NEMA ICS 8

INDUSTRIAL CONTROL AND SYSTEMS CRANE AND HOIST CONTROLLERS

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NEMA Standards Publication ICS 8-2000

INDUSTRIAL CONTROL AND SYSTEMS
CRANE AND HOIST CONTROLLERS

Published by

National Electrical Manufacturers Association
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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 10 supersedes ICS 9 Part 1
Part 11 supersedes ICS 9 Part 2

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 its 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 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. customary 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.

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This Standards Publication was developed by the Industrial Automation Control Products and Systems Section. Section approval of the standard does not necessarily imply that all section members voted for its approval or participated in its development. At the time it was approved, the Section was composed of the following members:

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ABB Control, Inc.—Wichita Falls, TX
Allen-Bradley Co./Rockwell Automation—Milwaukee, WI
Alstom Drives and Controls—Pittsburgh, PA
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Automatic Switch Company—Florham Park, NJ
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Carlos Gavazzi, Inc.—Buffalo Grove, IL
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Bussmann Division - Cooper Industries—Ellisville, MO
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Killark Electric Mfg. Company—St. Louis, MO
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Master Control Systems, Inc.—Lake Bluff, IL
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R. Stahl, Inc.—Salem, NH
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Reliance Electric Co/Rockwell Automation—Euclid, OH
Renco Encoders, Inc.—Goleta, CA
Robert Bosch Corporation—Avon, CT
Rockwell Automation—Milwaukee, WI
Russelectric, Inc.—Hingham, MA
Siemens Energy & Automation, Inc.—Alpharetta, GA
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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

a. Referenced Standards
b. Scope
c. Normative Standards
d. 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.

Publication No.	**NEMA Standards Title**
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: Standards for Manual and Magnetic Controllers
	Part 2: Noncombination Magnetic Motor Controllers, Rated 600 Volts
	Part 3: Nonmagnetic Motor Controllers
	Part 4: Overload Relays
	Part 5: DC General-Purpose Constant-Voltage Controllers
	Part 6: AC Combination Motor Controllers
	Part 7: Magnetic Lighting Contactors
	Part 8: Disconnect Devices for Use in Industrial Control Equipment

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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
Part 8: AC Adjustable Frequency Controllers for Motors and Cranes
Part 9: Wireless Control Systems for Cranes
Part 10: Electromagnetic Brakes
Part 11: Resistors and Rheostats

ICS 10-1993 *Industrial Control and Systems AC Transfer Switch Equipment: Part 1*

ICS 10-1999 *Industrial Control and Systems AC Transfer Switch Equipment: Part 2 – Static AC Transfer Equipment*

ICS 12.1-1997 *Profiles of Networked Industrial Devices – Part 1: General Rules*

ICS 14-1998 *NEMA Application Guide for Electric Fire Pump Controllers*

ICS 15-1999 *Instructions for the Handling, Installation, Operation, and Maintenance of Electric Fire Pump Controllers Rated Not More Than 600V*

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Part 1

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

Section 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
1300 N. 17th Street, Suite 1847
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ICS 1-1993	*Industrial Control and Systems General Requirements*
ICS 1.3-1996	*Preventive Maintenance of Industrial Control and Systems Equipment*
ICS 2-1993	*Industrial Control and Systems Controllers, Contactors, and Overload Relays, Rated not More Than 2000 Volts AC or 750 Volts DC*
ICS 5-1993	*Industrial Control and Systems Control Circuit and Pilot Devices*
ICS 6-1993	*Industrial Control and Systems Enclosures*
ICS 7-1993	*Industrial Control and Systems Adjustable Speed Drives*
MG 1-1998	*Motors and Generators*

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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 100-1996	*Standard Dictionary of Electrical and Electronics*
AISE 1-1968	*DC Mill Motor Standard*
AISE 1A-1964	*AC Mill Motor Standard*
AISE 6-2000	*Specifications for Electric Overhead Traveling Cranes for Steel Mill Service (Technical Report)*
AISE 11-1997	*Brake Standards for Mill Motors (Technical Report)*
UL 674	*Motors for Use in Hazardous Locations*

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

Publication No. 70-1994 *Specifications for Electric Overhead Traveling Cranes*

National Fire Protection Association
Batterymarch Park
Quincy, MA 02269

NFPA 70-1999 *National Electrical Code*

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1.2 Scope

The standards in this section apply to controllers for crane service as applied to DC, wound-rotor AC, and inverter duty 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.

2 DEFINITIONS

2.1 General

For the purposes of this section, the following definitions apply. (Definitions are 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 (NEMA 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 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.

3.4 Crane Service Classes[1]

Service classes have been established so that the most economical crane for the installation may be specified in accordance with this specification.

The crane service classification is based on the load spectrum reflecting the actual service conditions as closely as possible.

Load spectrum is a mean effective load, which is uniformly distributed over a probability scale and applied to the equipment at a specified frequency. The selection of the properly sized crane component to perform a

[1] Extracted from the Crane Manufacturers Association of America (CMAA) standard CMAA70. To obtain a complete copy of specification CMAA 70, please contact Crane Manufacturers Association of America's literature department at: 8720 Red Oak Boulevard, Suite 201, Charlotte, North Carolina 28217.

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given function is determined by the varying load magnitudes and given load cycles which can be expressed in terms of the mean effective load factor.

$$k = \sqrt[3]{W_1^3 P_1 + W_2^3 P_2 + W_3^3 P_3 + \ldots W^3 * P_n}$$

Where:

W = Load magnitude; expressed as a ratio of each lifted load to the rated capacity. Operation with no lifted load and the weight of any attachment must be included.

r = Load probability; expressed as a ratio of cycles under each load magnitude condition to the total cycles. The sum of the load probabilities must equal 1.0.

k = Mean effective load factor (used to establish crane service class only).

All classes of cranes are affected by the operating conditions. Therefore, for the purpose of the classification, it is assumed that the crane will be operating in normal ambient temperature 0°F to 104°F (-17.7°C to 40°C) and normal atmospheric conditions (free from excessive dust, moisture, and corrosive fumes).

The cranes can be classified into loading groups according to the service conditions of the most severely loaded part of the crane. The individual parts which are clearly separate from the rest, or forming a self-contained structural unit, can be classified into different loading groups if the service conditions are fully known.

3.4.1 Class A (Standby or Infrequent Service)

This service class covers cranes which may be used in installations such as powerhouses, public utilities, turbine rooms, motor rooms, and transformer stations where precise handling of equipment at slow speeds with long, idle periods between lifts are required. Capacity loads may be handled for initial installations of equipment and for frequent maintenance.

3.4.2 Class B (Light Service)

This service covers cranes which may be used in repair shops, light assembly operations, service buildings, light warehousing, etc., where service requirements are light and the speed is slow. Loads may vary from no load to occasional full-rated loads with two to five lifts per hour, averaging ten feet per lift.

3.4.3 Class C (Moderate Service)

This service covers cranes which may be used in machine shops or paper mill machine rooms, etc., where service requirements are light and the speed is slow. Loads may vary from no load to occasional full rated loads with two to five lifts per hour, averaging ten feet per lift.

3.4.4 Class D (Heavy Service)

This service covers cranes which may be used in heavy machine shops, foundries, fabricating plants, steel warehouses, container yards, lumber mills, etc., and standard duty bucket and magnet operations where heavy duty production is required. In this type of service, loads approaching 50 percent of the rated capacity will be handled constantly during the working period. High speeds are desirable for this type of service with 10 to 20 lifts per hour averaging 15 feet, not over 65 percent of the lifts at rated capacity.

3.4.5 Class E (Severe Service)

This type of service requires a crane capable of handling loads approaching a rated capacity throughout its life. Applications may include magnet, bucket, magnet/bucket combination cranes for scrap yards, cement mills, lumber mills, fertilizer plants, container handling, etc., with 20 or more lifts per hour at or near the rated capacity.

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3.4.6 Class F (Continuous Severe Service)

This type of service requires a crane capable of handling loads approaching rated capacity continuously under severe service conditions throughout its life. Applications may include custom designed specialty cranes essential to performing the critical work tasks affecting the total production facility. These cranes must provide the highest reliability with special attention to ease of maintenance features.

3.5 Crane Service in terms of Load Class and Load Cycles[1]

The definition of CMAA crane service in terms of load class and load cycles is shown in Table 1-3-1.

Table 1-3-1
DEFINITION OF CMAA CRANE SERVICE CLASS IN TERMS OF LOAD CLASS AND LOAD CYCLES

Load Class	Load Cycles				K = Mean Effective Load Factor
	N_1	N_2	N_3	N_4	
L_1	A	B	C	D	0.35–0.53
L_2	B	C	D	E	0.531–0.67
L_3	C	D	E	F	0.671–0.85
L_4	D	E	F	F	0.851–1.00
	Irregular occasion use followed by long idle periods	regular use in intermittent operation	Regular use in continuous operation	Regular use in severe continuous operation	

Load Classes:

L1 = Cranes which hoist the rated load exceptionally and normally very light loads.
L2 = Cranes which rarely hoist the rated load and normally loads of about 1/3 of the rated load
L3 = Cranes which hoist the rated load fairly frequently and normally loads between 1/3 and 2/3 of the rated load.
L4 = Cranes which are regularly loaded close to the rated load.

Load Cycles:

N_1 = 20,000 to 200,000 cycles
N_2 = 200,000 to 600,000 cycles
N_3 = 600,000 to 2,000,000 cycles
N_4 = Over 2,000,000 cycles

[1] Extracted from the Crane Manufacturers Association of America (CMAA) standard CMAA70. To obtain a complete copy of specification CMAA 70, please contact Crane Manufacturers Association of America's literature department at: 8720 Red Oak Boulevard, Suite 201, Charlotte, North Carolina 28217.

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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 in accordance with Section 610 of NFPA 70. 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

Text deleted.

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 2-3-1 or 2-3-2 in ICS 8, Part 11. Resistors for CMAA Class D, E, or F cranes shall have ratings 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 Table2-3-3 in ICS 8, Part 11.

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 8, Part 10.

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4.6.1 Holding Brake Ratings

Under fault conditions, the shoe brake shall have sufficient torque and thermal energy absorption capability to stop and hold the load. The brake sizing shall include a static torque, single-stop kinetic energy, and a duty cycle thermal analysis.

4.7 Control Circuit Device Ratings

Ratings of control circuit contacts in pushbuttons, master switches, limit switches, and auxiliary contacts that operate directly in contactor operating coil circuits of crane controls and electrically operated disconnect means shall be in accordance with ICS 5. 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.

6 SERVICE AND STORAGE CONDITIONS

See ICS 1, Clause 6.

7 CONSTRUCTION

7.1 Disconnecting Means

The disconnecting means shall be in accordance with Section 610 of NFPA 70.

7.2 Branch Circuit Protection

The branch circuit protection required by Article 610 of NFPA 70 may be achieved by the use of devices on the controllers for each motion when specified, or by using 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 ICS 2, Table 1-7-1.

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.

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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.
d. 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 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.

9 APPLICATION

9.1 Pushbuttons

See ICS 5, Part 5.

9.2 Crane Limit Switches

9.2.1 Direct Acting Power Limit Switches

See Part 6.

9.2.2 Overtravel and Slowdown Sensors

See ICS 5, Part 3.

9.2.2.1 Hoist Motion Upper Overtravel Sensors

Limiting devices actuated by the crane hoist motion in the hoisting direction are employed to limit the hook block movement where the hook can be hoisted beyond rated hook travel under normal operating conditions.

Upper overtravel sensors, when actuated by the motion of the hook block or other part of the crane, operate in the control circuit of the motor controls to remove motor power and initiate braking action.

Upper limit switches shall be applied as required by ANSI/ASME B30.2, B30.3, or B30.4

9.2.2.2 Hoist Motion Lower Overtravel Sensors

Limiting devices actuated by crane hoist motion in the lowering direction may be employed to limit the hook block movement where the hook can be lowered beyond rated hook travel under normal operating conditions or the hook can enter areas not visible to the operator.

Lower overtravel sensors, when actuated by the motion of the hook block or other part of the crane, operate in the control circuit of the motor controls to remove motor power and initiate braking action.

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9.2.2.3 Hoist, Trolley, or Bridge Slowdown Sensors

Limiting devices actuated by motion of the hoist, trolley, or bridge may be employed to limit the speed of the motion when travel reaches predetermined positions.

When actuated by the motion of the hoist, trolley, or bridge, sensors operate in the control circuit of the motor controls to initiate slowdown.

9.2.2.4 Trolley or Bridge End Travel (Overtravel) Sensors

Limiting devices actuated by motion of the trolley or bridge may be employed to stop the speed of the motion when travel reaches predetermined positions.

When actuated by the motion of the trolley or bridge, sensors operate in the control circuit of the motor controls to initiate stopping.

9.3 Auxiliary Contacts

See ICS 5, Parts 2 and 3.

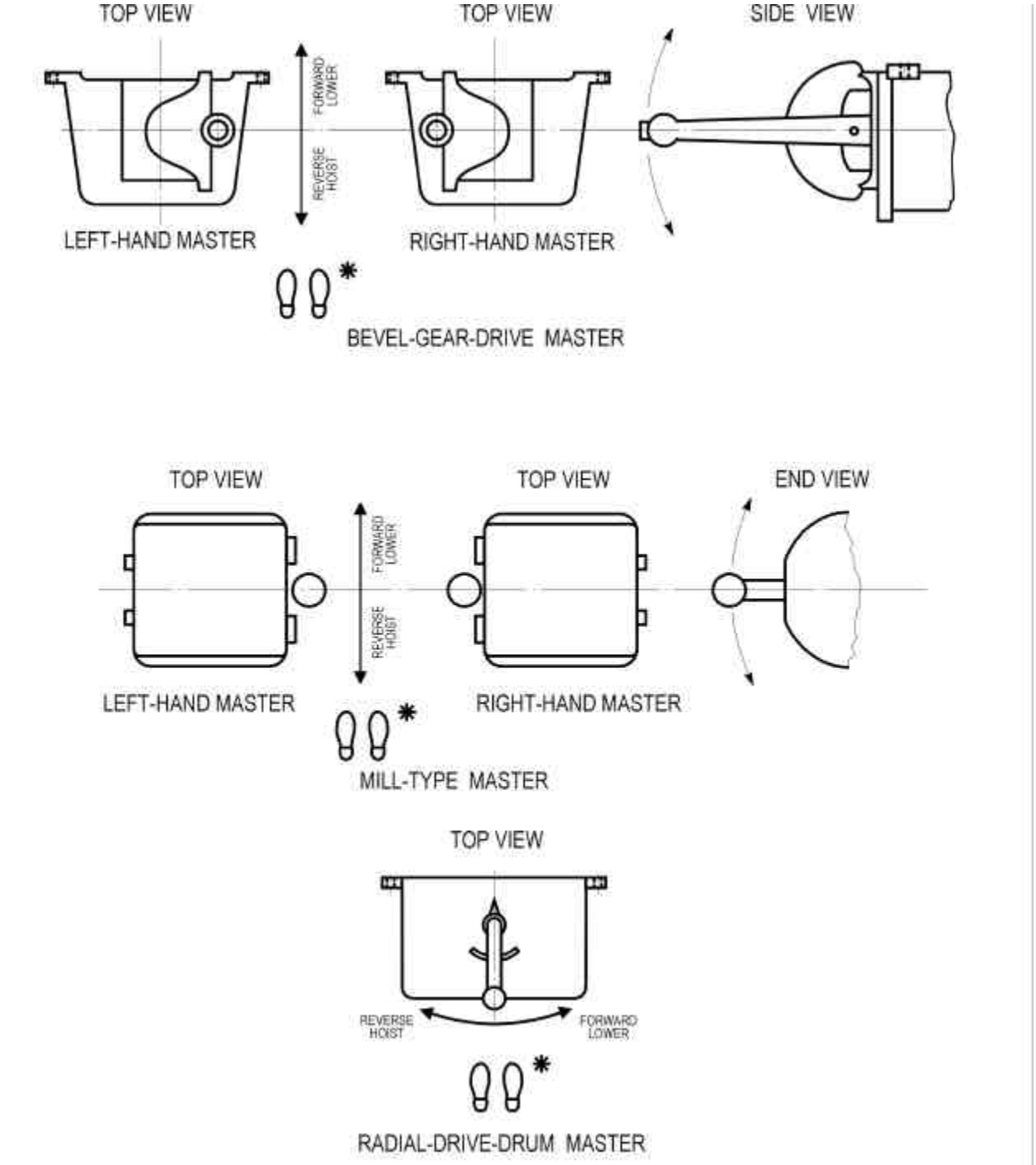
9.4 Master Switches

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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* 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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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 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 to 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 ratings 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 2-4-2 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.

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

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.

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

				Ratings for Grouped Protection	
Size Conductor	**8-Hour Open Rating, Amperes**	**Maximum Intermittent-Duty Rating, Amperes**	**Ratings for Controller Maximum Horsepower**	**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	---	---

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

		Ratings for Grouped Protection	
Size Conductor 8-Hour Open Rating, Amperes	**Ratings for Controller Maximum Horsepower**	**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

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 ICS 1.3 for preventive maintenance instructions.

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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.

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	---

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.

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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. Multiple power circuit isolating switch or circuit breaker with provisions for locking in the open position 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 with 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 lower 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 DC MOTORS

	Class I Controller	Class II Controller
1. Multiple control-circuit isolating switch and fuse, 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 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.

8 PERFORMANCE AND TEST

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

9 APPLICATION

See Parts 1 and 7.

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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.

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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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

7.1 Equipment Required

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

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 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.

8 PERFORMANCE AND TEST

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

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9 APPLICATION

See Parts 1 and 7.

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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. See ICS 2 for standards applying to these contactors.

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

4.1.3 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.

4.1.4 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.

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.

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Table 4-4-1
AC CONTACTOR RATINGS*

		Maximum Intermittent	Rating for Controller Maximum Horsepower		Maximum Total Motor Horsepower		Maximum Horsepower for any Motion	
Size Contactor	8-Hour Open Rating, Duty Rating, Amperes	460 and 575 Amperes †	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

* Ratings of contactors are based on their thermal capabilities. On cranes with high duty cycles endurance may be a significant factor. In these cases, consult ICS 2, Part 2, Clause 4.1.11 for wound-rotor motors.

† 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.

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 not be 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.

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Table 4-7-1

MINIMUM EQUIPMENT (ACCELERATING CONTACTORS) FOR AC MOTORS

	Minimum Number of Accelerating Contactors Per Motion for AC Hoist, Bridge, and Trolley Controllers	
Motor Horsepower	**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.

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. Multiple power circuit isolating switch or circuit breaker with provision for locking in the open position *	X	X	X	
2. Mulitpole control circuit switch and fuses, circuit breaker, or fuse pullout *	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	---	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 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. Multiple control-circuit isolating switch and fuses, circuit breaker, or fuse pullout, common in 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, the pushbutton required by 7.5.3 of Part 1.	X	X

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

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.

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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 that serve as a magnetic disconnect means in AC static controllers shall have Class A load current interrupting ability. See ICS 2 for standards applying to these contactors.

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

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

Text combined with Section 4.1.2.

4.1.4 Ratings of Accelerating Contactors

Accelerating contactors shall have intermittent-duty current ratings 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.

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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.

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 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 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

* The 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.

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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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 that 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 that 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

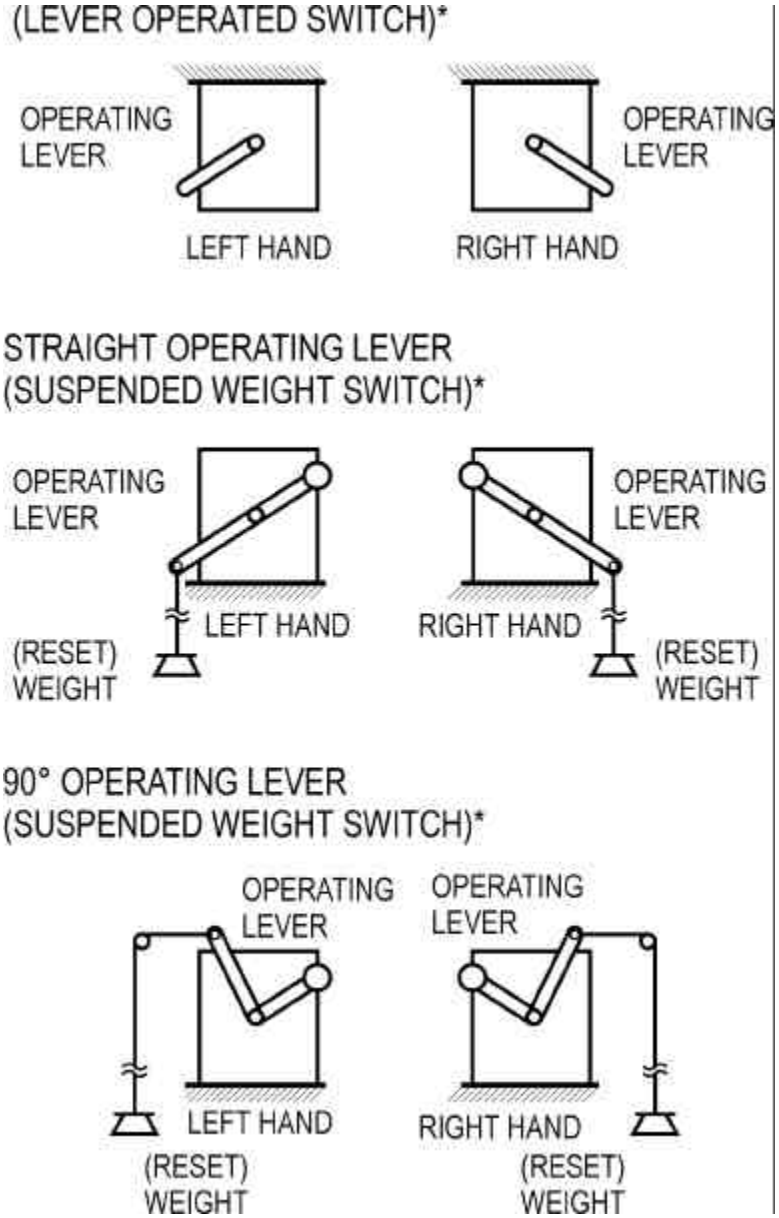
A crane and hoist power-circuit limit switch is either suspended-weight operated or lever operated.

3.2.1 Suspended-Weight Type

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

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* All switches shown in normal contact (running) position.

Figure 6-3-1
MECHANICAL CONFIGURATIONS

3.2.2 Lever Type

A weighted or spring-biased operating lever shall maintain the power contacts in the normal position. When the load block or other mechanism is moved beyond the point where it contacts the operating lever, the load block or other mechanism shall supply 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.

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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	220-440 Volts	440-480 Volts	550-600 Volts
1	27	22.5	5	5	7.5	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 intermittent rating at a 50 percent or less duty cycle with an on time not to exceed 10 minutes. See ICS 8, Part 6, Clause 9.8.

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.

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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 wire rope movement

e. Replacing contacts when worn to a level which might impair the operation of the equipment

Also see ICS 1.3.

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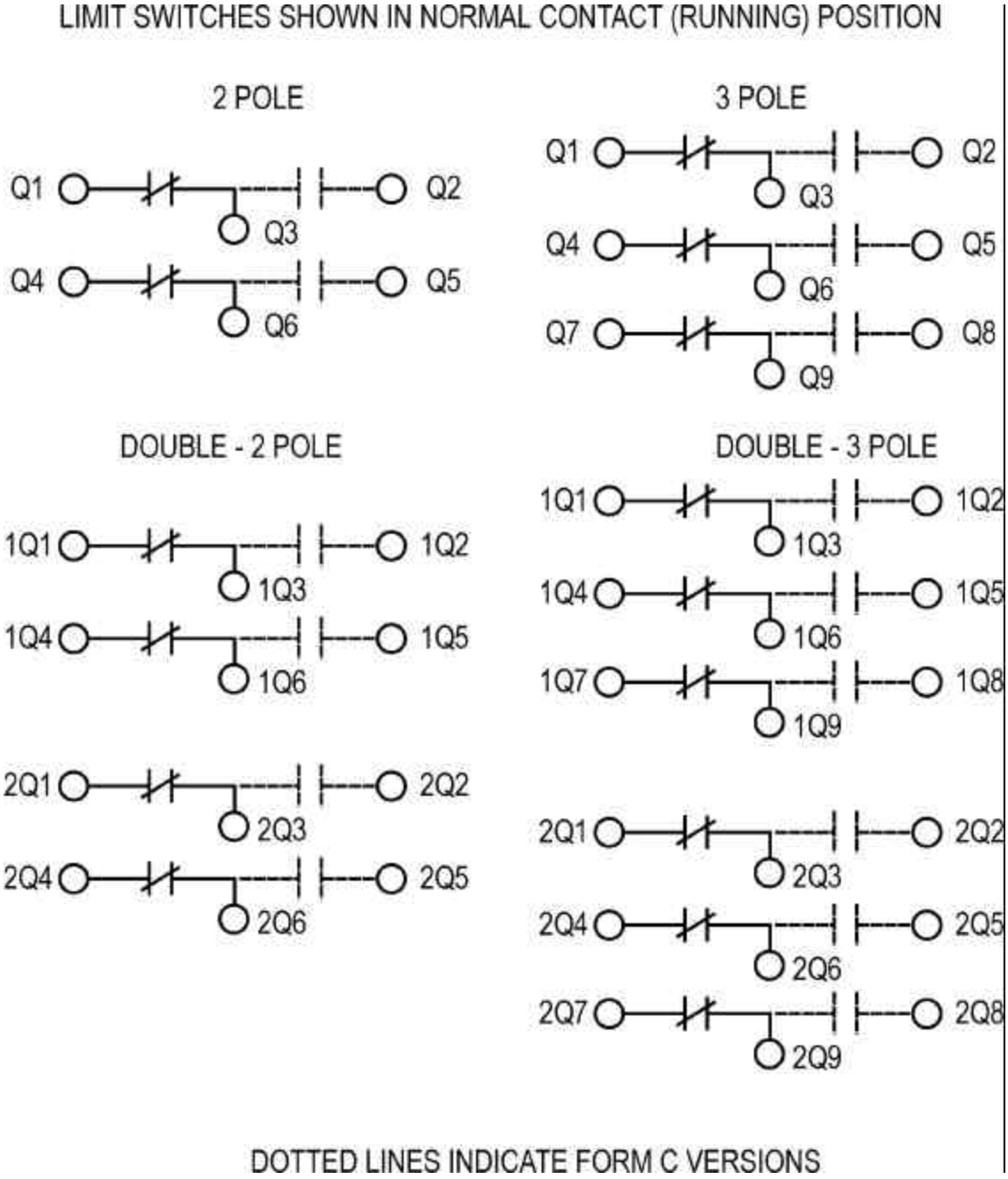


Figure 6-5-1
TERMINAL MARKINGS

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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 wire rope lengths specified in Table 6-9-1 and shall 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.

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

*Tolerance $\pm$ 15 percent

**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.

Where :

I = test current

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

Ve = highest rated voltage (refer to 4.2)

For AC <

Ie = continuous current for Ve $\leq$ 480

Ie = continuous current for Ve > 480 x $\frac{480}{Ve}$

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Ie = continuous current for Ve $\leq$ 250

For DC <

Ie = continuous current for Ve > 250 x $\frac{250}{Ve}$

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; it is 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 shall then be 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 non-time-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.

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.

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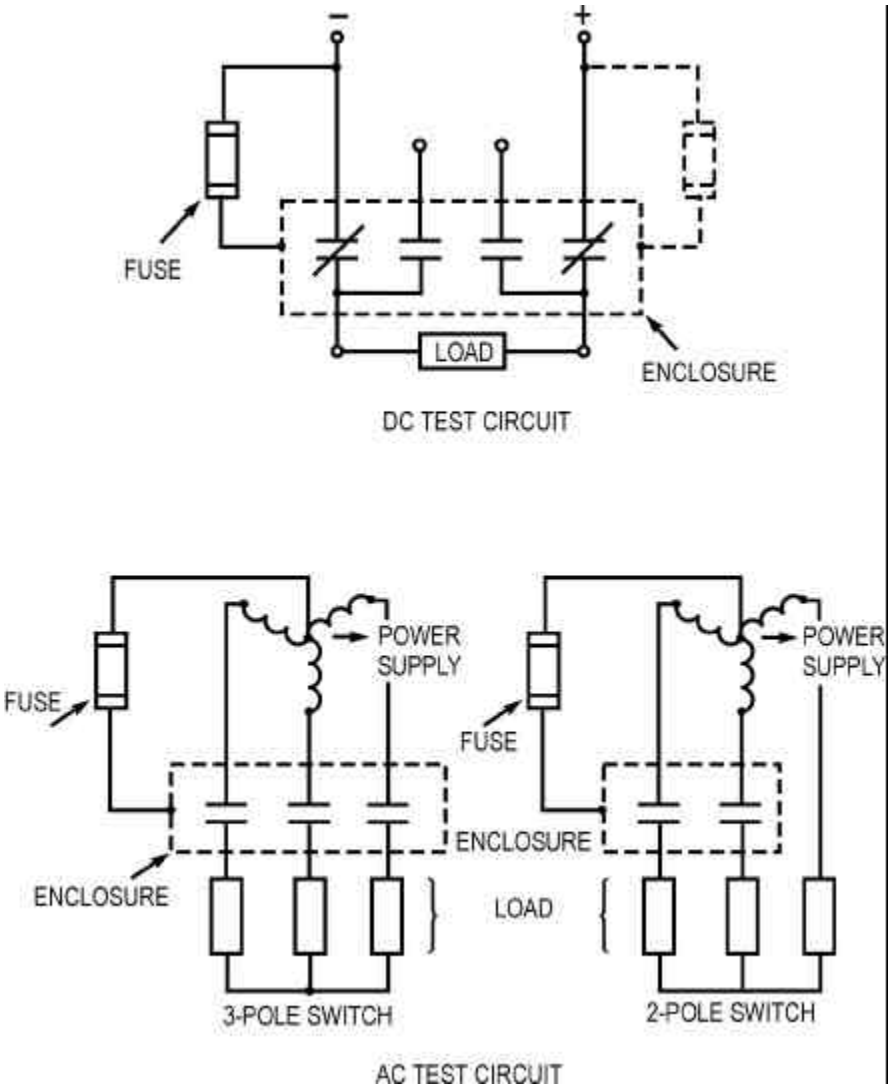


Figure 6-8-1
MAKE AND BREAK (OPERATING OVERLOAD) TEST CIRCUITS

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 6-9-1) installed.

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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 6-8-2 6,000 times.

A DC switch shall successfully make and break the current specified in Table 6-8-2 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.

Table 6-8-2
ELECTRICAL ENDURANCE TEST LEVELS

	Make and Break			
	I/Ie	**V/Ve**	**Power Factor**	**L/R* (ms)**
AC**	2.06	1	40% - 50%	---
DC	2.0	1	---	2

*Tolerance $\pm$ 15 percent

**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.

Where :

I = test current

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

Ve = highest rated voltage (refer to 4.2)

For AC <

Ie = continuous current for Ve $\leq$ 480

Ie = continuous current for Ve > 480 x $\frac{480}{Ve}$

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Ie = continuous current for Ve $\leq$ 250

For DC <

Ie = continuous current for Ve > 250 x $\frac{250}{Ve}$

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 Wire Rope Sheaves

The design of the reset-weight wire rope 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 wire rope 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 wire rope, sheave and guard system should ensure free running operation for the life of the limit switch. Particular attention should be paid to possible wire rope sag conditions.

Where it is necessary to use a sheaved system, the vector sum of the forces from the wire rope, sheave(s), and guard system (excluding the reset weight) tangent to the lever motion should not exceed the weight of the maximum length of wire rope as shown in Table 6-9-1.

9.3 Wire Rope Length

The length of the wire rope 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. Wire ropes (of the size shown) should not exceed the maximum lengths shown in Table 6-9-1.

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 6-9-1. 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 6-9-1. The crane and hoist power-circuit limit switch manufacturer should be consulted when reset weights outside the limits shown in Table 6-9-1 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.

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Table 6-9-1
RESET WEIGHTS AND WIRE ROPE LENGTHS

			Maximum Permissible Length*		User Supplied Reset Weight**			
					Minimum		Maximum	
NEMA Size	Type	Wire Rope Size, Inches	Feet	Meters	Pounds	Kilograms	Pounds	Kilograms
3	Single	0.025	15	4.6	35	15	50	25
4	Single	0.375	20	6.1	55	25	80	35
4	Double	0.375	30	9.2	100	45	150	70
5	Single	0.375	20	6.1	100	45	150	70
5	Double	0.375	30	9.2	135	60	200	90
6	Single	0.375	20	6.1	135	60	200	90
6	Double	0.375	40	12.2	235	110	350	160
7	Single	0.5	40	12.2	265	120	400	180
7	Double	0.5	50	15.2	500	230	750	340
8	Single	0.5	40	12.2	265	120	400	180
8	Double	0.5	50	15.2	500	230	750	340

*Lengths based: 0.25 inch — .11 lbs./ft
0.375 inch — .22 lbs./ft
0.5 inch — .42 lbs./ft

**Refer to 6-9.4

9.7 Low Current DC Operation

Where it is anticipated that any pole of a DC 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 through an arcing overlap between the normally-open and the normally-closed contacts. For reversing or plugging applications, consult the manufacturer.

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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 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 Tables 2-4-1 or 2-4-2 of Part 2 or Table 3-4-1 of Part 3.

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Table 7-4-1
CURRENT RATINGS OF DC CONTACTORS

	8-Hour Rating—Amperes	
Size of Contactor	**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.)

4.4 Horsepower Ratings of DC Contactors

Horsepower ratings of full-voltage magnetic DC contactors shall be in accordance with Tables 2-4-1 or 2-4-2 of Part 2 or Table 3-4-1 of Part 3.

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.

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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. Minimum interlocking provisions shall be for contactors that are horizontally adjacent and of the same rating.

7.2 Terminal Sizes

Service connections of DC contactors shall be capable of accepting conductor sizes in accordance with ICS 2, Table 1-7-1.

8 PERFORMANCE AND TEST

8.1 General

All of the test performance requirements of ICS 2 Part 1 shall apply except ICS 2, Part 1, Clause 8. 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. For contactors rated more than 100 amperes, however, 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.

8.2 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.

8.3 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.

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

	Test Parameters	
$\frac{I}{I_e}$	$\frac{V}{V_e}$	$\frac{L*}{R}$
4	1.1	7.5

* Tolerance $\pm$ 15 percent
Where:
I = Test current
I_e = Rated current (open) per Table 7-4-1
V = Test current (See 8.2)
V_e = 600 Volts
L/R = Time constant of the load in milliseconds

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

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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.

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.

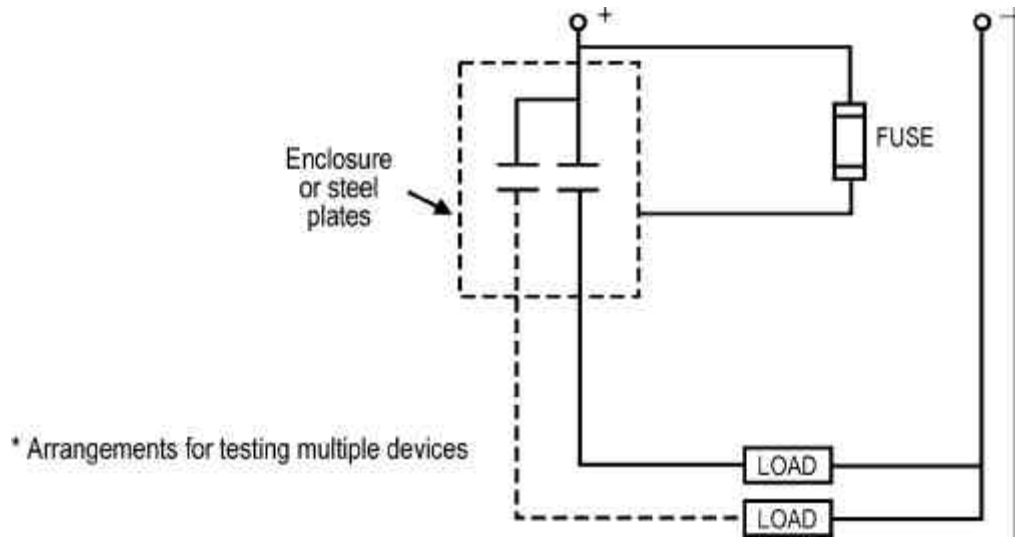


Figure 7-8-1
MAKE AND BREAK (OPERATING OVERLOAD) TEST CIRCUITS

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 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.

8.5 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.

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8.5.1 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 contactor 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.

8.5.2 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. If the distributed 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 are a total of two or more failures.

8.5.3 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.

8.6 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.

Table 7-8-2
ELECTRICAL ENDURANCE

$\frac{I}{L}$	$\frac{V}{V_e}$	$\frac{L}{R}$ *	**Number of On-Load Cycles**
2.5	1	3.5	6,000

* Tolerance $\pm$ 15 percent
Where:
I_e = Rated current (open) per Table 7-4-1
V = Test current (See 8.2)
V_e = 600 Volts
L/R = Time constant of the load in milliseconds

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

8.6.1 Test Conditions—Electrical

The contactor shall be mounted in its intended mounting arrangement in the open position. 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.

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8.6.2 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.

8.7 Operating Voltage Test

8.7.1 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.

8.7.2 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 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.

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Part 8
AC ADJUSTABLE FREQUENCY CONTROLLERS FOR MOTORS AND CRANES

1 GENERAL

1.1 Scope

Part 8 applies to AC adjustable frequency controllers for AC motors used with cranes. For the purpose of this section an adjustable frequency crane drive system includes a motor or motors, the power conversion controller that shall be in accordance with ICS 7 and control devices per ICS 8, Table 4-4-1.

Essential to this section are hoist controllers that have positive control under all operating conditions such as roll back, transition stages (i.e. stop to start, start to stop, acceleration, deceleration, etc.), drive fault, unintended motor direction, etc. See Clause 8.6.

1.2 Classifications

See Parts 2 and 8.

2 CHARACTERISTICS AND RATINGS

2.1 Ratings

Adjustable-frequency crane drive system motors shall be rated in terms of horsepower output at base speed frequency and voltage.

Adjustable-frequency crane drive system controllers shall be rated in terms of current output at base speed frequency and voltage of the motor.

The power conversion and control equipment for a multimotor drive are not necessarily the same as those for a single-motor drive of the same horsepower and current rating. The drive system supplier should be consulted.

Consideration must be given to matching the adjustable frequency controller characteristics with the motor characteristics.

In selecting the power-supply capacity for the motor, the current ratings of such motors as high-speed motors, totally-enclosed fan-cooled motors, short-time-rated motors, etc., should be considered.

2.2 Speed Ratings

Adjustable-frequency crane drives shall have a "base-speed" rating, this being the lowest speed at which the drive can develop rated horsepower continuously at the time rating the motor is applied.

Drives which provide for operation above base speed by increasing the frequency shall have a maximum speed rating and a corresponding horsepower rating.

2.3 Overload Capacity Ratings

2.3.1 Travel Drives

Following continuous operation at rated load and duty cycle, travel drives (controller and motor) shall be capable of producing a minimum 150 percent of rated drive torque for 1 minute, followed by a period of light load operation of such duration that the rms load does not exceed rated continuous current without exceeding the temperature rise limitations of ICS 1, Clause 8.

2.3.2 Hoist Drives

Following continuous operation at rated load and duty cycle, hoist drives (controller and motor) shall be capable of producing a minimum of 150 percent of rated drive torque for 1 minute, followed by a period of

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light load operation of such duration that the rms load does not exceed rated continuous current without exceeding the temperature rise limitations of ICS 1, Clause 8.

2.4 Holding Brake Ratings

Under fault conditions, the brake shall have sufficient torque and thermal energy absorption capability to stop and hold the load. The brake sizing shall include a static torque, single-stop kinetic energy, and a duty cycle thermal analysis.

2.5 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 contactor of the circuit it isolates, including drive losses (form factor, etc.).

3 PRODUCT MARKING, INSTALLATION, AND MAINTENANCE INFORMATION

See NEMA standards publication No. ICS 1.3 for preventative maintenance instructions.

4 SERVICE AND STORAGE CONDITIONS

Clause 6 of ICS 1 applies.

5 CONSTRUCTION

5.1 Controller Contactors

5.1.1 Contactor Interrupting Ability

Contactor shall have a Class A load-current interrupting ability in accordance with Part 2 of ICS 2.

5.1.2 Ratings of Line or Motion Contactor for Single Motor Protection

The horsepower and intermittent-duty current ratings of contactors used in the power circuits of alternating-current 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.

5.1.3 Ratings of Line or Motion Contactor Used for Grouped Motion Protection

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

5.1.4 Ratings of Line or Motion Contactors at Voltages Not Listed in Table 4-4-1 But Less than 460 Volts

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

5.2 Acceleration Control

Drives shall be provided with either a torque limit or timed acceleration.

5.3 Dynamic Braking Controller

The dynamic braking controller continuous current rating shall be no less than 100 percent of the maximum dynamic braking current required to decelerate the hoist or travel drive.

5.4 Dynamic Braking Slowdown

When dynamic braking slowdown is provided for crane traverse drives, the resistors used for this purpose shall have a wattage rating equal to or greater than 25 percent of the motor horsepower without exceeding the specified temperature rise per ICS 8, Part 11.

5.5 Dynamic Braking Lowering

When dynamic braking lowering is provided for crane hoist drives the resistors used for this purpose shall have a wattage rating equal to or greater than 85 percent full load rated hoisting horsepower. The resistor

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may be de-rated as a function of the duty cycle of the application without exceeding the specified temperature rise per ICS 8, Part 11.

5.6 Adjustable Frequency Equipment Required

Controllers shall have the equipment listed in Table 8-5-1.

6 PERFORMANCE AND TEST

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

7 APPLICATION

There are no application guidelines unique to this section.

Table 8-5-1
MINIMUM EQUIPMENT FOR CLASS I AND II ADJUSTABLE FREQUENCY CONTROLLER FOR AC MOTORS

	Bridge or Trolley	Hoist
Multiple main circuit isolating switch, circuit breaker, or fuse pullout*	X	X
Multiple control switch and fuses, circuit breaker, or pullout*	X	X
Automatically reset inverse time trip running overload protection in each phase for each motor with thermal time constant the same as the motor, electronic motor protection, or as integral sensing device*	X	X
Undervoltage protection*	X	X
Static reversing	X	X
Adjustable means to provide a limit on acceleration and deceleration	X	X
Means for electrically regulating motor speed hoisting and lowering		X
Brake relay when required by the particular application	X	X
Line contactor*	X	X
Second and fourth quadrant dynamic braking	X	X
Motor torque proving prior to holding brake release**		X
Independent protective device to prevent load overspeed conditions		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.

**Not required if mechanical system provides controlled operating speeds under all control failure modes.

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Part 9
WIRELESS CONTROL SYSTEMS FOR CRANES

1 GENERAL

1.1 Scope

The standards in this section apply to wireless control systems used with cranes. All equipment shall be designed to provide a system that, when installed, will become an operating unit integral with the crane controls (new or existing).

1.2 Normative References

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

2 DEFINITIONS

For the purposes of this section, Wireless Control Systems are defined as either:

radio frequency control: Utilizing radio wave transmission.

infrared control: Utilizing pulsed infrared radiation transmission within the near infrared range.

3 CLASSIFICATIONS

See Part 1.

4 CHARACTERISTICS AND RATINGS

All Radio Frequency Control systems shall be "type accepted" by the FCC and bear the FCC label. Frequency assignment for equipment requiring an FCC site license shall be the responsibility of the purchaser in coordination with the system designer.

5 PRODUCT MARKING, INSTALLATION, AND MAINTENANCE INFORMATION

5.1 See ICS 1.3 for preventive maintenance instructions.

5.2 All Radio Frequency Control systems shall bear labels required by the FCC.

6 SERVICE AND STORAGE CONDITIONS

ICS 1, Clause 6 applies.

7 CONSTRUCTION

7.1 Technology

Wireless control system electronics shall be solid state with self-contained protection, except for the interposing relays. Standard components and modules shall be used wherever possible.

All system modulation and de-modulation shall be accomplished with electronic devices. No electromechanical devices, such as reeds, shall be used.

7.2 Equipment Required

A "wireless control system" shall include, but not be limited to, the following:

7.2.1 Transmitters

7.2.1.1 General

The transmitter shall be turned on only with a switch system that must be operated deliberately and cannot be operated accidentally. Examples of deliberate operating devices are a key switch, a snap-action push-pull device, a combination of key and toggle switches, or two toggle switches.

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The transmitter unit shall be arranged for positive, convenient, and easy operation. All control switches or other mechanisms for operator use and all switch positions shall be clearly and permanently marked to show function and position or positive indication of direction of motion.

The transmitter shall include a safety label containing the following information, or as listed in ANSI Standard B30.

Floor-operated and remote-operated cranes shall have a safety label or labels affixed to the pendant station, portable operating station, or load block. The label or labels shall be in compliance with ANSI Z535.1, ANSI Z535.3, and ANSI Z535.4, and shall include cautionary language against:

a. Lifting more than the rated load

b. Operating a hoist when the load is not centered under the hoist

c. Operating a hoist with twisted, kinked, or damaged chain or rope

d. Operating a damaged or malfunctioning crane

e. Lifting people

f. Lifting loads over people

g. Operating a rope hoist with a rope that is not properly seated in its groove

h. Operating manual motions with other than manual power

i. Removing or obscuring the safety label

7.2.1.2 Transmitter Functions

Each master switch or push-button shall be supplied with a spring return to the center (off) position. The system designer shall insure the transmitter conforms to the users standards regarding switch position, left to right.

The following functions shall be controlled by a lever, toggle switch, or pushbutton:

a. Main line contactor or manual-magnetic disconnect switch closing. The stop function shall be clearly identified.

b. Load holding device "pick-up" (such as magnet, vacuum lifter, grab, etc.), if applicable.

The following functions shall each be controlled by two (2) spring-return switches that must be operated simultaneously, and are separated on the transmitter by sufficient distance to require two-handed operation:

a. Magnet line contactor or manual-magnetic disconnect switch opening.

b. Load holding device "drop out," such as a magnet, vacuum lifter, grabs, etc., if applicable.

The load holding device disconnect switch and pick-up/engage switches shall control latching relays. Turning the transmitter on or off, loss of crane power, or loss of any signal systems, command, safety, or continuous carrier, shall not cause the latching relays to change state.

The crane activity warning device shall be controlled by a pushbutton or spring return toggle switch.

A transmitter shall include low battery indicator.

7.2.1.3 Multi-transmitter Systems

Transmitter control on systems with more than one transmitter shall follow a first-come, first-served priority. Each transmitter shall have positive keying or lockout identification and release features that will prevent the other transmitter(s) from controlling the same crane simultaneously or without consent, will identify the transmitter which is in control, and will have a positive means of enabling crane control to be relinquished by one transmitter and acquired by another.

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Transfer of crane control from one transmitter (one operator) to another shall be possible only after all crane motions have been turned off and crane magnet functions are locked to the condition or mode in effect at the time.

A stop command from any one of the central stations shall be effective when required by the risk assessment of the application.

7.2.2 Battery Charger

The transmitter shall be furnished with a battery charger, if required, and batteries for the transmitter.

7.2.3 Receiver

The receiver unit shall include the necessary receiver, decoder, and interface equipment to the crane controls, housed in an enclosure.

The receiver unit shall be responsive only to signal from the transmitters (portable or fixed) furnished and shall be responsive only to signals from one designated or selected transmitter at a time.

Where the receiver unit includes interposing relays (electromechanical or solid state), the system designer shall coordinate the need for arc suppression.

The receiver unit shall include a control transfer switch if manual back-up control is used (master switch, remote pulpit, or pendant). The system designer shall coordinate transfer switch isolation requirements.

The system designer shall insure the receiver unit includes appropriate power supply(s) necessary to operate all receiver functions.

7.2.4 Receiving Antenna/Sensor, Antenna Mount, Cable, and Connectors

The receiver antenna or sensor shall be arranged for suspended mounting under the crane bridge girder. The antenna or sensor shall be capable of withstanding sudden crane stops without excessive whipping.

8 PERFORMANCE AND TEST

8.1 The system designer shall insure that the wire-less control system adheres to the following:

a. No off channel interference shall be generated that affects existing plant remote control systems.

b. No unintended operation of the wireless control system shall be caused by interference from plant electrical noise, radio signals, or other wireless control systems

8.2 Failure of the wireless control system due to either interference with the transmitted signal or component failure shall cause the motion or function in progress at the time to stop, and, if applicable, cause the load holding device controller (such as a magnet controller, vacuum lifter, grab, etc.), if used, to lock to the condition or mode in effect at the time.

8.3 Interference

The radio control system shall operate safely, without initiating a false motion, in the presence of the following:

8.3.1 Extraneous RFI (Radio Frequency Interference) that may originate from other radio-controlled equipment, communication equipment, or any other source. Examples of sources of this type of interference are radio transmitters, aircraft, beacons, electrical noise navigational aids, two-way radios, and local carrier control and communication equipment.

8.3.2 Extraneous EMI (Electromagnetic Interference) that may originate from any source. Examples of sources of this type of interference are: induction and dielectric heaters; motor brushes; AC and DC relays, contactors, and electronic drives; collector shoes; arc welders; and ignition, lighting, and power distribution equipment.

8.3.3 The failure of any component in the wireless control system shall not cause un-commanded crane motion.

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8.4 System Operating Range

The system designer shall review with the user to ensure that the transmitting range of the wireless control system will be within acceptable limits. When separation between the receiving antenna and the transmitter having control of the crane exceeds the acceptable distance, all crane motions shall stop.

8.5 Safety Coding

The wireless control system shall include safety-coding and command-coding signal systems in addition to a carrier signal or signals. Both the safety-coding signal system and continuous carrier shall be received before any motion command or auxiliary function signal may be acted upon.

The command coding signal system shall be a combination of unique codes that are sufficiently complex to ensure that no un-commanded motions occur due to extraneous radio signals, RFI, or EMI.

9 APPLICATION

The system designer shall provide drawings that cross reference the wireless control system with the crane controls.

The wireless control system, including emission, modulation, and transmission characteristics shall be certified to meet the applicable FCC or other government regulatory requirements.

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Part 10
ELECTROMAGNETIC BRAKES

1 GENERAL REQUIREMENTS

1.1 Scope

The standards in this part apply to electromagnetic friction brakes that are spring, hydraulic, permanent magnet, or electromagnetically set. Brakes may include provisions for manual release.

1.2 Normative References

In addition to the references and standards of ICS 1, the following references also apply to this part.

AISE 1-1968	*DC Mill Motor Standard*
AISE 1A-1964	*AC Mill Motor Standard*
AISE 6-2000	*Specifications for Electric Overhead Traveling Cranes for Steel Mill Service (Technical Report)*
AISE 11-1997	*Brake Standards for Mill Motors (Technical Report)*
NEMA MG 1-1998	*Motors and Generators*
UL 674	*Motors for Use in Hazardous Locations*

2 DEFINITIONS

For the purposes of this NEMA standards publication, the following definitions apply:

2.1 Brake Actuators

series coil brake: A series brake that has an electromagnetic coil. The brake release coil is connected in series with the motor armature and field, or both. It is used with DC series motors.

shunt coil brake: A shunt brake that has an AC or DC electromagnetic coil. The brake release coil is arranged for connection to a motor or power source. It is used with either AC or DC motors.

rectifier operated brake: A shunt brake that has a DC electromagnetic coil. It is used with an AC power source and provides rectified DC for the coil. It is used with either AC or DC motors.

thruster operated brake: A brake that uses electrohydraulic or electromechanical actuation. Typically, these brakes use AC or DC motors connected to the motor or power source. It is used with either AC or DC motors.

hydraulic operated brake: A brake that uses hydraulic or electrohydraulic actuation. It is used with either AC or DC motors.

2.2 Indicators

adjustment indicator: A mechanism for indicating the condition of the brake with respect to its specified adjustment. It shows if readjustment is required as a result of wear of the braking surfaces or other parts and provides indication of proper brake adjustment.

electrical release indicator: A control circuit contact complying with ICS 5, Part 1 that changes state when the brake setting mechanism has moved to the release position.

mechanical release indicator: A brake mounted visual indicator that changes state when the brake setting mechanism has moved to the release position.

wear indicator: A device that shows when lining replacement is required.

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2.3 Manual Release Mechanisms

manual release: A device by which the braking surfaces are manually disengaged without disturbing the torque adjustment.

manual release with automatic-reset: A manual release which, when operated, will maintain the braking surfaces in disengagement but will automatically disengage the release mechanism as soon as electric power is again applied.

manual release with manual-reset: A manual release that requires an additional manual action to disengage the release mechanism.

manual release that is self-resetting: A manual release that is operative only while it is held manually in the release position.

2.4 Other Mechanisms

self-adjusting brake: A brake that incorporates a mechanism that automatically compensates for lining wear by maintaining a predetermined position relationship between the braking surfaces.

setting mechanism: A spring, hydraulic, permanent magnet, or electromagnetic actuator (coil or motor) that provides a force that is transmitted to the braking surfaces through the brake linkages. Combinations of setting mechanisms may be used on the same brake when adjustable service braking and fixed parking braking are provided.

releasing mechanism: A spring, hydraulic, permanent magnet, electrohydraulic, or electromagnetic actuator (coil or motor) which provides a means to remove the force that is transmitted to the braking surfaces through the brake linkages. Combinations of releasing mechanisms may be used on the same brake when adjustable service braking and fixed parking braking are provided.

3 CLASSIFICATIONS

3.1 Brake Types

caliper disc brake: A brake that uses both sides of an exposed rotating disc as the friction surfaces. Friction pads press axially against the disc.

flat plate disc brakes: Enclosed brakes with full circular contact between friction and brake plates.

shoe brake: A brake that uses the cylindrical outer diameter of the brake wheel as the friction surface. Shoe brakes engage the brake wheel by moving radially inward.

3.2 Mounting Arrangements

3.2.1 Shoe and Caliper Disc Brakes (Bracket or Base-Mounted)

3.2.1.1 NEMA Type 1 Mounting—Floor-Mounted Horizontal-Shaft Brake

A floor-mounted horizontal-shaft brake is a brake that is arranged for floor mounting with the wheel located on a shaft, which is approximately parallel to the floor, and with the brake actuator located at the side of the brake wheel.

3.2.1.2 NEMA Type 1A Mounting—Floor-Mounted Horizontal-Shaft Brake

Type 1A mounting is similar to Type 1, except that the brake actuator is located either above or below the brake wheel.

3.2.1.3 NEMA Type 2 Mounting—Wall-Mounted Horizontal-Shaft Brake

A wall-mounted horizontal-shaft brake is a brake that is arranged for wall mounting with the wheel located on a shaft that is approximately parallel to the floor and to the wall and with the brake actuator located above the brake wheel.

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3.2.1.4 NEMA Type 2A Mounting—Wall-Mounted Horizontal-Shaft Brake

A wall-mounted horizontal-shaft brake is a brake that is arranged for wall mounting with the wheel located on a shaft that is approximately parallel to the floor and to the wall and with the brake actuator located below the brake wheel.

3.2.1.5 NEMA Type 3 Mounting—Ceiling-Mounted Horizontal-Shaft Brake

A ceiling-mounted horizontal-shaft brake is a brake that is arranged for ceiling mounting with the wheel located on a shaft that is approximately parallel to the floor, with the brake actuator located at the side of the brake wheel.

3.2.1.6 NEMA Type 4 Mounting—Wall-Mounted Vertical-Shaft Brake

A wall-mounted vertical-shaft break is a brake that is arranged for wall mounting with the wheel located on a shaft that is approximately perpendicular to the floor, with the brake actuator located at the side of the brake wheel.

3.2.2 Flat Plate Disc Brakes

Standard disc brakes shall be suitable for mounting to horizontal shaft motor frames as shown in Part 4 of NEMA MG 1.

Mounting to other than horizontal shaft motors is nonstandard and shall be specified when required.

4 CHARACTERISTICS AND RATINGS

4.1 General Purpose Shoe and Caliper Brake Torque Ratings

The torque ratings of brakes with series or shunt coils shall be as shown in Table 1-4-1.

Direct-current brakes with rectifiers, when applied on alternating-current circuits, may be given the direct-current one-hour shunt torque ratings if used with one-hour coils. If used with continuous duty coils, continuous torque ratings may be given.

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Table 1-4-1

TORQUE RATINGS OF SHOE AND CALIPER DISC BRAKES FOR USE WITH AISE[1] 600 FRAME OR 800 FRAME MOTORS; AC FRAME AISE MILL MOTORS, AND NEMA FRAME MOTORS

		Torque Ratings (Lbs.-Ft.)					
Brake Size (In)		Shunt		Series		Rectifier Operated	
Shoe Brake	Caliper Disc Brake	Cont.* (8 Hour) Duty	1 Hour (50% Duty Cycle) or 8 Hour (100% Duty) Hi-Speed Forced	1 Hour* (50% Duty Cycle)	1/2 Hour* (30% Duty Cycle)	8 Hour (100% Duty)**	1 Hour (50% Duty Cycle) or 8 Hour (100% Duty) Hi-Speed Forced**
8	12	75	100	65	100	75	100
10	14	150	200	130	200	150	200
13	17	400	550	365	550	400	550
16	21	750	1000	650	1000	750	1000
19	24	1500	2000	1300	2000	1500	2000
23	29	3000	4000	2600	4000	3000	4000
N/A	34	4500	6000	3900	6000	4500	6000
30	38	6750	9000	6000	9000	6750	9000

*Ratings shown are for 8-hour, 1-hour, and 1/2 hour and are the thermal ratings of the coil. The duty cycles apply, providing the on-time does not exceed 10 minutes.

The torque ratings apply at a worn lining condition defined as the point where the brake readjusts, or where adjustment is required as recommended by the brake manufacturer.

**See 2.1.3

4.2 Torque Ratings for Flat Plate Disc Brakes

Torque ratings for alternating- and direct-current disc brakes, corresponding to motor frame sizes, shall be as shown in Table 1-4-2.

Brake designations A, B, C, and D refer to brake diameter. No attempt is made to identify a specific diameter. For each size of brake, there are various torque ratings available that may be obtained by varying the number of discs that, in turn, will vary the length of the brake.

Table 1-4-2

TORQUE RATINGS FOR FLAT PLATE DISC BRAKES

Brake Size	Motor Frame	Brake Torque, Pound-Free
A	56C*, 143TC*, 182TCH*, 145TC*, 148TCH*	Static Torque Range—1 to 25 (1-1/2, 3, 6, 10, 15, 20, 25-Typical Static Torque Increments
B	182TC*, 184TC*, 213TC*, 215TC*, 254TC*, 256TC*	Static Torque Range—10 to 105 (10, 15, 25, 35, 50, 75, 105—Typical Static Torque Increments)
C	285TFC, 286TFC	Static Torque Range—25 to 175 (25, 35, 50, 70, 75, 105, 125, 175—Typical Static Torque Increments)
D	324TFC, 356TFC, 364TFC, 365TFC, 404TFC, 405TFC	Static Torque Range—75 to 550 (75, 90, 105, 125, 175, 230, 345, 460, 550—Typical Static Torque Increments)

*Certain brakes can be used on the drive end, but when the face mounting is at the end opposite the drive end, the prefix F shall be used, making the suffix letter FC.

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4.3 Shoe and Caliper Disc Brake Coil Ratings

Shoe and caliper disc brake coil ratings of the brake types indicated in 4.1 are established based on the brake operating duty cycle and thermal capacity of the operating coil. Refer to the manufacturer for maximum current coil ratings.

4.4 Brake Operating Time

Brake release and set times are different for each manufacturer and can be obtained by contacting the brake manufacturer. These operating times can be provided based on rated operating conditions or as described in 8.1.

5 PRODUCT MARKING INFORMATION, INSTALLATION, AND MAINTENANCE

5.1 Brake Mounting Tolerances

For shoe and caliper brakes indicated in 4.1, see Table 1-7-1 for mounting tolerances, with respect to the motor, required for the proper operation of the brake.

5.2 Maintenance

In order to assure proper equipment operation, a periodic maintenance program should be established. Maintenance instructions should be obtained from the manufacturer for incorporation into this program.

5.2.1 Inspection

Brakes should be inspected to see that magnet gaps and torque spring settings are correct. The brake should be operated to verify that the brake linings are being released from the wheel or disc. Linings should be examined to determine if new linings are needed. Electrical connections and mechanical joints should be inspected for proper tightness; in particular, the hardware securing the wheel to the motor shaft and the brake mounting bolts. Dirt and dust should be removed from the brake with particular attention being given to the armature gap which tends to collect magnetic particles. The brake wheel or disc should be examined for unusual scoring, overheating, cracking, or wear to determine the need for replacement. The condition of bearings and bushing should be checked along with the overall mechanical and electrical integrity of the complete braking system. Brake maintenance requirements are different for each manufacturer and can be obtained by contacting the manufacturer.

5.2.2 User Testing

The user should establish a schedule to test for the following.

a. The brake operates properly.
b. The brake can stop and hold the rated load.

5.2.3 Preventive Maintenance Guide

See ICS 1.3.

5.3 Special Precautions

5.3.1 Mounting

Consult with the manufacturer for any special precautions required when mounting brakes in positions other than floor or horizontal-shaft mounted, since certain modifications may be required for proper operation of the brake.

5.3.2 Brake Torque

Since the brake torque may vary due to conditions such as moisture on the friction surfaces, rusty wheels or discs, lining glaze, alignment of linings and brake wheels or discs, and other variables. Allowance for these variations should be considered during application and use.

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5.3.3 Braking Surfaces

One hundred percent contact of braking surfaces is not required. Refer to the manufacturer for recommendations.

5.4 Brake Wheel or Disc Overheating

Brakes included in this standards publication may overheat if the thermal rating of the brake is exceeded, or if the linings are rubbing due to improper adjustments or mechanical or electrical failure, resulting in the brake not releasing.

Expansion of overheated braking surfaces may take up the brake operating clearance and may result in rapid deterioration of the braking surfaces. Overheating of the braking surfaces may also result in fade (reduction of braking torque).

5.5 Brake Lining Replacement

See Table 1-5-1 for minimum brake lining thickness prior to replacement for the DC operated shoe brakes described in 4.1.

Table 1-5-1

MINIMUM BRAKE LINING THICKNESS FOR DC OPERATED BRAKE SHOES

Wheel Diameter (Inches)	Max Rpm	Minimum Wheel Diameter (Inches)*	Lining Thickness (Inches)**	
			Riveted***	Bonded
8	5000	7.94	.010	.016
10	4000	9.92	.010	.020
13	3300	12.90	.010	.026
16	2600	15.87	.015	.032
19	2300	18.87	.015	.038
23	1900	22.87	.015	.046
30	1600	29.87	.015	.060

*Minimum after remachining
**Minimum permissible prior to replacement
***Above rivet head at maximum wear point

5.6 Device Markings

Brakes shall be marked with the following data:

a. Rated voltage, current, or both
b. Torque
c. Brake identification number
d. Manufacturer's name or identification mark
e. Special mounting arrangements (disc brakes only)

6 SERVICE AND STORAGE CONDITIONS

6.1 Unusual Environmental Conditions

Consult with the manufacturer for any special precautions or modifications required when any of the following conditions exist.

a. Airborne magnetic particles
b. Ambient temperatures above 40°C or below 0°C
c. High shock or vibration

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d. Airborne oil, salt, corrosives, abrasives, or water

e. Exposure to radiation

f. Other unusual environmental conditions

g. In hazardous (classified) locations, as defined in NEMA 250, Section 5, special consideration should be given to non-sparking friction materials or NEMA Type 7 and NEMA Type 10 enclosures.

7 CONSTRUCTION

7.1 Dimensions of Shoe and Caliper Disc Brakes

The outline and mounting dimensions of DC-operated shoe and caliper disc brakes for the 600 frame, 800 frame, wound-rotor motors, AC frame AISE[1] mill motors, and short-time rated crane and hoist motors shall be as shown in Table 1-7-1. These brakes are floor-mounted and are of open construction. The brake lining width is 0.25 inch less than dimension C. Brake mounting tolerances, both horizontal and vertical with respect to the motor, shall be as indicated in Table 1-7-1.

[1] Refers to AISE Standards 1 and 1-A.

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Table 1-7-1

DIMENSIONS OF SHOE AND CALIPER DISC BRAKES FOR THE 600 FRAME AND 800 FRAME MOTORS AND AC FRAME AISE[1] MILL MOTORS AND NEMA FRAME SIZE CRANE AND HOIST MOTORS[2]

	Motor Frame	Wheel and disk Dimensions – Inches						Mounting Dimensions – Inches					
D/D1	Size	C	E	F	O	D3[3]	T	A	B	H	J	Z[4]	M
8/12	254X	3.25	2.5	1.8125	2.6875	6.50	0.50	3.25±.032	2.875 ±.032	0.6875	7±032	-	6.350
	256X	"	2.75	2.1875	3.3125	"	"	"	"	"	"	-	.7625
	284X	"	"	"	"	"	"	"	"	"	"	-	6.250
	286X	"	"	"	"	"	"	"	"	"	"	-	7.00
	324X	"	3	1.O625	???		"	"	"	"	"	-	8.00
	326X	"	"	"	"	"	"	"	"	"	"	-	8.00
	364X	"	3.675	2	4	"	"	"	"	"	"	-	9.00
	365X	"	"	"	"	"	"	"	"	"	"	-	9.00
	602 802	"	3.00	2.625	4.00	6.50	0.50	"	"	"	"	8.25	7.625
	603 803	"	3.50	2.125	"	"	"	"	"	"	"	9	8.50
	604 804	"	3.50	2.125	"	"	"	"	"	"	"	9.5	9.00
	606 806	"	4	1.625	"	"	"	"	"	"	"	9.5	10.00
	AC1 AC2	"	3	2.625	"	"	"	"	"	"	"	9.625	7.00
	AC4	"	"	"	"	"	"	"	"	"	"	10.125	8.00
	AC8	"	4	1.625	"	"	"	"	"	"	"	10.875	9.00
10/14	284X	3.75	2.75	2.625	3.75	6.50	0.50	4±.032	3.125 ±.032	0.6875	8.375 ±.032	-	-7.00
	286X	"	"	"	"	"	"	"	"	"	"	-	-7.00
	324X	"	"	"	"	"	"	"	"	"	"	-	-8.00
	326X	"	3	2.125	3.25	"	"	"	"	"	"	-	-8.00
	364X		3.675	1.875	3.675		"	"	"	"	"	-	9.00
	365X	"	"	"	"	"	"	"	"	"	"	-	9.00
	404X		3.875	1.875	3.875	"	"	"	"	"	"	-	10.00
	405X	"	"	"	"	"	"	"	"	"	"	-	10.00
	444X		4.25	1.5		"	"	"	"	"	"	-	11.00
	445X	"	"	"	"	"	"	"	"	"	"	-	11.00
	602 802		3	3.125	4.25	6.50	0.50	"	"	0.69	"	8.5	7.625
	603 803		3.50	2.625	"	"	"	"	"	"	"	9.25	8.50
	604 804	"	"	"	"	"	"	"	"	"	"	9.75	9.00
	606 806		4	2.125	"	"	"	"	"	"	"	9.75	10.00
	608		4.5	1.625	"	"	"	"	"	"	"	9.875	11.250
	AC1 AC2		3	3.125	"	"	"	"	"	"	"	9.875	7.000
	AC4	"	"	"	"	"	"	"	"	"	"	10.375	8.000
	AC8		4	2.125		"	"	"	"	"	"	10.875	9.000
	AC12	"	"	"	"	"	"	"	"	"	"	11.625	10.000

[1] Refers to AISE Standards 1 and 1A.

[2] Per NEMA MG 1-1998, Part 18. For unlisted NEMA frame motors, refer to MG 1, Part 4.

[3] This a restricted zone, which defines brake pad swept area (D1 - D3).

[4] Z Dimensions have not been established for wound-rotor motors. Refer to NEMA MG 1-1998, Part 18.

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Table 1-7-1 (Continued)

DIMENSIONS OF SHOE AND CALIPER DISC BRAKES FOR THE 600 FRAME AND 800 FRAME MOTORS AND AC FRAME AISE[1] MILL MOTORS AND NEMA FRAME SIZE CRANE AND HOIST MOTORS[2]

	Motor Frame	Wheel and disk Dimensions – Inches						Mounting Dimensions – Inches					
D/D1	Size	C	E	F	O	D3[3]	T	A	B	H	J	Z[4]	M
13/17	324X	5.75	3	3.75	4.5	9.00	0.75	5.25±.032	4.5±.032	0.8125	9.875±.045	-	8.000
	326X	"	"	"	"	"	"	"	"	"	"	-	8.000
	364X	"	3.675	4.3125	5.0625	"	"	"	"	"	"	-	9.000
	365X	"	"	"	"	"	"	"	"	"	"	-	9.00
	404X	"	3.875	3.125	4.125	"	"	"	"	"	"	-	10.000
	444X	"	"	"	"	"	"	"	"	"	"	-	11.000
	445X	"	4.25	2.50	3.875	"	"	"	"	"	"	-	11.000
	603 803	"	3.50	4.38	5.00	"	"	"	"	0.81	9.88	10.00	8.500
	604 804	"	"	"	"	"	"	"	"	"	"	10.50	9.000
	606 806	"	4.00	3.88	"	"	"	"	"	"	"	"	10.000
	608 808	"	4.50	3.75	5.38	"	"	"	"	"	"	11.00	11.250
	610 810	"	"	"	"	"	"	"	"	"	"	11.63	13.375
	612 812	"	5.00	3.25	"	"	"	"	"	"	"	12.13	14.750
	614 814	"	"	"	"	"	"	"	"	"	"	13.13	9.000
	AC8	"	4.00	3.88	5.00	"	"	"	"	"	"	11.63	10.000
	AC12	"	"	"	"	"	"	"	"	"	"	12.38	12.500
	AC18	"	4.50	3.75	5.38	"	"	"	"	"	"	14.69	14.500
	AC25 AC30	"	5.00	3.25	"	"	"	"	"	"	"	15.81	
16/21	404X	6.75	3.875	5.375	5.875	9.00	0.75	7.50±.032	5.375±.032	1.0625	13.25±.062	-	10.000
	405X	"	"	"	"	"	"	"	"	"	"	-	10.000
	444X	"	4.25	4.50	5.375	"	"	"	"	"	"	-	11.000
	445X	"	"	"	"	"	"	"	"	"	"	-	11.000
	606 806	"	4.00	5.88	6.50	"	"	"	5.38	1.06	12.13	12.00	10.000
	608 808	"	4.50	5.38	"	"	"	"	"	"	"	12.13	11.250
	610 810	"	"	"	"	"	"	"	"	"	"	12.75	12.250
	612 812	"	5.00	4.88	"	"	"	"	"	"	"	13.25	13.375
	614 814	"	"	"	"	"	"	"	"	"	"	14.25	14.750
	616 816	"	5.50	4.38	"	"	"	"	"	"	"	15.50	16.000
	AC18	"	4.50	5.38	"	"	"	"	"	"	"	15.47	12.500
	AC25 AC30	"	5.00	4.88	"	"	"	"	"	"	"	16.94	14.500
	AC40 AC50	"	"	"	"	"	"	"	"	"	"	18.50	17.000

[1] Refers to AISE Standards 1 and 1A.

[2] Per NEMA MG 1-1998, Part 18. For unlisted NEMA frame motors, refer to MG 1, Part 4.

[3] This a restricted zone, which defines brake pad swept area (D1 - D3).

[4] Z Dimensions have not been established for wound-rotor motors. Refer to NEMA MG 1-1998, Part 18.

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Table 1-7-1 (Continued)

DIMENSIONS OF SHOE AND CALIPER DISC BRAKES FOR THE 600 FRAME AND 800 FRAME MOTORS AND AC FRAME AISE[1] MILL MOTORS AND NEMA FRAME SIZE CRANE AND HOIST MOTORS[2]

	Motor Frame	Wheel and Disc Dimensions – Inches						Mounting Dimensions – Inches					
D/D1	Size	C	E	F	O	D3[3]	T	A	B	H	J	Z[4]	M
19/24	444X	8.75	4.25	5.5625	5.3125	12.6	1.00	9.25±.032	6.50±.032	1.0625	13.25±.062		11.000
	445X	"	"	"	"	"	"	"	"	"	"		11.000
	608 808	"	4.50	5.38	"	"	"	"	"	"	"	12.13	11.250
	610 810	"	"	"	"	"	"	"	"	"	"	12.75	12.250
	612 812	"	5.00	4.88	"	"	"	"	"	"	"	13.25	13.375
	614 814	"	"	"	"	"	"	"	"	"	"	14.25	14.750
	616 816	"	5.50	4.38	"	"	"	"	"	"	"	15.50	16.000
	AC18	"	4.50	5.38	"	"	"	"	"	"	"	15.47	12.500
	AC25 AC30	"	5.00	4.88	"	"	"	"	"	"	"	16.94	14.500
	AC40 AC50	"	"	"	"	"	"	"	"	"	"	18.50	17.000
23/29	612 812	11.25	5.00	8.88	8.25	14.00	1.00	11.75	8.00	1.31	15.88	15.00	13.375
	614 814	"	"	"	"	"	"	"	"	"	"	16.00	14.750
	616 816	"	5.50	8.38	"	"	"	"	"	"	"	17.25	16.000
	618 818	"	6.00	"	8.75	"	"	"	"	"	"	"	17.750
	620 820	"	6.75	8.63	9.75	"	"	"	"	"	"	18.25	20.875
	622 822	"	7.25	8.13	"	"	"	"	"	"	"	17.50	23.000
	624 824	"	9.25	6.13	"	"	"	"	"	"	"	18.25	24.000
	AC25 AC30	"	5.00	8.88	8.25	"	"	"	"	"	"	18.69	14.500
	AC40 AC50	"	"	"	"	"	"	"	"	"	"	20.25	17.000

[1] Refers to AISE Standards 1 and 1A.

[2] Per NEMA MG 1-1998, Part 18. For unlisted NEMA frame motors, refer to MG 1, Part 4.

[3] This a restricted zone which defines brake pad swept area (D1 - D3).

[4] Z Dimensions have not been established for wound-rotor motors. Refer to NEMA MG 1-1998, Part 18.

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Table 1-7-1 (Continued)
DIMENSIONS OF SHOE AND CALIPER DISC BRAKES FOR THE 600 FRAME AND 800 FRAME MOTORS AND AC FRAME AISE[1] MILL MOTORS AND NEMA FRAME SIZE CRANE AND HOIST MOTORS[2]

	Motor Frame	Wheel and Disc Dimensions – Inches						Mounting Dimensions – Inches					
-/34	614 814		5.00		10.25	16.00	1.50	13.25	8.75	1.56	19.00	17.25	14.750
	616 816		5.50		"	"	"	"	"	"	"	18.50	16.000
	618 818		6.00		"	"	"	"	"	"	"	18.00	17.750
	620 820		6.75		"	"	"	"	"	"	"	"	20.875
	622 822		725		10.75	"	"	"	"	"	"	17.75	23.000
	624 824		9.25		"	"	"	"	"	"	"	18.50	24.000
30/36	616 816	"	5.50	11.88	10.25	20.00	1.50	15.00	9.50	1.56	20.75	19.25	16.000
	618 818	"	6.00	11.38	"	"	"	"	"	"	"	18.75	17.750
	620 820	"	6.75	10.63	"	"	"	"	"	"	"	"	20.875
	622 822	"	7.25	"	10.75	"	"	"	"	"	"	18.50	23.000
	624 824	"	9.25	8.63	"	"	"	"	"	"	"	19.25	24.000

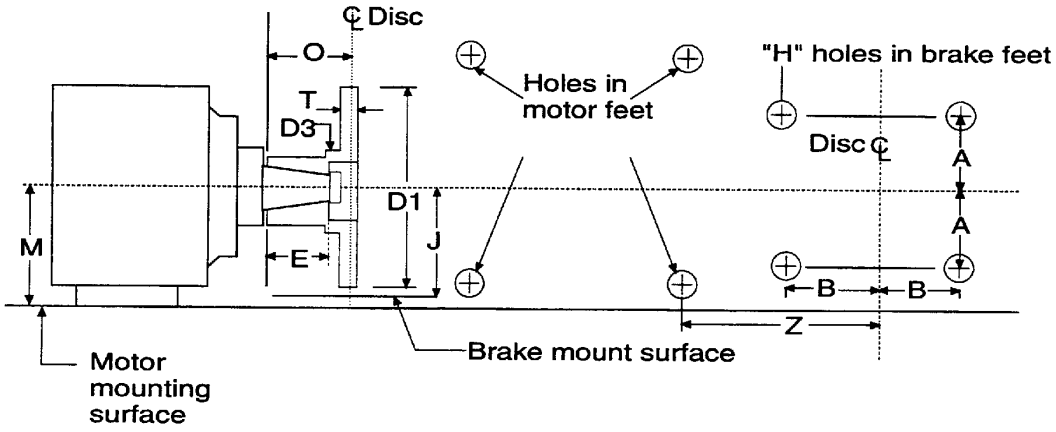


Figure 1-7-1
DISC BRAKE CONFIGURATION
(Refer to Table 1-7-1 to determine actual dimensions for the applicable frame size.)

[1] Refers to AISE Standards 1 and 1A.
[2] Per NEMA MG 1-1998, Part 18. For unlisted NEMA frame motors, refer to MG 1, Part 4.

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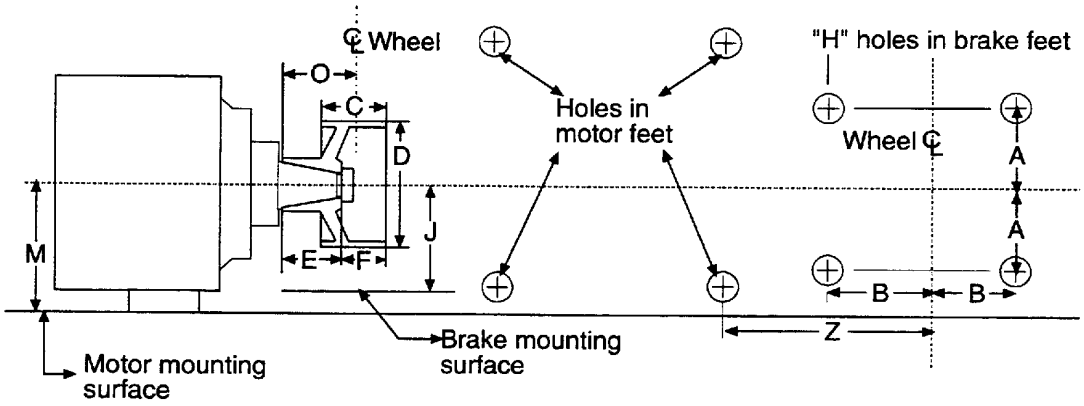


Figure 1-7-2
WHEEL AND SHOE BRAKE CONFIGURATION
(Refer to Table 1-7-1 to determine actual dimensions for the applicable frame size.)

7.2 Maximum Allowable Brake Wheel Unbalance

See Table 1-7-2.

Table 1-7-2
MAXIMUM ALLOWABLE BRAKE WHEEL UNBALANCE

Wheel Diameter	Maximum Static Unbalance in Ounce-Inches
8	4
10	5
13	6
16	10
19	19
23	32
30	60

7.3 Mounting Dimensions for Flat Plate Disc Brakes

Dimensions for Type FC face-mounted disc brakes on the end opposite the drive of alternating-current motors are shown in Table 1-7-3.

The disc brake mounting surface shall have bolt holes suitable for tabulated FBI screw sizes in the motor face. Such holes shall be located on diametrical lines 45 degrees from the vertical centerline of the brake.

Any hole or holes required by the disc brake for leads from the motor shall be provided within an available area defined by a circle having the diameter and radial location as shown. This provision shall not apply to disc brakes employing Type 7 enclosures. See ICS 6.

Standards for disc brake hub bore, keyway, and permissible length of motor shaft extension have not been developed.

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Table 1-7-3
DIMENSIONS FOR TYPE FC FACE-MOUNTED DISC BRAKES

Type FC Face Mounting Dimensions (See MG 1 Part 4)								Brake Data		
		FBF Hole			FBD Outside	FAK Outside	FBB	Area for Leads		
Frame Designation	FAJ Bolt Circle	Nr.	Tap Size	Min Depth	Diameter of Face	Diameter of Pilot	Depth of Pilot	Size	Diameter	DP Radial Location
*56C										
143TFC, 145TFC	5.875	4	3/8-16	0.56	6.50 NOM	4.50	0.16 MAX	A	0.41	2.81
182TFC, 184TFC	5.875	4	3/8-16	0.56	6.50 NOM	4.50	0.16 MAX	A	0.41	2.81
213TFC, 215TFC	7.250	4	1/2-13	0.75	9.00 MIN	8.50	0.25 MIN	B	0.62	3.81
254TFC, 256TFC	7.250	4	1/2-13	0.75	10.00 MIN	8.50	0.25 MIN	B	0.62	3.81
284TFC, 286TFC	9.000	4	1/2-13	0.75	11.25 MIN	10.50	0.25 MIN	C	0.62	4.50
324TFC, 326TFC	11.000	4	5/8-11	0.94	14.00 MIN	12.50	0.25 MIN	D	0.62	5.25

*Mounting dimensions are not standardized.

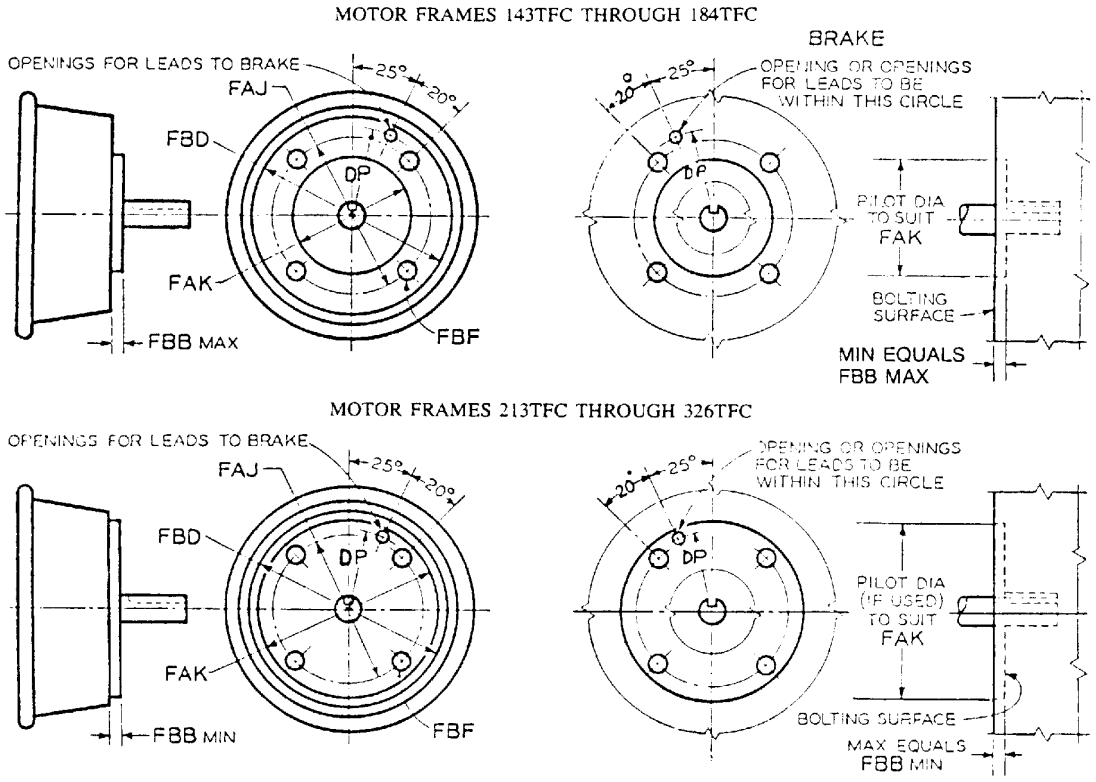


Figure 1-7-3
MOTOR FRAMES

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7.4 Enclosures

7.4.1 General

Enclosures for brakes shall comply with ICS 6.

7.4.2 Brake Coil Terminal Enclosures

Brake coil terminal enclosures, if supplied, shall be suitable for the environment specified and shall be in accordance with ICS 6.

7.4.3 Disc Brakes Employing Type 7D Enclosures

Disc brakes employing Type 7D enclosures (when the brake hub is supported, as it would be on the Type C motor face) for installation in hazardous locations shall conform to UL 674.

8 PERFORMANCE REQUIREMENTS AND TESTS

8.1 Range of Operating Voltage and Current

8.1.1 DC brakes operated by series coils shall release at 40 percent or less of rated motor current and shall set at 10 percent or less of rated motor current.

8.1.2 DC brakes operated by shunt coils shall release at 80 percent or less of rated voltage and shall operate satisfactorily at 110 percent of rated voltage.

8.1.3 AC brakes operated by shunt coils shall release at 85 percent of rated voltage and shall operate satisfactorily at 110 percent of rated voltage.

8.1.4 A brake that is operated by a shunt coil shall operate successfully at its minimum voltage when the temperature of the brake coil or of the operator is at the maximum temperature obtainable under its normal operating rating.

8.2 Temperature Rise of Coils

The operating coil of a shoe or disc brake shall not exceed the temperature rise specified in Clause 8.3 of ICS 1 when operated at rated voltage and duty cycle.

Exception: *When Class F coil insulation is incorporated, a temperature rise, determined by resistance, of 115°C above an ambient of 40°C, shall be allowed.*

8.3 Braking Torque

A new brake should equal or exceed the rated torque values in both a dynamic and static mode and at operating temperatures of the braking surfaces as defined by the manufacturer when installed, adjusted, and aligned per the manufacturer's instructions. For exceptions, see 5.3.2.

8.4 Dielectric Test

The operating coil shall withstand a power frequency dielectric test as specified in Clause 8.4 of ICS 1.

9 APPLICATION

9.1 Brake Energy Dissipation

9.1.1 One-Time Emergency Energy Dissipation

Starting from an operating temperature as defined by the manufacturer, a new shoe brake or caliper disc brake of the type indicated in 4.1 should be capable of the one-time emergency energy dissipation available from the manufacturer, without apparent damage to the brake, brake wheel, or brake disc.

9.1.2 Allowable Rate of Energy Dissipation

The rate of energy dissipation allowable, under operating duty cycle conditions, in order not to exceed the normal operating temperature of the brake, brake wheel, or brake disc can be obtained from the brake

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manufacturer if the manufacturer is provided with the brake size, number of brakes, maximum system Wk^2, running motor speed duty cycle sequence (accelerating time, running time, decelerating time, off time), and ambient temperature.

9.2 Shunt Brake Coil Control

9.2.1 Shunt brakes provided with series resistors, or with other voltage reduction control methods, are used to enable the use of one-hour torque ratings on continuously energized brakes. They may also be used to obtain quicker setting and releasing than the standard brake (forcing circuit).

9.2.2 A control system including a suitable rectifier and series resistors, or with other voltage reduction methods, is used to enable the use of one-hour torque ratings on continuously energized brakes. They may also be used to obtain quicker setting and releasing than the standard brake (forcing circuit).

9.3 Reaction Loads

CAUTION: Single caliper disc brakes cause a reaction load on the shaft of the equipment. Due consideration should be given to over-hung loads. Consideration should be given to all components of the drive to determine the applied brake torque value. Excessive applied braking torque can cause drive component damage.

Brake manufacturers should provide the distance from the center of the hub to the equivalent force actuation point on the face of the disc.

9.4 Rotating Speed

Due consideration should be given to the maximum rotating speed in each installation. Not all wheels and discs of any given size have the same allowable maximum rotating speed. See Table 1-5-1 for maximum drum speed. For maximum disc speed contact the disc manufacturer.

9.5 Disc Flatness and Runout

Acceptable tolerances on disc flatness and runout may be different for each brake manufacturer. Information should be obtained from the brake manufacturer.

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Part 11
RESISTORS AND RHEOSTATS

1 GENERAL

1.1 Scope

The standards in this section apply to resistors and rheostats used in power circuits of crane control.

1.2 Normative References

The definitions and standards of ICS 1, also apply to this part.

2 DEFINITIONS

For the purposes of this part, the following definitions apply:

class number: A number that identifies a resistor's current carrying capability under a specified duty cycle.

emergency dynamic braking: A resistor inserted into a travel circuit to decelerate the travel motion under controlled conditions after loss of power.

emergency dynamic lowering: A resistor inserted into a hoist circuit to lower a load under controlled conditions after loss of power.

primary resistor: A resistor inserted into the circuit supplying the primary winding of a motor for the purpose of limiting the inrush current to the motor.

resistor*: A device with the primary purpose of introducing resistance into an electric circuit.

rheostat*: An adjustable resistor so constructed that its resistance may be changed without opening the circuit in which it may be connected.

secondary resistor*: A resistor connected in the secondary of a wound-rotor motor for the purpose of controlling motor acceleration.

series-wound motor*: A commutator motor in which the field circuit and armature circuit are connected in series, i.e., the excitation is supplied by a winding or windings connected in series with or carrying a current proportional to that in the armature winding.

service dynamic braking: A resistor inserted into a travel circuit to decelerate the travel drive under normal operating conditions.

service dynamic lowering: A resistor inserted into a circuit during lowering to absorb regenerative energy under normal operating conditions.

shunt-wound motor*: A DC motor in which the field circuit and armature circuit are connected in parallel.

starting duty: A resistor application in a motor circuit where the resistor is removed from the circuit when the motor is operating at rated speed.

wound-rotor motor*: An induction motor in which a primary winding of one member (usually the stator) is connected to the alternating-current power source, and a secondary polyphase coil winding on the other member (usually the rotor) carries alternating current produced by electromagnetic induction.

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* Identical to ANSI/IEEE Standard 100, IEEE Standard Dictionary of Electrical and Electronic Terms.

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3 CLASSIFICATION

3.1 Resistors, General

Resistors shall be designated by class numbers in accordance with Tables 2-3-1 through 2-3-3.

Table 2-3-1
CLASS NUMBERS OF RESISTORS FOR TRAVEL CONTROLLERS

Approximate Percent of Full-load Current on First Point Starting from Rest with All Resistance in Circuit	15 Seconds ON 45 Seconds OFF	15 Seconds ON 30 Seconds OFF	15 Seconds ON 15 Seconds OFF	Continuous Duty
25	151P	161P	171P	91P
50	152P	162P	172P	92P
70	153P	163P	173P	93P
100	154P	164P	174P	94P

a. The class numbers apply to the complete resistor, but the duty cycles apply to the alternating resistor only.
b. When an armature shunt resistor is added, the class number shall include the suffix AS. For example, "Class 153P-AS" is a plugging resistor which includes an armature shunt and which will allow an initial inrush to 70 percent with the armature shunt open.
c. When a dynamic braking resistor is added, the class number shall include the suffix DB. For example, "Class 153P-DB."

Table 2-3-2
CLASS NUMBER OF RESISTORS FOR DYNAMIC LOWERING CRANE AND HOIST CONTROLLERS

Approximate Percent of Full-load Current on First Point Hoisting Starting from Rest without Armature Shunt	15 Seconds ON 45 Seconds OFF	15 Seconds ON 30 Seconds OFF	15 Seconds ON 15 Seconds OFF	Continuous Duty
50	152DL	162DL	172DL	92DL
70	153DL	163DL	173DL	93DL
100	154DL	164DL	174DL	94DL

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Table 2-3-3

CLASS NUMBERS OF RESISTORS FOR CONTINUOUS-DUTY SPEED -REGULATING SERVICES WITH DIRECT-CURRENT SHUNT MOTORS AND ALTERNATING-CURRENT WOUND-ROTOR MOTORS

	Class Numbers						
	Percent of Rated Motor Torque at Reduced Speed						
Percent Speed Reduction	**40**	**50**	**60**	**70**	**80**	**90**	**100**
5	405	505	605	705	805	905	1005
10	410	510	610	710	810	910	1010
15	415	515	615	715	815	915	1015
20	420	520	620	720	820	920	1020
25	425	525	625	725	825	925	1025
30	430	530	630	730	830	930	1030
35	435	535	635	735	835	935	1035
40	440	540	540	740	840	940	1040
45	445	545	645	745	845	945	1045
50	450	550	650	750	850	950	1050

a. The stability of the motor speed obtained by simple rheostatic control is dependent upon the stability of the load on the motor. The degree of instability is directly proportional to the amount of speed reduction. Variations in load have a greater proportional effect on the speed when the load is light. For these reasons, Table 2-3-3 has not been carried beyond a speed reduction of 50 percent and a load torque of 40 percent.

b. With a DC shunt motor, the percent of rated motor current, which is obtained at the reduced speed, is assumed to be the same as the percent of rated torque.

   1. With a DC series motor operating at less than 100 percent current, the percent of torque is less than the percent of current.

   2. With a wound-rotor motor and resistor in the motor circuit, the percentage of rated motor (secondary) current, which is obtained at the reduced speed, is assumed to be the same as the percent of rated torque.

4 CHARACTERISTICS AND RATINGS

4.1 Characteristics

4.1.1 Starting-Duty and Intermittent-Duty Resistors

Starting-duty and intermittent-duty resistors are primarily designed for use with motors that require an initial torque corresponding to the stated percent of full-load current on the first point and that require an average accelerating current (rms value) of 125 percent of full-load current.

4.1.2 Secondary-Resistor AC Controllers

With a secondary-resistor AC controller, the figures given in the tables for the percent of full-load current on the first point, starting from rest, apply to rotor (secondary) current and to torque. The primary current will, in general, be a higher percentage of the full-load current.

4.1.3 Starting-Duty and Intermittent-Duty Primary Resistors

Starting-duty and intermittent-duty primary resistors that are designed for use with squirrel-cage motors and that meet the test described in 9.2.2 are included in the tables.

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4.1.4 Starting Resistor for an Adjustable-Speed DC Motor

An adjustable-speed DC motor having a given horsepower rating, when started with full field generally requires a resistor having a larger ohmic value than does a constant-speed motor of the same horsepower rating. For this reason, the current on the first point and the capacity of the complete resistor of the same NEMA classification for an adjustable-speed motor may be different from that for a constant-speed motor of the same horsepower.

4.1.5 Continuous-Duty Resistor

A continuous-duty resistor for motor applications shall be so designed that the controller may be operated continuously on any point when the load follows its normal speed-torque curve, except that the motor must not be operated continuously below the minimum speed specified.

4.2 Ratings

Resistors shall be rated in ohms, amperes, and class of service.

5 PRODUCT INFORMATION, INSTALLATION, AND MAINTENANCE

5.1 Specific Maintenance Instructions

In order to assure proper equipment operation, a periodic maintenance program should be established. Maintenance instructions should be obtained from the manufacturer for incorporation into this program.

Resistors should be examined for evidence of overheating and all connections should be checked for proper tightness. Check to see that proper clearance is maintained to any combustible material near the resistor. The resistor mounting feet, any supporting structures, or both, should be checked for tightness of mounting hardware.

CAUTION—Disconnect all power sources to the resistors before attempting preventive maintenance.

5.2 Preventive Maintenance Guide

See ICS 1.3.

6 SERVICE AND STORAGE CONDITIONS

6.1 Normal Service Conditions

The service and storage conditions of ICS 1 apply for altitudes up to 6600 feet.

6.2 High Altitude Applications

For altitudes between 6600 feet (2000 meters) and 12,000 feet (3500 meters):

a. Continuous-duty resistors shall be derated to 75 percent of their normal power rating.
b. Starting-duty and Intermittent-duty resistors shall be applied on a duty cycle selected on the basis of the next higher “time-on” classification.

7 CONSTRUCTION

7.1 General

A resistor as used in electric circuits for purposes of operation, protection, or control commonly consists of an aggregation of units. Resistors, as commonly supplied, consist of wire, metal ribbon, metal stampings, cast metal, or carbon compounds supported by or embedded in an insulating medium. The insulating medium may enclose and support the resistance material as in the case of the porcelain tube type or the insulation may be provided only at the points of support, as in the case of heavy duty ribbon or cast iron grids mounted in metal frames.

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8 MARKING END CONNECTORS FOR RESISTOR UNITS

Where a resistor consists of two or more units that are to be connected, the use of the letters, i.e., “A” to “A,” “B” to “B,” etc., is recommended.

8.1 Direction of Rotation for Rheostats

8.1.1 A rheostat connected in series with the shunt field of a motor shall increase the speed of the motor when the operating handle is turned in a clockwise direction viewed from the operator's position.

8.1.2 A rheostat which is connected in series with the shunt field of a generator for the ultimate purpose of controlling the voltage of the generator shall increase the voltage of the generator when the operating handle is turned in a counterclockwise direction viewed from the operator's position.

8.1.3 A rheostat, or rheostats, applied to a DC adjustable-voltage drive shall increase the speed of the motor when the generator rheostat or the motor rheostat is turned in a clockwise direction viewed from the operator's position.

9 PERFORMANCE REQUIREMENTS AND TESTS

9.1 Temperature Rise Performance Criteria

Temperature rise limits are a performance requirement for resistors.

When a temperature rise test is made on a resistor, rheostat at the current values, duty cycle and elapsed time specified, the temperature rise above the ambient temperature and the methods of temperature measurement shall be in accordance with the following:

a. For bare resistive conductors, the temperature rise shall not exceed 375◦C, as measured by a thermocouple in contact with the resistive conductor.
b. For resistor units and rheostats that have an embedded resistive conductor, the temperature rise shall not exceed 300◦C, as measured by a thermocouple in contact with the surface of the embedding material.
c. The temperature rise of the issuing air shall not exceed 175◦C, as measured by a mercury thermometer at a distance of 1 inch from the enclosure.

9.2 Temperature Rise Tests

9.2.1 Resistors

9.2.1.1 Starting-Duty or Intermittent-Duty Resistor

When a temperature rise test is made on a starting-duty or intermittent-duty resistor without its motor, the resistor shall be connected to a voltage that will give the initial inrush current specified. In addition, the steps shall be cut out at equal intervals of time in the time-on period of the cycle specified, and the current shall be maintained at 125 percent of the full-load current for those steps through which 125 percent of full-load current can flow. The specified cycle shall be repeated for one hour.

9.2.1.2 Continuous-Duty Resistor

When a temperature rise test is made on a continuous-duty resistor without its motor, any tested step shall be subjected to 100 percent of the current for which the resistor is designed, and this value of current shall be maintained until the maximum temperatures are reached.

9.2.2 Primary Resistors for Squirrel-Cage Motors

When a temperature rise test is made on a general-purpose single-step primary starting resistor for a squirrel-cage motor, the resistor shall be tested with 300 percent of normal full-load current of the motor for which the resistor is designed, and the current shall be maintained for a duty cycle as indicated in the resistor classification. This cycle shall be repeated for one hour, after which, the temperature rise shall not exceed the limitations given in 8.1.

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9.3 Dynamic Braking Resistors

Dynamic braking resistor selection for ohmic value and thermal capability shall not exceed their rated temperature rise and should be designed to provide sufficient torque and sufficient mass and energy dissipating capability for the duty cycle.

The current time profile and duty cycle time on and off shall be defined based on the motor and load inertia and the load characteristics considering the effects of gravity, wind and process requirements, such as retardation torque during stopping.

9.4 Current-Carrying Ability

Continuous-duty resistors shall be capable of carrying continuously the current for which they are designed without exceeding the specified temperature rise. See 9.1.

10 APPLICATION

10.1 Current-Carrying Capacity of Resistor Wires for Motors

The connecting wires between the motor and its resistors shall have minimum current-carrying capacity and temperature rating in accordance with the National Electrical Code.

10.2 Resistor Application Table

Table 2-9-1 is intended as a guide in specifying and designing resistors. The classifications are those which experience has shown to be correct for the average installation. It is recognized that there will be exceptions. Table 2-9-1 applies to resistors composed of wire-wound units, metal ribbon, metal stampings, or cast metal. It is also applicable to unbreakable resistors provided that the time-on period does not exceed the values given in 4.1.3. Table 2-9-1 gives the basic class number. Where plugging, dynamic braking, armature shunt, or dynamic lowering functions are required, the appropriate suffix letters shown in Tables 2-3-1 and 2-3-2 should be added to the basic number.

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Table 2-9-1
APPLICATION GUIDE

Installation	Class No. of resistor	Installation	Class No. of resistor
By-product Coke Plants		Cranes— AISE TR 6	
Door machine	153	Hoist	162, 163-172,173
Leveler ram	153	Bridge or trolley with:	
Pusher bar	153	Sleeve bearings	163-173
Valve reversing machines	153	Roller bearings	162-172
Coal and Ore Bridges		Hoists	
Bridge	153	Winch	153
Closing	162	Mine slope	172
Holding	162	Mine vertical	162
Trolley	162, 163	Contractor's hoists	152
Coal Mines		Larry Cars	153
Car Hauls	162	Lift Bridges	152
Hoists		Steel Mills	
Slope	172	Charging machines	
Vertical	162	Bridge	153-163
Rotary car dumpers	153	Peel	153-163
Cranes—Service Classes A, B, and C*		Trolley	153-163
Hoist	152, 153	Cranes	*
Bridge or trolley with:		Ingot buggy	153
Sleeve bearings	153		
Roller bearings	152		
Cranes—Service Classes D, E, and F*			
Hoist	162, 163-172,173		
Bridge or trolley with:			
Sleeve bearings	163-173		
Roller bearings	162-172		

*Definition per CMAA 70.

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Annex A

Crane Information

The following crane information form is to be used as an aid to crane users and crane builders to help specify the crane electrical control equipment required.

It is not intended to be so complete as to cover all information required or pertinent, but as a guide to information frequently helpful in defining the required products to meet the crane user's needs.

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CRANE CONTROL INFORMATION FORM

(COMPLETE AS MUCH AS POSSIBLE OF PERTINENT SECTIONS)

TYPE OF CRANE _____ CRANE NUMBER _____(I.E., OVERHEAD, GANTRY, DOCKSIDE, ETC.)

CRANE SERVICE CLASS[1]*: A B C D E F AISE 6 (CIRCLE APPROPRIATE)

CRANE SERVICE (I.E., SCRAP HANDLING, LADLE, INCINERATOR GRAPPLE, ETC.)

DEFINE:

POWER SUPPLY DATA:

AC _____ DC _____

LINE VOLTAGE MAX:

AT CRANE

MIN:

FREQUENCY _____ ± _____ NO. PHASES:

DIESEL/GAS-ALTERNATOR

POWER MANAGEMENT:

POWER FACTOR CORRECTION REQUIRED

LINE IMPEDANCE

HARMONIC DISTORTION LIMITATION

HARMONIC LOAD ABSORPTION REQUIRED

POWER FEED TO CRANE:

COLLECTORS _____ SINGLE SHOE GRAVITY _____

FESTOON _____ DOUBLE SHOE PANAGRAPH _____

CABLE REEL _____

[1] Service Class as defined by CMAA specification #70-1994 and AISE specification #6, September 1996

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CRANE CONTROL INFORMATION (continued)

CRANE ENVIRONMENT

AMBIENT TEMPERATURE CRANE MAX _____ ^{o}F

MIN _____ ^{o}F

ALTITUDE _____ FEET ABOVE SEA LEVEL

INDOOR

OUTDOOR

DUST: HIGH

LOW

DUST CHARACTERISTIC: CONDUCTIVE

NONCONDUCTIVE

ABRASIVE

NONABRASIVE

OILY

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MOTOR DATA:					
1.	AMBIENT TEMPERATURE CORRECTION FACTOR USED IN SELECTING MOTOR AND/OR CONTROL (IF OTHER THAN 1.0).				
2.	SERVICE FACTOR USED IN SELECTING MOTOR AND/OR CONTROL (IF OTHER THAN 1.0).				
3.	MANUFACTURER	HOIST		TRAVEL	
		MAIN	AUXILIARY	TROLLEY	BRIDGE
* 4.	NO. OF MOTORS PER MOTION/CONFIGURATION (IF TWO OR MORE MOTORS - SERIES, PARALLEL, OR SERIES-PARALLEL)				
* 5.	TYPE (INDUSTRIAL OR MILL)				
6.	FRAME SIZE				
* 7.	HORSEPOWER - NAMEPLATE - NOMINAL				
* 8.	HORSEPOWER - MECHANICAL (CALCULATED FOR LOAD)				
* 9.	RATING (1/2, 1 HOUR, 2 HOUR, CONTINUOUS)				
* 10.	SPEED AT RATED LOAD (RPM)				
* 11.	FIELD WINDING (SERIES, SHUNT, COMPOUND)				
	A.FIELD WINDING VOLTAGE	/ /	/ /	/ /	/ /
	B.% COMPOUNDING	/ /	/ /	/ /	/ /
* 12.	TERMINAL VOLTAGE (DC ONLY)				
* 13.	IF AC DEFINED - SQUIRREL CAGE OR WOUND ROTOR?				
	A.TERMINAL VOLTAGE/NO. OF PHASES/FREQUENCY	/ /	/ /	/ /	/ /
	B.PRIMARY FULL LOAD CURRENT				
	C.SECONDARY VOLTAGE/SECONDARY CURRENT AT FULL LOAD - WOUND ROTOR	/	/	/	/
	D.SCALER VARIABLE FREQUENCY MOTOR MOTOR DESIGN - B C D HIGH EFFICIENCY				
	E.FLUX VECTOR MOTOR DESIGN - B C D HIGH EFFIENCY				
	F.FLUX VECTOR MOTOR ENCODER PULSES PER REVOLUTION				
* MUST HAVE INFORMATION					

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ELECTROMECHANICAL HOLDING BRAKE DATA:				
MANUFACTURER	HOIST		TRAVEL	
	MAIN	AUXILIARY	TROLLEY	BRIDGE
BRAKE SIZE / NUMBER OF BRAKES	/	/	/	/
WHEEL DIAMETER				
TORQUE RATING (LBS. FT.)				
TYPE OF BRAKE - ELECTRIC				
SHOE BRAKE (DRUM)				
AC SHUNT COIL				
DC SHUNT COIL - NON-FORCED				
DC SHUNT - FORCED				
DC SERIES COIL				
THRUSTER SHOE BRAKE				
CALIPER DISC BRAKE				
DISC BRAKE				
TYPE OF BRAKE - HYDRAULIC SHOE TYPE				
TYPE OF BRAKE - ELECTRO HYDRAULIC SHOE TYPE				
POWER ASSIST PACKAGE REQUIRED?				
NUMBER OF BRAKES				
BRAKE ENCLOSURE				
OPEN				
CLOSED				
BRAKE WHEEL MATERIAL				
NODULAR IRON				
STEEL				
OTHER				

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MECHANICAL DATA:		
WEIGHTS ARE: (CHECK ONE) ___ SHORT TON (2000 LBS.) ___ LONG TON (2240 LBS.)		
HOIST: (CHECK ONE) ___ SLEEVE BEARINGS ___ ANTI-FRICTION BEARINGS		
	HOIST	
	MAIN	AUXILIARY
A. TOTAL HOIST WEIGHT (INCLUDING LOAD, BLOCK, CABLES, SPREADER, GRAPPLE, MAGNET, ETC.) IN TONS		
B. LOAD WEIGHT ONLY (TONS) (IF BUCKET HOIST SPECIFY MIN/RATED/MAX LOAD WEIGHT)		
C. DESIRED FULL LOAD HOISTING SPEED (FEET PER MINUTE)		
D. MECHANICAL EFFICIENCY OR NO. OF GEAR REDUCTIONS/NO. OF ROPE REDUCTIONS		
E. ROPE REDUCTION BETWEEN DRUM AND HOOK (MECHANICAL ADVANTAGE)		
F. DRUM DIAMETER (INCHES)		
G. GEAR RATIO BETWEEN MOTOR AND DRUM		
TRAVEL: (CHECK ONE) ___ SLEEVE BEARINGS ___ ANTI-FRICTION BEARINGS		
	TRAVEL	
	TROLLEY	BRIDGE
A. LOAD WEIGHT (TONS) (NOT REQUIRED IF GIVEN IN ITEM B ABOVE)		
B. TROLLEY AND BRIDGE WEIGHTS WITHOUT LOAD (TONS)		
C. DESIRED SPEED (FEET PER MINUTE)		
D. WHEEL DIAMETER (INCHES)		
E. DRAW BAR PULL (LBS. PER TON) (NOT REQUIRED IF F AND K ARE GIVEN)		
F. DESIRED ACCELERATION RATE (FEET PER SEC. PER SEC.) (NOT REQUIRED IF E AND K ARE GIVEN)		
G. GEAR RATIO BETWEEN MOTOR AND WHEEL		
H. SERVICE FACTOR (KS)		
I. KA FACTOR (NOT REQUIRED IF E AND F ARE GIVEN) *		
J. COEFFICIENT OF WHEEL ADHESION (BETWEEN .1 TO .3)		
K. MECHANICAL EFFICIENCY		
L. TOTAL NO. OF WHEELS		
M. NO. OF WHEELS DRIVEN PER MOTOR		
N. SAIL AREA OF STRUCTURE (SQUARE FEET)		
O. WORST CASE WIND SPEED (FPM)		
P. SKEW CORRECTION REQUIRED?		
Q. SKEW DETECTION REQUIRED?		

* SOURCE CMAA SPECIFICATION #70-1994

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DUTY CYCLE: (IF REQUIRED)					
		HOIST		TRAVEL	
		MAIN	AUXILIARY	TROLLEY	BRIDGE
1.	INERTIA OF GEARS AND DRUM REFLECTED TO EACH MOTOR (WR^2)				
2.	NUMBER OF CYCLES PER HOUR				
3.	NUMBER OF BRAKES PER MOTOR				
4.	REQUIRED NUMBER OF LIFTS PER HOUR				
5.	AVERAGE LOAD PER LIFT				
6.	NUMBER OF FULL LOAD LIFTS PER HOUR				
7.	AVERAGE LIFT DISTANCE				
8.	MAX TIME SPENT IN FLOAT CONTROL ZONE IN SECONDS PER 5 MINUTE PERIOD				
9.	AVERAGE TRAVEL DISTANCE WITH LOAD				
10.	AVERAGE LOAD PER RETURN TRAVEL IN PERCENT OF RATED LOAD				

AUTOMATIC CRANE CONTROL			
FOR EACH MOTION THAT IS TO OPERATE IN AN AUTOMATIC MODE, PLEASE ENTER THE FOLLOWING INFORMATION:			
	HOIST	TROLLEY	BRIDGE
POSITIONING ACCURACY (INCHES)			
NUMBER OF DESTINATION LOCATIONS			
NUMBER OF DIFFERENT ORIGIN LOCATIONS			
NUMBER OF MOVES PER CYCLE			
AVERAGE MOVE LENGTH (FEET)			
NUMBER OF CYCLES PER HOUR			
SPAN OF STRUCTURE (FEET)			
SKEW CORRECTION (ACCURACY IN INCHES)			

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DIAGNOSTIC REQUIRED
DEFINE:

DATA LOGGING REQUIRED
DEFINE:

PLC REQUIRED
DEFINE:

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HOIST CONTROL		
	MAIN	AUXILIARY
TYPE		
CONTACTOR		
STATIC		
TORQUE REGULATED		
SPEED REGULATED		
METHOD OF CONTROLLING OVER HAULING LOAD:		
SINGLE SPEED SQUIRREL CAGE MOTOR		
MULTI-SPEED SQUIRREL CAGE MOTOR		
MECHANICAL LOAD BRAKE		
EDDY CURRENT BRAKE - AC WOUND ROTOR MOTOR		
COUNTER TORQUE - AC WOUND ROTOR MOTOR		
SINGLE PHASE AC PRIMARY BRAKING - AC WOUND ROTOR MOTOR		
DC INJECTION - AC WOUND ROTOR MOTOR		
DC INJECTION - SLIP RECOVERY AC WOUND ROTOR MOTOR		
DC DYNAMIC LOWERING (CONSTANT POTENTIAL)		
DC REGENERATIVE (VARIABLE VOLTAGE)		
AC VARIABLE FREQUENCY - DYNAMIC BRAKING		
AC VARIABLE FREQUENCY - REGENERATIVE BRAKING		
CONSTANT HOIST POWER SPEED RANGE REQUIRED (LIGHT LOAD - HIGH SPEED OPERATION) - DEFINE AS % OF FULL LOAD SPEED HOISTING AND LOWERING		
NUMBER OF SPEED POINTS		
STEPLESS - DEFINE MINIMUM SPEED AS A % OF RUNNING SPEED		
LOAD FLOAT - MAXIMUM TIME IN FLOAT IN MINUTES		
RESISTOR THERMAL CLASS (152, 162, 172, ETC.) *		
RESISTOR TORQUE 1ST SPEED POINT (161, 162, 163, 164, ETC.) *		
SHORT CIRCUIT PROTECTION IN MOTION CONTROL		
CIRCUIT BREAKERS		
FUSES		
ENCLOSURE REQUIRED TYPE:		
NEMA IA, III, IV, 12, ETC.		
OVER HOIST LIMIT SWITCHES CONTROL TYPE		
OVER HOIST LIMIT SWITCHES POWER TYPE		
OVER HOIST LIMIT SWITCHES POWER TYPE WITH EARLY OPEN CONTROL SWITCH **		
HOIST LOWERING LIMIT SWITCH		

* NEMA SPECIFICATION #11

** REQUIRED IN CERTAIN STATIC DRIVE SYSTEMS

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TRAVERSE MOTION CONTROL		
	TROLLEY	BRIDGE
TYPE		
CONTACT		
STATIC		
TORQUE REGULATED		
SPEED REGULATED		
NUMBER OF SPEED POINTS		
STEPLESS / % SPEED MINIMUM		
RESISTOR THERMAL CLASS (152, 162, 172, ETC.) *		
RESISTOR TORQUE 1ST STEP (152, 153, ETC.)		
RESISTOR DYNAMIC BRAKING		
SINGLE STEP		
TWO STEP		
SLOW DOWN LIMIT SWITCH REQUIRED		
END OF TRAVEL LIMIT SWITCH REQUIRED		

* NEMA SPECIFICATION #11

OPERATOR COMMAND TO MOTION CONTROL - COMMUNICATION METHOD				
	MAIN HOIST	AUXILIARY HOIST	TROLLEY	BRIDGE
PENDENT STATION				
MASTER SWITCH				
VERTICAL				
BENCH				
JOY STICK				
RADIO REMOTE WIDE BAND				
RADIO REMOTE NARROW BAND				
INFRARED				

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Supplement 1

SCOPE OF THE INDUSTRIAL CONTROL AND SYSTEMS SECTION

The NEMA standards publications for Industrial Control and Systems covers 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.

The 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, 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, 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, or automatically regulated, including semiconductor power converters and inverters 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

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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 converters and transducers
h. Programmable controllers
i. Functional elements of systems, such as:
    1. Operational amplifiers
    2. Computer elements
    3. Encoders
    4. Tape readers
    5. Sensors
    6. Man-machine interface devices
    7. Gauging equipment

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, 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, plugging switches, speed switches, and 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

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n. Terminal blocks of the molded barrier or sectional type and terminal strips used for the connection of conductors and 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, 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, and slasher drives

p. Programmable controllers and their accessories devices used for the supervision, 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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