

**ASA
C19.1
1959**
UDC 621.316.7

**AIEE
No. 15**

American Standard
for
INDUSTRIAL CONTROL APPARATUS

**Approved as American Standard by the
American Standards Association
Dec. 28, 1959**

(Revision of 1943 edition)

SPONSORS
AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS
NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION

Published by
AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS
33 West Thirty-ninth Street, New York 18, N. Y.



Documents
Document Sharing Hub

CONTENTS

Section	Page
05 Scope	5
10 Definitions	5
15 General Standards	5
20 Contactors	12
25 Resistors	15
30 Enclosures	18
35 Autotransformers and Reactors	20
40 Pushbuttons—Master Controllers—Accessories	21
45 Brakes	24
50 Alternating-Current General-Purpose Controllers	26
55 Control Centers	30
60 Direct-Current General-Purpose Controllers	32
65 Controllers for Steel Mill Service	34
70 Crane Service Classifications	37

ACKNOWLEDGMENT

The contributions of time, effort, and experience on the part of the members of ASA Sectional Committee C19 to the preparation of this edition of the American Standard for Industrial Control Apparatus is gratefully acknowledged by the sponsors.

The membership of the Sectional Committee at the time this material was prepared was:

P. B. Harwood, *Chairman*

H. B. Stoddard, *Secretary*

Organizations Represented

Representative

American Institute of Electrical
Engineers

P. B. Harwood
K. W. John
J. A. Cortelli (alternate)

Association of Iron and Steel
Engineers

H. H. Angel

Electric Light and Power Group

J. A. Heffernan
C. A. Paulus
A. T. Higgins (alternate)

National Electrical Manufacturers
Association

P. R. Goudy
G. W. Heumann
D. L. Pierce

National Machine Tool Builders
Association

L. Michelson

Underwriters Laboratories

R. H. Fries

U. S. Department of the Navy,
Bureau of Ships

Code 621

American Standard for **INDUSTRIAL CONTROL APPARATUS**

15.05—SCOPE

This Standard covers all of the following devices, whether electric, magnetic, mechanical or electronic, (except those 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 intended to function on commercial voltages of 750 volts or less direct current and 500 volts or less alternating current.

1. Contactors.
2. Drum switches.
3. Photoelectric relays.
4. Autotransformers used for starters.
5. Reactors, except those specifically intended for power generation and distribution equipment.
6. Rheostats used for starters.
7. Relays and timing devices used primarily with apparatus under the scope of these Standards.
8. Resistors used for starters.
9. Switch devices such as pushbutton switches, limit switches, etc., intended to be connected in control circuits of industrial control apparatus.
10. Switch devices having features intended primarily for the starting and the running protection of electric motors, except those used with domestic appliances.
11. Switch devices responsive to speed, temperature, pressure, vacuum, water-level or time-period variation and intended primarily for the control of motors, except those used with domestic appliances.
12. Resistance dimmers, reactor dimmers, and electronic dimmer systems. (Theater control boards providing for the control and dimming of circuits for theaters, schools, auditoriums, lodges, etc., are not included).
13. Electronic regulators for controlling power utilization apparatus.
14. Solenoids and magnets with frames and moving parts intended to perform some mechanical motion for industrial control applications.
15. Electromagnetic brakes.
16. Electronic follow-up and positioning controls.
17. Electronic inspection and gauging apparatus.

Industrial control equipment is limited to:

- a. Use with oil or air circuit breakers or contactors with interrupting ratings of 50,000 kva or less and for service voltages up to 5 kv.

- b. A combination of properly coordinated fuses and circuit breakers or contactors where interrupting capacity requirement does not exceed 150,000 kva at service voltages not exceeding 2500 volts, or where interrupting capacity required does not exceed 250,000 kva at service voltage greater than 2500 volts and not exceeding 5000 volts.

15.10—DEFINITIONS

For definitions applying to industrial control apparatus refer to ASA C42.25—1957. The title of this Standard is Definitions of Electrical Terms, Group 25, Industrial Control Equipment, and is published by the American Institute of Electrical Engineers.

15.15—GENERAL STANDARDS

15.15.00 Service Conditions

15.15.01 Temperature and Altitude

Control apparatus which conforms with this Standard shall be capable of carrying its rated load when:

1. The ambient temperature does not exceed 40C.
2. The altitude does not exceed 6000 feet.

15.15.02 Unusual Service Conditions

A. The use of apparatus at ambient temperatures higher than 40C or at altitudes greater than 6000 feet shall be considered as a special application.

B. Control apparatus which is designed for operation at altitudes above 6000 feet but not above 15,000 feet shall be derated as follows:

1. Continuous-duty resistors shall be derated to 75 percent of their normal power rating.
2. Intermittent- and starting-duty resistors shall be applied on a duty cycle selected on the basis of the next higher "time-on" classification.
3. A magnetic contactor shall be used to open the main-line circuit when manual or drum controllers are used.
4. Autotransformers and control-circuit transformers shall be derated to 75 percent of their normal kva rating.

C. Other unusual service conditions, where they exist, should be called to the manufacturer's attention since apparatus used in such

cases may require special construction or protection. Among such unusual conditions are:

1. Exposure to damaging fumes.
2. Operation in damp places.
3. Exposure to excessive dust.
4. Exposure to gritty or abrasive dust.
5. Exposure to steam.
6. Exposure to excessive oil vapor.
7. Exposure to salt air.
8. Exposure to vibration, shocks and tilting.
9. Exposure to explosive dust or gases.
10. Exposure to the weather or dripping water.

D. Apparatus which is intended for operation in tropical climates may be subject to unusual service conditions which, where they exist, should be called to the manufacturer's attention. Apparatus for use in such cases may require special construction or protection.

Service in the tropics involves a number of unusual service conditions, the incidence of which will change in different locations. It is not sufficient to specify that equipment should be suitable for service in the tropics. The specific service conditions encountered at a given location should be stated.

Unusual service conditions existing in tropical climates include:

1. Excessive ambient temperature.
2. Excessive and rapid changes in ambient temperature.
3. Excessive humidity.
4. Excessive dust in the atmosphere.
5. Exposure to salt air.
6. Exposure to corrosive atmosphere.
7. Attack by fungus.
8. Attack by insects (termites, etc.).
9. Attack by vermin (rats, lizards, snakes, etc.).

15.15.20 Rating Standards

15.15.21 Rating of Control Apparatus

In general, the rating of control apparatus shall be expressed in voltage, current, horsepower, kilowatts or other appropriate units.

15.15.22 Low-Voltage Ratings

Low-voltage ratings for control apparatus shall be:

1. Alternating-current multiphase—110, 220*, 440 and 550 volts.
2. Alternating-current single-phase—115 and 230 volts.

*Control apparatus rated and tested at 220 volts shall be considered adequate to take care of 208-volt alternating-current applications.

3. Direct-current—115, 230 and 550 volts.

Note—Standard voltages for resistance welding control higher than 230 volts shall be 460 and 575 volts.

15.15.23 Rating of a Controller

For the purpose of this Standard, the rating of a controller is based upon power governed and the duty service required. Unless specifically stated otherwise, standard ratings do not provide overload capacity.

15.15.24 Basis of Thermal Ratings

The thermal ratings of industrial control apparatus are based on an ambient temperature of 40C.

15.15.25 Interrupting Ability of Manual and Magnetic Controllers

Controllers shall be classified in accordance with their ability to interrupt currents, as follows:

CLASS A

Alternating-current air-break and oil-immersed manual or magnetic controllers for service on 600 volts or less and capable of interrupting operating overloads up to and including 10 times their normal motor rating but not short circuits or faults beyond operating overloads.

CLASS B

Direct-current air-break manual or magnetic controllers for service on 600 volts or less and capable of interrupting operating overloads but not short circuits or faults beyond operating overloads.

CLASS C

Alternating-current air-break and oil-immersed magnetic controllers for service on 600 volts or less and capable of interrupting short circuits or faults beyond operating overloads.

CLASS D

Direct-current, air-break manual or magnetic controllers for service on 600 volts or less, capable of interrupting short circuits or faults beyond operating overloads.

CLASS E

Alternating-current air-break and oil-immersed magnetic controllers for service on voltages from 2200 to 4600 volts, and capable of interrupting short circuits or faults beyond operating overloads.

Note—The majority of controllers are designed for interrupting operating overloads only and, unless it is specifically stated that a controller is of another class, it may be assumed to be either Class A or Class B.

In general, manual controllers are limited to 600 volts or less. A controller may be a combination of manually- and magnetically-operated components.

15.15.40 Testing Standards

15.15.41 Temperature Tests

A. Assembly of Apparatus

Control apparatus is an assembly of parts or devices which, when assembled to form a controller, meet applicable temperature-rise limitations of the parts or devices involved.

In calculating the over-all temperature rise of an enclosed controller, due allowance is made for the effect of the enclosure by adding to the temperature rise of the individual parts or devices in the open air the temperature rise of the air inside the enclosure.

B. Method of Temperature Determination

The temperature shall be determined in accordance with one of the following methods:

1. **Thermometer Method**—The temperature shall be determined by mercury or alcohol thermometers, by resistance thermometers, or by thermocouples, any of these instruments being applied to the hottest part of the apparatus accessible to mercury or alcohol thermometers.
2. **Resistance Method**—The temperature shall be determined by comparing the resistance of the winding at a temperature to be determined with the resistance at a known temperature.

C. Calculation of Coil Temperature

When the electric resistance of a copper winding at some reference temperature is known, the mean temperature may be determined by using the following formula:

$$T = \frac{R}{r} (234.5 + t) - 234.5$$

where:

- t = reference temperature in degrees C.
- r = resistance at reference temperature.
- R = observed resistance.
- T = temperature sought.

Note—This formula is derived from the experimentally determined relation between temperature and resistance of copper:

$$\frac{R}{r} = \frac{234.5 + T}{234.5 + t}$$

The temperature rise is the difference between the calculated temperature T and the temperature of the cooling medium at the time of test.

D. Ambient Temperature

1. **Value of Ambient Temperature During Tests**—The temperature test may be made at any ambient temperature, preferably not below 10C. It shall be assumed that the temperature rise is the same for all ambient temperatures between the limits of 10 and 40C.
2. **Placing of Thermometers**—The ambient temperature shall be measured by means of several thermometers placed at different points around the apparatus at a distance of 1 to 2 meters (3 to 6 feet) and protected from drafts and abnormal heat radiation. Thermometers shall be located in the path of the cooling medium.
3. **Mean Temperature**—The value to be adopted for the ambient temperature during a test is the mean of the readings of the thermometers (placed as specified in paragraph 2) taken at equal intervals of time during the last quarter of the duration of the test.

E. Altitude

For apparatus intended for operation at an altitude of 6000 feet or less, the temperature test shall be made at any altitude within this range, and no correction shall be applied to the observed temperature rise.

F. Covering of Glass Thermometers

The bulbs of glass thermometers used for taking temperatures shall be covered by felt pads cemented to the apparatus, by oil putty or by cotton waste.

The dimensions of felt pads for use with large apparatus shall be 4 cm by 5 cm by 3 mm thick (1.5 inch by 2 inches by $\frac{1}{8}$ inch thick). The use of smaller pads is permissible on small apparatus.

Note—The most suitable method of covering glass thermometers depends upon:

1. Whether the temperature is being observed during the progress of the test and whether the thermometer is subjected to moving air. In this case, the thermometer covering should be a good heat insulator since the principal purpose of the covering is to protect the thermometer bulb from the cooling air.
2. Whether the temperature is being observed during the test with the thermometer in still air or after the completion of the test run. In this case, the purpose of the thermometer covering is to improve the contact between the

thermometer bulb and the surface whose temperature is being measured.

G. Measurement of Temperature of the Device During Tests

The temperatures of all stationary parts shall be measured during the progress of the test. Temperatures of movable parts shall be taken during the test if practicable and, in any case, as soon after the completion of the test run as possible. When the temperature of a part is measured during the test, the temperature shall also be measured after the completion of the test run, and the highest figure obtained shall be used.

H. Duration of Test

When ratings require tests for very short periods or at very heavy loads, the specified rating may be replaced for test purposes by an equivalent periodic rating having a longer duration than that specified in paragraphs 1 and 2.

1. Continuous Rating—The temperature test shall be continued until the temperature rise has attained a steady final value or until sufficient evidence is available to show that the temperature rise would not exceed those specified in this Standard if the test were to be prolonged until the attainment of steady final values.
2. Periodic Rating—The temperature test shall be made in accordance with the periods of load and rest specified by the rating of the apparatus and shall be continued for the total time required by the rating. The test shall commence only when the windings and other parts of the

apparatus are within 5 C of the cooling-air temperature.

I. Enclosed Apparatus

If enclosures are provided as part of the apparatus, temperature tests shall be made with the enclosures in position. In the event that the manufacturer has made tests on duplicate apparatus, with and without enclosures, the test may be made without the enclosures, and a suitable correction shall be made in the results.

J. Made by Manufacturer

Control apparatus is ordinarily an assembly of standard parts or devices, and temperature tests are necessary only on those devices which embody new designs. Unless otherwise specified in this Standard, no temperature tests shall be made on control apparatus at the factory when the manufacturer can furnish records of temperature tests made in accordance with this Standard on duplicate devices.

15.15.60 Performance Standards

15.15.61 Temperature Rise of Coils

The temperature rise of coils above the ambient temperature, when the coils are tested in accordance with their ratings while mounted in the device with which they are intended to function, shall not exceed the values given in the following table. The temperature rise of shunt coils shall be determined by the resistance method. The temperature rise of series coils shall be determined by either the resistance or the thermometer method, whichever method is more practicable.

Limit of Temperature Rise Above Ambient Temperature, Degrees C (40C maximum)					
	*Method of Temperature Determination	Class of Insulation**			
		O	A	B	C
Insulated wire-wound coils	Thermometer	50	65	85	No limit specified
	Resistance	70	85	105	No limit specified
Single-layer series coils with uninsulated or enameled exposed surfaces	Thermometer	90***			No limit specified

*See 15.15.41.

**The temperature rises shown in the table are based on many years of satisfactory experience and many tests by the industrial control industry with coils designed to, and operated at, temperature rise limits as indicated.

***This applies to coils having a fiber or some other similar insulating sleeve or collar which insulates the coil from the frame or core.

15.15.62 Temperature Rise of Contacts

(Ambient temperature 40C maximum)

A. The temperature rise of contacts above the ambient temperature, when the contacts are tested in accordance with their ratings, shall not exceed the following:

1. Laminated contacts 50C.
2. Solid contacts 65C.

B. The temperature rise shall be determined by the thermometer method.

C. This Standard does not apply to contacts which are mounted directly on resistor elements.

15.15.63 Temperature Rise of Mechanical Parts

Mechanical parts which are not in contact with the insulation may reach such temperatures as will not be injurious in any respect.

15.15.64 Temperature Rise of Buses, etc.

(Ambient temperature 40C maximum)

The temperature rise of buses, connecting straps and terminals above the ambient temperature, when this equipment is tested in accordance with its rating, shall not exceed 50C. The temperature rise shall be determined by the thermometer method.

This Standard does not apply to connectors to a source of heat (for example resistors, thermal heaters and power-tube anodes).

15.15.65 Dielectric Tests

A. Where Made

Dielectric tests shall be made at the factory.

B. Test Voltages

1. Apparatus Rated at 600 Volts or Less—The test voltage shall be 1000 volts plus twice the rated voltage (see paragraph 3 for exception).
2. Apparatus Rated Above 600 Volts—The test voltage shall be 2000 volts plus $2\frac{1}{4}$ times the rated voltage.
Note—As a supplementary test, devices for outdoor use should be capable of withstanding for 10 seconds a dielectric wet test at 1000 volts plus twice the rated voltage.
3. If control apparatus includes devices which are properly applicable to this equipment under these Standards but which do not normally fall within the scope of the Industrial Control Standard and which require dielectric test voltages lower than those specified in paragraphs 1, 2 and 3, such devices shall be

disconnected and the remainder of the equipment subjected to the test. Typical examples are meters, instruments and pilot motors, lamp holders and snap switches.

4. Assembled Apparatus—Where a number of pieces of apparatus are assembled and tested as an electric unit, the test voltage for this unit shall be 15 percent lower than the lowest test voltage required on any of the individual pieces of apparatus.

C. Frequency and Wave Shape of Test Voltage

The frequency may be of any convenient value, and the shape of the wave shall be approximately a sine wave. Experience has shown that, with the comparatively low test voltages used for control apparatus, moderate variations in waveform or frequency have no appreciable influence on the effect of the test voltage.

D. Measurement of Test Voltage

The test voltage shall be measured by a voltmeter.

In measuring the voltage, the voltmeter should derive its voltage from the high-voltage circuit either directly or through an auxiliary ratio transformer, or by means of a voltmeter coil placed in the testing transformer.

E. Temperature at Which Tests are to be Made

Dielectric tests shall be made at the temperature attained under normal operation or at the temperature attained under the conditions of commercial testing.

F. Points of Application of Voltage

The test voltage shall be successively applied between each electric circuit and all other electric circuits and metal parts grounded.

G. Duration of Test

The test voltage for all switching and control apparatus shall be applied continuously for a period of 60 seconds. If the test voltage is 2500 volts or less, the apparatus or devices may be tested for one second with a test voltage which is 20 percent higher than the one-minute test voltage.

Autotransformers for motor starters shall be tested with the same voltage as the test voltage of the apparatus to which they are to be connected.

15.15.66 Durability of Control Apparatus

Parts or devices of control apparatus having moving parts or contacts which are subject to burning shall be capable of withstanding suitable endurance tests (depending upon the class of service) for mechanical durability or arc-rupturing ability or both. These tests shall be made by the manufacturer and shall not be required on duplicate devices.

15.15.70 Application

15.15.71 Application of Control-Circuit Transformers to Magnetic Controllers

When the control circuit of a magnetic controller is separable from the power circuit, it may be supplied from the secondary of a control-circuit transformer whose primary is connected to the power circuit. The following recommendations are intended as a guide in selecting the proper transformer so that the controller will operate in accordance with these Standards. For this purpose, certain information is required which cannot, in general, be derived from the ratings of either the controller or the transformer and special tests may be needed to obtain the required data.

A. Required Controller and Control-Circuit Data

1. Rated voltage and frequency of the controller.
2. Rated voltage of the operating coils. (The controller should be equipped with operating coils suitable for the intended control-circuit voltage).
3. Power factor of the connected-load current in the control circuit.
4. Maximum connected-load current in the control circuit. Where the connected load is a single contactor or relay coil, the maximum current is the current obtained when rated coil voltage is applied to the coil with the magnet in its open-gap position. Where two or more coils operate to close their magnets simultaneously, their several open-gap currents should be added. Other currents which are in the circuit at the same time should also be added. Vector addition is to be used. The largest of the currents obtained, taking into account all of the possible normal operations of the controller, is the maximum connected-load current.
5. Minimum connected-load current in the control circuit. Where the connected load is a single contactor or relay, the minimum current is the current in the operating coil when the magnet is sealed

and when rated coil voltage is applied to the coil terminals. The lowest value of the sum of the currents in the various controller devices for the various operating conditions is the minimum connected-load current.

6. Continuous-duty current in the control circuit. The continuous-duty current is the total current in the control circuit during continuous operation of the controller. It also includes additional currents such as for work lights. The continuous-duty current may also be calculated as the equivalent root-mean-square current where the contactors and other magnetic devices normally operate on a duty cycle.

B. Required Transformer Data

1. Rated primary voltage and frequency.
2. Rated secondary voltage.
3. Rated secondary current. This may be taken as the ratio of the rated volt-amperes divided by the rated secondary volts.
4. The turn ratio or the open-circuit secondary voltage with rated voltage applied to the primary.
5. Effective transformer short-circuit impedance referred to the secondary terminals. The effective impedance, for the purpose of this Standard, may be defined as:

$$Z = (KE) / (100 I)$$

where:

Z = effective impedance.

K = percent impedance voltage measured at the secondary terminals with the primary terminals short-circuited and with the coils at normal operating temperature.

E = rated secondary voltage.

I = rated secondary current.

The effective impedance should include both the resistance and reactance components and may be given in this form or in any equivalent form provided that both components of the impedance may be deduced from the given data.

C. Selection of Transformer*

*Since minor variations are to be expected in the margins by which individual sizes or types of contactors or other magnetic devices meet this Standard, there will be instances where advantage may be taken of any extra margin that may be present in the contactor or other magnetic devices to permit a corresponding relaxation in the requirements for the associated transformer. This may be done provided that the resulting combination will satisfy the standards of operation for the controller.

In selecting the transformer, the following principles should be observed:

1. The rated primary voltage of the transformer should not be less than the rated voltage of the controller. (It is satisfactory, for example, to apply a transformer having a primary rated at 440 volts or 460 volts to a controller rated at 440 volts).
2. The voltage ratio (rated primary voltage divided by rated secondary voltage) should be the same as the rated voltage of the controller† divided by the rated voltage of the operating coil.
3. The effective impedance of the transformer should be such that, with rated voltage† and frequency of the controller applied to the primary and with a load impedance corresponding to the power factor and maximum value of the load current connected to the secondary, the voltage at the secondary terminals should be not less than 95 percent of the rated voltage of the operating coils.
4. With rated voltage† and frequency of the controller applied to the primary and with the minimum value of the load connected to the secondary, the voltage at the secondary terminals should be not more than 105 percent of the rated voltage of the operating coil.
Note—This condition will be satisfied if, with rated voltage† of the controller applied to the primary, the open-circuit voltage at the secondary terminals is not more than 105 percent of the rated voltage of the operating coil.
5. The rated secondary current of the transformer should be not less than the continuous-duty current of the control circuit.

15.15.80 Miscellaneous

15.15.82 Overload Devices

Overload devices which de-energize magnets shall open the circuit of such magnets.

15.15.83 Control-Circuit Fuses

A. Control-circuit fuses are not included as part of general-purpose control apparatus rated 600 volts or less.

B. Control-circuit fuses shall be included on definite-purpose control apparatus rated 600 volts or less when so specified in this Standard.

†In items 2, 3 and 4, where a standard controller rated 220 volts is used on a 208-volt power system and the operating coils are rated 110 volts, the rated voltage of the controller should be taken as 208 volts instead of 220 volts.

C. Control-circuit fuses shall be included on all control apparatus rated 2200 volts and above and shall be installed in the secondary control circuits.

15.15.84 Time-Delay Undervoltage Devices

The time lag of time-delay undervoltage devices shall be adjustable to at least two seconds.

15.15.85 Motor Overload Protection

Motor overload protection shall function in response to overcurrent in either of two lines of a polyphase alternating-current circuit or in one line of a direct-current or single-phase alternating-current circuit.

15.15.86 Protection of Electron Tubes

A. Against Undervoltage

Electron tubes shall be protected against failure on restoration of voltage.

B. Against Premature Application of Anode Potential

Where necessary, a time-delay device shall be provided to protect tube cathodes against the premature application of anode potential during cathode heating.

C. Against Reduction or Failure of Cooling Medium

When cooled by a circulating cooling medium, electron tubes shall be protected against reduction or failure of a cooling medium.

15.15.87 Corrosion-Resistant Material

Iron, steel or other material having a suitable protective coating shall be considered as corrosion-resistant material.

15.15.88 Color Coding of Wiring

A. When wired with thermoplastic insulated wire and when color coding is specified, the color code for industrial control wiring shall be:

1. Line and load circuits, alternating- and direct-current power and motor circuits. . . . black or gray
2. Control circuits
 - a. Alternating-current. red
 - b. Direct-current. blue

B. Color coding, if specified, applies to the wiring between devices which are interconnected to form a control equipment and not to the wiring which is an integral part of the devices.

C. When solenoids, brakes and similar devices are employed as a part of the controller system, the panel wiring shall be color coded in the same manner as the power circuits.

However, the panel wiring shall be color coded in the same manner as the control circuit when solenoids, brakes and similar devices are:

1. Operated at line voltage and fused by control-circuit fuses, or are
2. Operated from a voltage lower than the line voltage.

D. The colors green and white have been recognized in equipment and distribution circuit work. Green usually indicates an equipment grounding conductor and white indicates the grounded neutral conductor of the circuit.

E. The shades of color specified in the foregoing paragraphs shall be identified in accordance with the following:

I C I			Munsell						TCCA Code (Nearest Match)	
Color	Coordinates X Y		Apparent Reflectance percent	Renotation			Book Notation			
Black										
Gray	L	.3170 .3301	31.8	3.5	GY	6.2/0.7	3.0	GY	6.1/0.6	70151
	D	.3048 .3105	18.0	5	PB	4.8/0.3	4.0	PB	4.8/0.2	70153
Red	L	.5298 .3126	11.2	5	R	3.9/11.2	5.0	R	3.7/11.5	70080
	D	.4569 .2991	6.2	3	R	2.9/6.7	4.5	R	2.5/7.5	70082
Blue	L	.2381 .2749	20.1	6.5	B	5.0/4.8	6.0	B	5.0/4.0	70142
	D	.2279 .2516	10.9	10	B	3.8/4.8	9.5	B	3.6/4.5	70176

ICI = International Commission on Illumination, TCCA = Textile Color Card Association, L = Light limit, D = Dark limit

15.15.89 Current-Carrying Capacity of Resistor Wires for Wound-Rotor Motors

The connecting wires between the rotor of a wound-rotor motor and its resistors shall have a minimum current-carrying capacity in accordance with the following table:

Resistor Class Number	Minimum Current-Carrying Capacity, Percent of Full-Load Secondary Current
101 to 106	35
111 to 116	35
131 to 136	45
141 to 146	55
151 to 156	65
161 to 166	75
171 to 176	85
91 to 96	110

15.15.90 Sizes of Terminal Connectors

Size of Controller	Size of Terminal Connector, AWG or Circular Mils
0	12
1	10
2	4
3	0
4	000
5	500,000
6	Two 500,000
7	Three 500,000
8	Four 500,000

Note—The values given in the foregoing table are based on the use of Type RH wire on ratings above 100 amperes.

15.20—CONTACTORS

15.20.21 Ratings of Low-Voltage Alternating-Current and Direct-Current Contactors

Size of Contactor	8-Hour Open Rating, amperes	
	A-C Contactors	D-C Contactors
0	20	—
1	30	25
2	50	50
3	100	100
4	150	150
5	300	300
6	600	600
7	900	900
8	1350	1350
9	2500	2500

The current ratings of enclosed low-voltage alternating-current contactors shall be 90 percent of the 8-hour open ratings.

The current ratings of contactors used on a two-phase three-wire circuit shall be based on the average of the currents in the three legs of the two-phase circuit.

15.20.22 Ratings of High-Voltage Alternating-Current Contactors

A. The 8-hour open ratings shall be 100, 200, and 400 amperes.

B. The voltage ratings shall be 2500 and 5000 volts.