransformer dimmers, reactor dimmers, and solid-state (static) dimmer systems
l. Solid-state logic devices
m. Control panels for machine tool and similar machines
n. Terminal blocks of the molded barrier or sectional type and terminal strips used for the connection of conductors, electrical and electronic circuits and equipment. These include, but are not limited to, terminal blocks using, wire binding screws, pressure wire connectors, stud and nut, quick connect, solder lug, and solderless wrapped terminations, and terminal blocks which incorporate fuse holders, test/disconnect features, indicator lamps, diodes, etc.
o. Automatically regulated adjustable speed drive systems such as: rolling mill drives, paper mill drives, slasher drives
p. Programmable controllers and their accessories devices used for the supervision, or control or command of industrial machines and processes

Exclusions:

Excluded from the product scope are:

a. Specific components and systems covered by the product scopes of other NEMA sections
b. Automatic and manual temperature and humidity controls and panels that are in the scope of the Residential Controls Section of the types principally used in air conditioning, refrigeration, and comfort heating of nonindustrial areas
c. Motors, generators and motor-generators, which function as control when constituting part of adjustable speed drives

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NEMA STANDARDIZATION BACKGROUND

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.

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, dimensions, tolerances, safety, operating characteristics, performance, rating, testing, and the service for which they are designed.

(Standardization Policies and Procedures, p. 1)

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. 6)

Categories of Standards

National Electrical Manufacturers Association Standards are of three classes, which have received the affirmative vote of at least two-thirds of the Subdivision votes cast in the affirmative or negative:

1. NEMA Standard, which relates to a product, process, or procedure commercially standardized and subject to repetitive manufacture.
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.
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. 5)

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 received the affirmative vote of at least two-thirds of the Subdivision votes cast in the affirmative or negative.

(Standardization Policies and Procedures, pp. 5)

Identification of Status

Standards in NEMA Standards Publications are identified as "NEMA Standard," "Suggested Standard for Future Design," or "Adoptive Standard." These indicate the status of the standard. A statement incorporating the auxiliary verb "shall" indicates that compliance with a requirement is mandatory for compliance with the standard. These classes of standards are identified in the foreword or throughout the text.

The material identified as "Authorized Engineering Information" is designated similarly. Statements incorporating other auxiliary verbs such as "should," "may," etc. refer to the authorized engineering information and not to procedures required for compliance with the standard.

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INDUSTRIAL CONTROL AND SYSTEMS SECTION
OF THE
NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION

ABB Control, Inc.
Wichita Falls, TX 76306

AEG Automation
Systems Corporation
Pittsburgh, PA 15238-0830

Allen-Bradley Company
Milwaukee, WI 53204

Amerace Electronic Components
Punta Gorda, FL 33950

Automatic Switch Company
Florham Park, NJ 07932

Balluff, Inc.
Florence, KY 41042

USD Products
Bussman, Div. of Cooper Ind.
Chicago, IL 60656

CEGELEC Automation Inc.
Macon, GA 31206

Challenger Electrical Equipment Corp.
Raleigh, NC 27609

Eaton Corporation
Cutler Hammer Products
Milwaukee, WI 53216

Electrical Power Systems Inc.
Tulsa, OK 74131

Electro Switch Corporation
Weymouth, MA 02189-2103

Elliott Control Company
Hollister, CA 95024-1329

Emerson Electric Company
Grand Island, NY 14072

Entrelec, Inc.
Irving, TX 75038-4312

Firetrol, Inc.
Cary, NC 27512

Furnas Electric Company
Batavia, IL 60510

GE
Plainville, CT 06062

General Equipment & Manufacturing
Company, Inc.
Louisville, KY 40213

Gettys Corporation
Racine, WI 53404

Giddings & Lewis, Inc.
Fond du Lac, WI 54936-1658

Halmar Robicon Group
Pittsburgh, PA 15239-2982

Harnischfeger Corporation
Milwaukee, WI 53215-1707

Honeywell, Inc.
Ft. Washington, PA 19034

Hubbell Incorporated
Madison, OH 44057

Joslyn Clark Controls, Inc.
Lancaster, SC 29720

Killark-Stahl, Inc.
St. Louis, MO 63115

Klockner Moeller Corporation
Franklin, MA 02038

Lexington Switch & Controls
Madison, OH 44057

Master Controls Systems, Inc.
Lake Bluff, IL 60044

Metron, Inc.
Denver, CO 80223

Micro Switch (Div. of Honeywell)
Freeport, IL 61032

Modicon Inc.
No. Andover, MA 01845

NAMCO Controls
An Acme Cleveland Corporation
Mentor, OH 44060

Omron Electronics, Inc.
Schaumburg, IL 60173

Onan Corporation
Minneapolis, MN 55432

OZ Gedney
Unit of General
Signal Corporation
Brooklyn, NY 11208

Pepperl + Fuchs, Inc.
Twinsburg, OH 44087

Phoenix Contact, Inc.
Harrisburg, PA 17111

Reliance Electric Company
Cleveland, OH 44117

Russelectric, Inc.
Hingham, MA 02043

Siemens Energy & Automation,Inc.
Alpharetta, GA 30201

Siemens Industrial Automation, Inc.
Johnson City, TN 37601

Square D Company
Palatine, IL 60067

R. Stahl, Inc.
Woburn, MA 01801

Texas Instruments, Inc.
Attleboro, MA 02703

Toshiba International Corporation
Houston, TX 77041

Turck, Inc.
Minneapolis, MC 55441-2656

Weidmuller Inc.
Richmond, VA 23236

Westinghouse Electric Corporation
Pittsburgh, PA 15220

Zenith Controls, Incorporated
Chicago, Il 60609

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