UL 508

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Industrial Control Equipment

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Revisions: This Standard contains revisions through and including July 16, 1999.

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The new and/or revised requirements are substantially in accordance with UL's Bulletin(s) on this subject dated June 16, 1998. The bulletin(s) is now obsolete and may be discarded.

The new and revised requirements were originally published as revisions to the sixteenth edition of this UL Standard. These requirements are now reissued for, and renumbered in accordance with, the seventeenth edition of this UL Standard.

The revisions dated July 16, 1999 include an editorial change in title for UL 489, Standard for Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures.

As indicated on the title page (page1), this UL Standard for Safety has been adopted by the Department of Defense.

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New product submittals made prior to a specified future effective date will be judged under all of the requirements in this Standard including those requirements with a specified future effective date, unless the applicant specifically requests that the product be judged under the current requirements. However, if the applicant elects this option, it should be noted that compliance with all the requirements in this Standard will be required as a condition of continued Listing, Recognition, and Follow-Up Services after the effective date, and understanding of this should be signified in writing.

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The Department of Defense (DoD) has adopted UL 508 on June 5, 1989. The publication of revised pages or a new edition of this Standard will not invalidate the DoD adoption.

Revisions of this Standard will be made by issuing revised or additional pages bearing their date of issue. A UL Standard is current only if it incorporates the most recently adopted revisions, all of which are itemized on the transmittal notice that accompanies the latest set of revised requirements.

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APPENDIX A

Standards for Components A1

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FOREWORD

A. This Standard contains basic requirements for products covered by Underwriters Laboratories Inc. (UL) under its Follow-Up Service for this category within the limitations given below and in the Scope section of this Standard. These requirements are based upon sound engineering principles, research, records of tests and field experience, and an appreciation of the problems of manufacture, installation, and use derived from consultation with and information obtained from manufacturers, users, inspection authorities, and others having specialized experience. They are subject to revision as further experience and investigation may show is necessary or desirable.

B. The observance of the requirements of this Standard by a manufacturer is one of the conditions of the continued coverage of the manufacturer's product.

C. A product which complies with the text of this Standard will not necessarily be judged to comply with the Standard if, when examined and tested, it is found to have other features which impair the level of safety contemplated by these requirements.

D. A product employing materials or having forms of construction which conflict with specific requirements of the Standard cannot be judged to comply with the Standard. A product employing materials or having forms of construction not addressed by this Standard may be examined and tested according to the intent of the requirements and, if found to meet the intent of this Standard, may be judged to comply with the Standard.

E. UL, in performing its functions in accordance with its objectives, does not assume or undertake to discharge any responsibility of the manufacturer or any other party. The opinions and findings of UL represent its professional judgment given with due consideration to the necessary limitations of practical operation and state of the art at the time the Standard is processed. UL shall not be responsible to anyone for the use of or reliance upon this Standard by anyone. UL shall not incur any obligation or liability for damages, including consequential damages, arising out of or in connection with the use, interpretation of, or reliance upon this Standard.

F. Many tests required by the Standards of UL are inherently hazardous and adequate safeguards for personnel and property shall be employed in conducting such tests.

INTRODUCTION

1 Scope

1.1 These requirements cover industrial control devices, and devices accessory thereto, for starting, stopping, regulating, controlling, or protecting electric motors. These requirements also cover industrial control devices or systems that store or process information and are provided with an output motor control function(s). This equipment is for use in ordinary locations in accordance with the National Electrical Code, NFPA 70.

1.2 These requirements cover devices rated 1500 volts or less. Industrial control equipment covered by these requirements is intended for use in an ambient temperature of 0 – 40°C (32 – 104°F) unless specifically indicated for use in other conditions.

1.3 These requirements also cover industrial control panels that are assemblies of industrial control devices and other devices associated with the control of motor operated and related industrial equipment. Examples of devices in an industrial control panel are industrial control devices, disconnecting means, motor branch circuit protective devices, temperature control devices, and electrical instruments.

1.4 Examples of industrial control devices described in 1.1 are:

a) Manual, magnetic, and solid-state starters and controllers.

b) Thermal, magnetic, and solid-state overload relays.

c) Pushbutton stations, including selector switches and pilot lights.

d) Control circuit switches and relays.

e) Float, flow, pressure, and vacuum-operated switches.

f) Resistors and rheostats.

g) Proximity switches.

h) Time-delay relays and switches.

i) Resistors and rheostats intended for industrial heating and lighting, including those for motor generator fields.

j) Control devices intended for industrial heating and lighting.

k) Solid-state time-delay relays.

l) Programmable controllers.

m) Numerical control systems.

n) Lighting dimmer systems and controls.

o) Mercury-tube switches.

p) Definite purpose controllers.

q) Solid-state logic controllers.

r) Industrial microprocessor/computer systems.

s) Variable voltage autotransformer.

t) Motor starting autotransformer.

1.5 An industrial control panel for the control of metalworking machine tools or plastics machinery is judged on the basis of compliance with the applicable requirements of this standard as well as requirements in the Standard for Industrial Machinery, NFPA 79.

1.6 A fire pump controller is judged on the basis of compliance with the applicable requirements in this standard and additional requirements in the Standard for Centrifugal Fire Pumps, NFPA 20.

1.7 An adjustable-speed drive and accessories or modules for use with an adjustable-speed drive are covered by the Standard for Power Conversion Equipment, UL 508C.

1.8 Equipment intended for use in hazardous locations as defined by the National Electrical Code, NFPA 70, are covered by the Standard for Industrial Control Equipment for Use in Hazardous (Classified) Locations, UL 698.

1.9 Devices that regulate temperature and/or control refrigeration equipment are covered by the Standard for Temperature-Indicating and -Regulating Equipment, UL 873, and other applicable standards.

1.10 Electrical instruments are covered by the Standard for Electrical Analog Instruments– Panel Board Types, UL 1437.

1.11 A product that contains features, characteristics, components, materials, or systems new or different from those covered by the requirements in this standard, and that involves a risk of fire, electric shock, or injury to persons shall be evaluated using the appropriate additional component and end-product requirements as determined necessary to maintain the acceptable level of safety as originally anticipated by the intent of this standard. A product whose features, characteristics, components, materials, or systems conflict with specific requirements or provisions of this standard cannot be judged to comply with this standard. Where considered appropriate, revision of requirements shall be proposed and adopted in conformance with the methods employed for development, revision, and implementation of this standard.

2 Glossary

2.1 For the purpose of this standard, the following definitions apply.

2.2 AMBIENT TEMPERATURE – The temperature of the air medium into which the heat of the equipment is dissipated. See 43.15.

2.2.1 AMBIENT TEMPERATURE RATING– A rating assigned to equipment that refers to the maximum ambient temperature of the room or space outside of the device enclosure or intended enclosure. See 43.16.

2.2.1 added July 16, 1999

2.3 CLOSED-OPEN OPERATION – An operation of closing the test device on the circuit. The letters ″CO″ signify this operation.

2.4 COMBINATION CONTROLLER – An open or enclosed device containing both a magnetic or solid-state controller and a disconnecting means. The controller may or may not contain overload protection, short circuit protection, or both. Where an individual controller is enclosed, it includes an external means for operating the disconnecting means. A combination controller may be self-protected.

2.5 COMBINATION MOTOR CONTROLLER – A combination controller intended for motor service. In addition, where an individual controller is enclosed, it includes means for locking the disconnecting device in the ″OFF″ position.

2.5.1 COMPONENT FOR GROUP INSTALLATION– A motor control, overload relay, or other switching device evaluated for use in group installation. See 2.11.1.

2.5.1 added July 16, 1999

2.6 CONTACTOR – A two-state (ON-OFF) device for repeatedly establishing and interrupting an electric power circuit. Interruption is obtained by introducing a gap or a very large impedance.

2.7 CONTROL CIRCUIT – A circuit that carries the electric signals directing the performance of a controller, but which does not carry the main power circuit (see IEEE Standards Dictionary of Electrical and Electronic Terms). A control circuit is generally limited to 15 amperes.

2.8 CONTROLLER – A device or group of devices that serves to govern, in some predetermined manner, the electric power delivered to the apparatus to which it is connected.

2.9 END-OF-LINE ENCLOSURE – An enclosure that is intended to be connected at the end of a run of conduit.

2.10 GENERAL PURPOSE RATING – This term is synonymous with ″General Use Rating.″

2.11 GENERAL USE RATING – A rating expressed in volts and amperes assigned to a device that is intended to control:

a) A load with a continuous or inrush ampere rating not exceeding the ampere rating of the device;

b) If AC rated, a load that has a power factor of 0.75 to 0.80 (inductive); and

c) If DC rated, a load that is resistive (noninductive).

2.11.1 GROUP INSTALLATION– A motor branch circuit for two or more motors, or one or more motors with other loads and protected by a circuit breaker or a single set of fuses.

Added 2.11.1 effective July 16, 2001

2.12 ISOLATED SECONDARY CIRCUIT – A circuit derived from an isolating source (such as a transformer, optical isolator, limiting impedance or electro-mechanical relay) and having no direct connection back to the primary circuit (other than through the grounding means). A secondary circuit that has a direct connection back to the primary circuit is considered part of the primary circuit.

2.12.1 MANUAL CONTROLLER– A hand-operated switching device whose contacts are controlled by the position of a mechanical actuator.

2.12.1 added July 16, 1999

2.12.2 MANUAL CONTROLLER WITH INSTANTANEOUS TRIP– A manual controller provided with an instantaneous trip element for short circuit protection only and optionally provided with an overload relay.

2.12.2 added July 16, 1999

2.13 MOTOR CONTROL DEVICE – Any product or equipment rated in horsepower and/or full load-locked rotor current capable of interrupting the maximum operating overload current of a motor of the same horsepower or full load-locked rotor current rating as the product or equipment at the rated voltage. Such devices may include, but is not limited to, contactors, controllers, starters, and switches.

2.14 NON-COMBINATION MOTOR CONTROLLERS – Motor control devices of the non-combination type are for use with separate protective devices, such as fuses or inverse-time circuit breakers, installed in the supply side of the motor control device.

2.15 OPEN OPERATION – An operation of closing the circuit on the test device. The letter ″O″ signifies this operation.

2.16 PILOT DUTY – The rating assigned to a relay or switch that controls the coil of another relay or switch.

2.17 POLE LEAST LIKELY TO STRIKE GROUND – A pole that is referenced to ground or by virtue of its position or potential or both relative to other poles of the device to be less likely than any other to strike ground. In a three pole device, this pole would usually be the middle pole. It is possible for several poles to be equally least likely to strike to ground. In this case any may be used for the test.

2.18 POLLUTION DEGREE 1 – No pollution or only dry, nonconductive pollution occurs. The pollution has no influence.

2.19 POLLUTION DEGREE 2 – Normally, only nonconductive pollution occurs; however, temporary conductivity caused by condensation may be expected.

2.20 POLLUTION DEGREE 3 – Conductive pollution occurs, or dry, nonconductive pollution occurs that becomes conductive due to condensation that is expected.

2.21 PRIMARY CIRCUIT – A circuit in which the wiring and components are conductively connected to the branch circuit.

2.22 RECOVERY VOLTAGE – The voltage impressed upon the equipment under test after a circuit is cleared.

2.23 STARTER – A form of controller that includes the switching means necessary to start and stop the connected load in combination with suitable overload protection.

2.23.1 SURROUNDING AIR TEMPERATURE RATING– A rating assigned to open type equipment that refers to the maximum ambient temperature of air immediately surrounding the equipment inside of the ultimate enclosure. See 43.16.

2.23.1 added July 16, 1999

2.24 SWITCH – A device for opening and closing, and for changing the connections of a circuit. A switch is understood to be manually-operated, unless otherwise stated.

2.25 TRANSIENT SUPPRESSIVE DEVICE – A component or assembly that limits the transient voltage such as an overvoltage protective device, a transformer with isolated windings, or a damping impedance suitably located.

3 Units of Measurement

3.1 If a value for measurement is followed by a value in other units in parentheses, the second value may be only approximate. The first stated value is the requirement.

4 Components

4.1 Except as indicated in 4.2, a component of a product covered by this standard shall comply with the requirements for that component. See Appendix A for a list of standards covering components generally used in the products covered by this standard.

4.2 A component need not comply with a specific requirement that:

a) Involves a feature or characteristic not needed in the application of the component in the product covered by this standard, or

b) Is superseded by a requirement in this standard.

4.3 A component shall be used in accordance with its recognized rating established for the intended conditions of use.

4.4 Specific components are recognized as being incomplete in construction features or restricted in performance capabilities. Such components are intended for use only under limited conditions, such as certain temperatures not exceeding specified limits, and shall be used only under those specific conditions for which they have been recognized.

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5 Installation and Operation Instructions

5.1 Literature intended to accompany a product, such as installation, rating, operation, and user-maintenance instructions or manuals shall be reviewed in the investigation of the product if the safe use of the product is dependent on the instructions. Since the literature is to be reviewed in the examination and test of the product, a draft copy of the literature may be used instead of a printed copy.

PART I – ALL EQUIPMENT

ENCLOSURE CONSTRUCTION

6 Frames and Enclosure

6.1 General

6.1.1 An enclosure of industrial control equipment shall be constructed and assembled so that it will have the strength and rigidity necessary to resist the abuses to which it is likely to be subjected, without total or partial collapse resulting in a risk of fire, electric shock, or injury to persons due to reduction of spacings, loosening or displacement of parts, or other serious defects.

6.1.2 Industrial controls with incomplete or partial enclosures are considered as open devices with respect to the performance requirements in this standard.

6.1.3 An enclosure shall be constructed so as to reduce the risk of unintentional contact with enclosed electrical devices, and to provide internal devices with protection from specified external conditions.

6.2 Cast metal

6.2.1 A cast-metal enclosure shall be at least 1/8 inch (3.2 mm) thick at every point, more than 1/8 inch thick at reinforcing ribs and door edges, and at least 1/4 inch (6.4 mm) thick at tapped holes for conduit.

Exception: Other than at plain or threaded conduit holes, malleable iron and die-cast or permanent mold cast aluminum, brass, bronze, or zinc shall be

a) At least 3/32 inch (2.4 mm) thick for an area greater than 24 square inches (155 cm^2) or having any dimension more than 6 inches (152 mm) and

b) At least 1/16 inch (1.6 mm) thick for an area of 24 square inches or less having no dimension more than 6 inches. The area considered may be bounded by reinforcing ribs subdividing a larger area.

6.3 Sheet metal

6.3.1 The thickness of a sheet-metal enclosure shall not be less than that specified in Tables 6.1 and 6.2, except that at points to which a wiring system is to be connected, uncoated steel shall be at least 0.032 inch (0.81 mm) thick, zinc-coated steel at least 0.034 inch (0.86 mm) thick, and nonferrous metal at least 0.045 inch (1.14 mm) thick.

Exception: Enclosure thickness at points other than where a wiring system is to be connected need not comply with these requirements if the enclosure complies with the requirements in Sections 28 and 29 of the Standard for Enclosures for Electrical Equipment, UL 50.

6.3.2 Tables 6.1 and 6.2 are based on a uniform deflection of the enclosure surface for any given load concentrated at the center of the surface regardless of metal thickness.

Table 6.1
Thickness of sheet metal for enclosures – carbon steel or stainless steel

Without supporting frame[a]				With supporting frame or equivalent reinforcement[a]				Minimum acceptable thickness, Uncoated	
Maximum width[b]		Maximum length[c]		Maximum width[b]		Maximum length			
Inches	(cm)	Inches	(cm)	Inches	(cm)	Inches	(cm)	Inches	(mm)
4.0	(10.2)	Not limited		6.25	(15.9)	Not limited		0.020[d]	(0.51)
4.75	(12.1)	5.75	(14.6)	6.75	(17.1)	8.25	(21.0)		
6.0	(15.2)	Not limited		9.5	(24.1)	Not limited		0.026[d]	(0.66)
7.0	(17.8)	8.75	(22.2)	10.0	(25.4)	12.5	(31.8)		
8.0	(20.3)	Not limited		12.0	(30.5)	Not limited		0.032	(0.81)
9.0	(22.9)	11.5	(29.2)	13.0	(33.0)	16.0	(40.6)		
12.5	(31.8)	Not limited		19.5	(49.5)	Not limited		0.042	(1.07)
14.0	(35.6)	18.0	(45.7)	21.0	(53.3)	25.0	(63.5)		
18.0	(45.7)	Not limited		27.0	(68.6)	Not limited		0.053	(1.35)
20.0	(50.8)	25.0	(63.5)	29.0	(73.7)	36.0	(91.4)		
22.0	(55.9)	Not limited		33.0	(83.8)	Not limited		0.060	(1.52)
25.0	(63.5)	31.0	(78.7)	35.0	(88.9)	43.0	(109.2)		
25.0	(63.5)	Not limited		39.0	(99.1)	Not limited		0.067	(1.70)
29.0	(73.7)	36.0	(91.4)	41.0	(104.1)	51.0	(129.5)		
33.0	(83.8)	Not limited		51.0	(129.5)	Not limited		0.080	(2.03)
38.0	(96.5)	47.0	(119.4)	54.0	(137.2)	66.0	(167.6)		
42.0	(106.7)	Not limited		64.0	(162.6)	Not limited		0.093	(2.36)
47.0	(119.4)	59.0	(149.9)	68.0	(172.7)	84.0	(213.4)		
52.0	(132.1)	Not limited		80.0	(203.2)	Not limited		0.108	(2.74)
60.0	(152.4)	74.0	(188.0)	84.0	(213.4)	103.0	(261.6)		
63.0	(160.0)	Not limited		97.0	(246.4)	Not limited		0.123	(3.12)
73.0	(185.4)	90.0	(228.6)	103.0	(261.6)	127.0	(322.6)		

[a] See 6.3.3.

[b] The width is the smaller dimension of a rectangular piece of sheet metal that is part of an enclosure. Adjacent surfaces of an enclosure may have supports in common and be made of a single sheet.

[c] Not limited applies only if the edge of the surface is flanged at least 1/2 inch (12.7 mm) or fastened to adjacent surfaces not normally removed in use.

[d] Sheet steel for an enclosure intended for outdoor use – raintight or rainproof – shall not be less than 0.032 inch thick.

Table 6.2
Thickness of sheet metal for electrical enclosures – aluminum, copper, or brass

Without supporting frame[a]				With supporting frame or equivalent reinforcement[a]				Minimum acceptable thickness,	
Maximum width[b]		Maximum length[c]		Maximum width[b]		Maximum length			
Inches	(cm)	Inches	(cm)	Inches	(cm)	Inches	(cm)	Inches	(mm)
3.0	(7.6)	Not limited		7.0	(17.8)	Not limited		0.023[d]	(0.58)
3.5	(8.9)	4.0	(10.2)	8.5	(21.6)	9.5	(24.1)		
4.0	(10.2)	Not limited		10.0	(25.4)	Not limited		0.029	(0.74)
5.0	(12.7)	6.0	(15.2)	10.5	(26.7)	13.5	(34.3)		
6.0	(15.2)	Not limited		14.0	(35.6)	Not limited		0.036	(0.91)
6.5	(16.5)	8.0	(20.3)	15.0	(38.1)	18.0	(45.7)		
8.0	(20.3)	Not limited		19.0	(48.3)	Not limited		0.045	(1.14)
9.5	(24.1)	11.5	(29.2)	21.0	(53.3)	25.0	(63.5)		
12.0	(30.5)	Not limited		28.0	(71.1)	Not limited		0.058	(1.47)
14.0	(35.6)	16.0	(40.6)	30.0	(76.2)	37.0	(94.0)		
18.0	(45.7)	Not limited		42.0	(106.7)	Not limited		0.075	(1.91)
20.0	(50.8)	25.0	(63.5)	45.0	(114.3)	55.0	(139.7)		
25.0	(63.5)	Not limited		60.0	(152.4)	Not limited		0.095	(2.41)
29.0	(73.7)	36.0	(91.4)	64.0	(162.6)	78.0	(198.1)		
37.0	(94.0)	Not limited		87.0	(221.0)	Not limited		0.122	(3.10)
42.0	(106.7)	53.0	(134.6)	93.0	(236.2)	114.0	(289.6)		
52.0	(132.1)	Not limited		123.0	(312.4)	Not limited		0.153	(3.89)
60.0	(152.4)	74.0	(188.0)	130.0	(330.2)	160.0	(406.4)		

[a] See 6.3.3.

[b] The width is the smaller dimension of a rectangular piece of sheet metal that is part of an enclosure. Adjacent surfaces of an enclosure may have supports in common and be made of a single sheet.

[c] Not limited applies only if the edge of the surface is flanged at least 1/2 inch (12.7 mm) or fastened to adjacent surfaces not normally removed in use.

[d] Sheet copper, brass, or aluminum for an enclosure intended for outdoor use – raintight or rainproof – shall not be less than 0.029 inch (0.74 mm) thick.

6.3.3 With reference to Tables 6.1 and 6.2, a supporting frame is a structure of angle or channel or folded rigid section of sheet metal that is rigidly attached to and has essentially the same outside dimensions as the enclosure surface and that has sufficient torsional rigidity to resist the bending moments that may be applied by the enclosure surface when it is deflected. A structure that is as rigid as one built with a frame of angles or channels is considered to have equivalent reinforcing. Constructions considered to be without supporting frame include:

a) A single sheet with single formed flanges – formed edges;

b) A single sheet that is corrugated or ribbed;

c) An enclosure surface loosely attached to a frame, for example, with spring clips; and

d) An enclosure surface having an unsupported edge.

6.4 Doors and covers

6.4.1 A part of an enclosure, such as a door or a cover, shall be provided with a means – such as latches, locks, interlocks, or screws – for firmly securing it in place.

Exception: A snap-on cover that complies with the requirements in Section 9 need not have additional securing means.

6.4.2 An enclosure cover shall be hinged if it gives access to a fuse or any other overload-protective device that requires renewal, or if it is necessary to open the cover in connection with the normal operation of the device.

Exception: A hinged cover is not required for an enclosure:

a) To which access is required only in the event of burnout of a current element or the like on short circuit;

b) In which the only fuse enclosed is a control-circuit fuse, if the fuse and control-circuit load – other than a fixed control-circuit load, such as a pilot lamp – are within the same enclosure; or

c) In which a means is provided for resetting all overload-protective devices from outside the enclosure, or kits are available to provide a means for resetting all overload-protective devices from outside the enclosure and a marking is provided in accordance with Details, Section 66.

6.4.3 Other than as noted in 6.4.4, a hinged cover provided in accordance with the requirement in 6.4.2 shall be provided with a snap latch or a captive multiturn or partial-turn fastener. Such securing means shall be located or used in multiple so as to hold the cover closed over its entire length. A captive fastener shall be operable by hand or by a simple hand tool such as a screwdriver.

6.4.4 A door more than 48 inches (1.2 m) long on the hinged side shall be provided with one of the following:

a) A multipoint latch operated by a single knob or handle;

b) Two or more snap latches or captive fasteners; or

c) One knob-operated latch and one snap latch or captive fastener.

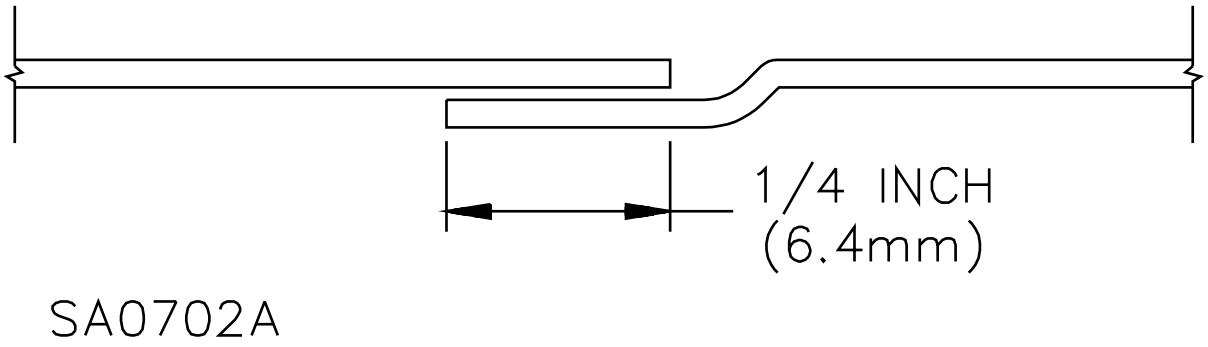
6.4.5 A hinged cover enclosure that is not required to comply with 6.4.2 may use noncaptive fasteners.

6.4.6 A door giving access to a fuse or any portion of a circuit breaker other than the operating handle shall shut closely against a 1/4-inch (6.4-mm) rabbet as illustrated in Figure 6.1 or the equivalent.

6.4.7 A cover giving access to a fuse or any position of a circuit breaker other than the operating handle shall have flanges for the full length of the four edges. Flanges on a cover shall fit closely with the outside walls of the enclosure, and shall comply with Figure 6.2 and Table 6.3. An acceptable combination of flange and rabbet may be used.

Exception No. 1: The flange width may be less than that specified if the construction complies with the Deflection Test in the Standard for Enclosures for Electrical Equipment, UL 50.

Figure 6.1
Rabbet



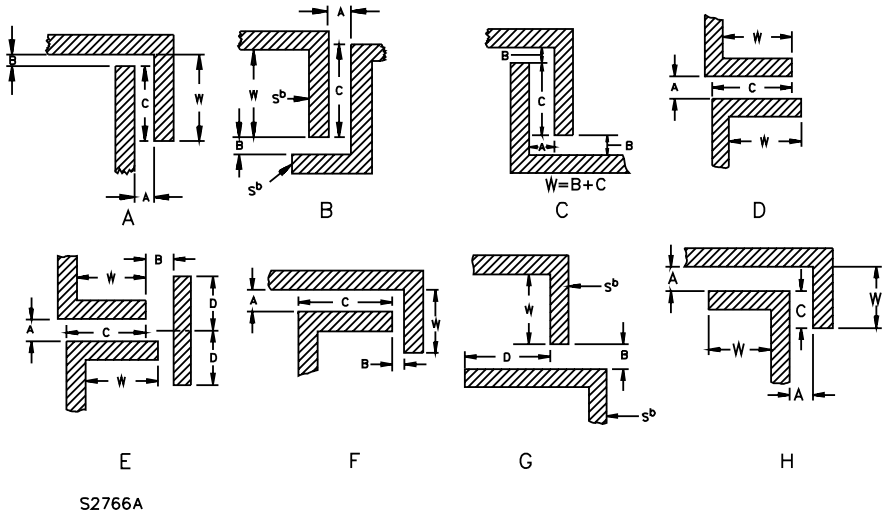
Exception No. 2: The flanges on the cover are not required to fit closely on the outside wall if a gasket suitable for the application provides the intended tight fit. The gasket shall comply with the Gasket Tests of UL 50, Standard for Electrical Equipment.

Exception No. 3: For equipment incorporating an enclosure rated Type 1 only, the gap distance between the flanges on the cover and the outside wall are not required to comply with those specified in Table 6.3 when the equipment complies with the Short Circuit Test – General, Section 50 (and cotton is used as a fire indicator) and Accessibility of Live Parts, 6.17.

6.4.8 To determine whether a flanged cover complies with the requirement in 6.4.7 regarding width of flange, the distance between the flat portion of the cover – clear of forming radii, beads, draws, and the like – and a straight edge placed anywhere across any two flanges at any points is to be measured.

6.4.9 A construction involving a gasketed joint that provides the intended tight fit shall be investigated to determine whether it is acceptable for the application. See Section 6.15.12.

Figure 6.2
Flanged cover constructions[a]



[a] See Table 6.3 for dimensions for sketches A – H.

[b] The surfaces ″S″ may be in line with one another – not as shown.

Table 6.3
Dimensions for flanged cover constructions

Sketch – see Figure 6.2	Dimensions									
	W Minimum flange width[a]		A Maximum space between parts		B Maximum gap		C Minimum overlap		D Minimum barrier extension	
	Inches	(mm)	Inch	(mm)	Inch	(mm)	Inch	(mm)	Inch	(mm)
A	1/2	12.7	1/8	3.2	1/8	3.2	7/16	11.1	–	–
A	3/4	19.1	3/16	4.8	3/16	4.8	5/8	15.9	–	–
A	1	25.4	1/4	6.4	1/4	6.4	7/8	22.2	–	–
B	1/2	12.7	1/8	3.2	1/8	3.2	7/16	11.1	–	–
B	3/4	19.1	3/16	4.8	3/16	4.8	5/8	15.9	–	–
B	1	25.4	1/4	6.4	1/4	6.4	7/8	22.2	–	–
C	1/2	12.7	3/16	4.8	3/16	4.8	1/4	6.4	–	–
C	3/4	19.1	1/4	6.4	1/4	6.4	7/16	11.1	–	–
D	1/2	12.7	3/32	2.4	–	–	7/16	11.1	–	–
E	1/2	12.7	1/8	3.2	1/8	3.2	7/16	11.1	1/4	6.4
F	1/2	12.7	1/8	3.2	1/4	6.4	7/16	11.1	–	–
G[b]	1/2	12.7	–	–	1/32	0.8	–	–	1/2	12.7
H	1/4	6.4	1/8	3.2	–	–	3/16	4.8	–	–

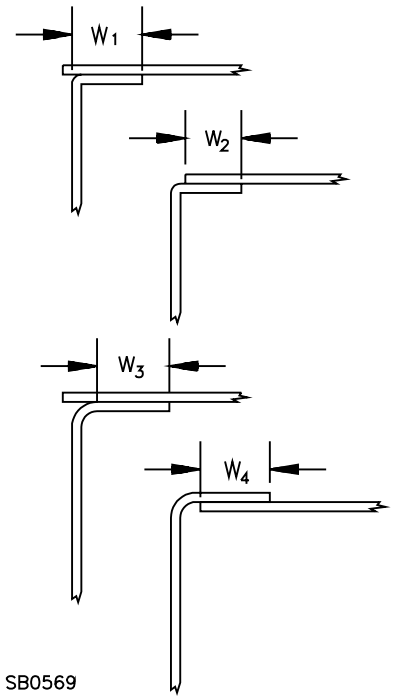
[a] Tolerance: minus 1/16 inch (1.6 mm)

[b] Equipment within the enclosure must be located on the side of the barrier extension D that is opposite the gap B.

6.4.10 Figure 6.3 illustrates the method of determining the amount of overlap between a flat cover and a flanged box wall and the amount of overlap at a corner or box seam. If the radius of the flange bend is small, the flange width and overlap are considered to be W1 or W2, depending upon the actual construction, and shall be at least 1/2 inch (12.7 mm). If the radius of the flange bend is excessive or if the flat sheet is on the inside of the flange, the overlap, W3 or W4, is to be measured over only that portion where the two pieces of metal are actually in contact with each other, and shall be at least 1/2 inch.

6.4.11 To determine the overlap of a telescoping cover, the enclosure is to be placed on its back on a bench, with the cover in its normally closed position, and a mark is to be scribed on all walls of the box along the edge of the flange. The overlap is the measured distance between the scribe marks and the edges of the box walls, noted as W4 in Figure 6.3. In scribing the marks, the cover is to be held in a fixed position with sufficient firmness to prevent displacement of the cover by the scribing tool, but without bending or distorting any portion of the box, cover, or other part of the enclosure.

Figure 6.3
Overlap between flat cover and box flange and at corner or box seam



6.4.12 A flat strip used to provide a rabbet, or an angle strip fastened to the edges of a door giving access to a fuse or any portion of a circuit breaker, other than the operating handle, shall be at least 60 percent of the required thickness of the metal of the box proper, but not less than 0.042 inch (1.07 mm) if of uncoated steel, not less than 0.045 inch (1.14 mm) if of zinc-coated steel, and not less than 0.058 inch (1.47 mm) thick if of nonferrous metal. It shall be secured at no fewer than two points. There shall not be more than 1-1/2 inches (38 mm) between an end of the strip and a point at which it is secured, and the distance between adjacent points at which the strip is secured shall not be more than 6 inches (152 mm).

6.5 Polymeric

6.5.1 A polymeric electrical enclosure shall comply with the applicable requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C and also with the additional requirements specified in this standard. See also 6.5.5 and 6.5.6.

6.5.1 revised July 16, 1999

6.5.2 A polymeric enclosure intended for connection to a rigid conduit system shall comply with the Polymeric Enclosure Rigid Metallic Conduit Connection Tests in the Standard for Enclosures for Electrical Equipment, UL 50.

6.5.3 A polymeric part assembled to an electrical enclosure or a polymeric part of an open-type component intended to be installed through an opening in an enclosure shall be made of a material rated in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, and shall comply with the following:

a) The polymeric part closes an opening in the enclosure having an area of not more than 1.2 square inches (775 mm^2) and is:

1) A pilot light lens classed V-0, V-1, V-2, or HB;

2) Rated V-0, V-1, or V-2; or

3) Rated HB and complies with the flammability test requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

b) The polymeric part closes an opening in the enclosure having an area of more than 1.2 square inches (775 mm^2) and having no dimension greater than 12 inches (304.8 mm), is rated V-0, V-1, V-2, or HB, and complies with the flammability and impact test requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

Exception: The polymeric part is not required to be subjected to the flammability test when it encloses only parts that do not pose a risk of fire, as in Section 29, and is protected from exposure to fire by an internal metal barrier or polymeric barrier that complies with the flammability test. A printed wiring board rated V-0 may serve as a polymeric barrier when the assembly complies with the flammability test.

c) The polymeric part closes an opening in the enclosure having any dimension greater than 12 inches (304.8 mm) shall comply with the flammability and impact requirements in (b) above and also comply with requirements for the crush resistance test in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

6.5.3 revised July 16, 1999

6.5.4 For an adhesive that secures a polymeric part closing an opening in an enclosure, the adhesive shall comply with the requirements for adhesives in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

Exception: A polymeric part of a component is not required to comply with this requirement when:

a) It only encloses parts which do not pose a risk of fire or electric shock; or

b) The device complies with 6.17.1 for the accessibility of live parts with the polymeric part removed and any internal parts that do pose a risk of fire or electric shock are enclosed by barriers that comply with 6.3.1 or 6.5.3, and 8.2.

6.5.4 added July 16, 1999

6.5.5 In addition to the requirements in 6.5.1 and 6.5.3 (b) and (c), polymeric materials used for Types 3, 3R, 3S, 4, and 4X enclosures or polymeric materials used for closures, fastenings, or hinges for these enclosures, or as a polymeric part of an open-type component for installation on these enclosures shall comply with the Ultraviolet Light Exposure test in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

6.5.5 revised July 16, 1999

6.5.6 In addition to the requirements in 6.5.1 and 6.5.3 (b) and (c), polymeric materials used for Types 6 and 6P enclosures or polymeric materials used for closures, fastenings, or hinges for these enclosures, or as a polymeric part of an open-type component for installation on these enclosures shall comply with the Ultraviolet Light Exposure Test and the Water Exposure and Immersion Tests in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

6.5.6 revised July 16, 1999

6.6 Bonding

6.6.1 An enclosure made of insulating material, either wholly or in part, shall have an acceptable bonding means to provide continuity of grounding between all conduit openings. The bonding means may be either completely assembled on the product or provided as separate parts for field installation. See 11.14 and 65.6.

Exception No. 1: A bonding means is not required for the enclosure of a pushbutton station or a selector switch that is intended to be connected to a single conduit. See 11.15.

Exception No. 2: A bonding means is not required to be provided with each enclosure if such means is available in the form of a kit from the manufacturer and the equipment complies with the marking requirements in 66.1.

6.6.2 The continuity of a conduit system shall be provided by metal-to-metal contact not relying on a polymeric material.

Exception: The continuity of the grounding system may rely on the integrity of the polymeric enclosure if samples have been subjected to the creep test requirements in the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A. Overcurrent Tests shall be conducted at 200 percent of the rated current of the branch circuit-protective device.

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6.6.3 A separate bonding conductor whether in a plastic or metal enclosure shall be copper, a copper alloy, or other material acceptable for use as an electrical conductor. Ferrous metal parts in the grounding path shall be protected against corrosion by enameling, galvanizing, plating, or other equivalent means. A separate bonding conductor shall:

a) Be protected from mechanical damage or be located within the confines of the outer enclosure or frame; and

b) Not be secured by a removable fastener used for any purpose other than bonding unless the bonding conductor is unlikely to be omitted after removal and replacement of the fastener.

6.6.4 The size of a separate component bonding conductor shall not be less than the applicable size specified in Table 6.4 or the size of the conductor supplying the component, whichever is smaller.

Exception: A bonding conductor may be smaller than the specified size if:

a) It does not open when carrying for the time specified in Table 6.5, a current equal to twice the branch-circuit overcurrent-device rating – see 6.6.5 – but at least 40 amperes; and

b) None of three samples of the bonding conductor opens during a limited-short-circuit test with a current as specified in Table 6.5 when in series with a fuse as described in 6.6.5.

Table 6.4
Size of bonding conductor

Maximum rating or setting of automatic overcurrent device in circuit ahead of equipment, amperes	Minimum acceptable size of bonding conductor[a]			
	Copper wire		Aluminum wire	
	AWG	(mm^2)	AWG or kcmil	(mm^2)
15	14	(2.1)	12	(3.3)
20	12	(3.3)	10	(5.3)
30	10	(5.3)	8	(8.4)
40	10	(5.3)	8	(8.4)
60	10	(5.3)	8	(8.4)
100	8	(8.4)	6	(13.3)
200	6	(13.3)	4	(21.2)
300	4	(21.2)	2	(33.6)
400	3	(26.7)	1	(42.4)
500	2	(33.6)	1/0	(53.5)
600	1	(42.4)	2/0	(67.4)
800	1/0	(53.5)	3/0	(85.0)
1000	2/0	(67.4)	4/0	(107.0)
1200	3/0	(85.0)	250	(127.0)

[a] Or equivalent cross-sectional area.

Table 6.5
Duration of current flow for bonding-conductor test

Overcurrent device rating, amperes	Minimum duration of current flow, minutes
30 or less	1
31 – 60	4
61 – 100	6

6.6.5 The circuit for the test required by the exception to 6.6.4 is to have a power factor of 0.9 – 1.0 and is to be limited to the current specified in Table 6.6. The open-circuit voltage of the test circuit is to be 100 to 105 percent of the specified voltage. The circuit is to be connected through a nonrenewable fuse that will conduct twice its rated current for at least 12 seconds. The fuse rating is to be that of the branch-circuit overcurrent device to which the equipment will be connected but at least 20 amperes. One test is to be performed on each of three samples of the bonding conductor.

Table 6.6
Bonding conductor short-circuit test capacity

Controller rating			Circuit capacity amperes
Horsepower	(kW Output)	Volts	
1/2	(0.373)	0 – 250	200
1/2	(0.373)	251 – 600	1,000
over 1/2 to 1	(0.374 – 0.746)	0 – 600	1,000
1 to 3	(0.747 – 2.24)	0 – 250	2,000
over 3 to 7-1/2	(2.25 – 5.59)	0 – 250	3,500
over 7-1/2 to 10	(5.60 – 7.46)	0 – 250	5,000
over 10 to 50	(7.47 – 37.3)	251 – 600	5,000
over 50 to 200	(37.4 – 149)	0 – 600	10,000
over 200	(over 150)	0 – 600	a

[a] See Table 51.3.

6.7 Resistance measurement

6.7.1 The resistance between two parts connected by a bonding conductor shall not be more than 0.1 ohm. The resistance is to be determined by a resistance measuring instrument, except that if unacceptable results are recorded, an alternating or direct current of at least 20 amperes from a power supply of not more than 12 volts is to be passed from the point of connection of the equipment grounding means to the metal part in the grounding circuit. The resulting drop in potential and the test current are to be measured between the two points. The resistance in ohms is to be determined by dividing the drop in potential in volts by the current in amperes.

6.8 Openings in enclosure

6.8.1 *Deleted July 16, 1999*

6.8.2 No covering is required across the bottom of an enclosure of a floor-mounted controller if the enclosure is within 6 inches (152 mm) of the floor or less and if exposed live parts within the device are at least 6 inches above the highest portion of the lower edge of the enclosure.

6.8.3 Openings in enclosures shall be filled by devices with suitable environmental ratings as specified in Table 6.7.

Table 6.7
Openings in enclosure

Table 6.7 revised July 16, 1999

Enclosure type	Openings shall be closed by equipment rated for enclosure types
2	2, 3, 3R, 3S, 4, 4X, 5, 6, 6P, 12, 12K, 13
3	3, 3S, 4, 4X, 6, 6P
3R	3, 3R, 3S, 4, 4X, 6, 6P
3S	3, 3S, 4, 4X, 6, 6P
4	4, 4X, 6, 6P
4X	4X
5	3, 3R, 3S, 4, 4X, 5, 6, 6P, 12, 13
6	6, 6P
6P	6P
12, 12K	12, 12K, 13
13	13

6.9 Ventilating openings

6.9.1 A ventilating opening is acceptable in an enclosure that contains a resistance-type starter, autotransformer-type starter, or other equipment if the conditions of use necessitate such ventilation and it is shown by test that electrical disturbances within the enclosure are contained or if the ventilation opening complies with 6.9.2 – 6.11.2.

6.9.2 A ventilation opening in an enclosure that contains a fuse or a circuit breaker shall comply with the requirements in 6.9.3 and:

a) The construction shall comply with the requirements in 6.9.5, 6.9.6 and 6.10.1 – 6.10.4; or

b) The fuse shall be of a type that has been shown by test to clear the circuit under fuse-interrupting and short-circuit tests without:

1) Emission of molten metal;

2) Charring of the fuse casing; or

3) Melting of external soldering connections; or

c) The opening shall be so constructed and located that flame or molten metal is not emitted during:

1) Arcing normally encountered in the operation of power-circuit switches, circuit breakers, or fuses of power-circuit switches, circuit breakers, or fuses of other than the type covered in 6.9.2 (b), or

2) Burnout of current elements as demonstrated by overload and short-circuit tests of sufficient magnitude to produce component malfunction or breakdown.

6.9.3 A ventilation opening in the top of a Type 1 enclosure shall be covered by a hood or protective shield spaced above the opening when there are energized components below the opening, and shall be in accordance with 6.9.4.

6.9.3 revised July 16, 1999

6.9.4 Any ventilating opening in a Type 1, 2, or 3R enclosure shall comply with 6.17.1 (a).

6.9.5 A louver shall not be more than 12 inches (305 mm) long.

6.9.6 The area of an opening covered by a louver, a perforated or an expanded-metal mesh panel that is thinner than the enclosure shall not exceed 200 square inches (0.129 m^2).

6.9.7 The diameter of the wires of a screen shall be at least 0.051 inch (1.30 mm) if the screen openings are 0.500 square inch (32.3 mm^2) or less in area, and shall be at least 0.081 inch (2.06 mm) for larger screen openings.

6.9.8 Perforated sheet steel and sheet steel employed for expanded-metal mesh shall be at least 0.042 inch (1.07 mm) thick if uncoated and at least 0.045 inch (1.14 mm) thick if zinc-coated for mesh openings or perforations 0.500 square inch (3.2 cm^2) or less in area, and shall be at least 0.080 inch (2.03 mm) thick if uncoated and at least 0.084 inch (2.13 mm) thick if zinc-coated for larger openings.

Exception: In a small device where the indentation of a guard or enclosure will not alter the clearance between uninsulated, movable, live parts and grounded metal so as to adversely affect the performance or reduce the spacings below the minimum value specified in Table 36.1, expanded-metal mesh of uncoated steel not less than 0.020 inch (0.51 mm) thick and of zinc-coated steel not less than 0.023 inch (0.58 mm) thick may be employed provided that:

a) The exposed mesh on any one side or surface of the device so protected has an area not more than 72 square inches (464 cm^2) and has no dimension greater than 12 inches (304.8 mm), or

b) The width of the opening so protected is not greater than 3.50 inches (88.9 mm).

6.10 Barriers used with ventilation openings

6.10.1 Unless a ventilating opening is located at least 12 inches (305 mm) from an arcing part, the requirements in 6.9.2 will necessitate the interposition of a barrier of metal or of a material such as those mentioned in 6.10.4 between the ventilating opening and a possible source of arcing, such as a switch, a fuse, the vent openings of a circuit breaker, and the like.

6.10.2 The barrier shall be of such dimensions and so located that any straight line drawn from any arcing part past the edge of the barrier intersects a point in the ventilating opening plane that is at least 0.25 inch (6.4 mm) outside of the edge of the ventilation opening.

6.10.3 A sheet-metal barrier shall be at least 0.053 inch (1.35 mm) thick if uncoated steel, 0.056 inch (1.42 mm) thick if zinc-coated or 0.075 inch (1.19 mm) thick if aluminum.

Exception: A metal barrier may be of thinner metal provided its strength and rigidity are not less than that of a flat sheet of steel having the same dimensions as the barrier and of the specified thickness.

6.10.4 A barrier of slate or marble shall be at least 0.500 inch (12.70 mm) thick. A nonmetallic barrier other than slate or marble or similar material shall be at least 0.250 inch (6.35 mm) thick and shall be supported to give the necessary strength and rigidity.

Exception: A nonmetallic material other than slate, marble, or other similar material may be less than 0.250 inch thick if the barrier is located so that it will not be subject to mechanical damage during installation, and supported so that it will have the necessary mechanical strength and rigidity.

6.11 Forced ventilation

6.11.1 If ventilation is fan forced – that is, ventilation is accomplished by one or more blowers within the enclosure that provide a positive intake and exhaust – the ventilation openings shall comply with the requirements in 6.11.2 in addition to the requirements in 6.9.2.

6.11.2 If operator controls are provided on the enclosure, the air outlet shall not direct exhaust air at the area occupied by the operator of the equipment.

6.12 Observation windows

6.12.1 Glass covering an observation opening and forming a part of the enclosure shall be reliably secured in such a manner that it cannot be readily displaced in service and shall provide mechanical protection of the enclosed parts. Glass for an opening not more than 4 inches (102 mm) in any dimension shall not be less than 0.055 inch (1.40 mm) thick; and glass for an opening having no dimension greater than 12 inches (305 mm) shall not be less than 0.115 inch (2.92 mm) thick. Glass used to cover a larger opening shall comply with the Crush Resistance and Resistance to Impact tests in accordance with the Standard for Polymeric Materials – Use in Electrical Evaluations, UL 746C, and shall otherwise be acceptable for the purpose.

6.13 Transformer or autotransformer

6.13.1 If a transformer or autotransformer is oil filled, means shall be provided for inspection and renewal of the oil.

6.14 Motor controller wire bending space

6.14.1 The space between the end of the soldering lug or pressure wire connector for the connection of field-installed wire and the wall of the enclosure toward which the wire will be directed upon leaving the lug or connector shall be at least that specified in Table 6.8.

6.14.2 The space specified in 6.14.1 is to be the length of a straight line extending from the end of the soldering lug or pressure wire connector where the wire would be connected toward and perpendicular to the enclosure wall toward which the wire would be initially directed.

6.14.3 If a wire is restricted by barriers or other means from being bent where it leaves the connector, the distance required by 6.14.1 and Table 6.8 is to be measured from the end of the barrier. A terminal lug or connector that is not prevented from turning as described in the exception to 17.2 is to be repositioned anywhere within the limits to obtain the shortest distance for measurement.

6.14.4 The wire size used to determine the wire bending space is based on 125 percent of the motor full-load current rating. See Tables 45.2 or 45.3 for the full-load current rating of horsepower rated motors.

6.15 Specific enclosures

6.15.1 An enclosure shall comply with the construction requirements applicable to an enclosure of the type number or numbers with which it is marked. See 11.1.

6.15.1.1 An enclosure provided with multiple compartments is able to be evaluated to different enclosure type requirements when the compartments are completely separated by a wall or barrier and:

a) The assembly is intended for indoor use and the compartments are rated Type 1, 2, 4, 4X, 5, 6, 6P, 12, 12K, 13; or

b) The assembly is intended for outdoor use and the compartments are rated Type 3, 3R, 3S, 4, 4X, 6, or 6P.

6.15.1.1 added July 16, 1999

6.15.2 An environmental type connection, such as a watertight connection at a conduit entrance, shall be a conduit hub or the equivalent, such as a knockout or fitting, located so that when conduit is connected and the enclosure is mounted in the intended manner, the enclosure is found to be acceptable when subjected to the tests specified in the table for Enclosure Types in the Standard for Enclosures for Electrical Equipment, UL 50.

Table 6.8
Wire bending space at the terminals of enclosed motor controllers

Size of wire[a]		Minimum bending space, terminal to wall, inches (mm)					
		Wires per terminal					
AWG or kcmil	(mm^2)	1		2		3	
14 – 10	(2.1 – 5.3)	–		–		–	
8 – 6	(8.4 – 13.3)	1-1/2	(38)	–		–	
4 – 3	(21.2 – 26.7)	2	(51)	–		–	
2	(33.6)	2-1/2	(64)	–		–	
1	(42.4)	3	(76)	–		–	
1/0	(53.5)	5	(127)	5	(127)	7	(178)
2/0	(67.4)	6	(152)	6	(152)	7-1/2	(191)
3/0	(85.0)	7	(178)	7	(178)	8	(203)
4/0	(107.2)	7	(178)	7	(178)	8-1/2	(216)
250	(127)	8	(203)	8	(203)	9	(229)
300	(152)	10	(254)	10	(254)	11	(279)
350	(177)	12	(305)	12	(305)	13	(330)
400	(203)	12	(305)	12	(305)	14	(356)
500	(253)	12	(305)	12	(305)	15	(381)
600	(304)	14	(356)	16	(406)	18	(457)
700	(355)	14	(356)	16	(406)	20	(508)
750 – 800	(380 – 405)	18	(457)	19	(483)	22	(559)
900	(456)	18	(457)	19	(483)	24	(610)

NOTE – Where provision for more than three conductors per terminals is provided, the bending space shall be in accordance with the appropriate tables for cabinets and boxes in Article 373 of the National Electrical Code, ANSI/NFPA 70-1996.

[a] The wire size is to be based on 25.5.1 (b).

6.15.3 TYPE 1 – A Type 1 enclosure shall comply with the requirement in 25.2.1.

6.15.4 TYPE 2 – A Type 2 enclosure shall have provision for drainage of water and shall have a threaded conduit hub or the equivalent for the connection of conduit at the top or sidewalls.

Exception No. 1: If the conduit connection opening is wholly below the lowest terminal lug or other live part intended for use within the enclosure, a threaded conduit hub or the equivalent need not be provided. See 11.13.

Exception No. 2: Provisions for a conduit hub or fitting need not be provided if information is provided in accordance with 11.10.

6.15.5 TYPE 3 – A Type 3 enclosure shall have:

a) A conduit hub or the equivalent for a watertight connection at conduit entrances – see 6.15.2;

b) A mounting means external to the equipment cavity; and

c) If a door is provided, provision for locking the door.

Exception: Provisions for a conduit hub or fitting need not be provided if information is provided in accordance with 11.10.

6.15.6 TYPE 3R – A Type 3R enclosure shall have:

a) A conduit hub or the equivalent for a watertight connection at conduit entrances – see 6.15.2;

b) Provision for drainage of water; and

c) If a door is provided, provision for locking the door.

Exception No. 1: If the conduit connection opening is wholly below the lowest terminal lug or other live part intended for use within the enclosure, a threaded conduit hub or the equivalent need not be provided. See 11.13.

Exception No. 2: Provisions for a conduit hub or fitting need not be provided if information is provided in accordance with 11.10.

6.15.7 TYPE 3S – A Type 3S enclosure shall have:

a) A conduit hub or the equivalent for a watertight connection at conduit entrances – see 6.15.2;

b) A mounting means external to the equipment cavity;

c) If a door is provided, provision for locking the door; and

d) Operating mechanisms that will support the additional weight of ice and withstand removal of ice by a hand tool to gain access to the interior of the enclosure. Auxiliary means may be provided to break the ice and to permit operation of external mechanisms.

Exception: Provisions for a conduit hub or fitting need not be provided if information is provided in accordance with 11.10.

6.15.7.1 TYPE 5 – A Type 5 enclosure shall have:

a) A conduit hub or the equivalent for a connection at conduit entrances – see 6.15.2; and

b) When a door is provided, provision for locking the door.

Exception: Provisions for a conduit hub or fitting are not required when information is provided in accordance with 11.10.

6.15.7.1 added July 16, 1999

6.15.8 TYPES 4, 4X, 6, AND 6P – A Type 4, 4X, 6, or 6P enclosure shall have a conduit hub or the equivalent mounted in place to provide a watertight connection at conduit entrances and shall have mounting means external to the equipment cavity – see 6.15.2.

Exception No. 1: The watertight conduit connection provision need not be mounted in place if information is provided in accordance with 11.12.

Exception No. 2: A hub or a fitting need not be provided or installed on a Type 4 or 4X enclosure if instructions are provided as specified in 11.16.

6.15.9 TYPE 12 – A Type 12 enclosure shall have no conduit knockout or conduit opening and no hole through the enclosure other than a hole for a Type 12 mechanism, or the equivalent. A gasket, if provided, shall be oil resistant.

Exception: A Type 12 enclosure may employ a conduit opening if the instructions required by 65.12 are included on the enclosure.

6.15.10 TYPE 12K – A Type 12K enclosure is as specified in 6.15.9, except it has knockouts located in the top or bottom walls, or both.

6.15.11 TYPE 13 – A Type 13 enclosure shall have oil-resistant gaskets and, if intended for wall or machine mounting, shall have a mounting means external to the equipment cavity. There shall be no conduit knockout or unsealed opening providing access to the equipment cavity. All conduit openings shall have provisions for oiltight connections.

6.15.12 A gasket of an elastomeric or thermoplastic material or a composition gasket utilizing an elastomeric material employed to comply with the requirements for a Type 2, 3, 3R, 3S, 4, 4X, 5, 6, 6P, 12, 12K, or 13 enclosure shall comply with the Gasket Tests in the Standard for Enclosures for Electrical Equipment, UL 50.

6.15.12 revised July 16, 1999

6.16 Components for use on specific enclosures

6.16.1 A component, such as a pilot light, a disconnect, a pushbutton, or similar component, intended for use with a type designated environmental enclosure, meets the requirements for use with a specific type enclosure when all of the following are met:

a) The component has been evaluated for its intended use installed on a representative enclosure.

b) All hardware, gaskets, or other parts needed to complete the installation are provided with the component.

Exception: Hardware, gaskets, or other parts are not required to be provided with the component when they are available from the component manufacturer in the form of a kit and the component is marked as specified in 66.1.

c) Installation instructions including such information as mounting hole location, opening configuration, and similar information, are provided either on the component, in the component package, or on a stuffer sheet.

d) The component, its carton, or accompanying instruction sheet is marked in accordance with the requirement in 63.6.

6.16.1 revised July 16, 1999

6.17 Accessibility of live parts

6.17.1 To reduce the likelihood of unintentional contact that may involve a risk of electric shock from an uninsulated live part, electrical energy - high current levels, or injury to persons from a moving part, an opening in an enclosure shall comply with either (a) or (b).

a) For an opening that has a minor dimension (see 6.17.4) less than 1 inch (25.4 mm), such a part or wire shall not be contacted by the probe illustrated in Figure 6.4.

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Exception: As an alternative to 6.17.1(a), the probe illustrated in Figure 6.5 may be used to determine accessibility.

b) For an opening that has a minor dimension of 1 inch or more, such a part or wire shall be spaced from the opening as specified in Table 6.9.

Table 6.9
Minimum acceptable distance from an opening to a part that may involve a risk of electric shock, electrical energy-high current level, or injury to persons

Minor dimension of opening[a,b]		Minimum distance from opening to part[b]	
Inches	(mm)	Inches	(mm)
1	(25.4)	6-1/2	(165.0)
1-1/2	(38.1)	8-3/8	(212.7)
2	(50.8)	11-5/8	(295.3)
Over 2 but not more than 3	(Over 50.8 but not more than 76.2	30	(762.3)

[a] See 6.17.4.
[b] Interpolation is to be used to determine a value between values specified in the table.

6.17.2 The probe specified in 6.17.1(a) shall be applied in any possible configuration; and, if necessary, the configuration shall be changed after insertion through the opening.

6.17.3 The probe specified in 6.17.1(a) shall be applied with a force not to exceed 2.2 pounds (10 N). The probe is to be used to determine the accessibility provided by an opening, and not as an instrument to determine the strength of a material.

6.17.4 With reference to 6.17.1, the minor dimension of an opening is the diameter of the largest cylindrical probe that can be inserted through the opening.

6.17.5 The probe specified in 6.17.1 is to be inserted as described in 6.17.2 into all openings, including those in the bottom of the unit. The unit is to be moved in whatever way necessary to make the entire bottom accessible for insertion of the probe.

Exception: For a floor-standing unit, the probe is to be inserted into all openings in the bottom that are accessible without tipping, turning over, or otherwise moving the unit from its intended installed position.

7 Protection Against Corrosion

7.1 General

7.1.1 Iron and steel parts shall be protected against corrosion by enameling, galvanizing, plating, or other equivalent means. This applies to all springs and other parts upon which proper mechanical operation may depend.

Exception: This requirement does not apply to:

a) Bearings, thermal elements, sliding surfaces of a hinge, or shaft, and the like, where such protection is impracticable;

Figure 6.4
Articulate probe with web stop

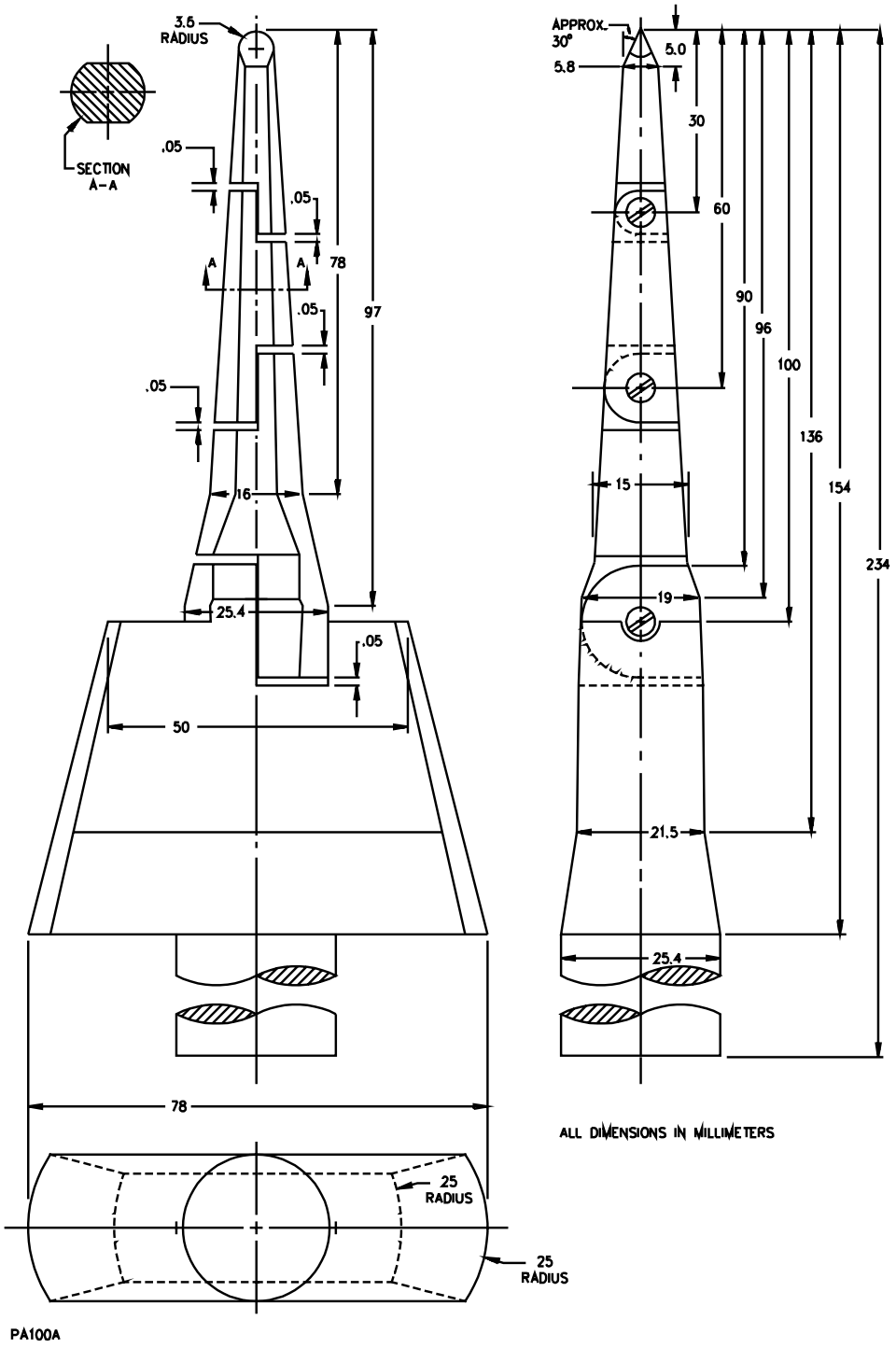
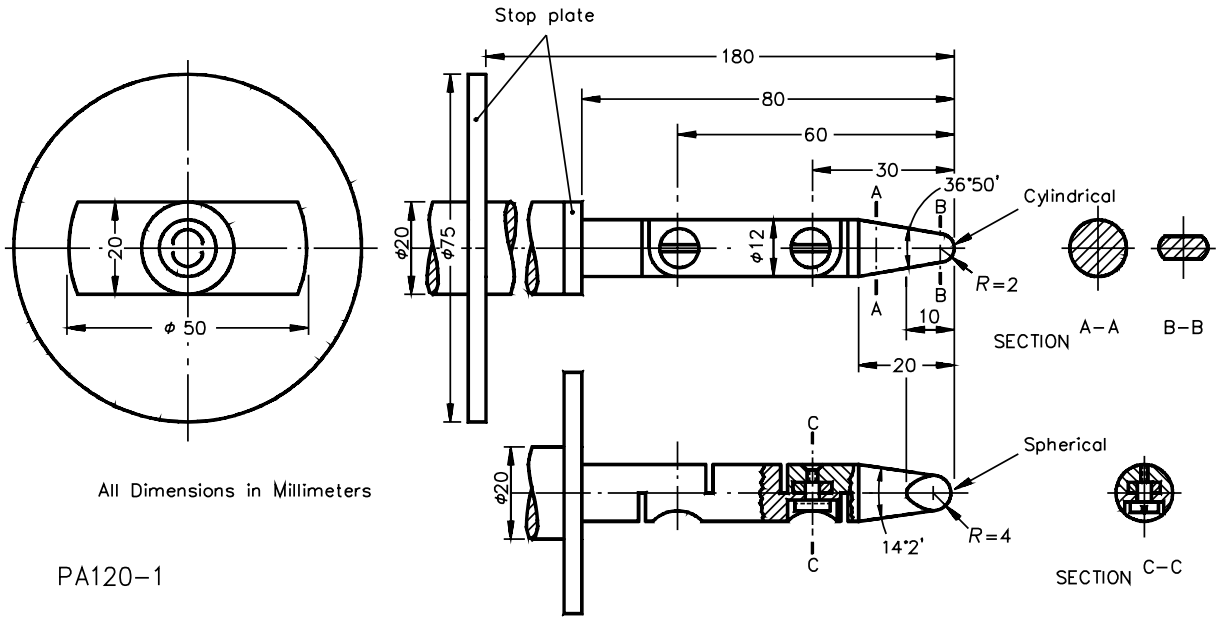


Figure 6.5
IEC articulate probe



b) Small parts of iron or steel, such as washers, screws, bolts, and the like, that are not current carrying, if the corrosion of such parts would not be likely to result in a risk of fire, electric shock, or injury to persons; and

c) Parts made of stainless steel that are polished or treated, if necessary.

7.1.2 For a Type 1, 2, 5, 12, 12K, or 13 enclosure, both the inside and outside surfaces of an enclosure including means for fastening, shall be protected against corrosion by enameling, galvanizing, plating, or other equivalent means.

Exception: An enclosure and means for fastening that are of a metal that is inherently resistant to corrosion need not comply with this requirement.

7.2 Outdoor enclosures

7.2.1 A Type 3, 3R, 3S, 4, 4X, 6, or 6P enclosure shall be protected against corrosion as specified under Protection Against Corrosion in the Standard for Enclosures for Electrical Equipment, UL 50.

ENCLOSURE PERFORMANCE

8 General

8.1 The performance requirements of an enclosure are determined by the specific environmental type designation and other features such as gasketing or use of materials thinner than required by Table 6.1 or 6.2.

8.2 An enclosure shall be subjected to the tests specified in the table for Enclosure Types in the Standard for Enclosures for Electrical Equipment, UL 50, applicable to an enclosure of the type number or numbers with which it is marked.

8.2.1 An enclosure having multiple compartments shall have each compartment subjected to the tests specified in the table for enclosure types, in the Standard for Enclosures for Electrical Equipment, UL 50, for its respective enclosure type designation. The internal barrier between compartments is not required to be directly subjected to these tests. Any joints and gasket materials between compartments shall be subjected to the environmental tests which are the most severe for either compartment.

8.2.1 added July 16, 1999

8.2.2 A Type 12 enclosure having ventilation openings shall be subjected to the indoor dust test in accordance with the Standard for Enclosures for Electrical Equipment, UL 50. When the enclosure is provided with a fan, the enclosure shall be subjected to all environmental tests required by 8.2, both with the fan on and with the fan off. As a result of these tests, there shall be no entry of dust into the compartment having a Type 12 rating.

8.2.2 added July 16, 1999

8.3 An external operating means – such as those for a disconnect, a pilot device, or a resetting operation – mounted on or through an enclosure shall withstand the tests specified for the enclosure unless otherwise indicated.

8.4 Types 1, 2, and 3R enclosures shall also comply with the requirements in 6.17.1.

8.5 A Type 4X enclosure intended for indoor use only and marked in accordance with 11.18 :

a) Need not be subjected to the Icing Test in the Standard for Enclosures for Electrical Equipment, UL 50; and

b) For a polymeric enclosure, need not have a material which is resistant to ultraviolet light weathering in accordance with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluation, UL 746C.

8.6 The conduit mentioned in 6.15.2 is to be tightened to the applicable torque value specified in Table 8.1. No sealing compound other than that normally provided by the end use manufacturer is to be used.

Exception No. 1: When conducting the Air Pressure Test in the Standard for Enclosures for Electrical Equipment, UL 50, and the Submersion Test in UL 50, a pipe thread sealing compound may be used when connecting conduit.

Exception No. 2: A lesser torque value may be used for polymeric enclosures if the device is marked as noted in 65.10.

Table 8.1
Tightening torque

Trade size of circuit hub, inches	Tightening torque, pound-inches	(N·m)
3/4 and smaller	800	(90.4)
1, 1-1/4, and 1-1/2	1000	(113)
2 and larger	1600	(181)

9 Securement of Snap-On Cover Test

9.1 A snap-on cover providing part of the overall enclosure that gives access to uninsulated live parts and does not have a separate tool-operated fastener shall have no apparent means for removal such as an extending tab, and is to comply with the following:

a) A cover that could be disengaged from the enclosure by a squeezing force applied with one hand shall not be released when a squeezing force of 14 pounds (62 N) or less is applied at any two locations not more than 5 inches (127 mm) apart. The distance is to be measured by a tape stretched tightly over that portion of the surface of the cover that would be encompassed by the palm of the hand.

b) A cover shall not disengage from the enclosure when a direct pull force of 14 pounds is applied by gripping the cover at any two convenient locations.

c) A cover shall not be disengaged from the enclosure by an impact force of 1 foot-pound (1.4 J) applied to the accessible faces of the cover – one blow per face. The impact is to be applied by a steel ball having a diameter of not less than 2 inches (51 mm).

9.2 The tests described in 9.1(a) and 9.1(b) are to be conducted in the as-received condition and after the cover has been removed and replaced ten times.

INSTRUCTIONS AND MARKINGS PERTAINING TO ENCLOSURES

10 Permanence of Marking

10.1 Any marking that is required to be permanent shall be molded, die-stamped, paint-stenciled, stamped or etched metal that is permanently secured, or indelibly stamped lettering on a pressure-sensitive label secured by adhesive. Ordinary usage, handling, storage, and the like, of a product are considered in the determination of the permanency of a marking.

11 Details

11.1 An enclosure shall be permanently marked with a type designation indicating the external conditions for which it is intended as specified in the table for Enclosure Types in the Standard for Enclosures for Electrical Equipment, UL 50. An enclosure that complies with the requirements for more than one type of enclosure may be marked with multiple designations. The marking shall be on either the inside or outside surface but shall be visible after installation upon inspection of the field wiring connections.

11.1.1 An enclosure having multiple compartments with different environmental ratings shall indicate on the nameplate, ″Install in Type ___ Environment″, or the equivalent where the marked type number is the type designation of the component affording the least protection from external conditions as specified in the table for enclosure types, in the Standard for Enclosures for Electrical Equipment, UL 50. Additional nameplate information regarding the level of protection provided for an individual compartment shall follow and be less prominent than the above marking.

11.1.1 added July 16, 1999

11.2 A Type 1 enclosure may be additionally marked ″indoor use only ″.

11.3 A Type 3, 3S, 4, 4X, 6, or 6P enclosure may be marked ″raintight ″.

11.4 A Type 3R enclosure may be marked ″rainproof ″.

11.5 A Type 4 or 4X enclosure may be marked ″watertight ″.

11.6 A Type 4X or 6P enclosure may be marked ″corrosion resistant ″.

11.7 A Type 2, 5, 12, 12K, or 13 enclosure is able to be marked ″drip tight ″.

11.7 revised July 16, 1999

11.8 A Type 3, 3S, 5, 12, 12K, or 13 enclosure is able to be marked ″dust tight ″.

11.8 revised July 16, 1999

11.9 Conduit hubs provided for compliance with 6.15.2, 6.15.4, 6.15.5, 6.15.6, 6.15.7, or 6.15.8 shall comply with the requirements in the Standard for Fittings for Conduit and Outlet Boxes, UL 514B.

11.10 When conduit hubs are not provided for a Type 2, 3, 3R, 3S, or 5 enclosure, the enclosure, the instruction sheet provided with the enclosure, or the packaging carton shall be marked to indicate raintight or wet location hubs that comply with the requirements in the Standard for Fittings for Conduit and Outlet Boxes, UL 514B, are to be used.

11.10 revised July 16, 1999

11.11 A separable conduit hub and a closure fitting shall be marked with the manufacturer's name or trademark and the catalog number or equivalent. Such a hub or fitting may be shipped separately, and any gasket, hardware, and instructions necessary for installation shall be shipped with the fitting or packaged with the enclosure.

11.12 An enclosure marked Type 4, 4X, 6, or 6P shall be provided with instructions for use of the watertight connection if the connection is not mounted on the enclosure.

11.13 A Type 2 or 3R enclosure that has knockouts for conduit in the sides or back of the enclosure and in which the equipment to be installed is not known shall be marked to indicate the area in which live parts are to be installed. See Exception No. 1 to 6.15.4 and Exception No. 1 to 6.15.6.

11.14 Installation instructions shall be provided with an enclosure intended for field assembly of the bonding means that identifies the parts for bonding and specifies the method of installation.

11.15 A pushbutton station or selector switch enclosure of insulating material that has no means for continuity of grounding between any conduit provision shall be marked that only one conduit is to be connected to the enclosure.

11.16 If a hub or fitting is not provided or installed on a Type 4 or 4X enclosure, instructions identifying the specific hub or fitting and installation instructions shall be provided with the enclosure.

11.17 A polymeric enclosure shall have instructions stating that the hub is to be connected to the conduit before the hub is connected to the enclosure if it:

a) Is intended for connection to a rigid conduit system;

b) Has not been subjected to the torque test described in Polymeric Enclosure Rigid Metallic Conduit Connection Tests, Section 41 in the Standard for Enclosures for Electrical Equipment, UL 50; and

No Text on This Page

c) Is not provided with a preassembled hub.

11.18 With reference to 8.5, a Type 4X enclosure intended for indoor use only shall be marked ″4X Indoor Use Only″ in letters at least 5/32 inch (4.0 mm) high.

DEVICE CONSTRUCTION

12 General

12.1 Industrial control equipment shall:

a) Be constructed so that it complies with the rules for installation and use of such equipment as given in the National Electrical Code, ANSI/NFPA 70-1990; and

b) Employ materials that are acceptable for the use.

13 Protection Against Corrosion

13.1 Iron and steel parts shall comply with the requirements in 7.1.1.

14 Provisions for Mounting

14.1 Provisions shall be made for securely mounting industrial control equipment to a supporting surface. A bolt, screw, or other part used to mount a component of the equipment shall not be used for securing the equipment to the supporting surface.

15 Insulating Material

15.1 A material that is used for the direct support of an uninsulated live part shall comply with the Relative Thermal Index (RTI), Hot Wire Ignition (HWI), High-Current-Arc Resistance to Ignition (HAI), and Comparative Tracking Index (CTI) values indicated in Table 15.1. A material is considered to be in direct support of an uninsulated live part if:

a) It is in direct physical contact with the uninsulated live part; and

b) It serves to physically support or maintain the relative position of the uninsulated live part.

Exception No. 1: A generic material provided in the thickness indicated in Table 15.2 is considered suitable for the direct support of uninsulated live parts without additional evaluation.

Exception No. 2: A material without an HWI Performance Level Category (PLC) value or with an HWI PLC value greater (worse) than the value required by Table 15.1 may alternatively be subjected to the end-product Abnormal Overload Test specified in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

Exception No. 3: A material without an HAI PLC value or with an HAI PLC value greater (worse) than the value required by Table 15.1 may alternatively be subjected to the end-product Special Arcing Test specified in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

Exception No. 4: A material that is used in a device not incorporating contacts need not comply with the HAI PLC requirements.

Exception No. 5: A material that is used in a device that incorporates contacts but is not used within 1/2 inch (12.7 mm) of the contacts need not comply with the HAI PLC requirements.

Exception No. 6: A material without a CTI PLC value or with a CTI PLC value greater (worse) than the value required by Table 15.1 may alternatively be subjected to the end-product Special Arcing Test specified in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

Exception No. 7: A material without a CTI PLC value or with a CTI PLC value greater (worse) than the value required by Table 15.1 shall be considered in compliance with the CTI PLC requirements if:

a) It has a High-Voltage-Arc Tracking (HVTR) PLC value of 1 or less; or

b) The over surface spacings between the uninsulated live parts are at least 1/2 inch (12.7 mm).

Table 15.1
Minimum material characteristics necessary for the direct support of uninsulated live parts

UL 94 Flame Class	RTI Elec	Performance Level Category (PLC)		
		HWI[b]	HAI[b]	CTI[c]
HB	a	2	1	4
V-2	a	2	2	4
V-1	a	3	2	4
V-0	a	4	3	4

[a] The electrical Relative Thermal Index (RTI) value of a material is to be determined in accordance with the Standard for Polymeric Materials – Long Term Property Evaluations, UL 746B, by test or by use of the generic RTI table. This material characteristic is dependent upon the minimum thickness at which the material is being used and shall not be exceeded during the Temperature Test, Section 43.

[b] The High Current Arc Resistance to Ignition (HAI) and Hot Wire Ignition (HWI) value of a material is to be determined by test in accordance the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A. This material characteristic is dependent upon the minimum thickness at which the material is being used.

[c] The Comparative Tracking Index (CTI) PLC value of a material is to be determined by test in accordance with UL 746A. This material characteristic is not dependent upon the minimum thickness at which the material is being used.

Table 15.2
Generic materials for direct support of uninsulated live parts

Table 15.2 revised July 16, 1999

Generic Material	Thickness, Inch	Thickness, (mm)	RTI, °C
Diallyl Phthalate	0.028	(0.71)	105
Epoxy	0.028	(0.71)	105
Melamine	0.028	(0.71)	130
Melamine-Phenolic	0.028	(0.71)	130
Phenolic	0.028	(0.71)	150
Unfilled Nylon	0.028	(0.71)	105
Unfilled Polycarbonate	0.028	(0.71)	105
Urea Formaldehyde	0.028	(0.71)	100
Ceramic, Porcelain, and Slate	No limit		No limit
Beryllium Oxide	No limit		No limit

Table 15.2 Continued on Next Page

Table 15.2 Continued

Generic Material	Thickness, Inch	(mm)	RTI, °C
NOTE – Each material shall be used within its minimum thickness and its Relative Thermal Index (RTI) value shall not be exceeded during the Temperature Test, Section 43.			

15.2 Insulating material – such as a relay dust cover, transformer bobbin, printed wiring broad (PWB) insulating sheet, encapsulation, or the like – that is used as a barrier in lieu of the required over surface or through air spacings (or both) shall comply with the requirements in 37.1 – 37.5.

15.3 A printed wiring board shall comply with the requirements in the Standard for Printed Wiring Boards, UL 796.

16 Means for Switching

16.1 The position of a handle of a manual switching means shall be marked in accordance with 63.12.

16.2 If a circuit breaker or switch is mounted such that movement of the operating handle, either vertically or rotationally, between the on and off positions results in one position being above the other position, the upper position shall be the on position. The requirement does not apply to a circuit breaker or switch that is operated horizontally or that is operated rotationally and the on and off positions are at the same level, nor to a switching device having two on positions, such as a transfer switch or a double throw switch.

16.3 A single-throw knife switch shall be mounted so that gravity will not tend to close it.

16.4 A knife switch shall be connected so that the blade or blades are connected to the load circuit and are de-energized when the switch is open.

Exception: The blade or blades of a switch may be energized by a backfeed circuit when the switch is in an open position if the switch is marked in accordance with 65.11.

16.5 A direct-current motor-starting rheostat shall not complete the electrical circuit in the off or initial position

16.6 A motor-starting rheostat shall be constructed so that the contact arm or similar part cannot be left in any but the off position or the full running position.

17 Live Parts

17.1 A current-carrying part shall have mechanical strength and ampacity for the intended use and shall be of metal or other material that is acceptable for the application.

17.2 An uninsulated live part, including a terminal, shall be secured to its supporting surface by a method other than friction between surfaces so that it will be prevented from turning or shifting in position if such motion may result in reduction of spacings to less than those required elsewhere in this standard. The security of a contact assembly shall maintain continued alignment of contacts.

Exception: A pressure terminal connector need not be prevented from turning providing no spacings less than those required result when the terminals are turned 30 degrees toward each other, or toward other uninsulated parts of opposite polarity, or toward grounded metal parts.

17.3 A live screwhead or nut on the underside of an insulating base shall be prevented from loosening and shall be acceptably insulated or spaced from the mounting surface. This may be accomplished by:

a) Countersinking such parts at least 1/8 inch (3.2 mm) and then covering them with a waterproof, insulating sealing compound that does not melt at a temperature of 15°C (27°F) higher than its normal operating temperature in the equipment, but at least 65°C (149°F); or

b) Securing such parts and insulating them from the mounting surface by a barrier, or the equivalent, or by through air or over surface spacings specified elsewhere in this standard.

18 Protective Devices

18.1 General

18.1.1 Protective devices are intended to provide motor branch-circuit short-circuit and ground-fault protection, or motor-overload protection required by the National Electrical Code, ANSI/NFPA 70-1990.

18.1.2 The number, arrangement, and ratings or settings of protective devices forming parts of the control equipment and the horsepower rating of the equipment shall be as required in the National Electrical Code, ANSI/NFPA 70-1990, for the given type of circuit and motor or other machine.

18.1.3 In general, the requirement in 18.1.2, when applied to a controller for a single motor, will necessitate that:

a) The voltage rating of the fuseholder or circuit breaker shall be at least the voltage of any assigned horsepower rating;

b) The ampere rating or setting of a fuseholder or circuit breaker shall be at least 115 percent of the full-load current of any assigned horsepower rating;

c) The ampere rating of the fuseholder shall be no more than:

1) Four times the largest full-load current of the assigned horsepower rating, for a fuse rated 600 amperes or less; and

2) Three times the largest full-load current of the assigned horsepower rating for a fuse rated 601 – 6000 amperes; and

d) The ampere rating of an inverse-time circuit breaker shall be no more than:

1) Four times the largest full-load current of the assigned horsepower rating for a full-load current of 100 amperes or less; and

2) Three times the largest full-load current of the assigned horsepower rating for a full-load current greater than 100 amperes.

18.2 Protection of internal primary and secondary control circuit conductors

18.2.1 Conductors of control circuits that are connected to the load side of the motor branch-circuit short-circuit protective device – common control – shall be protected against overcurrent in accordance with Table 18.1 by protective devices located within the controller. Overcurrent protective devices shall be provided in each ungrounded conductor, located no more than 12 inches (305 mm) from the point where the conductor is connected to the source of power.

Exception No. 1: Additional protection is not required if the rating or trip setting, in the case of an instantaneous-trip circuit breaker, of the intended motor branch-circuit short-circuit protective device is not more than the applicable value specified in Table 18.2, and the controller is marked in accordance with 63.19.

Exception No. 2: The protective device need not be assembled as part of the controller if the manufacturer makes available an accessory kit intended for installation in the controller enclosure, and the controller is marked in accordance with 63.18.

18.2.2 Direct leads measuring a maximum of 12 inches (305 mm) long or printed-wiring assemblies having no connection external to the motor controller, and having no more than casual contact with insulated or uninsulated parts of opposite polarity or with grounded parts need not be protected as required by 18.2.1.

Table 18.1
Overcurrent protection

Control-circuit wire size, AWG	Control-circuit wire size, (mm^2)	Maximum protective device rating, amperes
22	(0.32)	3
20	(0.52)	5
18	(0.82)	7
16	(1.3)	10
14	(2.1)	20
12	(3.3)	25

18.2.3 A protective device specified in 18.2.1 shall be either a supplementary or a branch-circuit overcurrent-protective device. A fuse shall be factory installed in a supplementary fuseholder, but may be omitted if a branch-circuit-type fuseholder is provided. The controller shall be marked in accordance with 63.20.

18.2.4 When the marked minimum short circuit current rating or marked maximum circuit capacity, required by 63.2 or 88.2, exceeds 10,000 amperes, only a branch-circuit overcurrent-protective device rated for the available fault current involved shall be used. When provided, fuses shall be Class CC, G, J, R, or T, and the fuseholder shall be appropriate for the fuse used.

18.2.4 revised July 16, 1999

Table 18.2
Branch-circuit short-circuit protection

Control-circuit wire size,		Maximum rating of branch-circuit-protective device, amperes	
AWG	(mm^2)	Conductors within enclosure	Conductors outside enclosure
22	(0.32)	12	3
20	(0.52)	20	5
18	(0.82)	25	7
16	(1.3)	40	10
14	(2.1)	100	45
12	(3.3)	120	60

18.3 Protection of control circuit transformer

18.3.1 A control circuit transformer shall be provided with overcurrent protection which complies with 18.2.3 and is one of the following types:

a) Individual overcurrent devices located in the primary circuit that are rated or set as specified in Table 18.3. Overcurrent protective devices shall be provided in each ungrounded conductor.

b) Secondary circuit protection rated or set at not more than 125 percent of the rated secondary current of the transformer and primary feeder circuit protection rated or set at not more than 250 percent of the rated primary current of the transformer.

Exception: If the rated secondary current of a transformer is 2 amperes or more, the current rating of the secondary overcurrent device may be as indicated in line 2 or 3 of Table 18.3, as applicable.

c) Coordinated thermal overload protection arranged to interrupt the primary circuit provided the primary circuit overcurrent device is rated for or set to open at a current of not more than:

1) For transformers having not more than 6 percent impedance – six times the rated current of the transformer.

2) For transformers having more than 6 but less than 10 percent impedance – four times the rated current of the transformer.

Exception: Overcurrent protection need not be provided if:

a) The transformer supplies a Class 1 power-limited, Class 2, or Class 3 remote-control circuit;

b) The transformer is rated less than 50 volt-amperes, is inherently protected, and is an integral part of the motor controller;

c) The primary feeder circuit overcurrent device provides the required protection; or

d) The protection is provided by other means that comply with the applicable requirements in the National Electrical Code, ANSI/NFPA 70-1990 and in UL 508.

Table 18.3
Maximum acceptable rating of overcurrent device

Rating primary current, amperes	Maximum rating of overcurrent protective device expressed as a percent of transformer primary current rating
Less than 2	500
2 to less than 9	167
9 or more	125[a]

[a] See 18.3.2.

18.3.2 If the rated primary current of the transformer is 9 amperes or more and 125 percent of this current does not correspond to a standard rating of fuse or nonadjustable circuit breaker, the next higher standard rating of protective device may be used. Standard ratings for fuses and inverse-time circuit breakers are specified in Section 240-6 of the National Electrical Code, ANSI/NFPA 70-1990.

18.3.3 A control transformer and its primary and secondary conductors may be protected by overcurrent devices located in the primary circuit provided:

a) The transformer is single phase and has only a two-wire (single voltage) secondary;

b) The maximum value of an intended overcurrent device is determined in accordance with 18.3.1;

c) The maximum value of an intended overcurrent device as determined in 18.3.3(b) does not exceed the value of the overcurrent device obtained from Table 18.1 for the secondary conductor multiplied by the secondary-to-primary voltage ratio of the transformer; and

d) The overcurrent device complies with 18.2.3.

18.4 Low-voltage protection

18.4.1 A direct-current motor-starting rheostat shall be provided with a low-voltage protective device, operative on the reduction of voltage to less than one-third of its normal value, to cause and maintain the interruption of power to the main circuit.

18.5 Open-phase protection

18.5.1 An open-phase protective device shall operate upon the loss of power in one conductor of a polyphase circuit to cause and maintain the interruption of power in all of the circuit.

Exception: An open-phase protective device for an intermittently operated machine, such as a crane or an elevator, that has a definitely limited travel and a limited time for continuous running, may function only to prevent the restarting of the motor upon the loss of power in one conductor to the motor.

18.6 Phase-reversal protection

18.6.1 A phase-reversal protective device shall operate on the reversal of the phase rotation in a polyphase circuit to cause and maintain the interruption of power in all of the circuit.

19 Capacitors

19.1 A motor starting capacitor employing a liquid dielectric medium more combustible than askarel shall comply with the protected oil filled capacitor requirements in the Standard for Capacitors, UL 810, including faulted overcurrent conditions based on the branch circuit in which it is used. See Short Circuit Test – General, Section 50. Also, these capacitors and any associated circuit solid-state components shall be evaluated in accordance with the Breakdown of Components Test, Section 57.

Exception: If the available fault current is limited by other components in the circuit such as a motor-start winding, the capacitor may be tested using a fault current less than the value specified in Table 51.3, but not less than the current established by dividing the rated circuit voltage by the impedance of the other components.

19.2 A non-motor starting capacitor employing a liquid dielectric medium more combustible than askarel, and any associated circuit solid-state components, need only be evaluated in accordance with the Breakdown of Components Test, Section 57.

20 Fuseholders

20.1 A fuseholder shall be of either the cartridge or plug fuse type.

20.2 A cartridge fuseholder shall be constructed for use with a branch-circuit fuse.

Exception: If a supplementary fuse is used as specified in 18.2.3, the fuseholder shall be constructed for use with the supplementary fuse.

20.3 A plug fuse shall not be used in equipment rated more than 125 or 125/250 volts.

20.4 Industrial control equipment incorporating a fuseholder and the location of fuses, the normal function of which requires renewal, shall be so constructed that the fuses will be readily accessible when the switch contacts are open so that a person need not touch any live part to replace any fuse. The electrical arrangement of a single-throw switch shall be such that if it is connected as intended and the contacts are open, the fuse terminals will be dead.

Exception: A control-circuit fuse arrangement need not comply with this requirement provided the fuse and control-circuit load – other than a fixed control-circuit load, such as a pilot lamp – are within the same enclosure.

21 Internal Wiring

21.1 General

21.1.1 The wiring and connections between parts of the equipment shall be protected from mechanical damage during installation.

21.1.2 The insulation on all internal wires of the equipment shall be rated for the voltage and the temperature conditions of use. It shall also be considered with respect to other conditions of service to which it is likely to be subjected. Wire insulation shall be at least 1/32 inch (0.8 mm) thick if it is subjected to movement, flexing, or handling during its intended use, or during maintenance.

Exception: Internal wires used for grounding or bonding need not be insulated.

21.2 Routing of internal wiring

21.2.1 A hole through which insulated wires pass in a sheet metal wall within the enclosure of the equipment shall be provided with a smooth, well-rounded bushing or shall have smooth, well-rounded surfaces upon which the wires may bear to reduce the risk of abrasion of the insulation.

21.2.2 Wires shall be routed away from sharp edges, screw threads, burrs, fins, moving parts, drawers, and the like, that can abrade the wire insulation.

21.3 Clamps and guides

21.3.1 Clamps and guides, either metallic or nonmetallic, used for routing stationary internal wiring shall be provided with smooth, well-rounded edges. The clamping action and bearing surface shall be such that abrasion or cold flow of the insulation cannot occur. Auxiliary nonconducting mechanical protection shall be provided under a metallic clamp that exerts pressure on a conductor having thermoplastic insulation less than 1/32 inch (0.8 mm) thick and having no overall braid.

21.4 Flexing of internal wiring

21.4.1 Wiring that is subject to flexing during servicing such as that from a stationary part to a part mounted on a hinged door shall be provided with additional insulation at any point where it is flexed, unless the wiring is flexible cord.

Exception: Additional insulation is not required if the test described in Wire Flexing, Section 58 is completed without evidence of damage to the wiring.

21.5 Additional insulation

21.5.1 Additional insulation, if used, shall be insulating sleeving, tubing, or a wrapping of not less than two layers of insulating tape. The insulation shall be made of materials rated for the temperature and voltage involved.

21.6 Splices and connections

21.6.1 All splices and connections shall be mechanically secure and shall provide electrical continuity.

21.6.2 Electrical connections shall be soldered, welded, crimped, or otherwise securely connected. A soldered joint shall be mechanically secure before soldering.

Exception: Printed wiring board joints need not be mechanically secure before soldering.

21.6.3 A soldered lead is mechanically secure when it is:

a) Wrapped at least halfway (180 degrees) around a terminal;

b) Provided with at least one right angle bend when passed through an eyelet or opening; or

c) Twisted with other conductors.

21.6.3 revised July 16, 1999

21.6.4 If stranded internal wiring is connected to a wire-binding screw, the construction shall be such that loose strands of wire cannot contact other uninsulated live parts not always of the same polarity as the wire, and de-energized metal parts. This can be accomplished by any acceptable means including use of machine- or tool-applied pressure terminal connectors, soldering lugs, or crimped eyelets, or soldering all strands of the wire together.

21.7 Splice insulation

21.7.1 A splice shall be provided with insulation equivalent to that of the wires involved.

21.7.2 In determining if splice insulation consisting of coated-fabric, thermoplastic, or other types of tubing is acceptable, consideration is to be given to electrical and mechanical properties including dielectric voltage-withstand ability, heat resistance, and moisture resistance. See 21.5.1. Thermoplastic tape shall not be wrapped over a sharp edge or connection.

22 External Interconnections

22.1 Open equipment

22.1.1 The means provided for the interconnection of open equipment within a control enclosure such as interconnecting cable, cord, or harness, shall be evaluated as internal wiring in accordance with the requirements for Internal Wiring, Section 21. The means provided for the interconnection of open equipment to remote equipment outside of the control enclosure, such as by means of permanently installed field wiring, shall comply with the requirements for Supply Connections, Section 25.

22.1.1 revised July 16, 1999

22.2 Enclosed equipment

22.2.1 The means provided for the interconnection of enclosed equipment shall comply with the requirements of 22.3.1 – 22.3.4, except that equipment with field wiring provisions to facilitate interconnection by means of permanently installed field wiring shall comply with the requirements of Supply Connections, Section 25.

22.3 Interconnecting cords and cables

22.3.1 Cable assemblies and flexible cords provided for interconnection between sections of equipment or between units of a system shall be of a type that is acceptable for the service or use involved and shall be provided with bushings and strain relief.

22.3.2 Misalignment of male and female connectors, insertion of a multipin male connector in a female connector other than the one intended to receive it, and other manipulations of parts that are accessible to the operator shall not result in mechanical damage or a risk of fire, electric shock, or injury to persons.

22.3.3 If either or each end of an external interconnecting cable terminates in a connector external to the enclosure on which there are one or more exposed contacts, risk of electric shock shall not exist between earth ground and any contact that is exposed on either the connector or its receptacle mounted on an enclosure surface while the connector is out of its receptacle.

22.3.4 An interlock circuit in the cable to de-energize the exposed contacts whenever an end of the cable is disconnected is an acceptable method of complying with the requirement in 22.3.3.

23 Transformers

23.1 A transformer employed in industrial control equipment shall comply with the appropriate UL standards for transformers, unless the load is part of the equipment, in which case the transformer shall comply with the Temperature Test, Section 43, and the Dielectric Voltage-Withstand Test, Section 49, in this standard.

Exception: Pulse and current transformers constructed in a manner other than allowed by the applicable UL transformer standard are considered to be in compliance with this requirement if they can withstand, without breakdown, a dielectric voltage withstand potential in accordance with Section 49, applied between the primary and the secondary windings. An example of transformer constructions for which this exception would apply are those that may rely upon magnet wire coating to provide isolation instead of inter-winding tape.

24 Blower Motors

24.1 Each blower motor shall be capable of delivering its maximum normal load without introducing risk of fire, electric shock, or injury to persons. The motor winding shall resist the absorption of moisture. See Coil Windings, Section 27.

24.2 Each blower motor shall incorporate one of the following forms of locked rotor protection:

a) Thermal protection complying with the applicable requirements in the Standard for Overheating Protection for Motors, UL 2111;

b) Impedance protection complying with the applicable requirements in the Standard for Overheating Protection for Motors, UL 2111; or

c) Other protection that is shown by test to be equivalent to the protection specified in 24.2(a).

25 Supply Connections

25.1 General

25.1.1 Supply connections are considered to be those electrical connections that are made in the field when the equipment is installed.

25.2 Permanently connected equipment

25.2.1 Industrial control equipment intended for permanent connection to the power supply shall have provision for connection of one of the applicable wiring systems in accordance with the National Electrical Code, ANSI/NFPA 70-1990.

Exception: An enclosure need not have provision for the connection of a wiring system, such as a conduit hub, a knockout or a fitting, if it is intended to be drilled or punched in the field to accommodate a wiring system and is provided with appropriate installation instructions.

25.3 Tapped holes for conduit

25.3.1 A tapped hole in a cast metal enclosure for the attachment of threaded rigid conduit shall be provided with:

a) An integral bushing having a smooth, rounded inlet hole with a diameter approximately the same as the internal diameter of a standard bushing to provide protection for the conductors equivalent to that provided by such a bushing, or shall be located so that a standard bushing may be attached to the end of the conduit; and

b) At least three full threads when tapped all the way through the wall of an enclosure, or with at least 3-1/2 full threads when used with an integral bushing.

25.4 Knockouts

25.4.1 A knockout in a sheet-metal enclosure shall be reliably secured but capable of being removed without undue deformation of the enclosure.

25.4.2 A knockout shall be provided with a flat surrounding surface for proper seating of a conduit bushing, and shall be located so that installation of a bushing at any knockout likely to be used during installation will not result in spacings between uninsulated live parts and the bushing that are less than the minimum values specified in this standard.

25.5 Wiring terminals and leads

25.5.1 Except as noted in 25.5.2, industrial control equipment shall be provided with wiring terminals or leads for connection of conductors having an ampacity or wire size not less than the largest of the following:

a) The ampere rating of the equipment.

b) One-hundred twenty-five percent of the full-load motor current specified in Table 45.2 or 45.3 for the horsepower rating, or, in the case of power conversion equipment, in which the input current is different from motor full-load current, 125 percent of maximum rated input current.

c) One-hundred twenty-five percent of the resistive ampere rating of the devices intended to control fixed electric space-heating equipment loads.

d) For equipment controlling a direct-current motor intended to be operated from a rectified single-phase power supply;

1) One-hundred ninety percent of full load current if a half wave rectifier is used.

2) One-hundred fifty percent of full load current if a full wave rectifier is used.

Exception: Item (d) does not apply if the product is marked in accordance with 64.10.

e) No. 14 AWG (2.1 mm^2) for control, signal, or sensor circuits unless the terminals are intended and marked (on product or installation instructions) for the connection of smaller conductor size or sizes.

25.5.2 A pressure terminal connector, including one that is compression tool applied, for field connection to line or load need not be provided for equipment with field wiring larger than No. 10 AWG (5.3 mm^2) if the construction complies with the following conditions:

a) Component terminal connectors are available from the equipment manufacturer and one or more are specified for field installation on the equipment.

b) A fastening device, such as a stud, nut, bolt, spring or flat washer, or the like, that is required for installation provided as part of the component terminal assembly, or mounted on or separately packaged with the equipment.

c) The installation of the terminal assembly does not involve the loosening or disassembly of a part other than a cover or other part giving access to the terminal location. The means for securing the terminal connectors shall be accessible for tightening before and after installation of the conductor.

d) If the pressure connector provided in a component terminal assembly requires the use of other than an ordinary tool for securing the conductor, instructions referencing use of the tool shall be included with the component assembly or with the equipment.

e) Installation of a pressure terminal connector in the intended manner shall result in a product that complies with the requirements in this standard.

f) The equipment is marked in accordance with 64.10.

25.5.3 It is assumed that industrial control equipment having a current rating or a horsepower rating with a full-load motor current as specified in Table 45.2 or 45.3 will be connected with wire of a size determined in accordance with Table 310-16 of the National Electrical Code, ANSI/NFPA 70-1990. Unless marked for use only with wire rated 75°C (167°F), the size is to be based upon wire rated for a 60°C (140°F) temperature for equipment rated 100 amperes or less; and upon wire rated for 75°C for equipment rated greater than 100 amperes. The type of insulation is not specified.

25.5.4 If a wiring terminal will receive the next larger size conductor than that required in 44.3, the terminal shall comply with secureness and pullout requirements with that size conductor, unless the equipment is marked to restrict its use to only the smaller size conductor.

25.5.5 If a field wiring terminal is intended for field wiring of conductors smaller than No. 14 AWG (2.1 mm^2) of other than Class 2 or Class 3 circuits as specified by the installation instructions or wiring diagram furnished with the device, the terminal shall comply with the secureness and pullout test requirements:

a) For such conductors; and

b) For No. 18 AWG (0.8 mm^2) if the specified conductors are smaller than No. 18 AWG.

25.5.6 Revised and relocated as 25.5.15 July 16, 1999

25.5.7 A terminal to which field wiring is to be connected shall be a soldering lug or pressure wire connector.

Exception: A terminal to which No. 10 AWG (5.3 mm^2) or smaller wiring connections are to be made may consist of a clamp or binding screw with a terminal plate having upturned lugs or the equivalent to hold the wire in position.

25.5.8 A field-wiring pressure wire connector provided with or specified for use with industrial control equipment shall comply with one or more of the following, as applicable:

a) The performance requirements in the Standard for Wire Connectors and Soldering Lugs for Use With Copper Conductors, UL 486A;

b) The performance requirements in the Standard for Wire Connectors for Use With Aluminum Conductors, UL 486B; or

c) The performance requirements in the Standard for Equipment Wiring Terminals for Use With Aluminum and/or Copper Conductors, UL 486E.

25.5.9 The tightening torque for a field-wiring terminal shall be as specified by the industrial control equipment manufacturer and shall be marked as specified in 64.11. The specified tightening torque shall not be less than 90 percent of the value employed in the static heating test as specified in the requirements in the Standard for Wire Connectors for Use With Aluminum Conductors, UL 486B, or the Standard for Wire Connectors and Soldering Lugs for Use With Copper Conductors, UL 486A, or the Standard for Equipment Wiring Terminals for Use With Aluminum and/or Copper Conductors, UL 486E, for that wire size corresponding to the ampere rating of the industrial control equipment. See 59.1.

Exception No. 1: The value of tightening torque may be less than 90 percent of the value specified if the connector is investigated in accordance with UL 486A, UL 486B, or UL 486E, with the lesser assigned torque value.

Exception No. 2: A field-wiring terminal intended only for the connection of a control circuit conductor need not be marked with a value of tightening torque if tested in accordance with the applicable requirements in UL 486A or UL 486E, with a value of tightening torque of 7 pound-inches (0.8 N·m).

25.5.10 A nominal 0.110-, 0.125-, 0.187-, 0.205-, or 0.250-inch wide quick-connect terminal shall comply with the Standard for Electrical Quick-Connect Terminals, UL 310. Other sizes of quick-connect terminals shall be investigated with respect to such areas as crimp pullout, engagement-disengagement forces of the connector and tab, and temperature rises in accordance with UL 310.

25.5.11 A wire-binding screw to which field-wiring connections are made shall have a diameter of 0.154 inches (3.91 mm) minimum.

Exception: A screw with a diameter of 0.128 iches (3.25 mm) minimum is able to be used for a terminal intended only for connection of a No. 14 AWG (2.1 mm^2) conductor.

25.5.11 revised July 16, 1999

25.5.12 A terminal plate tapped for a wire-binding screw shall be of metal not less than 0.030 inch (0.76 mm) thick for a No. 14 AWG (2.1 mm^2) or smaller wire, and not less than 0.050 inch (1.27 mm) thick for a wire larger than No. 14 AWG. There shall be at least two full threads in the plate.

Exception: Two full threads are not required if fewer threads result in a secure connection in which the threads will not strip upon application of a 20 pound-inch (2.3 N·m) tightening torque.

25.5.13 A terminal plate formed from stock having the required thickness specified in 25.5.12 may have the metal extruded at the tapped hole for the binding screw to provide two full threads.

25.5.14 A wire-binding screw shall thread into metal.

25.5.15 A lead that is intended to be spliced in the field to a circuit conductor shall not be smaller than 18 AWG (0.8 mm^2) and the insulation, when rubber or thermoplastic, shall not be less than 1/32 inch (0.8 mm) thick.

Exception: A lead of a proximity switch shall not be smaller than 24 AWG (0.2 mm^2).

25.5.6 revised and relocated as 25.5.15 July 16, 1999

25.5.16 The free length of a field wiring lead shall be not less than 6 inches (152 mm) long.

Exception: The free length of a field wiring lead shall not be less than 4 inches (100 mm) long when intended for installation in an outlet box.

25.5.16 added July 16, 1999

25.6 Cord-connected equipment

25.6.1 Industrial control equipment intended to be cord-connected to the power supply shall be provided with an acceptable length, size, and type of hard-service or junior hard-service flexible cord, such as Type S, SJ, or the equivalent, that is terminated in an attachment plug and rated for the temperature and voltage involved.

Exception: Such equipment need not be provided with a hard service or junior hard service type cord if the cord is No. 14 AWG or smaller and complies with requirements for proximity switches in Power-Supply Cord Tests, Section 206, Cable Gland Connector Tests, Section 207, Strain Relief Test, Section 208 and:

a) The application or design of the equipment is such that it does not allow the use of a hard service or junior hard service cord, and the previously evaluated cord will not be subjected to abuses seen in general use cord application; or

b) The cord is used in circuits which comply with Secondary Circuits, Section 32.

25.6.2 Strain relief shall be provided on power supply or signal multicable cords.

25.6.2 revised July 16, 1999

25.6.3 At the point at which the cord passes through the enclosure wall, protection shall be provided to prevent cord abrasion.

25.6.4 If a knot serves as strain relief in an attached flexible cord, any surface that the knot may contact shall be free from projections, sharp edges, burrs, fins and the like, that may cause abrasion of the insulation on the conductors.

25.6.5 Means shall be provided to prevent the supply cord from being pushed into the enclosure through the cord-entry hole when such displacement results in:

a) Subjecting the supply cord or lead to mechanical damage;

b) Exposing the supply cord or lead to a temperature higher than that for which it is rated;

c) Reducing spacings (such as to a metal strain-relief clamp) below the minimum required values; or

d) Damaging internal connections or components.

To determine compliance, the supply cord shall be tested in accordance with Section 57B, Push-Back Relief Test.

25.6.5 revised July 16, 1999

25.6.6 A power-supply or signaling connecting cord, used on equipment having a:

a) Type 3, 3R, 3S, 4, 4X, 6, or 6P enclosure shall be acceptable for outdoor use;

b) Type 6 or 6P enclosure shall be water resistant; and

c) Type 12, 12K, or 13 enclosure shall be oil resistant (such as SO, SJO, or STO).

25.6.7 For a device that is intended to provide a signaling function, an attachment plug is not required.

26 Cord-Connected Programming and Diagnostic Units

26.1 Auxiliary units such as portable programmers intended to be used only on a temporary basis, to diagnose or program industrial controls shall comply with the Standard for Information Technology Equipment, UL 1950. These units may be considered as a subsystem of the industrial electronic control equipment.

27 Coil Windings

27.1 A coil winding shall resist the absorption of moisture. This may be accomplished by impregnating, dipping in or brushing with varnish, or by other acceptable means.

Exception: A coil made with film-coated wire need not have additional treatment to resist moisture absorption.

28 Risk of Electric Shock

28.1 A risk of electric shock is considered to exist within a circuit unless that circuit meets one of the following criteria:

a) The circuit is supplied by an isolating source such that the maximum open circuit voltage potential available to the circuit is not more than 30 V ac or 42.4 V peak; or

b) The circuit is supplied by an isolating source such that the current available through a 1500 ohm resistor connected across any potential in the circuit (including to ground) does not exceed 5 mA.

28.2 The secondary circuits that do not involve a risk of electric shock are:

a) A Class 2 circuit;

b) A Limited Voltage/Current circuit;

c) A Limited Voltage circuit;

d) A Limited Energy circuit that involves open circuit potential less than or equal to 30 V ac or 42.4 V peak; and

e) A Limiting Impedance circuit that complies with 28.1.

29 Risk of Fire

29.1 A risk of fire is considered to exist within a circuit unless that circuit meets one of the following criteria:

a) The circuit is supplied by an isolating source such that the maximum open circuit voltage potential available to the circuit is not more than 30 V ac or 42.4 V peak and the current available is limited to a value not exceeding 8 amperes measured after 1 minute of operation; or

b) The circuit is supplied by an isolating source such that the power available to the circuit is limited to a value less than 15 watts.

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29.2 The secondary circuits that do not involve a risk of fire are:

a) A Class 2 circuit;

b) A Limited Voltage/Current circuit; and

c) A Limiting Impedance circuit.

30 Lithium Battery Circuits

30.1 A lithium battery circuit is a primary or secondary circuit that obtains power from lithium batteries.

30.2 A lithium battery circuit shall comply with the following:

a) The requirements in UL 1642, Standard for Lithium Batteries; and

Exception: A circuit that obtains power solely from a lithium battery (for example, a circuit in which the lithium battery serves as the sole power source as opposed to serving as a back-up power source) need not be subjected to the requirements in UL 1642.

b) The primary circuit requirements in this Standard or with the requirements for Secondary Circuits, Section 32.

31 Non-Lithium Battery Circuits

31.1 General

31.1.1 A non-lithium battery circuit is a primary or secondary circuit that obtains power from rechargeable or non-rechargeable, non-lithium batteries.

31.1.2 A non-lithium battery circuit shall comply with the following:

a) The primary non-rechargeable (see 31.2) or secondary rechargeable/non-rechargeable (see 31.3) requirements; and

b) The primary circuit requirements in this Standard or with the requirements for Secondary Circuits, Section 32.

31.2 Primary non-rechargeable

31.2.1 A primary non-rechargeable non-lithium battery circuit shall involve a battery that has an output in compliance with the requirements for a Class 2 (see 32.3) or Limited Voltage/Current secondary circuit (see 32.4).

31.3 Secondary rechargeable/non-rechargeable

31.3.1 A secondary rechargeable/non-rechargeable non-lithium battery circuit shall involve a battery that has an output in compliance with the requirements for a Class 2 (see 32.3) or Limited Voltage/Current (32.4) secondary circuit.

31.3.2 Charging circuitry for these battery circuits shall be derived from an isolating source that complies with the Class 2 (see 32.3), the Limited Voltage/Current (see 32.4), the Limited Voltage (see 32.5), the Isolated Power Supply (see 32.6), or the Limited Energy (see 32.7) circuit requirements in Section 32.

32 Secondary Circuits

32.1 General

32.1.1 A secondary circuit is a circuit that is isolated at all points from the primary branch circuit. This isolation shall be provided by means of a transformer, optical isolator, limiting impedance, or electro-mechanical relay.

32.1.2 In addition to the requirements for Separation of Circuits, Section 34, a secondary circuit shall comply with the requirements for a primary circuit or with the requirements for one of the following types of secondary circuits:

a) A Class 2 circuit;

b) A Limited Voltage/Current circuit;

c) A Limited Voltage circuit;

d) An Isolated Power Supply circuit;

e) A Limited Energy circuit; or

f) A Limiting Impedance circuit.

32.2 Differences between the level of evaluation required within each type of secondary circuit

32.2.1 The following applies to secondary circuits that comply with the Class 2 (see 32.3) or the Limited Voltage/Current (see 32.4) circuit requirements in this section:

a) Components located within these circuits need not be evaluated.

Exception: Lithium batteries shall be evaluated in accordance with Section 30.

b) Spacings located within these circuits and from these circuits to earth ground or to the enclosure need not be evaluated. However, spacings from these circuits to other circuits shall be in accordance with Section 36.

c) These circuits can be accessible from outside the enclosure.

32.2.2 The following applies to secondary circuits that comply with the Limited Voltage (see 32.5) circuit requirements in this section:

a) Components located within these circuits need not be evaluated.

Exception: Lithium batteries shall be evaluated in accordance with Section 30. Printed wiring boards shall be evaluated in accordance with UL 796, Standard for Printed Wiring Boards, and shall be rated V-2 or better. Wiring shall be evaluated in accordance with Section 21.

b) Spacings located within these circuits and from these circuits to earth ground or to the enclosure need not be evaluated. However, spacings from these circuits to other circuits shall be in accordance with Section 36.

c) These circuits shall not be accessible from outside the enclosure. Therefore, if these circuits provide power to components that extend through the enclosure (such as displays, keypads, and the like), then the ability of these components to serve as an enclosure will need to be evaluated.

32.2.3 The following applies to secondary circuits that comply with the Isolated Power Supply (see 32.6) circuit requirements in this section:

a) Components located within these circuits need not be evaluated.

Exception: Lithium batteries shall be evaluated in accordance with Section 30. Printed wiring boards shall be evaluated in accordance with UL 796, Standard for Printed Wiring Boards, and shall be rated V-2 or better. Wiring shall be evaluated in accordance with Section 21. Blower motors shall be evaluated in accordance with the requirements in Section 24. The effects of heat generating power components on adjacent components such as printed wiring boards and wiring shall be evaluated in accordance with the temperature requirements in Section 43.

b) Spacings located within these circuits need not be evaluated. However, spacings from these circuits to other circuits shall be in accordance with Section 36 and spacings from these circuits to earth ground or to the enclosure shall be in accordance with 32.6.1(h).

c) These circuits shall not be accessible from outside the enclosure. Therefore, if these circuits provide power to components that extend through the enclosure (such as displays, keypads, and the like), then the ability of these components to serve as an enclosure will need to be evaluated.

32.2.4 The following applies to secondary circuits that comply with the Limited Energy (see 32.7) circuit requirements in this section and that involve open circuit potentials less than or equal to 30 V ac or 42.4 V peak:

a) Components located within these circuits need not be evaluated.

Exception: Lithium batteries shall be evaluated in accordance with Section 30. Printed wiring boards shall be evaluated in accordance with UL 796, Standard for Printed Wiring Boards, and shall be rated V-2 or better. Wiring shall be evaluated in accordance with Section 21.

b) Spacings located within these circuits and from these circuits to earth ground or to the enclosure need not be evaluated. However, spacings from these circuits to other circuits shall be in accordance with Spacings, Section 36.

c) These circuits shall not be accessible from outside the enclosure. Therefore, if these circuits provide power to components that extend through the enclosure (such as displays, keypads, and the like), then the ability of these components to serve as an enclosure will need to be evaluated.

32.2.5 The following applies to secondary circuits that comply with the Limited Energy (see 32.7) circuit requirements in this section and that involve open circuit potentials in excess of 30 V ac or 42.4 V peak:

a) Components located within these circuits need not be evaluated.

Exception: Lithium batteries shall be evaluated in accordance with Section 30. Printed wiring boards shall be evaluated in accordance with UL 796, Standard for Printed Wiring Boards, and shall be rated V-2 or better. Wiring shall be evaluated in accordance with Section 21. Blower motors shall be evaluated in accordance with the requirements in Section 24. The effects of heat generating power components on adjacent components such as printed wiring boards and wiring shall be evaluated in accordance with the temperature requirements in Section 43.

b) Spacings located within these circuits need not be evaluated. However, spacings from these circuits to earth ground or to the enclosure and spacings from these circuits to other circuits shall be in accordance with Section 36.

c) These circuits shall not be accessible from outside the enclosure. Therefore, if these circuits provide power to components that extend through the enclosure (such as displays, keypads, and the like), then the ability of these components to serve as an enclosure will need to be evaluated.

32.2.6 The following applies to secondary circuits that comply with the Limiting Impedance (see 32.8) circuit requirements in this section:

a) Components located within these circuits need not be evaluated.

Exception: Lithium batteries shall be evaluated in accordance with Section 30.

b) Spacings located within these circuits and from these circuits to earth ground or to the enclosure need not be evaluated. However, spacings from these circuits to other circuits shall be in accordance with Spacings, Section 36.

c) These circuits may be accessible from outside the enclosure.

Exception: Circuits supplied from a limiting impedance that complies with Exception No. 1 to 32.8.2 shall not be accessible from outside the enclosure. Therefore, if these circuits provide power to components that extend through the enclosure (such as displays, keypads, and the like), then the ability of these components to serve as an enclosure will need to be evaluated.

32.3 Class 2 circuit requirements

32.3.1 A Class 2 circuit shall be supplied by an isolating source that complies with the requirements in the Standard for Class 2 Power Units, UL 1310, or the requirements in the Standard for Class 2 and Class 3 Transformers, UL 1585.

32.4 Limited voltage/current circuit requirements

32.4.1 A limited voltage/current circuit shall be supplied by an isolating source such that the maximum open circuit voltage potential available to the circuit is not more than 30 V ac or 42.4 V peak and the current available is limited to a value not exceeding 8 amperes measured after 1 minute of operation. The secondary winding of an isolating type transformer may be used to comply with this requirement.

32.4.2 With reference to these secondary voltage and current limits, these measurements are to be made as follows:

a) The input to the source of that secondary is to be connected as intended;

b) The maximum open circuit voltage potential available to the secondary circuit under consideration is to be measured across the source of that secondary; and

c) The current available to the secondary circuit under consideration is to be measured by connecting a variable resistive load across the source of that secondary and then varying the load until an available current of 8 amperes can be obtained for 1 minute of operation. If an available current of 8 amperes cannot be obtained under any condition of loading, up to and including a short circuit, then the test can be discontinued for that circuit.

32.4.3 For a transformer, only one secondary circuit of a multiple secondary transformer is to be tested at a time and all other secondaries not under test are to be loaded as intended. The voltage and current measurements can be made directly across the secondary output terminals of the transformer. When a tapped transformer winding is used to supply a full-wave rectifier, the measurements are to be made from either end of the winding to the tap. When the transformer is used as part of a switching-type power supply, the voltage and current measurements are to be made after the transformer secondary winding rectification means.

32.4.4 A secondary fuse or other such secondary circuit protective device used to limit the available current in accordance with 32.4.1, shall be rated at not more than the values specified in Table 32.1.

Table 32.1
Rating for fuse or circuit protective device

Open circuit volts (peak)	amperes
0 – 20	5.0
Over 20 – 30	100/V[a]

[a] V is defined as the peak open circuit voltage.

32.4.5 The secondary circuit protective device referenced in 32.4.4 may also be provided in the primary circuit. When provided in the primary circuit, there are no restrictions on the current rating of the protective device as long as it limits the available secondary current in accordance with Table 32.1.

32.4.6 When a protective device is used as specified in 32.4.4 or 32.4.5, this protective device shall comply with the requirements of this Standard and shall be provided with an adjacent replacement marking or replacement instructions that includes the required voltage and current rating. The printed wiring board, wiring, and spacings prior to the point at which the voltage and current are suitably limited shall comply with the requirements of this Standard.

32.4.7 A fixed impedance (such as a component or grouping of components in the same circuit) or a regulating network (such as used in a switching type power supply) may be provided to limit the voltage and/or the available current in accordance with 32.4.1. Such a fixed impedance or regulating network shall be able to function under single component fault conditions.

32.5 Limited voltage circuit requirements

32.5.1 A Limited Voltage circuit shall be supplied by an isolating source that complies with the following:

a) The maximum open circuit voltage potential available to the circuit shall not be more than 30 V ac or 42.4 V peak without any limitation on the available current or volt-ampere capacity;

b) Overcurrent protection shall be provided in accordance with the requirements for Limited Voltage Circuit Overcurrent Protection, Section 33; and

c) These circuits are intended for use in a pollution degree 2 environment.

The secondary winding of an isolating type transformer may be used to comply with this requirement.

32.5.2 The maximum open circuit voltage potential available to the secondary circuit under consideration is to be measured in the same manner as the voltage limit in 32.4.2.

32.6 Isolated power supply circuit requirements

32.6.1 An isolated power supply circuit shall be supplied by an isolating source that complies with the following:

a) The circuits are isolated from other circuitry in accordance with the requirements of Separation of Circuits, Section 34, and Isolation Devices, Section 35, and are supplied from the secondary windings of isolation transformers that are limited to the extent that the product of the open circuit voltage and the short circuit current available at the transformer terminals when protective devices are bypassed is 10 kilovolt-amperes or less.

b) A printed wiring board and any coatings shall comply with the requirements in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, and the Standard for Printed-Wiring Boards, UL 796, and shall be classed V-2 or better.

c) The source employs insulation on internal wiring that is FEP, PTFE, PVC, TFE, neoprene, or equivalent.

d) Working voltage of the secondary circuit shall not be more than 150 volts rms.

e) The construction or circuitry shall suppress internally and externally generated surges in the secondary circuit to at least 300 volts peak. See Transient-Voltage-Surge Suppression Test, Section 55.

f) Except for open equipment, there shall be no live parts in the secondary circuit accessible outside the enclosure where the open circuit voltage exceeds 30 volts rms or 42.4 volts peak or direct current.

g) Spacings between live parts of the secondary circuit and live parts of the primary circuit shall be maintained as specified in Spacings, Section 34 based on the voltage of the primary circuit.

h) Spacings shall not be less than 1/8 inch (3.2 mm) through air and over surface, between live parts of the secondary circuit and operator-accessible metal, or grounded dead metal including the enclosure.

Exception No. 1: These spacings shall not be less than 1/16 inch in secondary circuits rated 50 volts or less.

Exception No. 2: Instead of spacing considerations, the construction may be judged acceptable if it withstands without breakdown or arc-over the application of an ac potential of twice the rated voltage plus 1000 V (or a dc potential of 1.4 times the sum of twice the rated voltage plus 1000 V) for 60 seconds between the secondary and accessible or grounded noncurrent carrying metal parts. During the test any component normally connected to ground is to be disconnected.

32.7 Limiting energy circuit requirements

32.7.1 A limited energy circuit shall be supplied by an isolating source such that the maximum volt-ampere capacity available to the circuit is 200 volt-amperes or less at a maximum open circuit voltage potential of 100 V ac. The secondary winding of an isolating type transformer may be used to comply with this requirement.

32.7.2 A primary or secondary circuit fuse or other such circuit protective device may be used to limit the maximum available volt-ampere capacity in accordance with 32.7.1. While there are no restrictions on the current rating of this protective device as long as it limits the available secondary volt-ampere limit in accordance with 32.7.1, the protective device shall comply with the requirements of this Standard and shall be provided with an adjacent replacement marking or replacement instructions that includes the required voltage and current rating. The printed wiring board, wiring, and spacings prior to the point at which the voltage and volt-ampere capacity are suitably limited shall comply with the requirements of this Standard.

32.8 Limiting impedance circuit requirements

32.8.1 A limiting impedance circuit shall be supplied by an impedance that complies with the following:

a) The calculated power dissipation of the impedance, as the result of a direct short applied across the circuit downstream of the impedance, does not exceed the power rating of the impedance; and

b) The impedance shall be less than 15 Watts.

Exception: A limiting impedance circuit may be supplied by an impedance that complies with the following:

a) The impedance shall be rated such that the calculated power dissipation of the impedance, as the result of a direct short applied across the circuit downstream of the impedance, exceeds the power rating of the impedance but is still less than 15 Watts; and

b) The impedance shall not open or short when subjected to the effects of a direct short applied across the circuit downstream of the impedance. The method for setting up this limiting impedance test is the same as the method for setting up the Breakdown of Components Test, Section 57.

32.8.2 The limiting impedance referred to in 32.8.1 shall be able to function under single component fault conditions.

Exception No. 1: If the circuit limited by this impedance is enclosed, then this limiting impedance need not function under single component fault conditions.

Exception No. 2: A single resistor serving as a limiting impedance is considered to comply with this requirement without further investigation.

Exception No. 3: A single capacitor serving as a limiting impedance is considered to comply with this requirement without further investigation if the capacitor complies with requirements in the Standard for Across-The-Line, Antenna-Coupling, and Line-By-Pass Capacitors for Radio- and Television-Type Appliances, UL 1414.

33 Limited Voltage Circuit Overcurrent Protection

33.1 General

33.1.1 A Limited Voltage circuit described in 32.5.1 and 32.5.2 shall be provided with overcurrent protection specified in 33.2 and 33.3.

33.2 Overcurrent protection – primary circuits

33.2.1 All wiring, including bus bars and interconnecting cables, used in the distribution of primary electric energy within and between units of equipment and all transformers and other loading devices connected to the primary circuit shall be protected against burnout and damage to insulation resulting from any overload or short-circuit condition that can occur during operation of the equipment.

33.2.2 The protection referenced in 33.2.1 may be obtained from overcurrent devices included as integral parts of the control equipment or, if rated in accordance with 33.2.4, from the protection associated with the branch circuit to which the equipment is connected.

33.2.3 Overcurrent protective devices that are provided within the equipment and are types that are acceptable for branch-circuit protection in accordance with the National Electrical Code, ANSI/NFPA 70-1993 – for example, circuit breakers or Class CC, J, T, G, H, K, L, RK1, or RK5 cartridge fuses or Type S or Edison-base plug fuses – comply with the requirement in 33.2.2. Other types of overcurrent protection devices are to be investigated to determine their acceptability for the application.

33.2.4 The ratings of an overcurrent device in series with connecting wiring shall not exceed the following:

a) For motor loads alone – 300 percent of the motor full-load current observed during the maximum normal operation of the system.

b) For resistive loads, and for combination resistive and reactive loads, with or without motor loads – 250 percent of the full-load current of the circuit under consideration.

33.2.5 A device providing overcurrent protection shall be of a type that is acceptable for use when supplied directly by the branch circuit to which the equipment can be connected unless additional acceptable protection is provided in the equipment.

33.2.6 An overcurrent protective device shall be connected between the ungrounded branch-circuit supply conductor and the load.

33.2.7 If the equipment includes one or more circuits supplying power to one or more medium-base or smaller lampholders or to one or more attachment-plug receptacles, and if the overcurrent protection of the branch circuit to which the equipment can be connected in accordance with the National Electrical Code, ANSI/NFPA 70-1993, is unacceptable for the protection of the lampholder or receptacle circuits, each circuit shall have individual overcurrent protection at not more than 20 amperes provided as a part of the equipment.

33.3 Overcurrent protection – secondary circuits

33.3.1 All external secondary-circuit interconnecting cables and all secondary-circuit wiring between units shall be protected against burnout and damage to the insulation resulting from any overload or short-circuit condition that can occur during use of the equipment.

Exception No. 1: This requirement does not apply to Class 2 circuits.

Exception No. 2: The overcurrent protection provided in the primary circuit of the transformer may be considered to be acceptable protection for the secondary circuit if it operates to protect the circuit under all overload conditions including short circuit.

33.3.2 A conductor provided with overcurrent protection complying with the National Electrical Code, ANSI/NFPA 70-1993, is considered to comply with 33.3.1.

33.3.3 Secondary circuits that are derived from power supplies or other sources that are either inherently limited, or include sensing devices whose operation achieves the same result (prevention of burnout and damage to insulation resulting from overload), or de-energizes the equipment are acceptable if the output wiring can carry the maximum current available from the power supply without discoloration or softening of insulation.

34 Separation of Circuits

34.1 A factory-installed conductor shall be separated by a barrier or segregated as specified in 34.2 from:

a) A factory-installed conductor used in a different circuit unless the conductors of both circuits are insulated for the maximum voltage of either circuit; and

b) An uninsulated live part connected to a different circuit.

34.2 Segregation of a conductor shall be accomplished by clamping, routing, or equivalent means that provides permanent separation from a conductor or an uninsulated live part of a different circuit.

34.3 A conductor shall be provided with strain relief in accordance with 25.6.2 – 25.6.5 if stresses on the conductor might cause the conductor to move such that compliance with 34.1 is not maintained.

34.4 The equipment shall be constructed so that a field-installed conductor of any circuit is segregated as specified in 34.6 or separated by a barrier (see 34.5) from:

a) A field-installed conductor connected to any other circuit unless:

b) An uninsulated live part of any other circuit.

1) Both circuits are Class 2 or Class 3 or both circuits are other than Class 2 or Class 3; and

2) The conductors of both circuits will be insulated for the maximum voltage of either circuit.

c) A factory-installed conductor connected to any other circuit, unless the conductors of both circuits will be insulated or the maximum voltage of either circuit.

Exception: The field-installed conductors need not be segregated or separated by a barrier provided specific installation instructions are included that explain the proper procedure to be followed to install the equipment to achieve required separation.

34.5 With respect to 34.4, if the intended uses of the device are such that in some applications a barrier is required while in some other applications no barrier is required, a removable barrier or one having openings for the passage of conductors may be employed. Instructions for the use of such a barrier are to be a permanent part of the device.

34.6 Field-installed conductors may be segregated from each other and from uninsulated live parts or factory-installed conductors of the industrial control equipment connected to different circuits by arranging the location of openings in an enclosure for the various field-installed conductors with respect to the terminals or other uninsulated live parts and factory- or field-installed conductors so that a minimum permanent 1/4 inch (6.4 mm) separation is provided.

35 Isolation Devices

35.1 An optical isolator that is relied upon to provide isolation between primary and secondary circuits or between other circuits as required by this Standard shall be constructed in accordance with the Standard for Optical Isolators, UL 1577, and shall be able to withstand for 1 minute, without breakdown, an ac dielectric voltage withstand potential equal to 1000 V plus twice rated voltage between the input and output circuits.

Exception No. 1: An optical isolator need not be subjected to the requirements in UL 1577 if the internal insulation is of such a material and at such a thickness that it complies with 37.3.

Exception No. 2: An optical isolator that is constructed in accordance with the requirements in UL 1577, but at a dielectric potential less than 1000 V plus twice rated voltage ac is considered to comply with 35.1 if the internal insulation is at such thickness that it also complies with 37.3(b).

35.2 A power switching semiconductor device that is relied upon to provide isolation to ground shall be constructed in accordance with the Standard for Electrically Isolated Semiconductor Devices, UL 1557. The dielectric voltage withstand tests required by UL 1557 shall be conducted at a dielectric potential of 1000 V plus twice rated voltage for 1 minute.

Exception No. 1: A power switching semiconductor need not be subjected to the requirements of UL 1557 if the internal insulation is of such material and at such a thickness that it complies with 37.3.

Exception No. 2: A power switching semiconductor that is constructed in accordance with UL 1557 but at a dielectric potential less than 1000 V plus twice rated voltage ac is considered to comply with 35.1 if the internal insulation is at such thickness that it also complies with 37.2(b).

36 Spacings

36.1 Other than as noted in 36.2, 36.5, 36.12, 36.13, 36.14, and 180.1 and Clearance and Creepage Distances, Section 38, the electrical spacings in industrial control equipment shall be at least those specified in Table 36.1.

36.2 The spacing in industrial control equipment in which transient voltages are known and controlled by a transient suppressive device shall not be less than those specified in Table 36.2 except that spacings at a field-wiring terminal shall be in accordance with Table 36.1.

36.3 The transient suppressive device specified in 36.2 shall prevent peak transient voltages from exceeding 300 percent of the instantaneous peak working voltage or 300 volts, whichever is greater. See Transient-Voltage-Surge Suppression Test, Section 55.

36.4 With reference to the requirements in 36.2, industrial control equipment shall have provision for the maintenance of clean, dry electrical surfaces, such as a coating on a printed wiring board, or other equivalent means.

36.5 The primary circuit spacings in industrial control power supplies intended for use in a pollution degree 2 environment shall be at least those specified in Tables 36.3 and 36.4.

36.6 The spacing at a field-wiring terminal is to be measured with wire connected to the terminal as in service. The connected wire for a programmable controller is to be the size that would normally be required for the equipment rating. The connected wire for all devices other than a programmable controller is to be the next larger size than would normally be required for the equipment rating if the terminal will accommodate it or if the equipment is not marked to restrict its use.

Table 36.1
Minimum acceptable spacings

Potential involved in volts rms ac or dc		Minimum spacing, inch (mm)							
		A			B		C		D
		General industrial control equipment			Devices having limited ratings[a]		Other devices[b]		All circuits[e]
		51 – 150	151 – 300	301 – 600	51 – 300	301 – 600	51 – 150	51 – 150	51 – 150
Between any uninsulated live part and an uninsulated live part of opposite polarity,	Through air or oil	1/8[c] (3.2)	1/4 (6.4)	3/8 (9.5)	1/16[c] (1.6)	3/16[c] (4.8)	1/8[c] (3.2)	1/4 (6.4)	1/16[c] (1.6)
uninsulated grounded part other than the enclosure, or exposed metal part[g,h]	Over surface	1/4 (6.4)	3/8 (9.5)	1/2 (12.7)	1/8[c] (3.2)	3/8 (9.5)	1/4 (6.4)	1/4 (6.4)	1/16 (1.6)
Between any uninsulated live part and the walls of a metal enclosure including fittings for conduit or armored cable[d,f]	Shortest distance	1/2 (12.7)	1/2 (12.7)	1/2 (12.7)	1/4 (6.4)	1/2 (12.7)	1/4 (6.4)	1/4 (6.4)	1/4 (6.4)

NOTES

1. A slot, groove, or the like, 0.013 inch (0.33 mm) wide or less in the contour of insulating material is to be disregarded.

2. An air space of 0.013 inch or less between a live part and an insulating surface is to be disregarded for the purpose of measuring over surface spacings.

[a] See 36.7.

[b] See 36.8.

Table 36.1 Continued on Next Page

Table 36.1 Continued

Potential involved in volts rms ac or dc		Minimum spacing, inch (mm)							
		A			B		C		D
		General industrial control equipment			Devices having limited ratings[a]		Other devices[b]		All circuits[e]
		51 – 150	151 – 300	301 – 600	51 – 300	301 – 600	51 – 150	51 – 150	51 – 150

[c] The spacing between field wiring terminals of opposite polarity and the spacing between a field wiring terminal and a grounded dead metal part shall be at least 1/4 inch if short-circuiting or grounding of such terminals may result from projecting strands of wire. For circuits involving no potential greater than 50 volts rms ac or dc, spacings at field wiring terminals may be 1/8 inch through air and 1/4 inch over surface.

[d] For the purpose of this requirement, a metal piece or component attached or mounted to the enclosure is considered to be a part of the enclosure if deformation of the enclosure is likely to reduce the spacings between uninsulated live parts or between uninsulated live parts and metal parts.

[e] Spacings apply as indicated, except as specified in 36.5 and the spacings between the low-potential circuit are in accordance with the requirements that are applicable to the high-potential circuit.

[f] Applicable to devices with sheet metal enclosures regardless of wall thickness and cast metal enclosures with a wall thickness of less than 1/8 inch (3.2 mm).

[g] These spacings are also applicable between any uninsulated live parts and the walls of a cast metal enclosure with a wall thickness of minimum 1/8 inch (3.2 mm) for devices without a short circuit rating and complying with 36.7 or 36.8.

[h] These spacings are also applicable between an insulated live part and the wall of a metal enclosure to which the component is mounted. Deformation of the enclosure shall not reduce spacings and result in a shock hazard.

36.7 The spacings specified in column B of Table 36.1 are applicable to equipment:

a) Rated 1 horsepower (746 W output) or equivalent FLA, or less, 720 volt-amperes break pilot duty or less; or not more than 15 amperes at 51 – 150 volts, 10 amperes at 151 – 300 volts, or 5 amperes at 301 – 600 volts.

b) Of the type described in (a) which controls more than one load provided the total load connected to the line at one time does not exceed 2 horsepower (1492 W output), 1440 volt-amperes, or have a current rating greater than 30 amperes at 51 – 150 volts, 20 amperes at 151 – 300 volts, or 10 amperes at 301 – 600 volts.

36.8 The spacings specified in column C of Table 36.1 apply only to equipment rated at 300 volts or less, and 1 horsepower (746 W output) or less or 2000 volt-amperes or less per pole and to a device that has a current rating per pole of 15 amperes or less at 51 – 150 volts, 10 amperes at 151 – 300 volts, or both.

Table 36.2
Minimum acceptable spacings for products with known and controlled transient voltages

Short-circuit power[a]	Peak working voltage	Minimum Spacing, Inch (mm)			
		Between any uninsulated live part and an uninsulated live part of opposite polarity, uninsulated grounded part other than the enclosure, or exposed metal part		Between any uninsulated live part and the walls of a metal enclosure including fittings for conduit or armored cable[b]	
		Through air or oil	Over surface	Through air	Over surface
More than 10 kVA, for use where transient voltages are known and controlled	0 – 50	0.030 (0.76)	0.030 (0.76)	0.500[c] (12.70)	0.250 (6.35)
	51 – 225	0.075 (1.91)	0.100 (2.54)	0.500 (12.70)	0.500 (12.70)
	226 – 450	0.150 (3.81)	0.200 (5.08)	0.500 (12.70)	0.500 (12.70)
	451 – 900	0.075 (1.91)	0.400 (10.16)	0.500 (12.70)	0.500 (12.70
More than 500 VA but not more than 10 kVA	0 – 50	0.030 (0.76)	0.030 (0.76)	0.500[c] (12.70)	0.250 (6.35)
	51 – 225	0.060 (1.52)	0.060 (1.52)	0.500 (12.70)	0.500 (12.70)
	226 – 450	0.100 (2.54)	0.100 (2.54)	0.500 (12.70)	0.500 (12.70)
	450 – 900	0.200 (5.08)	0.200 (5.08)	0.500 (12.70)	0.500 (12.70)
500 VA or less	0 – 36	0.012 (0.30)	0.012 (0.30)	0.500[c] (12.70)	0.250 (6.35)
	37 – 72	0.016 (0.40)	0.016 (0.40)	0.500[c] (12.70)	0.250 (6.35)
	73 – 100	0.030 (0.76)	0.030 (0.76)	0.500[c] (12.70)	0.250 (6.35)
	101 – 225	0.045 (1.14)	0.045 (1.14)	0.500 (12.70)	0.500 (12.70)
	226 – 450	0.060 (1.52)	0.060 (1.52)	0.500 (12.70)	0.500 (12.70)
	451 – 900	0.100 (2.54)	0.100 (2.54)	0.500 (12.70)	0.500 (12.70)

[a] Maximum short-circuit power is the product of the open-circuit voltage and the short circuit current available at the supply terminals when protective devices are bypassed.

[b] A metal piece attached to the enclosure is considered to be part of the enclosure if deformation of the enclosure is likely to reduce spacings between the metal piece and uninsulated live parts. Spacings specified for parts other than enclosure walls are acceptable to metal walls of a subassembly mounted inside another enclosure if spacings in the subassembly are rigidly maintained.

[c] Where deflection of an enclosure wall cannot reduce the through-air spacing to the enclosure wall, the spacing through air may be 0.250 inch.

36.9 A motor controller rated more than 1 horsepower (746 W output) at 151 – 300 volts that complies with the spacings specified in column A of Table 36.1 for such rating may have an additional rating of 1 horsepower or less at 301 – 600 volts. See also 36.8 for multipole products.

36.10 A motor controller rated more than 1 horsepower (746 W output) at 51 – 150 volts that complies with the spacings specified in column A of Table 36.1 for such rating may have an additional rating of 1 horsepower or less at 51 – 300 volts. See also 36.9 for multipole products.

36.11 In an open-type controller, the spacings between live parts and metal parts that may be grounded, such as the heads of mounting screws that pass through an insulating panel, shall be judged as if they were grounded parts within an enclosure. The spacing between uninsulated live parts and the surface on which the device may be mounted is to be judged as if the mounting surface were part of an enclosure.

36.12 For other than providing isolation between different circuits or in a safety circuit, spacings between traces of different potential on a printed wiring board need not comply with Tables 36.1 – 36.3 if:

a) The printed wiring board has a flammability rating of V-0;

b) The printed wiring board base material has a minimum Comparative Tracking Index (CTI) of 100 volts; and

c) The equipment complies with the Printed Wiring Board Abnormal Operation Test, Section 60.

Table 36.3
Power supply primary-circuit spacings other than at field-wiring terminals

Potential involved in volts		Minimum spacings[a], inch (mm)			
rms	Peak	Over surface		Through air	
0 – 50	0 – 70.7	3/64	(1.2)	3/64	(1.2)
51 – 125	72.1 – 176.8	1/16	(1.6)	1/16	(1.6)
126 – 250	178.2 – 353.6	3/32	(2.4)	3/32	(2.4)
251 – 600	355.0 – 848.5	1/2	(12.7)[b]	3/8	(9.5)[b]

[a] On printed-wiring boards, their connectors, and board-mounted electrical components, wired on the load side of the line filters of similar voltage peak reduction networds and components, a minimum spacing of 0.0230 inch (0.584 mm) plus 0.0002 inch (0.005 mm) per volt peak shall be maintained over surface and through air between uninsulated live parts and any other uninsulated live or dead conductive parts not of the same polarity. See 36.15.

[b] Film-coated wire is considered to be an uninsulated live part. However, a spacing of not less than 3/32 inch (2.4 mm) over surface and through air is acceptable between a dead metal part and film-coated wire that is rigidly supported and held in place on a coil.

Table 36.4
Power supply primary-circuit spacings at field-wiring terminals

Potential involved, in volts	Minimum spacings[a], inch (mm)					
	Between field-wiring terminals		Between field-wiring terminals and other uninsulated parts not always of the same polarity			
	Through air or over surface		Over surface		Through air	
0 – 50	1/8	(3.2)	1/8	(3.2)	1/8	(3.2)
51 – 250	1/4	(6.4)	1/4	(6.4)	1/4	(6.4)
251 – 600	1/2	(12.7)	1/2	(12.7)	3/8	(9.5)

[a] These spacings apply to the sum of the spacings involved wherever an isolated dead metal part is interposed.

36.13 For a pilot light, the spacings shall be:

a) At least 3/64 inch (1.2 mm) between uninsulated live parts of opposite polarity at or within a lampholder – an inherent lampholder spacing – rated 250 volts or less and at least 1/8 inch (3.2 mm) for a lampholder rated more than 250 volts;

b) At least those specified in Table 36.1 between uninsulated live parts of opposite polarity – other than at or within the lampholder – based on the normal operating voltage existing between such parts; and

c) At least those specified in Table 36.1 between uninsulated live parts and grounded parts, exposed dead metal parts, or the enclosure based on the line voltage of the pilot-light circuit.

36.14 In a series circuit, the spacings between resistor terminals, transformer taps, and the like are to be based on the normal operating voltage existing between such parts.

36.15 To assist in determining the adequacy of opposite polarity spacings on printed wiring boards, a voltage map layout may be used. This layout would identify potential differences on the printed wiring board.

36.16 In a pushbutton, selector switch, limit switch, or the like, opposite polarity is not considered to exist on any one pole, including double-throw arrangements; but opposite polarity is considered to exist between poles and between live parts on adjacent units unless the parts in question are connected to the same line terminal or conductor.

36.17 The spacings at fuses and fuseholders are to be measured with the fuses having maximum standard dimensions in place, and shall be at least the spacings specified in column A of Table 36.1.

36.18 Where insulation is provided in lieu of spacings between a magnetic coil winding and other uninsulated live parts or grounded dead metal parts, insulation may differ from that required by 37.1 and 37.2. Crossover-lead insulation and insulation under coil terminals secured to the coil winding need not comply with the requirements in 37.1 and 37.2, if for thicknesses less than 0.013 inch (0.33 mm), or where only through air space is provided, there is no indication of breakdown in the system as a result of the tests described in 49.2.1 – 49.2.5.

36.19 A ceramic, vitreous-enamel, or similar coating is not acceptable as insulation in place of spacings unless, upon investigation, the coating is found to be acceptable for the purpose.

36.20 If contact arms, blades, or the like, in a motor controller remain connected to the motor load terminals when in the off position, the spacing from such parts to the enclosure or to exposed dead metal parts that are isolated (insulated) shall be at least 1/8 inch (3.2 mm) more than the spacings required for stationary uninsulated live parts.

36.21 Film-coated wire is considered to be an uninsulated live part in determining compliance with the spacing requirements in this standard.

36.22 For an enclosure without conduit openings or knockouts, spacings not less than the minimum specified in this section shall be provided between uninsulated live parts and a conduit bushing installed at any location likely to be used during installation. A permanent marking on the enclosure, a template, or a full-scale drawing furnished with the equipment may be used to identify such locations.

36.23 For the spacing between an uninsulated live part and a bushing installed in a knockout, it is to be assumed that a bushing having the dimensions specified in Table 36.5 is in place, in conjunction with a single locknut installed on the outside of the enclosure.

Table 36.5
Dimensions of bushings

Trade size of conduit, inches	Bushing dimensions, inches (mm)			
	Maximum overall diameter		Height	
1/2	0.97	(24.6)	3/8	(9.5)
3/4	1.14	(29.0)	27/64	(10.7)
1	1.42	(36.1)	33/64	(13.1)
1-1/4	2.28	(57.9)	9/16	(14.3)
1-1/2	2.60	(66.0)	19/32	(15.1)
2	3.18	(80.7)	5/8	(15.9)
2-1/2	3.56	(90.5)	3/4	(19.1)
3	4.25	(108)	13/16	(20.6)
3-1/2	4.80	(122)	15/16	(23.8)
4	5.40	(137)	1	(25.4)
5	6.67	(170)	1-3/16	(30.2)
6	7.93	(202)	1-1/4	(31.8)

37 Insulating Barriers

37.1 Insulating material may be used as a barrier in lieu of the required spacings per 36.1.

37.2 The insulating material of 37.1 shall comply with the requirements in 37.3 if:

a) The material is in direct physical contact with an uninsulated live part;

b) The material serves to physically support or maintain the relative positive position of the uninsulated live part; and

c) The material is used as a barrier in lieu of the required over surface or through air spacings, or both.

37.3 Insulating material used as specified in 37.1, 37.5, or 37.6 shall:

a) Comply with 15.1; and

b) Be at least 0.028 inch (0.71 mm) thick.

Exception No. 1: A material that complies with 15.1 but does not comply with the thickness limit in 37.3(b) may alternatively be subjected to a 5000 V ac Dielectric Voltage-Withstand Test in accordance with the Internal Barrier requirements in the Standard for Polymeric Materials – Use In Electrical Equipment Evaluations, UL 746C.

Exception No. 2: A material that complies with 15.1 and is used in addition to not less than one-half the required through air spacings may be less than the required thickness in 37.3(b) but shall be at least 0.013 inch (0.33 mm) thick. Material utilizing this exception shall:

a) Have the necessary mechanical strength if exposed or otherwise likely to be subjected to mechanical damage;

b) Be held in place; and

c) Be located so that it will not be adversely affected by operation of the equipment in service.

Exception No. 3: Material that does not comply with the thickness specification in 37.3(b) but is no smaller than 0.013 inch (0.33 mm) thick in combination with at least one-half the required through air spacings may be subjected to an ac potential of twice the rated voltage plus 1000 V (or a dc potential of 1.4 times the sum of twice the rated voltage plus 1000 V) in accordance with Section 39.

37.4 The requirements in 37.3 are independent of each other. For example, even if a material can be considered to comply with 15.1 at a thickness less than that required by 37.3, then the material will still need to be provided at a thickness in accordance with 37.3 or at a thickness in accordance with the exceptions to 37.3.

37.5 Insulating material that meets the following criteria shall also comply with the requirements in 37.3:

a) The material is in direct physical contact with an uninsulated live part;

b) The material does not serve to physically support or maintain the relative position of that uninsulated live part; and

c) The material is used in lieu of the required over surface or through air spacings, or both.

Exception: A generic insulating material included in Table 37.1 is considered suitable for this application without additional evaluation.

37.6 Insulating material shall also comply with the requirements in 37.3 if:

a) The material is not in direct physical contact with an uninsulated live part;

b) The material does not serve to physically support or maintain the relative position of that uninsulated live part; and

c) The material is used in lieu of the required through air spacings.

Exception No. 1: A generic insulating material specified in Table 37.1 is considered suitable for this application without additional evaluation.

Exception No. 2: A material that is located at least 1/32 inch (0.8 mm) from uninsulated live parts need not comply with the HWI, HAI, or CTI PLC requirements.

Exception No. 3: A material that is located at least 1/2 inch (12.7 mm) from uninsulated live parts need not comply with the HWI, HAI, or CTI PLC requirements and also need not comply with the RTI requirement.

Table 37.1
Generic materials suitable as a barrier

Generic material	Minimum thickness, Inch	(mm)	RTI, °C
Aramid Paper	0.010	(0.25)	105
Cambric	0.028	(0.71)	105
Electrical Grade Paper	0.028	(0.71)	105
Epoxy	0.028	(0.71)	105
Mica	0.006	(0.15)	105
Mylar (PETP)	0.007	(0.18)	105
RTV	0.028	(0.71)	105
Silicone	0.0.28	(0.71)	105
Treated Cloth	0.028	(0.71)	105
Vulcanized Fiber	0.028	(0.71)	105

NOTE – Each material shall have at least the minimum thickness specified and its Relative Thermal Index (RTI) value shall not be exceeded during the Temperature Test.

38 Clamped Insulating Joints in Lieu of Spacings

38.1 In the case of a clamped insulating joint, spacings are to be measured through cracks unless a clamped joint has passed the test described in 49.3.2. A clamped joint is a joint between two pieces of insulation that are under pressure as shown in Figure 38.1. Adhesives, cements, and the like, if used to effect a seal in place of a tightly mated joint, shall comply with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

39 Clearance and Creepage Distances

39.1 As an alternative approach to the spacing requirements specified in Spacings, Section 36, and other than as noted in 39.2 and 39.3, clearances and creepage distances may be evaluated in accordance with the requirements in the Standard for Insulation Coordination Including Clearance and Creepage Distances for Electrical Equipment, UL 840, as described in 39.4.

39.2 Clearances between an uninsulated live part and the walls of a metal enclosure, including fittings for conduit or armored cable, shall be as noted in Table 36.1. The clearances shall be determined by physical measurement.

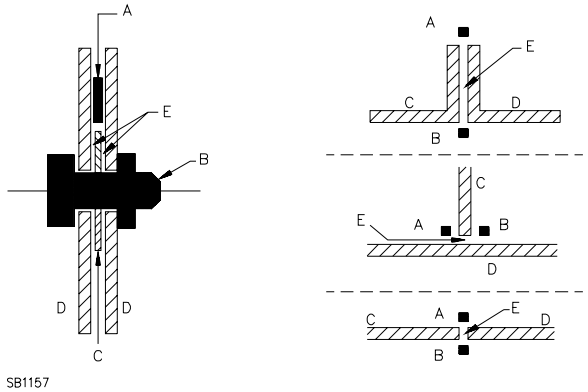
39.3 The clearance and creepage distance at field wiring terminals shall be in accordance with the requirements in Spacings, Section 36.

Exception: If the design of the field wiring terminals is such that it will preclude the possibility of reduced spacing due to stray strands or improper wiring installation, clearances and creepage distances at the field wiring terminal may be evaluated in accordance with the Standard for Insulation Coordination including Clearances and Creepage Distances for Electrical Equipment, UL 840.

39.4 In conducting evaluations in accordance with the requirements in the Standard for Insulation Coordination Including Clearance and Creepage Distances for Electrical Equipment, UL 840, the following guidelines shall be used:

a) Unless specified elsewhere in this standard, the pollution degree shall be considered to be pollution degree 3;

Figure 38.1
Clamped joint



Parts A, B – Live parts of opposite polarity, or a live part and grounded metal part with spacing through the crack between C and D less than required in Table 36.1 or 36.3.

Parts C, D – Insulating barriers clamped tightly together so that the dielectric strength between A and B is greater than the equivalent air spacing.

Part E – The clamped joint.

b) Equipment which operates in the direct line of the source of power to the load equipment shall be considered to be Overvoltage Category II. Other equipment covered under this standard shall be considered to be Overvoltage Category III;

c) Pollution degree 2 may be considered to exist on a printed wiring board between adjacent conductive material which is covered by any coating which provides an uninterrupted covering over at least one side and the complete distance up to the other side of conductive material;

d) Any printed wiring board which complies with the requirements in the Standard for Printed Wiring Boards, UL 796, shall be considered to provide a Comparative Tracking Index (CTI) of 100, and if it further complies with the requirements for Direct Support in UL 796 then it shall be considered to provide a CTI of 175;

e) For the purposes of compliance with the requirements for coatings of printed wiring boards used to achieve pollution degree 1 in accordance with UL 840, a coating which complies with the requirements for Conformal Coatings in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, is considered to be acceptable;

f) Pollution degree 1 may also be achieved at a specific printed wiring board location by application of at least a 1/32 inch (0.79 mm) thick layer of silicone rubber or for a group of printed wiring boards through potting, without air bubbles, in epoxy or potting material.

g) Evaluation of clearances, only, to determine equivalence with current through air spacings requirements may be conducted in accordance with Section 4, Clearance A (Equivalency) of UL 840. An impulse test potential having a value as determined in UL 840 is to be applied across the same points of the device as would be required for the Dielectric Voltage – Withstand Test, Section 49;

h) Evaluation of clearances and creepage distances shall be conducted in accordance with the requirements in UL 840 for Clearance B (Controlled Overvoltage), and Creepage Distances;

i) The Phase-to-Ground Rated System Voltage used in the determination of Clearances shall be the equipment rated supply voltage rounded to the next higher value (in the table for determining clearances for equipment) for all points on the supply side of an isolating transformer or the entire product if no isolating transformer is provided. The System Voltage used in the evaluation of secondary circuitry may be interpolated with interpolation continued across the table for the Rated Impulse Withstand Voltage Peak and Clearance; and;

j) Determination of the dimensions of clearance and creepage distances shall be conducted in accordance with the requirements for Measurement of Clearance and Creepage Distances of UL 840.

40 Grounding

40.1 General

40.1.1 The following enclosed industrial control equipment shall have provision for grounding all noncurrent carrying metal parts that are exposed or that are likely to be contacted by persons during normal operation or adjustment of the equipment and that are likely to become energized:

a) All fixed equipment; and

b) Portable equipment intended for use on circuits involving a potential of more than 150 volts to ground.

40.1.2 Acceptable means for grounding shall be as follows:

a) Motor controllers shall be provided with a means of attachment of a terminal or the equivalent for connecting an equipment grounding conductor as specified in Article 430-144 of the National Electrical Code. The terminal shall be sized to receive a grounding conductor as specified in Table 250-95 and Section 250-95, Exception No. 2, in ANSI/NFPA 70-1996;

b) Pendant, cord-connected equipment shall be provided with a terminal for connecting one conductor of a multiple-conductor cord to the enclosure;

c) Portable equipment shall be provided with a power-supply cord with a grounding conductor. The grounding conductor shall be connected to the grounding blade of a grounding attachment plug and shall be connected to the frame or enclosure of the equipment. The surface of the insulation on the grounding conductor shall be green with or without one or more yellow stripes;

d) A proximity switch, limit switch, and similar end-of-the-line devices shall be provided with a means for mounting all exposed dead metal parts to a metal frame, or shall be provided with a terminal mounted to exposed dead metal, or the equivalent, to receive an equipment grounding conductor; or

e) Other industrial control equipment requiring grounding shall be provided with a ground bus. A grounding terminal shall also be provided.

The grounding means may be in the form of a kit. See 64.10.

40.1.3 A wire binding screw intended for the connection of a field-installed equipment grounding conductor shall have a green colored head. See the Exception to 25.5.7 and 25.5.11 – 25.5.14 for requirements.

40.1.4 For wiring device type equipment, the wire binding screw shall have a hexagonal head. The head may or may not be slotted.

40.1.5 A pressure wire connector intended for connection of a field-installed equipment grounding conductor shall be green-colored or plainly identified, such as being marked ″G,″ ″GR,″ ″GRD,″ ″GND,″ ″GRND,″ ″Ground,″ ″Grounding,″ or the like. The symbol ⏚ (IEC Publication 417, Symbol 5019) may be used.

40.1.6 If the wiring diagram of a magnetic motor controller indicates that one side of the control circuit is or may be grounded, the control circuit shall be arranged so that an unintentional ground in the remote-control device will not cause the motor to start.

40.2 Internal insulated bonding, grounding, and grounded circuit conductors

40.2.1 Insulated grounding and bonding conductors shall be identified by the color green with or without one or more yellow stripes. No other leads shall be so identified in the field wiring area.

40.2.2 Insulated conductors that extend outside an enclosure and are connected to the grounded side of a transformer secondary as in 40.3 shall be identified by the color white or natural grey and no other conductor shall be so identified.

40.3 Transformer secondary grounding

40.3.1 A secondary circuit of a power or control transformer shall be grounded under any of the following conditions when field wiring is intended to be connected to the circuit which extends beyond the enclosure in which the transformer is mounted.

a) When the secondary is less than 50 volts and the transformer supply is over 150 volts to ground or the transformer supply at any voltage is ungrounded; or

b) When the secondary is 50 volts or greater and the secondary circuit is able to be grounded so that the maximum voltage to ground on the ungrounded conductors does not exceed 150 volts.

40.3.2 A transformer secondary that is required to be grounded in accordance with 40.3.1, shall have a main bonding jumper factory connected to the transformer secondary and to the grounding electrode conductor terminal (or to the enclosure when a grounding electrode conductor terminal is not provided). The size of the main bonding jumper shall be sized in accordance with the Reference Standard for Service Equipment, UL 869A, based on the transformer secondary rating. A grounding electrode conductor terminal sized to retain the required grounding electrode conductor in accordance with UL 869A, based on the transformer secondary rating, shall be provided in the enclosure containing the transformer and a marking as specified in 63.27 shall be provided.

Exception: When the transformer is rated not more than 1000 volt-amperes and supplies only remote control and signaling circuits, the grounding electrode conductor terminal is not required and the main bonding jumper shall not be smaller than a No. 14 AWG (2.1 mm^2) copper conductor. The jumper is not otherwise required to be larger than the phase conductors connected to the transformer secondary.

41 Accessories

41.1 Equipment having provision for the use of an accessory to be attached in the field shall comply with the requirements in this standard, and shall comply with the requirements for the equipment for which it is intended. See Details, Section 66 for instructions and markings.

41.2 As part of the investigation, an accessory is to be tested and trial-installed. The installation shall be feasible, and the instructions shall be detailed and correct. The installation shall be capable of being accomplished using tools that are readily available unless a special tool is provided with the accessory.

DEVICE PERFORMANCE

42 General

42.1 The performance of industrial control equipment shall be investigated by subjecting a representative sample or samples in commercial form to the tests described in Sections 43 – 59. Those tests that are required to be conducted in a sequence are indicated in Table 42.1.

42.2 Temperature or current sensitive devices or systems that cause termination of a test shall be additionally evaluated to determine their suitability for the application.

42.3 Unless otherwise indicated, the tests are to be conducted at rated frequency at the applicable voltage specified in Table 42.2.

42.4 Unless indicated otherwise, the tests are to be conducted at any ambient temperature within the range of 10 – 40°C (50 – 104°F). The ambient temperature is to be determined using either thermometers or thermocouples placed in the vicinity of the equipment being tested.

42.5 An industrial control device with an incomplete or partial enclosure is considered to be an open device with respect to the performance requirements in this standard.

Table 42.1
Sequence of tests

Standard reference section	Test	Sample number[a]	
		1	2
		Sequence	Sequence
43	Temperature	1	
44	Overvoltage and Undervoltage	2	
45	Overload		1
46	Endurance		2
49	Dielectric Voltage Withstand	3	3

[a] All or any combination of sequences may be conducted on a single sample if agreeable to those concerned. One sequence need not be completed as a prerequisite to the starting of another.

Table 42.2
Values of voltage for tests

Test	Voltage rating of equipment[a]						Standard section number
	110 – 120	220 – 240	254 – 277	380 – 415	440 – 480	560 – 600	
Temperature	120	240	277	415	480	600	43
Overvoltage, a-c or d-c	132	264	305	457	528	660	44
Undervoltage, a-c	102	204	235	353	408	510	44
Undervoltage, d-c	96	192	222	332	384	480	44
Overload	120	240	277	415	480	600	45
Endurance	120	240	277	415	480	600	46

[a] If the rating of the equipment does not fall within any of the indicated voltage ranges, it is to be tested at its rated voltage except for the overvoltage and undervoltage tests. See 43.8.

42.6 An open type device shall be mounted in an enclosure considered representative of the intended use. The maximum enclosure dimensions are to be determined by one of the following methods:

a) 150 percent of the dimensions of the device – that is, length, width, and height;

b) Dimensions needed to meet the wire-bending space specified in Table 6.7;

c) The intended enclosure, such as a standard outlet box; or

d) The intended enclosure, which may be larger than indicated in 42.6(a) – 42.6(c) provided the size is marked on the device or a separate stuffer sheet.

Exception: Relays rated as specified in 36.7(a) need not be so tested.

42.7 A reversing controller, a selector switch, a meter switch, 2-circuit or 3-circuit equipment, or other type of device in which there are two or more on and off positions is to be connected for tests so that opposite polarity representative of normal use exists between or across open contacts or parts. See 64.1.

Exception: Equipment on which same polarity is indicated by marking is to be connected as indicated in the marking.

42.8 During the tests, equipment shall be mounted and wired so as to represent the intended use. Except as indicated in Terminal Torque Test, Section 59, all field wiring terminal blocks or wire connectors shall be tightened to the value of torque marked on the product.

43 Temperature Test

43.1 Industrial control equipment tested under the conditions described in 43.8 – 43.25 shall:

a) Not attain a temperature at any point so high as to constitute a risk of fire or adversely affect any materials employed in the equipment;

b) Not exceed the temperature limit for any individual component within the equipment; and

c) Not exceed the temperature rise above the test ambient at specific points greater than those specified in Table 43.1.

43.1 revised July 16, 1999

43.2 All values for temperature rises specified in Table 43.1 apply to equipment intended for use in a maximum consistent ambient temperature of 40°C (104°F).

43.2 revised July 16, 1999

43.3 43.3 and 43.5 combined and relocated as 62.1.1 July 16, 1999

43.4 Deleted July 16,1999

43.5 43.3 and 43.5 combined and relocated as 62.1.1 July 16, 1999

43.6 For industrial control equipment rated above 40°C (104°F), the allowable temperature rise for this elevated ambient is to be calculated in accordance with the following formula:

$$T_R = T_T - [T_M - 40°C\ (104°F)]$$

in which:

T_R *is the Allowable Temperature Rise;*

T_T *is the Maximum Temperature Rise allowed by Table 43.1; and*

T_M *is the Elevated Ambient Temperature Marked on the equipment. See 62.1.1.*

43.7 For industrial control equipment rated below 40°C (104°F), the allowable temperature rise for this reduced ambient is to be calculated in accordance with the following formula:

$$T_R = T_T + [40°C\ (104°F) - T_M]$$

in which:

T_R *is the Allowable Temperature Rise;*

T_T *is the Maximum Temperature Rise allowed by Table 43.1; and*

T_M is the Reduced Ambient Temperature Marked on the equipment. See 62.1.1.

43.8 The coil test voltages are to be as specified in Table 43.2. However, if a manufacturer supplies transformer or magnet coils for various voltage ratings within each specified range in Table 43.2 (for example, 110, 115, or 120 volts), and if a coil is supplied for the maximum voltage rating of each range, tests may be conducted on representative coils within each range based on percentages specified in 44.1 of the marked voltage ratings of the coils selected for testing. If a coil is not provided for the maximum voltage rating for each range, tests are to be conducted on all coils at the test voltages indicated in Table 42.2.

43.9 To determine whether industrial control equipment complies with the temperature test requirements, it is to be operated:

a) Under normal conditions;

b) While carrying its rated current continuously (see 43.11 – 43.13);

c) At the voltage specified in Table 42.2 or as in 43.8 for coils;

Exception: Instead of the voltages specified, a low voltage source of supply is able to be used for temperature tests on parts other than voltage rated coils.

d) While mounted as intended in use (see 43.14 and 43.16);

e) At an ambient temperature as in 43.17; and

f) Until temperatures are constant (see 43.25).

At the conclusion of the test, the temperature rise of each material or component shall not exceed the maximum temperature rises as specified in 43.1, 43.6, and 43.7. The temperature rise of a material or component is the difference between its stabilized test temperature and the test ambient. Protective devices or circuitry shall not trip during the test. For equipment provided with a thermostat or other thermal protective device and tested as in 43.17(a), the temperature of the thermal device shall be measured, corrected for the difference in ambient temperature, and the resulting temperature compared to the trip temperature to determine whether the device would have been tripped as a result of the test.

43.9 revised July 16, 1999

43.10 Temperatures are to be measured with all parts operating simultaneously, as the heating of one part may affect the heating of another part.

43.11 The rated current for horsepower-rated equipment is to be as specified in Tables 45.2, 45.3, 62.2, or 62.3.

Table 43.1
Maximum temperature rises

Table 43.1 revised July 16, 1999

	Materials and components	°C	°F
1.	Knife-switch blades and contact jaws	30	54
2.	Fuse clip when tested with a dummy fuse that represents a fuse intended to provide branch circuit protection	30	54
3.	Fuse clip when tested with a fuse intended to provide branch circuit protection[o]	85	153
4.	Rubber- or thermoplastic-insulated conductors	a	a
5.	Field-wiring terminals[c,k,i]		
	Equipment marked 60°C or 60/75°C supply wires	50	90
	Equipment marked 75°C supply wires	65	117
6.	Buses and connecting straps or bars[d]	l	l
7.	Contacts		
	Solid and built-up silver, silver alloy, and silver faced	e	e
	All other metals	65	117
8.	Insulation systems		
	Class 105 insulation system[f]		
	Thermocouple method	65	117
	Resistance method	85	126
	Class 105(A) insulation systems on single-layer series coil with exposed surfaces either uninsulated or enameled, thermocouple method	90	162
	Class 120(E) insulation system[f,r]		
	Thermocouple method	75	135
	Resistance method	95	171
	Class 130(B) insulation systems[f,r]		
	Thermocouple method	85	153
	Resistance method	95	171
	Class 155(F) insulation systems[f,r]		
	Thermocouple method	95	171
	Resistance method	115	207
	Class 180(H) insulation systems[f,r]		
	Thermocouple method	115	207
	Resistance method	135	243
	Class 200(N) insulation system[f,r]		
	Thermocouple method	135	243
	Resistance method	155	279
	Class 220(R) insulation systems[f,r]		
	Thermocouple method	155	279
	Resistance method	175	315
9.	Insulating materials[b]	p	p
10.	In the issuing air, 1 inch (25.4 mm) above the enclosure	175	315
11.	On the embedding material of a resistor, a rheostat, and a wall-mounted dimmer with an embedded resistive element	300	540
12.	ON the embedding material of a rheostatic dimmer having embedded resistive conductors, and arranged for mounting on a switchboard, or in a noncombustible frame	350	630
13.	On bare resistor material, thermocouple method	375	675
14.	Capacitor	g	g
15.	Power switching semiconductors	m	m
16.	Printed-wiring boards	n	n

Table 43.1 Continued on Next Page

Table 43.1 Continued

Materials and components	°C	°F
17. Any component or material not specifically identified in 1 – 16	q	q

[a] For insulated conductors the maximum temperature rise shall not exceed the maximum operating temperature specified for the wire in question minus an assumed ambient (room) temperature of 40°C (104°F).

[b] For compounds which have been investigated for particular temperature ratings, the maximum temperature rise shall not exceed the temperature rating minus an assumed ambient of 40°C (104°F).

[c] The temperature on a wiring terminal or lug is measured at the point most likely to be contacted by the insulation of a conductor installed as in actual service.

[d] The limit does not apply to connections to a source of heat, such as a resistor and a current element of an overload relay.

[e] Temperature limited by the temperature limitations on the material for adjacent parts. See 43.18. There shall be no structural deterioration of the contact assembly, loosening of parts, cracking or flaking of materials, loss of temper of spring, annealing of parts, or other visible damage.

[f] See 43.19 – 43.25.

[g] For a capacitor, the maximum temperature rise is the marked temperature limit of the capacitor minus an assumed ambient temperature of 40°C (104°F).

[h] *Deleted*

[i] When the rise is 50°C (90°F) or less and an aluminum bodied connector is used or aluminum wire is intended, the connector shall be marked AL7CU or AL9CU; when the terminal temperature rise exceeds 50°C and does not exceed 65°C, the connector shall be marked AL9CU.

[j] *Deleted*

[k] See 63.3.

[l] The limit applies only to bus bars and connecting straps used for distribution of power to industrial control devices. The limit does not apply to short pieces of copper located within industrial control devices and used for the support of stationary contact assemblies or factory or field wiring terminations. The maximum temperature rises for this type of construction are determined by the temperature limitations on the support material, adjacent part material, or 100°C (212°F) temperature rise on the copper material, whichever is lower. There shall be no structural deterioration of the assembly, loosening of parts, cracking or flaking of material, loss of temper of spring, annealing of parts, or other visible damage.

[m] The maximum temperature rise on the case is the maximum case temperature for the applied power dissipation recommended by the semiconductor manufacturer minus an assumed ambient of 40°C (104°F).

[n] The maximum temperature rise of the printed-wiring board is the operating temperature of the board minus an assumed ambient of 40°C (104°F).

[o] See 63.23.

[p] See Tables 15.2 and 37.1.

[q] The maximum temperature rise of any component shall not exceed the temperature limit of the component minus an assumed ambient temperature of 40°C (104°F).

[r] The insulation system shall meet the requirements of UL 1446, Standard for Systems of Insulating Materials – General.

43.12 For equipment having a current-element table showing minimum and maximum full-load motor currents, the temperature test shall be conducted using the maximum full-load current shown in the table even though that current exceeds the maximum current rating of the equipment. For equipment having a current-element table showing only tripping current, the test current is to be 87 percent of the specified maximum tripping current.

43.13 For an auxiliary switch mounted directly to a contactor or starter, the test current is to correspond to the maximum break current consistent with the switch rating.

43.14 Industrial control equipment is to be tested with 4 feet (1.2 m) of wire attached to each field-wiring terminal. For example 8 feet (2.4 m) of conductor is required when the conductor is connected between two field-wiring terminals. The wire is to be of the smallest size having an ampacity of at least 125 percent of:

a) The maximum full-load motor-current in accordance with Table 45.2 or Table 45.3, as appropriate, and at least 100 percent for other loads;

b) The maximum full-load motor current for the component (as listed in Table 43.1) with the highest current-rated element for equipment employing an overload device with interchangeable current elements; or

c) The maximum full-load motor current for the overload relay for equipment employing an overload relay with non-interchangeable current elements.

The wire size is to be in accordance with Table 43.2 based on the wire temperature rating marked on the equipment. The type of insulation is not specified. The temperature test may be conducted with conductors having other than black insulation, but referee temperature measurements are to be conducted with black-insulated conductors. If the terminal will not receive the size of wire required for testing in accordance with 43.12 for equipment having an overload relay, or if the device is marked in accordance with 25.5.4 to limit the size of wire, the maximum allowable wire size is to be used.

Exception: If there is only provision for the connection of bus bars to industrial control equipment rated at 450 amperes or more, copper bus bars of the width specified in Table 43.3 and at least 4 feet in length are to be used. The temperature test may be conducted with other than black-painted bus bars, but if referee temperature measurements are required, black-painted bus bars are to be used. The spacing between multiple bus bars is to be 1/4 inch with no intentional wider spacing except as necessary at the individual terminals of the equipment.

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Table 43.2
Ampacities of insulated conductors

Wire size		60°C (140°F)		75°C (167°F)	
AWG	(mm^2)	Copper	Aluminum	Copper	Aluminum
24	(0.2)	2	–	–	–
22	(0.3)	3	–	–	–
20	(0.5)	5	–	–	–
18	(0.8)	7	–	–	–
16	(1.3)	10	–	–	–
14	(2.1)	15	–	15	–
12	(3.3)	20	15	20	15
10	(5.3)	30	25	30	25
8	(8.4)	40	30	50	40
6	(13.3)	55	40	65	50
4	(21.2)	70	55	85	65
3	(26.7)	85	65	100	75
2	(33.6)	95	75	115	90
1	(42.4)	110	85	130	100
1/0	(53.5)			150	120
2/0	(67.4)			175	135
3/0	(85.0)			200	155
4/0	(107.2)			230	180
kcmil					
250	(127)			255	205
300	(152)			285	230
350	(177)			310	250
400	(203)			335	270
500	(253)			380	310
600	(304)			420	340
700	(355)			460	375
750	(380)			475	385
800	(405)			490	395
900	(456)			520	425
1000	(506)			545	445
1250	(633)			590	485
1500	(760)			625	520
1750	(887)			650	545
2000	(1013)			665	560

NOTES

1. For multiple-conductors of the same size (1/0 AWG or larger) at a terminal, the ampacity is equal to the value in Table 43.2 for that conductor multiplied by the number of conductors that the terminal will accommodate.

2. These values of ampacity apply only if not more than three conductors will be field-installed in the conduit. If four or more conductors, other than a neutral that carries the unbalanced current, will be installed in a conduit (as may occur because of the number of conduit hubs provided in outdoor equipment, the number of wires necessary in certain polyphase systems, or other reasons), the ampacity of each of the conductors is: 80 percent of these values if 4 – 6 conductors are involved, 70 percent of these values if 7 – 24 conductors, 60 percent of these values if 25 – 42 conductors, and 50 percent of these values if 43 or more conductors.

Table 43.3
Width of copper bus bars

Product rating, Amperes	Bus bars per terminal	Width of bus bars, Inches	(mm)
450 – 600	1	2	(51)
601 – 1000	1	3	(76)
1001 – 1200	1	4	(102)
1201 – 1600	2	3	(76)
1601 – 2000	2	4	(102)
2001 – 2500	2	5	(127)
	4	2-1/2	(64)
2501 – 3000	3	5	(127)
	4	4	(102)

43.15 When referee measurements of ambient temperatures are required, several thermometers or thermocouples are to be placed at different points around the equipment. The thermometers or thermocouples are to be located in the ingoing path of the cooling medium, and are to be protected from drafts and abnormal heat radiation. The ambient temperature is to be the mean of the readings of the temperatures taken at equal intervals of time during the final quarter of the duration of the test.

43.15 revised July 16, 1999

43.16 Enclosed industrial control equipment is to be tested in the enclosure provided by the manufacturer. Open type industrial control equipment is to be tested in an enclosure as specified in 42.6.

Exception: Open type industrial control equipment is not required to be tested in an enclosure when marked with a surrounding air temperature rating.

43.16 revised July 16, 1999

43.17 The temperature test is to be conducted with the equipment placed in:

a) An ambient in accordance with 42.4; or

b) A non-air circulating test chamber with the ambient temperature of the test chamber adjusted to the rated ambient.

43.17 revised July 16, 1999

43.18 The acceptability of insulating materials other than those specified in Table 43.1 is to be determined with respect to properties such as flammability, arc-resistance, and the like, based on an operating temperature equal to the measured temperature rise plus 40°C (104°F) or other marked ambient temperature rating.

43.19 The thermocouple method for temperature measurement as specified in Table 43.1 consists of the determination of temperature by use of a potentiometer type instrument and thermocouples that are applied to the hottest accessible parts. The thermocouples are to be made of wires not larger than No. 24 AWG (0.21 mm^2) and not smaller than No. 30 AWG (0.05 mm^2). The thermocouples and related

instruments are to be accurate and calibrated in accordance with good laboratory practice. The thermocouple wire is to conform with the requirements for special thermocouples in Temperature Measurement Thermocouples, ANSI/ISA MC96.1-1982.

43.19 revised July 16, 1999

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43.20 A thermocouple junction and adjacent thermocouple lead wire are to be securely held in good thermal contact with the surface of the material of which the temperature is being measured. In most cases, adequate thermal contact will result from securely taping or cementing the thermocouple in place; but if a metal surface is involved, brazing or soldering the thermocouple to the metal may be necessary.

43.21 The resistance method for temperature measurement as specified in Table 40.1 consists of the calculation of the temperature rise of a winding using the equation:

$$\Delta t = \frac{r_2}{r_1}(k + t_1) - (k + t_2)$$

in which:

Δt is the temperature rise of the winding in degrees C

r_2 is the resistance of the coil at the end of the test in ohms.

r_1 is the resistance of the coil at the beginning of the test in ohms.

t_1 is the room temperature in degrees C at the beginning of the test.

t_2 is the room temperature in degrees C at the end of the test.

k is 234.5 for copper, 225.0 for electrical conductor grade (EC) aluminum; values of the constant for other conductors are to be determined.

43.22 Because it is generally necessary to de-energize the winding before measuring r_2, the needed value of r_2 at shutdown may be determined by taking several resistance measurements at short intervals, beginning as quickly as possible after the instant of shutdown. A curve of the resistance values and the time may be plotted and extrapolated to give the value of r_2 at shutdown.

43.23 The preferred method of measuring the temperature of a coil is the resistance method; but temperature measurements by either the thermocouple or resistance method are acceptable; except that the thermocouple method is not to be employed at any point where supplementary insulation is employed.

43.24 With reference to 43.23, when thermocouples are used for measuring the temperatures of a coil, at least two thermocouples are to be used. The thermocouples are to be placed on the surface of the coil assembly (wire plus insulation) which is the upper surface based on the orientation during testing. An additional thermocouple is to be placed on a surface subjected to heating by another source, such as another transformer or a hot resistor.

43.25 A temperature rise is considered to be constant when three successive readings that are taken at intervals of 10 percent of the previously elapsed duration of the test but not less than 10 minute intervals indicate no change in the temperature rise.

43.26 Infrared thermal analysis may be used to determine maximum temperature locations for placement of thermocouples for the temperature test.

43.27 A device having mechanical contacts may have the contacts cleaned by any non-abrasive, non-corrosive method or may be cycled under load several times prior to initiating the temperature test.

44 Overvoltage and Undervoltage Test

44.1 An assembly using one or more electromagnetic switching components shall withstand 110 percent of the rated voltage without damage to the operating coil that prevents full closure of the switched contacts and shall operate at 80 percent of its rated voltage when for use on direct current or 85 percent of its rated voltage when for use on alternating current.

44.1 revised July 16, 1999

44.2 If equipment, such as a combination motor controller, is provided with a control-circuit transformer, the voltage for conducting the undervoltage test is to be applied on the primary side of the transformer at 90 percent of the rated transformer primary voltage.

44.3 The electromagnet is first to be energized under the conditions of the temperature test until constant coil temperatures are observed. The control circuit voltage is then to be reduced to the undervoltage test voltage explained in 44.1. The control circuit is then to be opened and closed several times to determine if full closure of the armature results.

44.4 The control circuit voltage is to be increased to the overvoltage test value explained in 45.1 until constant temperatures are observed using the thermocouple method. The voltage is then to be rapidly reduced to the temperature test voltage and the control circuit is to be immediately opened and closed several times to determine if full closure of the armature results.

44.5 An electromagnet intended for intermittent duty is to be tested to determine whether it complies with the requirements in 44.1 – 44.4 for the time rating specified. If resistance is inserted into the electromagnet circuit after closing of the contactor, this resistance is to be included in the circuit when the coil is energized under temperature test conditions.

45 Overload Test

45.1 During the overload test described in this section, there shall be no electrical or mechanical breakdown of the equipment, no undue burning or pitting of the contacts and no welding of the contacts. The fuse specified in 45.13 shall not open.

45.2 Line and load terminals of industrial control equipment having clearances in accordance with Clearance B (Controlled Overvoltage), Section 5, in the requirements of the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840, are to be monitored for overvoltages during operation at rated operational voltage under load and no-load conditions. Generated voltages shall not be greater than the lowest impulse withstand voltage rating specified in Table 5.1 of UL 840. This monitoring is to be done during the overload test by an oscillographic study.

45.3 The wire used for this test is to have an ampacity of at least 125 percent of the maximum full-load motor-current in accordance with Table 45.2 or Table 45.3, as appropriate, or at least 100 percent for other loads.

45.4 The overload test or tests are to cover the conditions of maximum interrupted values of voltage, power, and current.

45.5 Tests on equipment having an alternating-current rating are to be conducted using a circuit having a frequency of 60 hertz.

Exception: A test circuit frequency in the range of 25 – 60 hertz may be considered to be representative.

45.6 Equipment is to close and open a test circuit having the current and power factor as described in Table 45.1. If a controller is rated in horsepower instead of current, the horsepower rating is to be converted to a full load current value using the information in Tables 45.2 and 45.3 in order to apply Table 45.1.

45.7 Air core type reactors are to be used to obtain the reactive power factor specified in Table 45.1. Reactors may be connected in parallel. No reactor is to be connected in parallel with a resistor.

Exception: An air-core reactor in any phase may be connected in parallel with a resistor (RSH) if the resistor power consumption is approximately 1 percent of the total power consumption in that phase calculated in accordance with the following formula:

$$R_{SH} = [100(1/PF - PF)]E/I$$

in which:

PF is the power factor;

E is the closed-circuit phase voltage; and

I is the phase current.

45.8 Except as specified in 45.9, the closed test circuit voltage is to be 100 to 110 percent of the overload test voltage specified in Table 42.2.

45.9 For a motor controller rated more than 25 horsepower (18.6 kW output) or a magnetically operated switch rated more than 100 amperes, the open-circuit voltage is to be as much above the voltage specified in Table 42.2 as the closed-circuit voltage is below that value, unless such adjustment results in the open-circuit voltage being more than 110 percent of the specified voltage. In that case, the test is to be conducted using whatever closed-circuit voltage is obtained when the open-circuit voltage is 110 percent of the specified voltage. However, the capacity of the supply circuit need not be greater than that of a circuit that is considered to be acceptable for the short circuit test as described in Short Circuit Test – General, Section 50.

45.10 Tests on a reversing controller provided with a factory-installed mechanical, electrical, or electronic interlock, or any combination thereof, are to be conducted with all such interlocks in operation. If an interlock system is provided as an option, that system is to be defeated during the test.

Table 45.1
Overload test circuit

Intended device application	Current, amperes	Power factor
Across-the-Line AC Motor Starting, single phase	6 times device full-load current	0.40 – 0.50
Across-the-Line AC Motor Starting, 2- and 3-phase	See Table 45.4 for Test Current	0.40 – 0.50
Across-the-Line DC Motor Starting	10 times device full-load current	dc[a]
DC General Use	1.5 times device rated value	dc[a]
AC General Use	1.5 times device rated value	0.75 – 0.80
DC Resistance	1.5 times device rated value	dc[a]
AC Resistance	1.5 times device rated value	1.0
AC Resistance Air Heating	1.5 times device rated value	1.0
DC Resistance Air Heating	1.5 times device rated value	dc[a]
AC Incandescent Lamps (Tungsten)	1.5 times device rated value	0.75 – 0.80
DC Incandescent Lamps (Tungsten)	1.5 times device rated value	dc
AC Electrical Discharge Lamps (Ballast)	3.0 times device rated value	0.40 – 0.50
Elevator Control, AC hp[b]		
Elevator Control, DC hp[b]		
Capacitive Switching (kVar)	1.5 times device rated value	c

NOTE – The test cycles are to be as described in 45.12.

[a] Load is a noninductive resistive load.

[b] No overload conditioning is required for an elevator control.

[c] The load is to consist of commercially available capacitors.

45.11 The equipment is to open and close the test circuit 50 times. A reversing controller is to be subjected to ten additional cycles of operation with both coils energized simultaneously after the 50 cycles of operation.

Table 45.2
Full-load motor-running currents in amperes corresponding to various a-c horsepower ratings

Horse power	110 – 120 Volts			220 – 240 Volts[a,b]			380 – 415 Volts		440 – 480 Volts			550 – 600 Volts		
	Single phase	Two phase	Three phase	Single phase	Two phase	Three phase	Single phase	Three phase	Single phase	Two phase	Three phase	Single phase	Two phase	Three phase
1/10	3.0	–	–	1.5	–	–	1.0	–	–	–	–	–	–	–
1/8	3.8	–	–	1.9	–	–	1.2	–	–	–	–	–	–	–
1/6	4.4	–	–	2.2	–	–	1.4	–	–	–	–	–	–	–
1/4	5.8	–	–	2.9	–	–	1.8	–	–	–	–	–	–	–
1/3	7.2	–	–	3.6	–	–	2.3	–	–	–	–	–	–	–
1/2	9.8	4.0	4.4	4.9	2.0	2.2	3.2	1.3	2.5	1.0	1.1	2.0	0.8	0.9
3/4	13.8	4.8	6.4	6.9	2.4	3.2	4.5	1.8	3.5	1.2	1.6	2.8	1.0	1.3
1	16.0	6.4	8.4	8.0	3.2	4.2	5.1	2.3	4.0	1.6	2.1	3.2	1.3	1.7
1-1/2	20.0	9.0	12.0	10.0	4.5	6.0	6.4	3.3	5.0	2.3	3.0	4.0	1.8	2.4
2	24.0	11.8	13.6	12.0	5.9	6.8	7.7	4.3	6.0	3.0	3.4	4.8	2.4	2.7
3	34.0	16.6	19.2	17.0	8.3	9.6	10.9	6.1	8.5	4.2	4.8	6.8	3.3	3.9
5	56.0	26.4	30.4	28.0	13.2	15.2	17.9	9.7	14.0	6.6	7.6	11.2	5.3	6.1
7-1/2	80.0	38.0	44.0	40.0	19.0	22.0	27.0	14.0	21.0	9.0	11.0	16.0	8.0	9.0
10	100.0	48.0	56.0	50.0	24.0	28.0	33.0	18.0	26.0	12.0	14.0	20.0	10.0	11.0
15	135.0	72.0	84.0	68.0	36.0	42.0	44.0	27.0	34.0	18.0	21.0	27.0	14.0	17.0

Table 45.2 Continued on Next Page

Table 45.2 Continued

Horse power	110 – 120 Volts			220 – 240 Volts[a,b]			380 – 415 Volts		440 – 480 Volts			550 – 600 Volts		
	Single phase	Two phase	Three phase	Single phase	Two phase	Three phase	Single phase	Three phase	Single phase	Two phase	Three phase	Single phase	Two phase	Three phase
20	–	94.0	108.0	88.0	47.0	54.0	56.0	34.0	44.0	23.0	27.0	35.0	19.0	22.0
25	–	118.0	136.0	110.0	59.0	68.0	70.0	44.0	55.0	29.0	34.0	44.0	24.0	27.0
30	–	138.0	160.0	136.0	69.0	80.0	87.0	51.0	68.0	35.0	40.0	54.0	28.0	32.0
40	–	180.0	208.0	176.0	90.0	104.0	112.0	66.0	88.0	45.0	52.0	70.0	36.0	41.0
50	–	226.0	260.0	216.0	113.0	130.0	139.0	83.0	108.0	56.0	65.0	86.0	45.0	52.0
60	–	–	–	–	133.0	154.0	–	103.0	–	67.0	77.0	–	53.0	62.0
75	–	–	–	–	166.0	192.0	–	128.0	–	83.0	96.0	–	66.0	77.0
100	–	–	–	–	218.0	248.0	–	165.0	–	109.0	124.0	–	87.0	99.0
125	–	–	–	–	–	312.0	–	208.0	–	135.0	156.0	–	108.0	125.0
150	–	–	–	–	–	360.0	–	240.0	–	156.0	180.0	–	125.0	144.0
200	–	–	–	–	–	480.0	–	320.0	–	208.0	240.0	–	167.0	192.0
250	–	–	–	–	–	602.0	–	403.0	–	–	302.0	–	–	242.0
300	–	–	–	–	–	–	–	482.0	–	–	361.0	–	–	289.0
350	–	–	–	–	–	–	–	560.0	–	–	414.0	–	–	336.0
400	–	–	–	–	–	–	–	636.0	–	–	477.0	–	–	382.0
500	–	–	–	–	–	–	–	786.0	–	–	590.0	–	–	472.0

[a] To obtain full-load currents for 200 and 208 volt motors, increase corresponding 220 – 240 volt ratings by 15 and 10 percent, respectively.

[b] To obtain full-load currents for 265 and 277 volt motors, decrease corresponding 220 – 240 volt ratings by 13 and 17 percent, respectively.

Table 45.3
Full-load motor-running currents in amperes corresponding to various d-c horsepower ratings

Horsepower	90 Volts	110 – 120 Volts	180 Volts	220 – 240 Volts	500 Volts	550 – 600 Volts
1/10	–	2.0	–	1.0	–	–
1/8	–	2.2	–	1.1	–	–
1/6	–	2.4	–	1.2	–	–
1/4[a]	4.0	3.1	2.0	1.6	–	–
1/3	5.2	4.1	2.6	2.0	–	–
1/2	6.8	5.4	3.4	2.7	–	–
3/4	9.6	7.6	4.8	3.8	–	1.6
1	12.2	9.5	6.1	4.7	–	2.0
1-1/2	–	13.2	8.3	6.6	–	2.7
2	–	17.0	10.8	8.5	–	3.6
3	–	25.0	16.0	12.2	–	5.2
5	–	40.0	27.0	20.0	–	8.3
7-1/2	–	58.0	–	29.0	–	12.2
10	–	76.0	–	38.0	–	16.0
15	–	110.0	–	55.0	27.0	24.0
20	–	148.0	–	72.0	34.0	31.0
25	–	184.0	–	89.0	43.0	38.0
30	–	220.0	–	106.0	51.0	46.0
40	–	292.0	–	140.0	67.0	61.0
50	–	360.0	–	173.0	83.0	75.0
60	–	–	–	206.0	99.0	90.0

Table 45.3 Continued on Next Page

Table 45.3 Continued

Horsepower	90 Volts	110 – 120 Volts	180 Volts	220 – 240 Volts	500 Volts	550 – 600 Volts
75	–	–	–	255.0	123.0	111.0
100	–	–	–	341.0	164.0	148.0
125	–	–	–	425.0	205.0	185.0
150	–	–	–	506.0	246.0	222.0
200	–	–	–	675.0	330.0	294.0

[a] The full-load current for a 1/4-horsepower, 32-volt d-c motor is 8.6 amperes.

Table 45.4
Locked-rotor motor currents corresponding to various a-c horsepower ratings (2- and 3-phase)

	110 – 120 V		220 – 240 V		440 – 480 V		550 – 600 V	
	Motor designations		Motor designations		Motor designations		Motor designations	
HP	B, C, D	E	B, C, D	E	B, C, D	E	B, C, D	E
1/2	40	40	20	20	10	10	8	8
3/4	50	50	25	25	12.5	12.5	10	10
1	60	60	30	30	15	15	12	12
1-1/2	80	80	40	40	20	20	16	16
2	100	100	50	50	25	25	20	20
3	–	–	64	73	32	36.5	25.6	29.2
5	–	–	92	122	46	61	36.8	48.8
7-1/2	–	–	127	183	63.5	91.5	50.8	73.2
10	–	–	162	225	81	113	64.8	90
15	–	–	232	337	116	169	93	135
20	–	–	290	449	145	225	116	180
25	–	–	365	562	183	281	146	225
30	–	–	435	674	218	337	174	270
40	–	–	580	824	290	412	232	330
50	–	–	725	1030	363	515	290	412
60	–	–	870	1236	435	618	348	494
75	–	–	1085	1545	543	773	434	618
100	–	–	1450	1873	725	937	580	749
125	–	–	1815	2341	908	1171	726	936
150	–	–	2170	2809	1085	1405	868	1124
200	–	–	2900	3745	1450	1873	1160	1498
250	–	–	–	–	1825	2344	1460	1875
300	–	–	–	–	2200	2809	1760	2247
350	–	–	–	–	2550	3277	2040	2622
400	–	–	–	–	2900	3745	2320	2996
450	–	–	–	–	3250	4214	2600	3371
500	–	–	–	–	3625	4682	2900	3746

NOTES

1. A device marked in accordance with 63.8 is to be evaluated in accordance with the values for motors designated Design E.

2. A device not marked for use with a Design E motor is to be evaluated in accordance with the values for motors designated Design B, C, and D.

45.12 For all equipment except a reversing controller, the test cycle time is to be 1 second on and 9 seconds off. For a reversing controller, the test cycle time is to be 1 second forward, 1 second reverse, and 8 seconds off.

Exception No. 1: If the device operation will not permit these cycle times, times as close as possible to these are to be used.

Exception No. 2: If it is determined that for a duration less than one second, the device conducts the test current without interrupting the circuit or being adversely affected by heat and the device contacts are properly seated before the break is initiated as confirmed by oscilloscopic or oscillographic measurements, the on time may be reduced to that duration.

Exception No. 3: The off time for equipment conducting a test current of 500 – 1499 amperes is to be no more than 120 seconds, and for devices conducting a test current more than 1499 amperes, the off time is to be no more than 240 seconds.

45.13 During the test, the enclosure is to be connected through a 30-ampere cartridge fuse that does not have a time delay to the electrical test circuit pole considered least likely to strike to ground.

45.14 A device having two or more poles is to be tested with opposite polarity between two adjacent poles.

Exception: If the device is marked same polarity, opposite polarity need not exist between adjacent poles.

45.15 During tests on multipole devices for use in opposite-polarity applications, all unused poles are to be connected electrically to the enclosure.

45.16 Unless a device is provided with a wiring diagram or equivalent marking indicating the number of poles to be used to control the load, the device is to be tested using one pole to control single-phase or direct-current loads and using two poles to control polyphase loads.

45.17 Figure 45.1 shows typical connection diagrams.

a) Diagrams A and B show connections for a device for single- and 3-phase loads, respectively, that are unmarked regarding load connection.

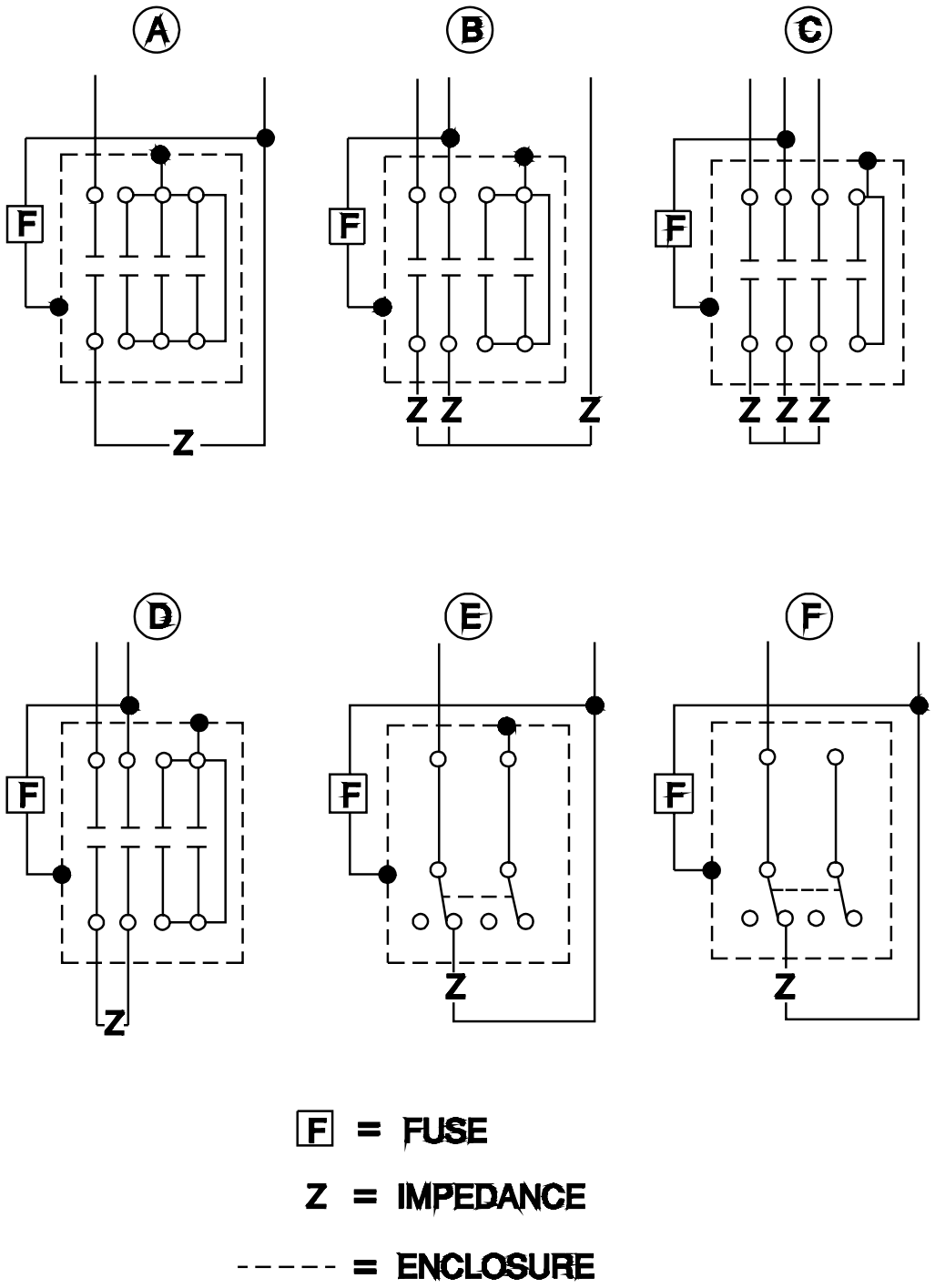
b) Diagram C and D show connections for a device for 3-phase and single-phase loads, respectively, that are marked ″Break All Lines″ or the equivalent.

c) Diagram E shows connections for a double-pole, double-throw relay that is unmarked for polarity connection. Diagram F shows connections for a double-pole, double-throw relay marked for same polarity. For a double-throw device, either the normally open or normally closed position may be tested, provided, for each position the contacts, the travel distance, and the contact force are the same. This also applies to a single-pole, double-throw relay.

46 Endurance Test

46.1 During the endurance test described in this section, there shall be no electrical or mechanical breakdown of the device, welding, undue burning or pitting of the contacts. The fuse specified in 45.13 shall not open. After the test, the device shall comply with the requirements of the Dielectric Voltage-Withstand Test, Section 49.

Figure 45.1
Overload test connection diagrams



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46.2 The conditions for the endurance test shall be the same as the conditions for the overload test as specified in Section 45, except as described in this section.

46.3 The equipment is to close and open a test circuit having the applicable current and power factor specified in Table 46.1. The number of test cycles and the test cycle times are to be as specified in Table 46.1. The closed circuit test voltage is to be 100 to 110 percent of the endurance test voltage specified in Table 42.2.

46.4 If tungsten-filament lamps are used as the load, the load is to be made up of the smallest possible number of 500-watt lamps, or of larger lamps if agreeable to those concerned; except that one or two lamps smaller than the 500-watt size may be used if necessary to make up the required load.

Table 46.1
Endurance test

Intended device application	Test current, amperes	Power factor	Number of cycles	Test cycle times, seconds	
				On	Off
Across-the-Line AC Motor Starting[a]	Twice Full-Load Current	0.40 – 0.50	1000[b]	f	f
Across-the-Line DC Motor Starting	Twice Full-Load Current	dc[h]	1000[b]	f	f
DC General Use	Rated Current	h	6000	1[d]	9[d]
AC General Use	Rated Current	0.75 – 0.80[c]	6000	1[d]	9[d]
DC Resistance	Rated Current	h	6000	1[d]	9[d]
AC Resistance	Rated Current	1.0	6000	1[d]	9[d]
DC Resistance Air Heating[i]	Rated Current	dc[h]	100,000	1[d]	9[d]
AC Resistance Air Heating[i]	Rated Current	1.0	100,000	1[d]	9[d]
AC Incandescent Lamps (Tungsten)	Rated Current. See 46.4 – 46.7.	1.0	6000[g]	1[e]	59[e]
DC Incandescent Lamps (Tungsten)	Rated Current. See 46.4 – 46.7.	dc	6000[g]	1[e]	59[e]
AC Electrical Discharge Lamps (Ballast)	Twice Rated Current	0.40 – 0.50	6000	1	9
Elevator Control, AC hp	Twice Full-Load Current	0.40 – 0.50	500,000	1	9
Elevator Control, DC hp	Twice Full-Load Current	dc[h]	500,000	1	9
Capacitive Switching (kVar)	Rated Current	j	6000	1[d]	9[d]

[a] For an alternating current combination controller, the manual switch is to be tested for 6000 cycles at the rate of 6 cycles per minute at 0.75 – 0.80 power factor, and at rated full-load current.

[b] These devices are to be subjected to at least 6000 mechanical cycles at any convenient rate.

[c] If the device is marked ″resistance only″ in accordance with 63.7, the test may be conducted using a noninductive resistance load. This ″resistance only″ rating is different than a resistance heating rating or a resistance air heating rating.

[d] The cycle times are to be shown or as described in 45.12.

[e] A control may be operated faster than 1 cycle per minute if synthetic loads are used or if a sufficient number of banks of lamps controlled by a commutator are employed so that each bank will cool for at least 59 seconds between successive applications.

[f] Other than as noted in note a, the test cycle is to be as indicated in Table 46.2.

[g] For a magnetic relay intended to turn a television receiver on and off, and marked in accordance with 63.22, the number of test cycles is to be 25,000.

[h] Load is a noninductive resistive load.

Table 46.1 Continued on Next Page

Table 46.1 Continued

Intended device application	Test current, amperes	Power factor	Number of cycles	Test cycle times, seconds	
				On	Off

[I] Applicable only to a device that controls the power to a resistance heating element used for comfort heating, and is controlled by an automatic reset safety control required by the end product standard.

[J] The load is to consist of commercially available capacitors.

Table 46.2
Test cycle for motor controllers

Type of controller	Test current, amperes	Time on,[a] second	Maximum time off, seconds
Nonreversing	Less than 200	1/2	1/2
	200 – 499	1	1
	500 – 1499	1	120
	1500 or more	1	240
Reversing	Less than 200	1/2 forward 1/2 reverse	1
	200 – 499	1 forward 1 reverse	2
	500 – 1499	1 forward 1 reverse	120
	1500 or more	1 forward 1 reverse	240

[a] Or as noted in Exception Nos. 1 and 2 to 45.12.

46.5 With regard to 46.4, the circuit is to be such that the peak value of the inrush current will be reached in 1/240 of a second after the circuit is closed.

46.6 A synthetic load may be used in place of tungsten-filament lamps if it is equivalent to a tungsten-filament lamp load on the test circuit in question, and the inrush current is at least ten times the normal current.

46.7 A synthetic load used in place of tungsten-filament lamps may consist of noninductive resistors if they are connected and controlled so that a portion of the resistance is shunted during the closing of the switch under test. A synthetic load may also consist of a noninductive resistor or resistors that are connected in parallel with a capacitor.

47 Endurance Test for Relays for Television Applications

47.1 A relay having contacts connected in the supply circuit to turn a television receiver on and off and controlling a peak inrush current (rms times 1.414) that exceeds the contact rating of the relay shall perform acceptably without breakdown when subjected to 25,000 cycles of operation making and breaking the test loads specified for incandescent lamp control (tungsten) in Table 46.1 at the test potential specified for the endurance test in Table 42.2.

47.2 The conditions for the endurance test shall be the same as those specified for the overload test in 45.1 – 45.16.

47.3 A relay tested in accordance with 47.1 and 47.2 shall be marked as specified in 63.22.

48 Calibration Test

48.1 These requirements apply to an overload relay, or industrial control equipment incorporating an overload relay.

48.2 When tested at an ambient temperature of 40°C (104°F), an overload relay shall operate:

a) Ultimately when carrying 100 percent of the current element rated tripping current;

b) Within 8 minutes when carrying 200 percent of the current element rated tripping current; and

c) Within:

1) 20 seconds when carrying 600 percent of the current element rated tripping current; or

2) The time specified in Table 146.1 if marked in accordance with 146.2.

48.3 The test sequence for an overload relay with respect to 48.2 is to be the test in 48.2(c), followed by the test in 48.2(b), followed by the test in 48.2(a), all conducted on the same overload relay. If a relay employs interchangeable type current elements, the tests are to be conducted on the same current elements. The overload relay and the current elements are to be cooled to ambient temperature between tests.

48.4 An overload relay mounted in a starter or other enclosure is to be tested with the enclosure in the 40°C (104°F) ambient.

48.5 An adjustable overload relay is to be set at the 100 percent mark on the calibration scale and subjected to the tests specified in 48.2. The relay is also to be tested carrying a current of 200 percent of the current element rating, at the high and low points of the operating range – such as 120 and 80 percent of the element rating – to determine that the times of operation will be consistently longer and shorter, respectively, than the operating time at the 100 percent setting.

48.6 If an adjustable relay covers several tripping current ratings, the relay shall comply with the requirements in 48.2 for each separate rating.

48.7 In addition to the tests described in 48.2 at 40°C (104°F) ambient, an ambient-compensated overload relay or a starter provided with an ambient-compensated relay is to be subjected to those tests in ambient temperatures of 25 and 50°C (77 and 122°F).

48.8 The overload relay or a starter provided with an overload relay is to be tested with 4 feet (1.2 m) of wire attached to each field-wiring terminal. For example 8 feet (2.4 m) of conductor is required when the conductor is connected between two field-wiring terminals. The wire is to have the ampacity of at least 125 percent of the maximum full-load motor-current rating of the current element. The wire size is to be determined in accordance with Table 43.2 based on the wire temperature rating marked on the equipment. The type of insulation is not specified. If the terminal will not receive that size of wire, or if the device is marked in accordance with 25.5.4 to limit the size of wires, the maximum allowable wire size is to be used.

48.9 The overload relay or relays in a starter intended for polyphase use are to be calibrated with only two current elements in the circuit during 600 and 200 percent calibration tests to cover single-phasing and with three current elements in the circuit during 100 percent tests.

Exception: An electronic overload relay that offers loss of phase protection is not required to be calibrated at 600 percent and 200 percent in the single phase mode. For this type of function, the tests at 600 percent and 200 percent are optionally to be conducted in the three phase mode.

48.10 The overload relay in a starter employing one current element for single-phase use is to be calibrated with one current element in the circuit during all tests. The overload relay or relays in a starter employing two current elements for single-phase use are to be calibrated with two current elements in the circuit during all tests.

48.11 A separate overload relay – one not furnished as part of a starter – having two or more current elements is to be calibrated with one element in the circuit during all tests unless provided with marking to indicate other connection.

49 Dielectric Voltage-Withstand Test

49.1 General

49.1.1 While at its maximum normal operating temperature, industrial control equipment shall withstand for 1 minute without breakdown the application of a 60 hertz essentially sinusoidal potential or a direct-current potential:

a) Between uninsulated live parts and the enclosure with the contacts open and closed;

b) Between terminals of opposite polarity with the contacts closed; and

c) Between uninsulated live parts of different circuits.

49.1.2 With respect to 49.1.1, the test potential shall be the following values for alternating-current, or 1.414 times the following values for direct-current:

a) 500 volts – For industrial control equipment rated not more than 50 volts; and

b) 1000 volts plus twice the rated voltage of the equipment – For all other industrial control equipment rated more than 50 volts.

Exception: 1000 volts – For industrial control equipment rated more than 50 volts but not more than 250 volts and intended for use in a pollution degree 2 location.

49.1.3 A transformer, a coil, an electronic part, or a similar device normally connected between lines of opposite polarity is to be disconnected from one side of the line during the test described in 49.1.1(b).

49.1.4 If the equipment has a meter or meters, they are to be disconnected from the circuit for the dielectric voltage-withstand test described in 49.1.1 and 49.1.2. The meter or meters are to be tested separately for dielectric voltage withstand, with an applied potential of 1000 volts in the case of an ammeter, and 1000 volts plus twice rated voltage in the case of any other instrument having a potential circuit.

49.1.5 To determine whether industrial control equipment complies with the requirements in 49.1.1 and 49.1.4, it is to be tested by means of a 500 volt-ampere or larger capacity transformer, the output voltage of which is essentially sinusoidal and can be varied. The applied potential is to be increased from zero to the required value at a substantially uniform rate and as rapidly as is consistent with its value being correctly indicated by a voltmeter. A direct-current source shall be used for a direct-current circuit.

Exception: A 500 volt-ampere or larger capacity transformer need not be used if the transformer is provided with a voltmeter that directly measures the applied output potential.

49.2 Coils

49.2.1 A coil assembly that complies with the construction requirements in 36.18 shall be subjected to the tests described in 49.2.2 – 49.2.5. There shall be no breakdown of the coil assembly during these tests.

49.2.2 Three separate samples of the assembly of coil and frame shall be subjected to this test after constant temperatures have been reached as the result of operation under the conditions specified in 43.8 – 43.14. While heated from the normal temperature test, the coil terminals are to be connected to an alternating current source of twice the normal rated voltage at any frequency up to 400 hertz.

49.2.3 The required test voltage specified in 49.2.2 is to be obtained by starting at one-quarter or less of the full rated value and increasing to twice full rated value in not more than 15 seconds. After being held for 7200 electrical cycles or for 60 seconds, whichever is less, the voltage is to be reduced within 5 seconds to one-quarter or less of the maximum rated value and the circuit is to be opened.

49.2.4 While heated following operation at 110 percent of its rated voltage, each of the three samples are to be subjected to the test described in 49.2.2 and 49.2.3, except that the test voltage is to be 130 percent of the temperature test voltage.

49.2.5 If the temperature that a coil winding reaches in the tests described in 49.2.2 and 49.2.4, is known, an oven that can be set at the required temperature may be used to condition the sample to that temperature before conducting the test.

49.3 Secondary circuits

49.3.1 A secondary circuit intended for use in a pollution degree 2 location shall also comply with the requirements in 49.1.1 – 49.2.5.

Exception: A secondary circuit that has a maximum voltage of 30 volts rms or 42.4 volts peak is not required to have a dielectric voltage-withstand test applied between the secondary voltage and ground.

49.3.2 With respect to 38.1, a clamped joint between two insulators is to be tested using two samples.

a) The first sample is to have the clamped joint opened up to produce a space 1/8 inch (3.2 mm) wide. This may be accomplished by loosening the clamping means or by drilling a 1/8 inch diameter hole at the joint between the insulators at a point of minimum spacing between the metal parts on the opposite sides of the joint. The drilled hole shall not decrease spacings between the opposite polarity parts as measured through the crack between the insulators. The 60 hertz dielectric breakdown voltage through this hole is then determined by applying a gradually increasing voltage (500 volts per second) until breakdown occurs.

b) The second sample with the clamped joint intact is to be subjected to a gradually increasing 60 hertz voltage until 110 percent of the breakdown voltage of 49.3.2 (a) has been reached. If the breakdown voltage of 49.3.2 (a) was less than 4600 volts rms, the voltage applied to the second sample is to be further increased to 5000 volts rms and held for 1 second. The clamped joint is acceptable if there is no dielectric breakdown of the second sample.

50 Short Circuit Test – General

50.1 General

50.1.1 The requirements in this section shall be used in conjunction with Section 51, Standard Fault Current Circuits, Section 52, High Available Fault Current Circuits, Section 52A, Group Installation, Section 53, Standard and High Fault Acceptance Criteria, and Section 54, Calibration of Test Circuits.

Revised 50.1.1 effective July 16, 2001

50.1.2 The requirements for device performance of Section 42, General, are to be applied.

50.1.3 A short circuit test is to be conducted on:

a) A motor control device that is rated more than 1 hp (746 W) and 300 V or more than 2 hp (1492 W);

b) A starter;

c) An overload relay;

d) Industrial control equipment incorporating an overload relay; and

e) Combination motor controllers.

Exception No. 1: Short circuit tests on a motor control device rated more than 1 horsepower (746 W) and 300 V or more than 2 horsepower (1492 W output) are not required when the motor control device has successfully completed short circuit tests as part of a starter.

Exception No. 2: Testing with inverse-time circuit breakers is not required when it is shown that the let-through energy (I^2t) and peak let-through current (I_p) of the inverse-time circuit breakers is less than that of the fuse with which the product has been tested.

50.1.3 revised July 16, 1999

50.1.4 Motor control devices, overload relays, and combination motor controllers intended for use in a motor branch circuit are evaluated for use in a circuit protected by either a fuse or by an inverse-time circuit breaker.

Exception No. 1: When such equipment is marked to limit protection to fuses only and is marked as specified in the Exception to 63.2, it is not required to be evaluated for use in a circuit protected by an inverse-time circuit breaker.

Exception No. 2: An overload relay that is part of a combination motor controller that employs fuses is not required to be evaluated for use in a circuit protected by an inverse-time circuit breaker, and an overload relay that is part of a combination motor controller that employs an inverse-time circuit breaker is not required to be evaluated for use in a circuit protected by fuses.

Exception No. 3: An overload relay that is part of a combination motor controller that is a self-protected control device is not required to be evaluated for use in a circuit protected by fuses or an inverse-time circuit breaker.

Exception No. 4: When the fault current is applied for 3 electrical cycles, the test covers the use of fuses and circuit breakers provided the clearing time of such branch circuit protective devices is less than 3 cycles.

50.1.4 revised July 16, 1999

50.1.5 After each operation, the contacts of the motor control devices, or the entire motor control device, may be replaced and new current elements may be installed in the overload relay. The same sample may be used provided that no additional impedance is introduced. If an overload relay employs noninterchangeable current elements, the entire overload relay may be replaced.

50.1.6 If the marked rating of the equipment includes both alternating and direct current, or if the marked rating does not exclude one or the other, the acceptability of the equipment for both ratings is to be determined. The ac rating is to be verified in accordance with 54.2. The dc rating is to be verified in accordance with 54.3.

50.2 Enclosure

50.2.1 For open-type equipment, the requirements of 42.6 (a) – (d) and Tables 6.1 and 6.2 (for the thickness of the enclosure) and 50.2.2 – 50.2.5.

50.2.1 revised July 16, 1999

50.2.2 Openings may be provided in any enclosure if the combined area of all openings does not exceed 10 percent of the total external enclosure area and if no opening is directly opposite a vent in a circuit breaker case, if provided with a circuit breaker.

50.2.3 An enclosure having the smallest dimensions and the least provision for pressure relief is to be selected.

50.2.4 The enclosure cover is to be held closed only by the intended latch mechanism and securement means.

50.2.5 An enclosure for testing of open-type equipment provided with a door shall be secured by one latch point when less than 48 inches (1.2 m) long, or shall comply with the requirement of 6.4.4 when over 48 inches (1.2 m) long.

Exception: Additional latching points are able to be used when information is provided to the user in the form of an instruction sheet.

50.2.5 added July 16, 1999

50.2.6 For enclosed equipment, the intended enclosure shall be used or, when multiple enclosure options are provided, representative enclosures shall be selected as specified in 50.2.3.

50.2.6 added July 16, 1999

50.3 Sample preparation

50.3.1 The equipment is to be tested with 4 feet (1.2 m) of wire attached to each line terminal and with the wires routed through a 10 – 12 inch (250 – 305 mm) length of conduit installed on the enclosure. All openings are to be acceptably closed. The wire is to have an ampacity of at least 125 percent of the maximum full-load motor-current rating of the current element. The wire size is to be determined in accordance with Table 43.2 based on the wire temperature rating marked on the equipment. If the terminal will not receive that size of wire, or if the equipment is marked in accordance with 25.5.4 to limit the size of wires, the maximum allowable wire size is to be used. The load terminals are to be shorted together, using wire sized in the same manner as the line terminals.

Exception No. 1: The test wires may exceed 4 feet in length in accordance with 54.2.1.2.

Exception No. 2: For motor control devices rated more than 200 horsepower (150 kW), the line and load connections may be made with bus bars equivalent in cross-sectional area to the wires specified.

50.3.2 The metal enclosure is to be connected to the phase of the source of supply which is connected to the pole judged as having the least risk of arcing to ground. The connection is to be made to the load side of the limiting impedance by a No. 10 AWG (5.3 mm^2) solid copper wire that is 4 – 6 feet (1.22 – 1.83 m) long. Continuity shall be verified between the enclosure and the pole least at risk of arcing to ground.

Exception No. 1: The connection shall be made with No. 12 or 14 AWG (3.3 or 2.1 mm^2) solid copper wire when the branch-circuit conductors that the equipment is intended to be connected to are No. 12 or 14 AWG, respectively.

Exception No. 2: For equipment marked 600Y/347 or 480Y/277 volts, the enclosure shall be connected to the center of the wye.

50.3.2 revised July 16, 1999

50.3.3 The enclosures may be provided with length(s) of conduit of any convenient trade size.

Exception: If conduit is not provided, the conductors outside the enclosure may be restrained to prevent whipping during the test.

50.3.4 The armature or cross bar is to be held in the closed position either mechanically or by a separate electrical supply for a magnetically-operated device. The contacts of the motor control devices may be held closed only by the movement of the armature or cross bar.

50.3.5 Revised and relocated as 52.3.5 July 16, 1999

50.4 Group fusing

50.4.1 Deleted effective July 16, 2001

50.4.2 Deleted effective July 16, 2001

50.4.3 Deleted effective July 16, 2001

50.4.4 Deleted effective July 16, 2001

50.4.5 Deleted effective July 16, 2001

51 Standard Fault Current Circuits

51.1 Protective devices

51.1.1 General

51.1.1.0 A combination motor controller, motor control device, or overload relay shall be tested according to the requirements in this section and shall additionally comply with Section 50, Short Circuit Test – General.

51.1.1.0 added July 16, 1999

51.1.1.1 For non-time delay fuses, if the calculated value of the fuse is between two standard ratings as specified in 51.1.2.2, a fuse of the nearest standard rating but not more than four times the full-load motor-current rating is to be used. If the calculated value of the fuse is less than 1 ampere, a fuse rated 1 ampere is to be used, and no marking of fuse size is required on the product.

51.1.1.2 If the calculated value of the circuit breaker is between two standard ratings as specified in 51.1.3.2, a circuit breaker of the nearest standard rating less than the calculated value is to be used.

51.1.2 Fuses

51.1.2.1 The fuses used for the tests are to be specified by the manufacturer in accordance with Table 51.1.

Table 51.1
Ratings of fuses used for tests

Table 51.1 revised July 16, 1999

Type of fuse[a]	Current, amperes	Maximum percent of rated motor full-load current[b]	Fuse size marking required[j]
Nontime Delay	0 – 600	400[c,d]	No
Nontime Delay	0 – 600	< 400 but ≥ 300[e]	Yes
Nontime Delay	0 – 600	< 300 but > 225[f]	Yes
Time Delay	0 – 600	≤ 225[g]	Yes
Nontime Delay	601 – 6000	300[f,h]	No
Nontime Delay	601 – 6000	< 300[i]	Yes
Time Delay	601 – 6000	225[g]	Yes

[a] Tests with 225 percent full load ampere time delay fuses are not representative of tests with 400 percent full load ampere nontime delay fuses.

[b] These values are to be used when the manufacturer does not specify fuse sizes and refers to a maximum percent level, such as ″Fuse not to exceed 300 percent of motor full load amps.″

[c] See 51.1.1.1.

[d] Tests with 400 percent nontime delay fuses cover use with 225 percent time delay fuses.

[e] Tests with nontime delay fuses rated less than 400 percent, and equal to or greater than 300 percent cover use with 175 percent time delay fuses.

[f] Tests with less than 300 percent nontime delay fuses requires additional testing with 225 percent (or as marked) time delay fuses.

[g] The product is marked to indicate the level of protection and that the branch-circuit protective device is able to be of the time-delay type.

Table 51.1 Continued on Next Page

Table 51.1 Continued

Type of fuse[a]	Current, amperes	Maximum percent of rated motor full-load current[b]	Fuse size marking required[j]
[h] When the calculated value of the fuse is between two standard ratings as specified in 51.1.2.2, a fuse of the nearest standard rating and not more than three times the full-load motor-current rating is to be used. [i] The protective device is able to be a nontime delay fuse smaller than the size specified in note h when the product is marked to indicate this limit of protection. [j] When the fuse size employed for the short circuit test requires a marking, the device shall be marked as specified in 63.2.			

51.1.2.2 Standard ampere ratings for fuses are 1, 3, 6, 10, 15, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, 90, 100, 110, 125, 150, 175, 200, 225, 250, 300, 350, 400, 450, 500, 600, 601, 700, 800, 1000, 1200, 1600, 2000, 2500, 3000, 4000, 5000, and 6000.

51.1.2.3 Testing with Class RK5 fuses is considered representative of tests using Class H and K fuses.

51.1.2.4 A motor control device with specified protective device ratings above and below 600 amperes is to be tested with a 600 ampere one-time, nonrenewable fuse at 10,000 amperes and in addition is to be tested in accordance with 51.3.3.1.

51.1.3 Circuit breakers

51.1.3.1 An inverse-time circuit breaker used for the test described in 51.1.3.3 and Table 51.2 is to be specified by the manufacturer in accordance with either of the following:

a) The inverse-time circuit breaker shall be rated not more than four times the maximum full-load motor-current rating for full-load currents of 100 amperes or less or not more than three times the maximum full-load motor-current rating for full-load currents greater than 100 amperes. When the calculated value of the circuit breaker is less than 15 amperes, a circuit breaker rated 15 amperes is to be used. No marking of the circuit breaker rating is required on the product.

b) The inverse-time circuit breaker is able to have a rating less than that specified in 51.1.3.1(a) when the product is marked to indicate the limit of protection as specified in 63.2.

51.1.3.1 revised July 16, 1999

Table 51.2
Ratings of inverse-time circuit breaker used for tests

Maximum ratings of inverse-time circuit breakers used for tests	Circuit breaker marking requirement	Maximum full load motor current rating, amperes
4 times rated maximum full-load motor current	No	100 A or less
3 times rated maximum full-load motor current	No	greater than 100 A
15 A	No	Where calculated value is less than 15 A
Other ratings less than specified above	Yes	–

51.1.3.2 Standard ampere ratings for inverse-time circuit breakers are 15, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, 90, 100, 110, 125, 150, 175, 200, 225, 250, 300, 350, 400, 450, 500, 600, 700, 800, 1000, 1200, 1600, 2000, 2500, 3000, 4000, 5000, and 6000.

51.1.3.3 Short circuit tests with an inverse-time circuit breaker are to be conducted employing the minimum resistance current element per size or construction of the current element. If burn-out of the elements occurs, the test is repeated with the minimum resistance element in the smallest size or construction that does not cause burnout.

51.1.3.4 An instantaneous trip circuit breaker or a self-protected Type E combination motor controller with an integral adjustable instantaneous trip circuit breaker mechanism shall be adjusted to its maximum setting or 13 times the full load current, whichever is less.

Exception: The device shall be adjusted to its maximum setting or 17 times the full load current, whichever is less, when used as the protection for Design E motors and high efficiency Design B motors.

Revised 51.1.3.4 effective July 16, 2001

51.2 Sample selection for overload relay

51.2.1 A sufficient number of overload-relay current elements considered to be representative of the line are to be subjected to short circuit tests in series with a motor protective device. Representative samples are to be selected on the basis of configuration, material, and resistance.

51.2.2 The overload relay is to be tested in the motor control device with which it is intended to be used, if furnished as part of a motor control device. A shunt or current transformer that is used to reduce the current in the current element of the overload relay is considered to be a part of the relay for the purpose of this test.

Exception: Overload relays, supplied by current transformers which limit the current to the relay, do not have to be subjected to this test, provided that the current is limited to a level which the overload relay has already been evaluated.

51.3 Parameters

51.3.1 For all equipment

51.3.1.1 The equipment is to be subjected to the number and type of operations in accordance with Table 51.4 and shall comply with Table 53.1. Successive operations are to be conducted by closing the circuit on the equipment (″O″ operation) by means of any appropriate switching device, using random closing.

51.3.1.1 revised July 16, 1999

51.3.1.2 The test circuit is to be capable of delivering the current specified in Table 51.3 for a given horsepower rating.

Table 51.3
Short circuit test current values for devices rated 600 volts or less

Ratings		Test current	
Horsepower	(kW)	Amperes[a]	Power factor
1 – 1.5[b]	(0.7 – 1.1)	1,000	0.7 – 0.8
2 – 50	(1.4 – 37.3)	5,000	0.7 – 0.8
51 – 200	(39 – 149)	10,000	0.7 – 0.8
201 – 400	(150 – 298)	18,000	0.25 – 0.30
401 – 600	(299 – 447)	30,000	0.20 or less
601 – 900	(448 – 671)	42,000	0.20 or less
901 – 1600	(672 – 1193)	85,000	0.20 or less
1601 or more	(1194 or more)	100,000, 125,000, 150,000 or 200,000	0.20 or less

[a] Symmetrical rms amperes

[b] For a motor control device rated more than 1 hp and greater than 300 V.

51.3.1.3 Fuses and circuit breakers used as main devices need not be mounted in an enclosure. The conductor between the branch circuit protection and the motor control device shall be included in the 4 foot (1.2 m) length as described in 50.3.2.

51.3.2 Provided with fuses – equipment rated 200 hp or less

51.3.2.1 Short circuit tests with fuses on a device having a rating not greater than 200 horsepower (150 kW) are to be in accordance with (a), (b), or (c), as follows:

a) On a single-phase circuit with two poles and one current element in the circuit – three test operations for each current element selected;

No Text on This Page

b) If rated single-phase only and provided with two current elements – three test operations for each current element selected on a single-phase circuit with two poles and two current elements in the circuit; or

c) If rated 3-phase – two test operations for each current element selected on a 3-phase circuit with three poles and three current elements.

51.3.2.2 The poles – contacts – referred to in 51.3.2.1 may be omitted from the circuit after a sufficient number of tests have been conducted to determine that subsequent malfunction or breakdown of the equipment due to contact arcing is unlikely. Consideration is to be given to contact arcing while testing the intermediate as well as the higher-rated current elements.

51.3.3 Provided with circuit breaker – equipment rated 200 hp or less

51.3.3.1 Short circuit tests on a device having a maximum rating of 200 horsepower (150 kW) or less with an inverse-time or instantaneous-trip circuit breaker are to consist of:

a) Two operations on a 3-phase circuit with three poles and three overload relays in the circuit for a device having three or more poles.

b) For a product rated single phase only:

1) Two poles and two overload relays are to be used if overload relays are provided in each conductor to the motor and

2) Two poles and one overload relay are to be used for other arrangements.

51.3.4 For equipment rated over 200 hp

51.3.4.1 Short-circuit tests on a device having a maximum rating in excess of 200 horsepower (150 kW) are to consist of one test operation on a 3-phase circuit, with three poles and three overload relays in the circuit. The tests are to be performed with protective devices selected in accordance with either note (h) or (i) of Table 51.1 or 51.1.3.1(a) or (b). If an inverse-time circuit breaker is adjustable, it is to be set at the maximum tripping time unless the product is marked to indicate a limit of protection. A product not provided with three overload relays is to be tested with three poles and two overload relays in the circuit.

Exception: The test may be performed for a period of time at least equivalent to the opening time of the protective device specified on the motor control device at the required level of test current.

51.3.4.2 The number of test operations for each current element selected is to be as specified in Table 51.4.

Table 51.4
Required number of test operations

Table 51.4 revised July 16, 1999

Rating		Number of poles for a device	Number of current elements[a]	Type of branch circuit protection and number of poles provided		Number of operations[b]
Horsepower	(kW)			Fuse	Circuit breaker	
0 – 200	(0 – 149)	1 phase, single pole	1	1	single pole inverse-time	3 ″O″ operations
		1 phase, 2 poles	2	2	2 pole inverse-time	3 ″O″ operations
		3 phase, 3 poles	3	3	3 pole inverse-time	2 ″O″ operations
201 – 1600	(150 – 1193)	3 phase, 3 poles	3	3	3 pole inverse-time	1 ″O″ operation

[a] Applies to devices provided with or incorporating a thermal overload relay. See 51.3.2.1, 51.3.3.1, and 51.3.4.1.

[b] Number of operations for each current element selected, when device is provided with or incorporates thermal overload relays.

52 High-Available Fault Current Circuits (Optional)

52.1 General

52.1.1 The optional requirements in this section cover combination motor controllers and motor control devices with or without overload relays for use on circuits having available short circuit currents in excess of the minimum levels specified in Table 51.3, and not more than 200,000 amperes rms symmetrical. For other than a combination motor controller with integral protective devices, the specific type of protective device shall be specified for the product and marked as specified in 63.2.

52.1.1 revised July 16, 1999

52.1.2 Combination motor controllers and motor control devices with or without overload relays shall additionally comply with Section 51, Short Circuit Tests – Standard Fault Current Circuits which is able to be conducted on a separate set of samples.

52.1.2 added July 16, 1999

52.2 Sample selection

52.2.1 Overload relay

52.2.1.1 Samples for the test are to be selected among motor control devices employing the largest and smallest size current element that may be used with the protective device specified for the motor control device.

52.2.1.2 The maximum number of current elements that can be accommodated by the device are to be in place during each test. Three-phase tests are considered to cover single-phase tests for a device of the same design.

52.2.2 Protective devices

52.2.2.1 For a motor control device or overload relay intended to be used with circuit breakers, the protective devices used for the test are to be sized in accordance with 51.1.3.1 and are to be selected as follows:

a) A circuit breaker installed within a combination motor control device is considered to be representative of all other breakers of the same manufacturer, rating, and frame construction. The interrupting rating of the circuit breaker is to be at least the marked short-circuit current rating of the motor control device.

Exception: A circuit breaker with a lower interrupting rating is able to be used when the combination is evaluated and subjected to the appropriate requirements of the Standard for Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures, UL 489.

b) For noncombination controllers, the circuit breaker to be used is to be selected from commercially available units of the molded-case type having essentially the same characteristics with respect to let-through (I^2t) and peak let-through current (I_p) and current-limiting features.

c) For circuit breakers with current limiters provided as part of the control device, the current limiter shall be selected such that when tested on a single-phase circuit, the peak let-through current and a clearing I^2t are not less than the maximum value established for the current limiter intended to be used with the motor control device being tested.

d) For instantaneous circuit breaker, they shall be adjusted to their maximum setting and no more than 13 times the full load current or 17 times the full load current for controllers marked for use with Design E motors and high-efficiency Design B motors.

Exception: Combination motor controller self-protecting control devices are provided with integral short-circuit and ground-fault protection.

52.2.2.1 revised July 16, 1999

52.2.2.2 For a motor control device or overload relay intended to be used with fuses, the protective devices used for the test are to be sized in accordance with 51.1.2.1 and are to be selected as follows:

a) Fuses specified for branch-circuit protection for motor control devices rated over 10,000 amperes shall be limited to high-interrupting capacity, current-limiting types – for example, Class CC, G, J, L, R, and T.

Exception: A motor control device rated 50 horsepower (37 kW) or less and tested at 10,000 amperes, is able to specify Class H or K fuses for motor-branch-circuit protection.

b) A motor control device that is required to be used with RK1 or RK5 fuses is to be tested with fuses having I^2t and I_p characteristics for Class RK5 fuses. All references to Class R fuses are intended to mean fuses with energy let-through (I^2t), characteristics of Class RK5 fuses.

Exception: A motor control device that is marked to restrict its use to RK1 fuses is able to be tested with fuses having energy let-through characteristics of a Class RK1 fuse.

c) A Class CC, G, J, L, R, or T fuse, or motor short-circuit protector is to be selected such that, when tested on a single-phase circuit, the peak let-through current and clearing I^2t are not less than the maximum value established for the fuse – see the UL 248 series of standards – or motor short-circuit protector rating that is intended to be used with the controller being tested. For a fuse with I_p and I^2t limits established for several different short-circuit current levels, the test fuse is to be selected to have at least the maximum values of the current corresponding to the marked short-circuit current rating of the motor control device.

Exception No. 1: A test limiter is able to be used in place of the fuses.

Exception No. 2: Combination motor controller self-protecting control devices are provided with integral short-circuit and ground-fault protection.

52.2.2.2 revised July 16, 1999

52.3 Procedure

52.3.1 A combination motor controller or motor control device with or without overload relays shall be tested according to the requirements in this section and shall additionally comply with Section 50, Short Circuit Test – General. The terminals of the test circuit described in 50.3.1 are to be connected together by a copper bar, and the test circuit is to be calibrated as described in Section 54, Calibration of Test Circuits, at the maximum available short circuit current for which the motor control device is rated.

52.3.1 revised July 16, 1999

52.3.2 The test circuit is to have the characteristics specified in Table 52.1.

Table 52.1
High-capacity short circuit test values for devices rated 600 V or less

Test current, amperes[a]	Power factor[b]
10,000 amperes or less	0.70 – 0.80
10,001 – 20,000	0.25 – 0.30
Greater than 20, 000	0.15 – 0.20

[a] Symmetrical rms amperes

[b] Lower power factor circuits than specified may be used.

52.3.3 For the short-circuit-closing test (“CO” shot), each switching device of the motor control device is closed on the test circuit. This requires separate tests for each switching device, as specified in Table 52.2: one in which the disconnecting means, when provided, is closed on the circuit, and a second in which the contactor is closed on the circuit. Complete physical closure of the switching contacts is not required to be established. When complete physical closure of the switching contact is established, the closing test on the disconnecting means is able to cover the withstand test (“O” shot) on the motor control device and the closing withstand test on the motor control device is able to cover the withstand test on the disconnecting means. To determine whether complete physical closure of the contacts has occurred, the oscillogram of the short circuit current and voltage traces are reviewed between circuit initiation and current interruption by the protective device. A smooth sinusoidal waveform in this area of the trace is an indication of complete physical closure.

52.3.3 revised July 16, 1999

Table 52.2
Required number of test operations

Table 52.2 revised July 16, 1999

Disconnecting means provided	Type of test	Number of test operations
Yes	Disconnecting means closed on the circuit (″CO″ shot)	1[a,b]
Yes	Motor control device closed on the circuit (″CO″ shot)	1[a]
Yes	Circuit closed on equipment (″O″ shot)	1
No	Motor control device closed on the circuit (″CO″ shot)	1
No	Closed circuit on equipment (″O″ shot)	1

[a] If complete physical closure of the switching contact is established during closing tests (″CO″ shots), the withstand test (″O″ shot) is not required.

[b] When a motor control device and its control circuit are supplied from the same source (common control), the closing test on the disconnect switch is not required.

52.3.4 The equipment is to be subjected to the number and type of operations in accordance with Table 52.2 and shall comply with Table 53.1. Successive operations on a motor control device or overload relay without a disconnecting means are to be conducted by alternating closing the equipment on the circuit (″CO″ operation) and closing the circuit on the equipment (″O″ shot), using random closing.

52.3.4 revised July 16, 1999

52.3.5 When closing the circuit on the equipment (″O″ shot), the disconnecting means, when provided, and the motor control device are to be in the fully closed position. When manual motor control devices are to be closed onto the test circuit (″CO″ shot), they are to be operated in a manner that would normally be anticipated in service (i.e., in a continuous, uniform movement of the operating handle from the ″off″ to the ″on″ position).

50.3.5 revised and relocated as 52.3.5 July 16, 1999

52A Group Installation (Optional)

52A.1 General

52A.1.1 A motor control device or overload relay intended for group installation at standard fault currents shall be tested in accordance with 52A.2 and 52A.3 and shall also comply with the short circuit test requirements in Section 51, Standard Fault Current Circuits, conducted on a separate set of samples. A motor control device or overload relay intended for group installation at high fault currents shall be tested in accordance with 52A.2, 52A.3, and 52A.4. All devices for group installation shall be marked in accordance with 63.2.1.

Added 52A.1.1 effective July 16, 2001

52A.1.2 The requirements in this section cover a motor control device or overload relay:

a) For use on circuits having available short circuit currents at standard fault levels or at high fault levels; and

b) Protected by a circuit breaker or fuse(s), intended to provide branch circuit protection for two or more motors, or one or more motors and other loads. The protective device(s) shall be selected in accordance with 51.1, except the current rating of the protective device is not limited

to those values specified in Table 51.1 or 51.2. The maximum size of the branch circuit protective device shall not exceed the ampere rating calculated from the following formula:

Amperes = [9.6 x (maximum wire size)] − [2.2 x (minimum motor FLA)]

in which:

Maximum wire size is the ampacity from Table 43.2 of the largest conductor size for which the device terminals have been evaluated; and

Minimum motor FLA is the smallest rated FLA (or equivalent FLA from horsepower rating per Table 45.2) marked on the device.

Added 52A.1.2 effective July 16, 2001

52A.2 Sample selection

52A.2.1 A sample of a motor control device, three samples of an overload relay current element, or one sample of a three phase overload relay that complies in all other respects with requirements in this standard shall be subjected to short circuit tests where the device is connected in series with a nonrenewable cartridge fuse(s) or an inverse-time circuit breaker of the maximum standard rating with which the motor control device or element is intended to be used and not more than specified in 52A.1.2(b).

Added 52A.2.1 effective July 16, 2001

52A.2.2 Samples of overload relays shall be selected in accordance with 51.2 for standard fault ratings.

Added 52A.2.2 effective July 16, 2001

52A.2.3 Samples of overload relays are to be selected in accordance with 52.2.1.1 for high fault ratings.

Added 52A.2.3 effective July 16, 2001

52A.3 Group installation for standard fault circuit ratings

52A.3.1 A motor control device or overload relay having short circuit ratings at levels specified in Table 51.3 shall comply with Table 53.1 when subjected to a short circuit test described in 52A.3.2.

Added 52A.3.1 effective July 16, 2001

52A.3.2 The requirements in 51.3 are to be applied, and the test circuit is to be calibrated as described in Section 54, Calibration of Test Circuits, at the standard available short circuit current for which the motor control device or overload relay is rated.

Added 52A.3.2 effective July 16, 2001

52A.4 Group installation for high capacity short circuit ratings

52A.4.1 A motor control device or overload relay having short circuit ratings in excess of the levels specified in Table 51.3 shall comply with Table 53.1 when subjected to a short circuit test described in 52A.4.2.

Added 52A.4.1 effective July 16, 2001

52A.4.2 The requirements in 52.3 are to be applied and the test circuit is to be calibrated as described in Section 53.1, Calibration of Test Circuits, at the maximum available short circuit current for which the motor control device or overload relay is rated.

Added 52A.4.2 effective July 16, 2001

53 Standard and High Fault Acceptance Criteria

53.1 After the protective device or the motor control device has cleared the fault, an overload relay, industrial control equipment incorporating an overload relay, a starter, a combination motor controller, or a motor control device shall comply with Table 53.1.

53.1 revised July 16, 1999

Table 53.1
Maximum damage criteria

Revised Table 53.1 effective July 16, 2001

Product	Damage criteria reference
Motor control device, non-combination motor controller	a – h
Overload relay	a – e, i – k
Starter, industrial control equipment incorporating an overload relay	a – k
Combination motor controller	a – n
All devices	
a) The solid AWG wire connected between the live pole and the enclosure shall not open.	
b) The door or cover shall not be blown open, and it shall be possible to open the door or cover. When deformation of the enclosure occurs, all resulting openings in the enclosure shall comply with 6.17.1 for accessibility of live parts under normal operating conditions.	
c) There shall be no damage to a conductor or terminal connector and no conductor shall pull out of a terminal connector.	
d) There shall be no breakage or cracking of insulating bases to the extent that the integrity of the mounting of live parts is impaired.	
e) Discharge of parts or any risk of a fire shall not occur.	
Motor control devices	
f) The load switching function of the motor control device is able to be inoperative at the conclusion of the test. The contacts of the motor control device are able to weld or completely disintegrate. Following high fault short circuit tests on a self-protected combination motor controller, the contacts of the control device module are able to weld when the module is located on the load side of the disconnection and branch circuit contacts and the module is replaceable.	
g) The contacts of a manual motor controller intended for use as a motor disconnecting means shall not weld and the contacts of the manual motor controller shall be capable of being opened manually with the intended operating means. Following the short circuit tests, the controller shall be subjected to the Voltage-Withstand Test, Section 73E.	
h) The motor control contacts of a manual motor controller with instantaneous trip release are able to open the short circuit instead of the protective devices when they are additionally tested in accordance with the magnetic trip out test, Section 73F, immediately following the short circuit test.	
Overload relays	
i) When burnout of the current element of a mechanical overload relay occurs, the device shall be marked as specified in 65.7 and the test shall be repeated with the minimum resistance element in the smallest size or construction that does not burn out.	
j) A current element of a mechanical overload relay provided with a manual motor controller with instantaneous trip that does not burn out shall be subjected to the calibration test – 200 percent, Section 73G.	
k) All electronic overload relays shall be operable immediately after the test and shall be subjected to the calibration test in Section 151.	
Combination motor controllers	
l) The disconnecting means of the combination motor controller shall be capable of being opened manually with the intended operating means. The contacts of the disconnecting means shall not weld. Following high fault short circuit tests only, the disconnecting means shall be subjected to the Voltage Withstand Test, Section 80.	
m) Contacts that serve as the branch circuit protection means shall not weld. Self-protected control devices shall be operable immediately after the test for compliance with the Magnetic Trip-Out Test, Section 81.	

Table 53.1 Continued on Next Page

Table 53.1 Continued

Product	Damage criteria reference
n) When provided as part of the equipment, neither end of a protective device – such as a fuse, current limiter, or motor short-circuit protector – shall be completely separated from the mounting means, and the line end of a fuse, current limiter, or motor short-circuit protector shall not bridge from the mounting means to dead metal.	

54 Calibration of Test Circuits

54.1 Circuit characteristics

54.1.1 Equipment rated for direct current is to be tested using a direct current electrical source; alternating-current equipment is to be tested on a 60-hertz essentially sinusoidal current electrical source. The open-circuit voltage of the test circuit is to be 100 to 105 percent of the voltage rating of the overload relay, except that the voltage may exceed 105 percent of the rated voltage with the concurrence of those concerned. The test circuit is to be capable of delivering the specified current when the system is short-circuited at the testing terminals to which the device under test is to be connected, and this is to be verified by means of an oscillograph.

54.1.2 For available fault current circuits, air core type reactors are to be employed in the line to obtain the power factor in accordance with Table 51.4. The reactors may be connected in parallel, but no reactor is to be connected in parallel with a resistor; except that a reactor in any phase may be shunted by a resistor if the power consumed by the resistor is in the range between 0.55 – 0.65 percent of the reactive volt-amperes in the reactor in that phase. The minimum value of the shunting resistance used with a reactor having negligible resistance is to be calculated from the equation:

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$$R = 167 \frac{E}{I}$$

in which E is the phase voltage across the reactor with phase current I flowing as determined by oscillographic measurement during the short circuit calibration or by proportion from meter measurements at some lower current.

54.2 Alternating-current circuits

54.2.1 General

54.2.1.1 The available current capacity of the circuit is to be at least the value required for the short-circuit-withstand rating of the motor control device. The frequency of the test circuit is to be 60 ±12 hertz for an alternating-current circuits.

54.2.1.2 The available rms symmetrical current is to be determined at the device terminals.

Exception No. 1: For a circuit rated 25,000 amperes or less, the available current may be determined at the test-station terminals.

Exception No. 2: The available current may be determined at the test-station terminals if for a circuit having a maximum available short-circuit current:

a) Between 25,001 – 50,000 amperes, the available current is determined to be 5 percent higher than the required test current: or

b) Between 50,001 – 200,000 amperes, the available current is determined to be 10 percent higher than the required test current.

If the available current is determined at the test-station terminal and the physical arrangement in the test station requires leads longer than 8 feet (2.4 m) per terminal, the additional length of leads is to be included in the circuit calibration.

54.2.2 Available current of 10,000 amperes or less

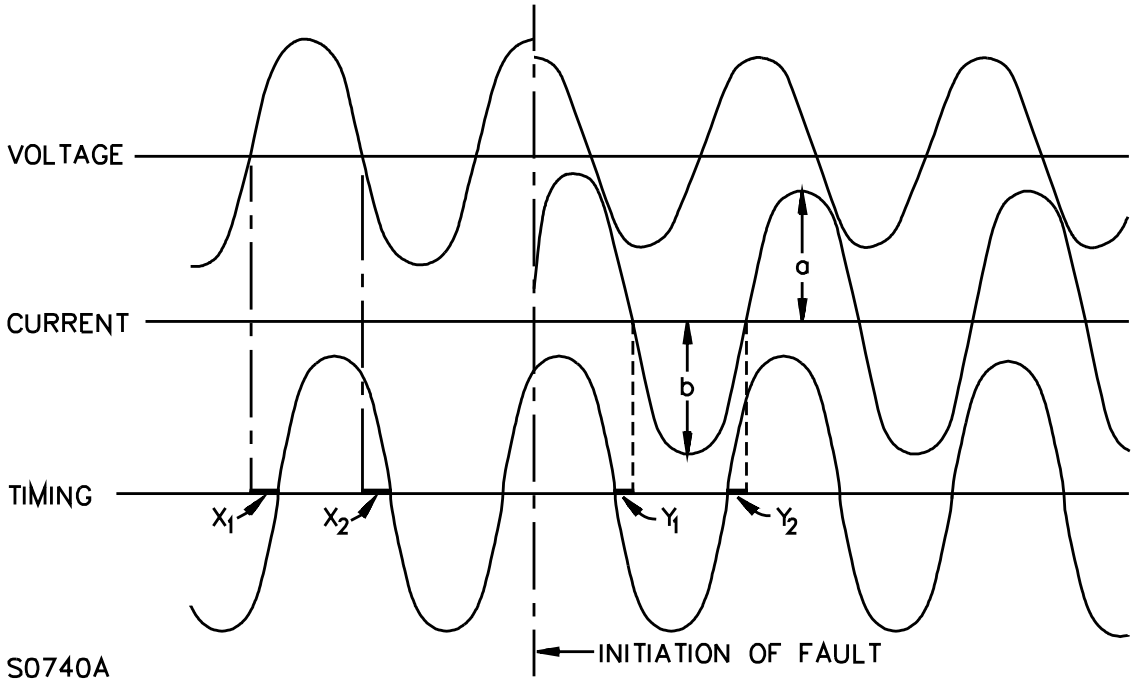
54.2.2.1 For an alternating-current circuit intended to deliver 10,000 amperes or less, the current and power factor are to be determined as follows:

a) For a 3-phase test circuit, the current is to be determined by averaging the rms values of the first complete cycle of current in each of the three phases; the voltage to neutral is to be used to determine the power factor.

b) For a single-phase test circuit, the current is to be the rms value of the first complete cycle – see Figure 54.1 – when the circuit is closed to produce an essentially symmetrical current waveform. The direct-current component is not to be added to the value obtained when measured as illustrated. In order to obtain the desired symmetrical waveform of a single-phase test circuit, controlled closing is recommended although random closing methods may be used. The power factor is to be determined by referring the open-circuit voltage wave to the two

adjacent zero points at the end half of the first complete current cycle by transposition through a suitable timing wave. The power factor is to be computed as an average of the values obtained by using these two current zero points.

Figure 54.1
Determination of current and power factor for circuits of 10,000 amperes and less



$$Current = \frac{a+b}{2} \; rms \; calibration \; of \; instrument \; element$$

$$Power\ Factor = \frac{Cosine[(Y_1 + X_1) \times 180°] + Cosine[(Y_2 + X_2) \times 180°]}{2}$$

Where X_1, X_2, Y_1, and Y_2 values of the power factor are fractions of the 1/2-cycle distance in which they occur.

54.2.3 Available current of more than 10,000 amperes

54.2.3.1 For circuits intended to deliver more than 10,000 amperes, the current and power factor are to be determined in accordance with the requirements in 54.2.3.2 – 54.2.3.6. Instrumentation used to measure test circuits of over 10,000 amperes is to comply with the requirements in 54.4.

54.2.3.2 The rms symmetrical current is to be determined, with the supply terminals short-circuited by measuring the alternating-current component of the wave at an instant 1/2 cycle – on the basis of the test frequency timing wave – after the initiation of the short circuit. The current is to be calculated in accordance with Figure 7 in the Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis, ANSI/IEEE C37.09-1979(R1989).

54.2.3.3 For a 3-phase test circuit, the rms symmetrical current is to be the average of the currents in the three phases. The rms symmetrical current in any one phase is not to be less than 90 percent of the required test current.

54.2.3.4 The test circuit and its transients are to be such that 3 cycles after initiation of the short circuit, the symmetrical alternating component of current will not be less than 90 percent of the symmetrical alternating component of current at the end of the first 1/2 cycle, or the symmetrical alternating component of current at the time at which the overcurrent-protective device will interrupt the test circuit is at least 100 percent of the rating for which the motor control device is being tested. In 3-phase circuits, the symmetrical alternating component of current of all three phases is to be averaged.

54.2.3.5 The power factor is to be determined at an instant 1/2 cycle – on the basis of the test frequency timing wave – after the short circuit occurs. The total asymmetrical rms amperes are to be measured in accordance with 54.2.3.2 and the ratio M_A or M_M is to be calculated as follows:

$$M_A\ (3\ phase) = \frac{Av.\ 3\ phases-Asymmetrical\ RMS\ Amperes}{Av.\ 3\ Symmetrical\ RMS\ Amperes}$$

$$M_M\ (1\ phase) = \frac{Asymmetrical\ RMS\ Amperes}{Symmetrical\ RMS\ Amperes}$$

Using ratio M_A or M_M, the power factor is to be determined from Table 54.1.

54.2.3.6 The power factor of a 3-phase circuit may be calculated by using controlled closing so that upon subsequent closings a different phase will be caused to have maximum asymmetrical conditions. The power factor of each phase could then be determined using the method described for single-phase circuits in 54.2.3.5. The power factor of the 3-phase circuit is considered to be the average of the power factors of each of the phases.

Table 54.1
Short-circuit power factor

Short-circuit power factor, percent	Ratio M_M[a]	Ratio M_A[a]	Short-circuit power factor, percent	Ratio M_M[a]	Ratio M_A[a]
0	1.732	1.394	30	1.130	1.066
1	1.696	1.374	31	1.121	1.062
2	1.665	1.355	32	1.113	1.057
3	1.630	1.336	33	1.105	1.053
4	1.598	1.318	34	1.098	1.049
5	1.568	1.301	35	1.091	1.046
6	1.540	1.285	36	1.084	1.043
7	1.511	1.270	37	1.078	1.039
8	1.485	1.256	38	1.073	1.036
9	1.460	1.241	39	1.068	1.033
10	1.436	1.229	40	1.062	1.031
11	1.413	1.216	41	1.057	1.028
12	1.391	1.204	42	1.053	1.026
13	1.372	1.193	43	1.049	1.024
14	1.350	1.182	44	1.045	1.022
15	1.330	1.171	45	1.041	1.020
16	1.312	1.161	46	1.038	1.019
17	1.294	1.152	47	1.034	1.017
18	1.277	1.143	48	1.031	1.016
19	1.262	1.135	49	1.029	1.014
20	1.247	1.127	50	1.026	1.013
21	1.232	1.119	55	1.015	1.008
22	1.218	1.112	60	1.009	1.004
23	1.205	1.105	65	1.004	1.002
24	1.192	1.099	70	1.002	1.001
25	1.181	1.093	75	1.0008	1.0004
26	1.170	1.087	80	1.0002	1.00005
27	1.159	1.081	85	1.00004	1.00002
28	1.149	1.075	100	1.00000	1.00000
29	1.139	1.070			

[a] See 54.2.3.5.

54.2.4 Recovery voltage

54.2.4.1 The recovery voltage is to be at least equal to the rated voltage of the motor control device. The peak value of the recovery voltage within the first complete half cycle after clearing and for the next five successive peaks is to be at least equal to 1.414 times the rms value of the rated voltage of the motor control device. Each of the peaks is not to be displaced by more than ±10 electrical degrees from the peak values of the open-circuit recovery voltage – that is, the displacement of the peak from its normal position on a sinusoidal wave. The average of the instantaneous values of recovery voltage each of the first six, half cycles measured at the 45 degree and 135 degree points on the wave is to be not less than 85 percent of the rms value of the rated voltage of the controller. The instantaneous value of recovery voltage measured at the 45 degree and 135 degree points of each of the first six, half cycles is in no case to be less than 75 percent of the rms value of the rated voltage of the motor control device.

54.2.4.2 If there is no attenuation or phase displacement of the first full cycle of the recovery voltage wave when compared with the open-circuit secondary voltage wave before current flow in a circuit that employs secondary closing, the detailed measurement of recovery voltage characteristics as indicated in 54.2.4.1 is not required.

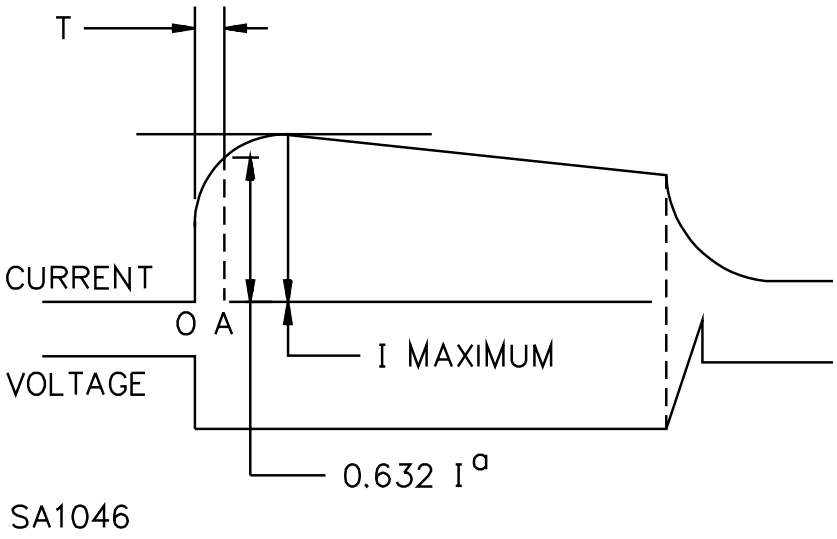
54.3 Direct current circuits

54.3.1 An equipment intended for use on a dc system is to be tested with dc and with the equipment connected so that the frame and enclosure will be positive in potential with regard to the nearest arcing point.

54.3.2 Oscillograph recordings, or an equivalent method, are to be used to determine circuit characteristics.

54.3.3 For a dc source, the requirements of 54.3.4 – 54.3.8 are to be applied. The time constant of the test circuit is to be determined by the method shown in Figure 54.2 and is to be no less than the value shown in Table 54.2.

Figure 54.2
Determination of the short circuit test constant (Oscillographic method)of direct-current circuits



[a] The value of the time constant is given by the abscissa OA corresponding to the ordinate 0.632I of the oscillograph of calibration of the circuit.

Table 54.2
Time constant of test circuit

Rated interrupting current, amperes	Minimum time constant, seconds
10,000 or less	0.003
Over 10,000	0.008

54.3.4 The dc open circuit voltage measurement mentioned in 54.1.1 is to be made with a voltmeter. In addition, the open circuit voltage, as determined by the arithmetic average of the maximum and minimum values of the voltage wave read from the oscillograph, is to be within 99 percent and 105 percent of the rated voltage of the equipment, except that a higher voltage may be used if agreeable to all concerned.

54.3.5 The minimum point on the dc voltage wave is to be no less than 90 percent of the rated voltage of the equipment.

54.3.6 The available dc capacity of the circuit is to be no less than the value as required for the rating of the equipment as indicated in Table 51.3 or Table 52.1, as appropriate. The prospective current is to be determined with the supply terminals short circuited by measuring the maximum displacement on an oscillogram at a time, after the start of current, of no less than 4 times the required time constant. Any overshot above time-current curve (exponentional curve) is not to be considered.

54.3.7 The time constant of the circuit is the time measured on the oscillogram where the current is 63.2 percent of the prospective current.

54.3.8 If the current source has a ripples, measurements are to be made from the midpoint of the ripple.

54.4 Instrumentation for test currents above 10,000 amperes

54.4.1 The galvanometers in a magnetic oscillograph employed for recording voltage and current during circuit calibration and while testing are to be of a type having a flat (±5 percent) frequency response from 50 – 1200 hertz. For fast acting fuses, current limiters, or motor-short-circuit protectors, a galvanometer may need to have a flat frequency response from 50 – 9000 hertz or an oscilloscope may be needed to obtain accurate values of peak current, (I_p), and energy let-through, (I^2t).

54.4.2 Galvanometers are to be calibrated as described in 54.4.3 – 54.4.6.

54.4.3 When a shunt is used to determine the circuit characteristics, a direct-current calibrating voltage is normally used. The voltage applied to the oscillograph galvanometer circuit is to result in a deflection of the galvanometer approximately equivalent to that which is expected when the same galvanometer circuit is connected to the shunt and the nominal short-circuit current is flowing. The voltage is to be applied so as to cause the galvanometer to deflect in both directions. Additional calibrations are to be made using approximately 50 percent and approximately 150 percent of the voltage used to obtain the deflection indicated above, except that if the anticipated maximum deflection is less than 150 percent, such as a symmetrically closed single-phase circuit, any other suitable calibration point is to be chosen. The sensitivity of the galvanometer circuit in volts per inch (or millimeter) is to be determined from the deflection measured in each case, and the results of the six trials averaged. The peak amperes per inch (or millimeter) is obtained by dividing the sensitivity by the resistance of the shunt. This multiplying factor is to be used for the determination of the rms current as described in 54.2.3.2.

54.4.4 A 60 hertz sine-wave potential may be used for calibrating the galvanometer circuit, using the same general method described in 54.4.3. The resulting factor is to be multiplied by 1.414.

54.4.5 When a current transformer is used to determine the circuit characteristics, an alternating current is to be used to calibrate the galvanometer circuit. The value of current applied to the galvanometer circuit is to result in a deflection of the galvanometer approximately equivalent to that which is expected when the same galvanometer is connected to the secondary of the current transformer and nominal short circuit current is flowing in the primary. Additional calibrations are to be made at approximately 50 percent and approximately 150 percent of the current used to obtain the deflection indicated above except that if the anticipated maximum deflection is less than 150 percent, such as in a symmetrically closed single-phase

circuit, any other suitable calibration point is to be chosen. The sensitivity of the galvanometer circuit in rms amperes per inch (or millimeter) is to be determined in each case and the results averaged. The average sensitivity is to be multiplied by the current-transformer ratio and by 1.414 to obtain peak amperes per inch. This constant is to be used for the determination of the rms current as described in 54.2.3.2.

54.4.6 All the galvanometer elements employed are to line-up properly in the oscillograph, or the displacement differences are to be noted and used as needed.

54.4.7 The sensitivity of the galvanometers and the recording speed are to be such that the values of voltage, current, and power factor can be determined accurately. The recording speed is to be at least 60 inches (1.5 m) per second.

54.4.8 With the test circuit adjusted to provide the specified values of voltage and current and with a noninductive (coaxial) shunt that has been found acceptable for use as a reference connected into the circuit, the tests described in 54.4.9 and 54.4.10 are to be conducted to verify the accuracy of the manufacturer's instrumentation.

54.4.9 With the secondary open-circuited, the transformer is to be energized and the voltage at the test terminals observed to see if rectification is occurring making the circuit unacceptable for test purposes because the voltage and current will not be sinusoidal. Six random closings are to be made to demonstrate that residual flux in the transformer core will not cause rectification. If testing is done by closing the secondary circuit, this check can be omitted providing testing is not commenced before the transformer has been energized for approximately 2 seconds, or longer if an investigation of the test equipment shows that a longer time is necessary.

54.4.10 With the test terminals connected together by means of a copper bar, a single-phase circuit is to be closed as nearly as possible at the moment that will produce a current wave with maximum offset. The short circuit current and voltage are to be recorded. The primary voltage is to be recorded if primary closing is used. The current measured by the reference shunt is to be within 5 percent of that measured using the manufacturer's instrumentation and there is to be no measurable variation in phase relationship between the traces of the same current. Controlled closing is not required for polyphase circuits.

54.4.11 When the verification of the accuracy of the manufacturer's instrumentation is completed, the reference coaxial shunt is to be removed from the circuit. The reference coaxial shunt is not to be used during the final calibration of the test circuit nor during the testing of motor control device.

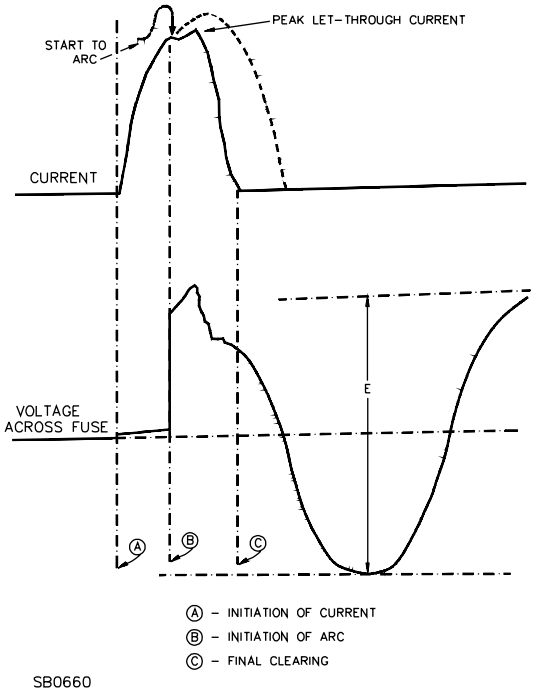
54.5 Calibration characteristics for protective device

54.5.1 To obtain the required values specified in 54.2.2.1, it may be necessary to employ a fuse, current limiter, or motor short-circuit protector larger than that specified for use with the device being tested; or a commercially available test fuse designed and calibrated to exhibit I^2t and I_p characteristics at least equal to the maximum permitted limits for the fuse, current limiter, or motor short-circuit protector rating. The let-through characteristics are to be determined in accordance with 54.4.3 – 54.4.6.

54.5.2 Fuses, current limiters, or motor short-circuit protectors used for tests are to be selected from a batch from which two samples have been selected. The value of the I_p and I^2t determined for the two selecte samples is to be equal to or greater than the required values. These determinations are to be made in accordance with 54.5.3 and 54.5.4.

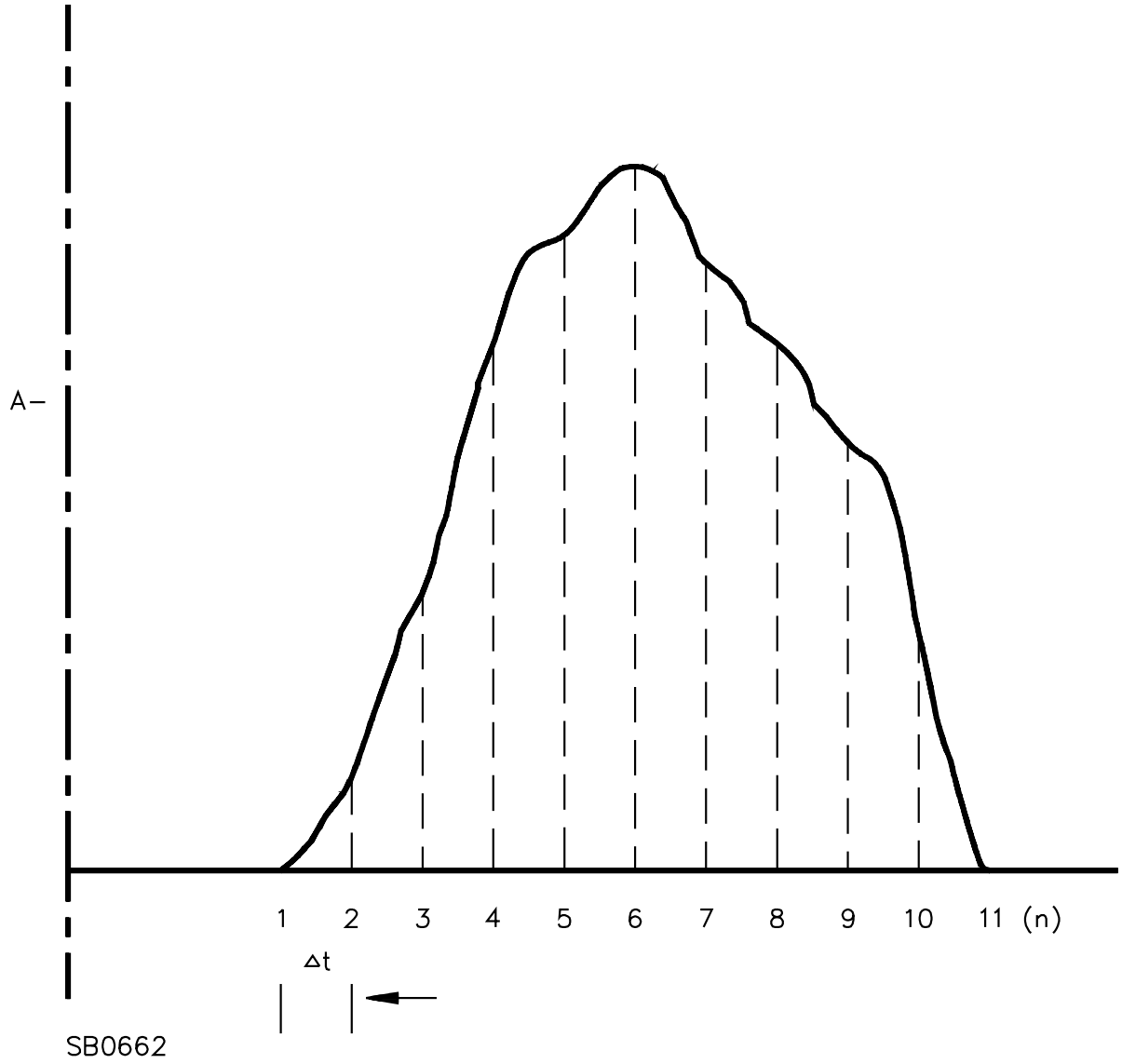
54.5.3 Figure 54.3 is typical of oscillograms obtained during the test of a fuse, current limiter, or motor short-circuit protectors on an alternating-current circuit; and represents a circuit that opened before the current could reach its first major peak. The peak let-through current I_p is to be determined as illustrated.

Figure 54.3
Peak let-through current



54.5.4 The let-through energy (I^2t) is to be determined from an oscillogram showing a current trace during the interruption of the circuit by the fuse, current limiter, or motor short-circuit protectors. The determination is to be made by the application of Simpson's rule illustrated in Figure 54.4 or the use of an integrating planimeter.

Figure 54.4
Application of Simpson's Rule to fuse current oscillogram to obtain let-through I^2t



1. Odd numbers of ordinates (n) are to be chosen evenly spaced (Δt). The more uneven the curve, the more ordinates.

2. Each ordinate is to be measured, multiplied by ampere scale (indicated by A in this figure), and squared.

3. I^2t is calculated as follows:

$$I^2t = (\Delta t/3)[(I_1^2 + I_n^2) + 4(I_2^2 + I_4^2 + I_6^2 \ldots I_{(n-1)}^2) + 2(I_3^2 + I_5^2 + I_7^2 \ldots I_{(n-2)}^2)]$$

54.5.5 The time base in degrees-per-inch (degrees/cm) is to be determined by averaging the distance, between zero-line crossover points of the voltage wave or a timing wave, in which the fuse-current trace is most nearly centered.

55 Transient-Voltage-Surge Suppression Test

55.1 A surge-controlled circuit as specified in 36.2 and 36.3 shall withstand without breakdown a single 1.2 by 50 microseconds full-wave impulse with a crest value of 5.0 kilovolts. See Techniques for High-Voltage Testing, ANSI/IEEE 4-1995. The transient voltage surge shall not exceed 300 percent of the peak working voltage, or 300 volts, whichever is greater and the equipment shall be operative after conclusion of the test.

55.2 The wave form mentioned in 55.1 may typically be provided by an impulse generator illustrated in Figure 55.1 when operated under open-circuit conditions. Caution should be exercised to prevent back surges on the line.

55.3 The equipment is to be connected to a single-phase source of supply operating at rated voltage with the impulse generator connected across the equipment.

56 Accelerated Aging Test

56.1 When tested as described in 56.2, a sealing compound shall not melt, become brittle, or otherwise deteriorate to a degree that will affect its sealing properties as determined by comparing the conditioned sample to an unconditioned sample.

56.2 A sealing compound is to be applied to the surface it is intended to seal. For a temperature rise not exceeding 35°C (63°F), a representative sample of the surface with the sealing compound applied is to be conditioned for 7 days in an air oven at 87°C (189°F).

57 Breakdown of Components Test

57.1 There shall be no emission of flame or molten metal nor ignition of cotton loosely placed over all openings of ventilated equipment or totally around open type devices when capacitors, diodes, or other solid state components are short- or open-circuited.

Exception: The test is not required:

a) If circuit analysis indicates that no other component or portion of the circuit will be seriously overloaded as a result of the assumed open circuiting or short circuiting of another component.

b) For components in Class 2 circuits (see 32.3).

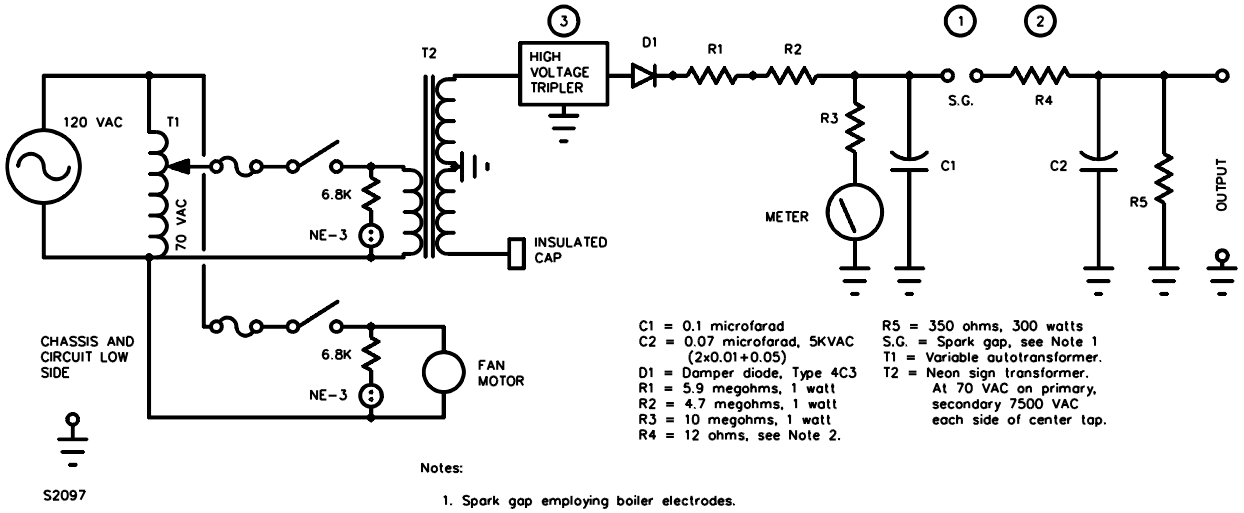
c) For components in Limited Voltage/Current (see 32.4), Limited Energy involving open circuit potentials less than or equal to 30 V ac or 42.4 V peak (see 32.7), and Limiting Impedance (see 32.8) secondary circuits.

d) On power semiconductor devices if equivalent testing is accomplished during short circuit tests.

e) For components complying with requirements applicable to the component.

f) For components whose failure may result in an increased risk of fire or electric shock and that have previously been investigated and found suitable for the application.

Figure 55.1
Typical impulse generator



C1 = 0.1 microfarad
C2 = 0.07 microfarad, 5KVAC (2x0.01+0.05)
D1 = Damper diode, Type 4C3
R1 = 5.9 megohms, 1 watt
R2 = 4.7 megohms, 1 watt
R3 = 10 megohms, 1 watt
R4 = 12 ohms, see Note 2.
R5 = 350 ohms, 300 watts
S.G. = Spark gap, see Note 1
T1 = Variable autotransformer.
T2 = Neon sign transformer. At 70 VAC on primary, secondary 7500 VAC each side of center tap.

Notes:

1. Spark gap employing boiler electrodes.
2. R4 is 12 ohm surge resistor, No.22 AWG (0.32 mm^2) nichrome wire wound on flat mount to reduce reactance.
3. High voltage tripler, Murata No. MSR 2513-RRET002ICE22.

57.2 The breakdown of the component shall be simulated after the device is fully energized and in operation.

57.3 Components shall be evaluated one at a time.

57.4 For an open type device, a wire mesh cage that is 1.5 times the size of the device may be provided to simulate the intended enclosure.

57.5 The outer enclosure or wire mesh cage (if any) and any grounded or exposed dead-metal part are to be connected through a 30-ampere fuse to the supply circuit pole least likely to arc to ground. The 30-ampere fuse shall not open.

57A Strain Relief Test

57A.1 The device provided with a strain relief as in 25.6.2 shall withstand without damage to the cord or conductors and without displacement, a direct pull of 35 pounds (156 N) applied to the cord for 1 minute. Supply connections within the equipment are to be disconnected from terminals or splices during the test when applicable.

57A.1 added July 16, 1999

57A.2 A field wiring lead shall withstand without damage or displacement a direct pull of:

a) 20 pounds (90 N) for 1 minute applied to a lead extending from the enclosure such as through a hub or nipple; and

b) 10 pounds (44.5 N) for 1 minute applied to a lead within a wiring compartment or an outlet box.

57A.2 added July 16, 1999

57B Push-Back Relief Test

57B.1 To determine compliance with 25.6.5, a product shall be tested in accordance with 57B.2 without occurrence of any of the conditions specified in 25.6.5 (a) – (d).

57B.1 added July 16, 1999

57B.2 The supply cord or lead is to be held 1 inch (25.4 mm) from the point where the cord or lead emerges from the product and is then to be pushed back into the product. When a removable bushing which extends further than 1 inch is present it is to be removed prior to the test. When the bushing is an integral part of the cord, then the test is to be carried out by holding the bushing. The cord or lead is to be pushed back into the product in 1-inch (25.4-mm) increments until the cord buckles or the force to push the cord into the product exceed 6 pounds-force (26.7 N). The supply cord or lead within the product is to be manipulated to determine compliance with 25.6.5.

57B.2 added July 16, 1999

58 Wire Flexing

58.1 The wiring to components mounted on a door is to be tested by opening the door as far as possible – restraints such as a chain are to remain in place – and then closing it for 500 cycles of operation. Following this test, the equipment is to be subjected to the dielectric voltage withstand test described in 49.1.1 applied between conductors and between conductors and ground.

59 Terminal Torque Test

59.1 The insulating base of a field-wiring terminal shall not be damaged when a conductor of rated ampacity is connected to the terminal and the clamping screw is torqued to 110 percent of the value marked on the equipment.

59.2 To determine that an insulating base complies with the requirement in 59.1, the equipment is to be mounted as intended and may be fitted with a short length of rigid conduit. A short length of field-wiring conductor of rated ampacity is to be routed through the conduit, if fitted, and connected to the terminal. The wiring terminal clamping screw is then to be tightened to 110 percent of the value of torque specified on the equipment. For equipment marked for use with copper and aluminum conductors, the wire connectors are to be torqued to 110 percent of the highest torque value marked for either conductor.

59.3 Damage is considered to have occurred if the base insulating material breaks or cracks; bosses, recesses, or other means to prevent turning do not perform their intended function; straps or bus bars bend or twist; or members move at electrical joints if such movement would reduce spacings to an unacceptable degree or otherwise impair the electrical connection. Minor chipping or flaking of brittle insulating material or momentary flexing of metallic members without permanent deformation is acceptable.

60 Printed Wiring Board Abnormal Operation Test

60.1 Spacings on printed wiring boards that are less than those specified in Tables 36.1 – 36.3 and that are relied upon to provide operational insulation are to be tested as described in 60.2 – 60.8. As a result of this test:

a) The overcurrent protection in the branch circuit to which the equipment is connected shall not open.

b) If a wire or a printed wiring board trace opens, the gap is to be electrically shorted and the test continued until ultimate results occur. This applies to each occurrence.

c) A flame shall not be emitted from the overall enclosure of the equipment.

No Text on This Page

d) The cheesecloth or tissue paper shall not glow or flame.

e) The 3-ampere fuse connected in the equipment grounding circuit shall not open.

60.2 Operation of an overcurrent protection device, other than the branch circuit overcurrent protection device, before any abnormal condition results is acceptable. If an overcurrent protective device opens, then the marking specified in 63.20 shall be provided.

60.3 With respect to the limiting impedance circuit requirements in 32.8, a circuit supplied by a limiting impedance shall comply with the following:

a) The supply to the device shall be as specified in the Temperature Test, Section 43.

b) Starting at the input to the circuit, the maximum wattage available to the secondary circuit under consideration is to be measured by connecting a variable resistive load between the load side point of each component in line with the source and the supply return. The variable resistance is to be adjusted to a value which maintains a level of 15 watts as measured by a wattmeter. Each component capable of maintaining 15 watts or more for a period of 5 seconds is to be identified.

c) That portion of the circuit that is supplied by a maximum power availability of 15 watts is considered as a derived low voltage circuit.

60.4 A sample of the equipment employing the printed wiring board is to be wired as intended to an electrical supply circuit sized and protected to simulate end-use conditions. If the live parts on the printed wiring board have spacings between them that are less than those specified in Tables 36.1 – 36.3, they are to be short-circuited one at a time.

60.5 A 3-ampere fuse is to be connected between the supply circuit pole least likely to arc to ground, and the outer enclosure (if any) and grounded or exposed dead metal parts.

60.6 During the abnormal test, the equipment is to be placed on a white-tissue-paper covered softwood surface. A single layer of cheesecloth is to be draped loosely over the entire enclosure. Open equipment is to be tested in an enclosure judged to be representative of that likely to be encountered in service. If agreeable to those concerned, tests may be conducted without an enclosure and considered representative of tests conducted using an enclosure. If tests are to be conducted without an enclosure, cheesecloth is to be placed on a wire cage surrounding and in close proximity to the equipment under test so as to closely simulate the intended enclosure.

60.7 The test is to be continued for 1 hour or until one of the conditions described in 60.1 occurs. However, if at the end of 1 hour no condition described in 60.1 occurs, but indications are that such a condition may eventually occur, the test is to be continued until ultimate results are obtained (usually 7 hours).

60.8 If the circuit is interrupted by the opening of a component, the test is to be repeated twice, using new components as necessary.

61 Secondary Circuits Test

61.1 With reference to the secondary voltage and volt-ampere capacity limits, the measurements are to be made as follows:

a) The input to the source of that secondary is to be connected as intended;

b) The maximum open circuit voltage potential available to the secondary circuit under consideration is to be measured across the source of that secondary; and

c) The maximum volt-ampere capacity available to the secondary circuit under consideration is to be measured by connecting a variable resistive load across the source of that secondary and then measuring the voltage and current while varying the resistive load from open circuit to short circuit in 1-1/2 to 2-1/2 minutes. The maximum available volt-ampere capacity is then calculated by multiplying the simultaneously measured values of secondary voltage and secondary current.

61.2 For a transformer, only one secondary circuit of a multiple secondary transformer is to be tested at a time and all other secondaries not under test need not be connected to a load. The voltage and volt-ampere capacity measurements can be made directly across the secondary output terminals of the transformer. When a tapped transformer winding is used to supply a full-wave rectifier, the measurements are to be made from either end of the winding to the tap. When the transformer is used as part of a switching-type power supply, the voltage and volt-ampere capacity measurements are to be made after the transformer secondary winding rectification means.

DEVICE RATING

62 Details

62.1 Unless otherwise indicated, industrial control equipment shall be rated in volts; and also in horsepower, amperes, volt-amperes, or any combination thereof; and the rating shall indicate whether the equipment is for direct or alternating current. The rating of alternating-current equipment shall include the number of phases and, if necessary, the frequency; except that the rating of equipment obviously intended for single-phase use only need not include the number of phases. The rating of a controller for slip-ring motors shall include the secondary rated current.

62.1.1 Equipment shall be rated for service in an ambient temperature of 40°C (104°F) or at a higher or lower ambient temperature at an interval from 40°C (104°F) in a whole number multiple of ±5°C (9°F), such as 45, 50, 55, 60.

43.3 and 43.5 combined and relocated as 62.1.1 July 16, 1999

62.2 A motor control device rated more than 1 horsepower (746 W output) and 300 V or more than 2 horsepower (1492 W output), an overload relay, or industrial control equipment incorporating an overload relay shall have a short circuit withstand rating.

62.3 The rating of industrial control equipment that requires a remote control device shall include the volt-ampere rating, or the equivalent, of any operating-coil with a sealed rating of more than 125 volt-amperes or more than the value specified in Table 62.1.

Table 62.1
Ratings for operating coils

Rating of device	Rating of coil, volt-amperes
(Size 1) 30 amperes or less	30
(Size 2) 50 amperes	75
(Size 3 and 4) 150 amperes	100
(Size 5 or greater) 300 amperes or more	125

62.4 Industrial control equipment, intended for use with a motor with horsepower and voltage ratings as given in Table 45.2 or 45.3, shall be rated in horsepower in accordance with Table 45.3 and may also be rated in full-load and locked-rotor current. The full-load current rating, if provided, shall be the current specified in Table 45.2 or 45.3 for the associated horsepower and voltage, and the locked-rotor current rating, if provided, shall be as indicated in Table 45.4 or ten times that indicated in Table 45.3.

Exception No. 1: The full-load and locked-rotor current rating need not be as specified if the equipment is plainly marked to indicate that the rating is applicable to a hermetic compressor.

Exception No. 2: A device intended to control a motor rated 2 horsepower (1.5 kW output) or less need not be rated in horsepower if it is rated in full-load current and locked-rotor current. The full load current rating need not be a value that appears in Table 45.2 or 45.3. The overload test current is to be six times (for alternating current) or ten times (for direct current) the rated full-load current, but the marked locked-rotor current rating of the equipment may be less than the value of current employed for the overload test.

62.5 The rating of a magnetic motor controller may also include a size designation as described in 63.24. Equipment designated as a specific size shall be rated with the continuous current and horsepower ratings corresponding to that size as specified in Table 62.2 and 62.3.

Table 62.2
Ratings for magnetic motor controller sizes

Size of controller	Continuous current rating, amperes	Three phase horsepower ratings, volts, ac			
		60 hertz		50 hertz	60 hertz
		200	230	380	460 or 575
00	9	1-1/2	1-1/2	1-1/2	2
0	18	3	3	5	5
1	27	7-1/2	7-1/2	10	10
2	45	10	15	25	25
3	90	25	30	50	50
4	135	40	50	75	100
5	270	75	100	150	200
6	540	150	200	300	400
7	810		300		600
8	1215		450		900
9	2250		800		1600

NOTE – As specified in Table 2-4-1 of ANSI/NEMA ICS2-1993.

Table 62.3
Ratings for magnetic motor controller sizes

Size of controller	Continuous current rating, amperes	Single phase horsepower ratings, volts AC	
		60 hertz	
		115	230
00	9	1/3	1
0	18	1	2
1	27	2	3
1P	36	3	5
2	45	3	7-1/2
NOTE – As specified in Table 2-4-2 of ANSI/NEMA ICS2-1993.			

62.6 The ratings of equipment intended to control a motor load rated more than 500 horsepower (373 kW output) or the ratings of equipment tested in accordance with footnote a of Table 42.2 shall, in addition to the horsepower ratings, include the maximum full-load current for each rating.

62.7 With reference to 62.1, the rating of the device controlling an external load shall have the load designation marked in accordance with Table 62.4.

Table 62.4
Ratings of a device controlling an external load

Load	Load designations
General Purpose	Amperes
Resistance (heating)	Amperes, resistance, only
Incandescent lamp	Amperes or watts, tungsten
Ballast (electric discharge lamp)	Amperes, ballast
Coil	Code designation, volt-amperes, standard or heavy pilot duty
Motor	Horsepower (also see 62.4 and 62.5)
Capacitive Switching	kVar, Full-Load amperes (FLA)

MARKING

63 General

63.1 Industrial control equipment shall be plainly marked with:

a) The manufacturer's name, trademark, or other descriptive marking by which the organization responsible for the product may be identified – hereinafter referred to as the manufacturer's name;

b) The electrical rating;

c) The catalog number or equivalent.

All marking shall be located so as to be visible after installation.

63.1.1 Equipment shall be marked to indicate the maximum ambient temperature rating or surrounding air temperature rating for which the equipment was evaluated.

Exception: Equipment with an ambient temperature rating of 40°C (104°F) is not required to be marked.

63.1.1 added July 16, 1999

63.2 A motor control device rated more than 1 horsepower (746 W output) and 300 V or more than 2 horsepower (1492 W output), a starter (contactor incorporating an overload relay), an overload relay, or industrial control equipment incorporating an overload relay – other than a combination motor controller – shall be marked ″Suitable For Use On A Circuit Capable Of Delivering Not More Than _____ rms Symmetrical Amperes, _____ Volts Maximum. ″ The short circuit current rating is not to be more than the value for which the controller was tested in accordance with Table 51.3 or Table 52.1. When the short circuit tests are conducted with fuses only as specified in Exception No. 1 of 50.1.4, the marking shall include ″Use Fuses Only″. When short circuit tests are conducted with a protective device of a size requiring a marking as in Table 51.1 or 51.1.3(b), the marking shall additionally include the type of protective device used and the maximum size of the protective device.When tested in accordance with 51.1.1, the marking shall also include the following or the equivalent:

a) ″When Protected by _____ Class Fuses ″; or

b) ″When Protected By A Circuit Breaker Having An Interrupting Rating Not Less Than _____ rms Symmetrical Amperes, _____ Volts Maximum ″.

Exception No. 1: The marking is able to be on a separate sheet or in the installation instruction when there is not room on the device for the marking.

Exception No. 2: Any overload relay which derives its operating currents from an associated magnetically-coupled only (primary winding not part of current transformer) current transformer, for which current saturation at low current level has been demonstrated, is not required to be marked with a short circuit current rating. The current transformer referenced in this exception is able to be either separate from, or an integral part of, the device.

63.2 revised July 16, 1999

63.2.1 For group installation, a motor control device or overload relay as described in 52A.1.2 shall be marked with the following or the equivalent:

a) When tested using both fuses and circuit breakers of the maximum allowable size: ″Suitable for motor group installation on a circuit capable of delivering not more than ____ rms symmetrical amperes, ____ V max″;

b) When tested using only fuses rated at the maximum size specified in 52A.1.2(b), the marking shall additionally state: ″when protected by (A) ″;

c) When tested using branch circuit protective devices rated less than the maximum size specified in 52A.1.2(b), the marking shall additionally state: ″when protected by (B) with a maximum rating of (C) ″.

where:

(A) – ″Fuses″ or, when specified for a high fault short circuit rating, ″Class ___ fuses″;

(B) – The type of overcurrent protective devices, either ″fuses″ or ″a circuit breaker.″ When specified for a high fault short circuit rating, ″Class ___ fuses″ or ″A circuit breaker having an interrupting rating not less than ___ rms symmetrical amperes, ___ V maximum″;

(C) – The maximum ampere rating of the overcurrent protective device used for the short circuit test in 52A.3 or 52A.4.

Added 63.2.1 effective July 16, 2001

63.3 Industrial control equipment shall be marked to indicate the temperature rating (60°C only, 60/75 or 75°C only) of the field installed conductors for which the equipment has been investigated.

Exception: A field-wiring terminal need not be marked to indicate the temperature rating if it is intended for the connection of a control circuit conductor only.

63.4 The marking required by 63.1 need not be located on the outside of an enclosure provided it is readily visible by opening a door or removing a cover after installation.

63.5 The marking required by 11.1 shall be visible after installation and shall specify the environmental condition type number or numbers.

63.6 The marking referenced in 6.16.1 (d) shall include the following statement or equivalent, ″For Use on a Flat Surface of a Type _____ Enclosure.″ The type or types of enclosures for which the component has been evaluated and found to be acceptable shall be marked in the blank space.

63.7 A device intended for control of a specific load may be marked to indicate the intended use of the control, such as ″Resistance only,″ ″Tungsten only,″ ″Ballast,″ ″Resistance Air Heating.″

63.8 A device intended to control a Design E Motor shall be marked ″For use with a Design E Motor,″ or the equivalent. The device is to be evaluated in accordance with the column for motors designated Design E in Table 45.4 (see the note to that table).

63.9 Industrial control equipment shall be marked with only one single and/or three phase horsepower rating for each assigned voltage.

63.10 If the manufacturer produces or assembles industrial control equipment at more than one factory, each finished item of equipment shall have a distinctive marking, by which it may be identified as the product of a particular factory.

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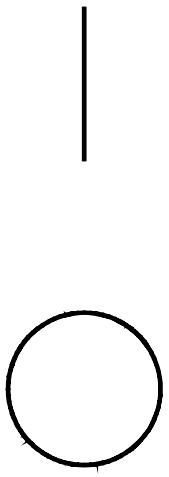
63.11 An oil tank may be marked to indicate the proper oil level. If a visual oil indicator is provided, the marking shall indicate the proper oil level with the starter assembled. If a visual indicator is not provided, the marking shall indicate the proper oil level prior to assembly.

63.12 The position of the handle of a manual motor controller, drum controller, or the like – other than a push button station, a selector switch, or both – shall be marked as a guide to proper operation. Such marking shall not be subject to rubbing off, washing off, or otherwise being rendered unreadable during normal use. See 10.1.

63.13 In reference to the requirement in 63.12, the ″ON″ and ″OFF″ positions of a control device may be marked using the symbols illustrated in Figure 63.1.

63.14 For equipment that may be assembled in different combinations, all components shall be identified and reference shall be made on the basic equipment to all components that may be assembled together.

Figure 63.1
″On″ and ″off″ symbols



S3486

IEC Publication 417, Symbols 5007 and 5008

63.15 An industrial control device that has been investigated as a part of a system shall be marked to identify other parts of the system with which it is intended to be used.

63.16 A rheostat or resistor that does not have the required electrical spacings and is intended for use only as series resistance shall be marked ″For use as a series resistor.″

63.17 Industrial control equipment employing an automatic reset overload relay and a wiring diagram indicating 2-wire control shall be marked to indicate that a motor connected to the circuit may start automatically when the relay is in the automatic reset position. The marking shall be permanently secured to enclosed equipment and shall be furnished with open types.

63.18 With reference to the requirement in Exception No. 2 to 18.2.1, a controller provided with a protective device in an accessory kit shall be marked to identify the kit to be used in that controller.

63.19 With reference to the requirement in Exception No. 1 to 18.2.1, a controller shall be marked with the maximum control-circuit protective-device size corresponding to the size of control-circuit wire used within the equipment as specified in Table 18.2.

63.20 If a supplementary fuse is provided in accordance with 18.2.3, there shall be a marking near the fuseholder specifying the voltage and current rating of the replacement fuse.

63.21 When a branch-circuit type fuse (other than supplementary) is provided in accordance with 18.2.4 and if the fuseholder will accept a fuse having a higher current rating than covered in 18.1.1 a marking specifying the maximum fuse size shall be provided near the fuseholder.

63.22 A relay intended for television applications and tested in accordance with Section 47 shall be marked ″TV-X,″ where ″TV″ signifies the television and ″X″ is the steady-state current rating of the relay to be replaced by the actual ampere value (such as TV-5, TV-3, and the like).

63.23 If a fuse used to determine compliance with item 3 of Table 43.1 is a Class G or K, there shall be a marking near the fuseholder specifying the class of the replacement fuse.

63.24 A motor controller marked as a specific size in accordance with Tables 62.2 and 62.3 shall be marked with all and only with the horsepower ratings specified in Tables 62.2 and 62.3. Controllers with three or more poles may omit single phase ratings. Two pole controllers shall not be marked with three phase ratings. Marking of the continuous current and 50 hertz ratings is optional.

63.25 A controller that complies with the elevator control requirements in Overload Test, Section 45, and Endurance Test, Section 46, may be marked to indicate that the device is suitable for use in elevator control applications.

63.26 The marking referred to in 51.1.3.1 and Table 51.1 may be located on the current element table.

63.27 With respect to 40.3.2, industrial control equipment containing a power or control transformer feeding circuits leaving the equipment from a secondary winding not conductively connected to the primary shall be marked to indicate the need for connecting the secondary neutral conductor to a grounding electrode in accordance with existing installation requirements pertaining to separately derived systems.

Exception: The marking is not required when the grounding electrode conductor terminal is not required in accordance with the Exception to 40.3.2.

64 Wiring Terminal Markings

64.1 Wiring terminals shall be marked to indicate the proper connections for the power supply, load, control circuit, and the like, or a wiring diagram coded to the terminal marking shall be securely attached to the equipment.

Exception No. 1: The terminals need not be marked if the wire connections are plainly evident, as for a 2-terminal switching device.

Exception No. 2: A wiring diagram with multiple circuit arrangements may be provided loose or in an envelope provided the nameplate or similar permanent attachment visible after installation references the wiring diagram, for example, by number.

Exception No. 3: For open-type equipment, the wiring diagram may be furnished loose with the equipment.

64.2 A terminal for the connection of a grounded supply circuit conductor shall be identified by means of a metallic plated coating substantially white in color and shall be readily distinguishable from the other terminals, or proper identification of the terminal for the connection of the grounded supply circuit conductor shall be clearly shown in some other manner, such as on an attached wiring diagram. If wire leads are provided, the lead intended to be connected to a grounded supply circuit shall have a white or natural gray color and shall be readily distinguishable from other leads.

64.3 A single white terminal – in other than a single-pole device – for the connection of an ungrounded conductor is not acceptable, but two or more terminals may be white if:

a) It does not make any difference how line connections are made;

b) It is obvious which terminal is intended for the connection of the grounded conductor; or

c) The line connections are plainly indicated on a wiring diagram.

64.4 If low-voltage equipment or a part of low-voltage equipment is intended to be wired in the field to become only part of a Class 1 circuit or a Class 2 circuit wired with Class 1 wire, the terminals of the equipment or part of the equipment shall be marked accordingly. Low-voltage switching or power-consuming equipment or a part of equipment that is intended to be wired in the field to become part of a Class 2 circuit only shall be marked accordingly, but a low-voltage power-supply device that includes a transformer is not required to be marked to indicate that it is acceptable for use in a Class 2 circuit only. Low-voltage equipment or a part of equipment that is acceptable for connection to either a Class 1 or a Class 2 circuit is not required to be so marked.

64.5 Equipment incorporating two or more separate circuits that are capable of being connected to separate power supplies but that are intended to be connected to a common power supply shall be marked ″All circuits must have a common disconnect and be connected to the same pole of the disconnect,″ or with an equivalent wording. The wiring diagram of the equipment shall illustrate a typical connection of the various circuit connected to the common power supply.

64.6 Equipment employing a special fitting for the connection to a specific wiring system shall be marked to indicate that it must be installed with such a wiring system.

64.7 Equipment that is acceptable for installation with a nonmetal-enclosed wiring system only shall be marked to indicate that it must be installed with such a wiring system.

64.8 Equipment having field-wiring terminals shall be marked with the following, if applicable, or the equivalent:

a) ″Use Aluminum Conductors Only″ if the terminal is acceptable only for connection to aluminum wire.

b) ″Use Copper or Aluminum Conductors″ or ″Use Copper, Copper-Clad Aluminum, or Aluminum Conductors″ if the terminal is acceptable for connection to either copper or aluminum wire.

c) ″USE COPPER OR COPPER-CLAD ALUMINUM CONDUCTORS″ if the terminal is acceptable for connection to either copper or copper-clad aluminum wire.

64.9 A wiring terminal that is not intended to receive a conductor one size larger than that specified in 25.5.1 shall be marked to restrict its use to the smaller size conductor.

64.10 If leads, wire binding screws, or pressure wire connectors are not provided on the equipment as shipped, the equipment shall be marked stating which pressure wire connector or component terminal kits are acceptable for use with the equipment. A wire connector of the type mentioned in the marking may be installed in the equipment at the factory with instructions, if necessary, to effect proper connection of the conductor. A terminal kit shall carry an identifying marking, wire size, and manufacturer's name or trademark.

64.11 With reference to 25.5.9, equipment shall be marked to show a range of values or a nominal value of tightening torque in pound-inches to be applied to the clamping screws of all terminal connectors for field wiring. The marking may be located adjacent to the terminal or on the wiring diagram.

65 Cautionary Markings

65.1 Cautionary markings shall be located on a part that cannot be removed without impairing the operation or appearance of the equipment.

65.2 A cautionary marking shall be prefixed with the word ″CAUTION″ or ″WARNING″, as applicable, in letters not less than 1/8 inch (3.2 mm) high. The remaining letters of such marking, unless specified otherwise in individual marking requirements, shall not be less than 1/16 inch (1.6 mm) high.

65.3 A cautionary marking intended to instruct the operator shall be legible and visible to the operator during normal operation of the equipment. A marking that provides servicing instructions shall be legible and visible when such servicing is being performed.

65.4 If more than one disconnect switch may be required to disconnect all power within a control assembly or compartment, the assembly or compartment shall be marked with the word ″CAUTION″ and the following or the equivalent, ″Risk of Electric Shock – More than one disconnect switch may be required to de-energize the equipment before servicing.″

65.5 The marking required by 65.4 shall be in a permanent location on the outside of the equipment or on a stationary fixed, nonremovable part inside the equipment. The warning marking shall not be placed inside the cover or on the connection diagram attached to the inside of a cover.

65.6 The marking required for enclosures that are intended for field assembly of the bonding means in accordance with 6.6.1 shall be located where visible during installation, such as inside the cover, and consist of the word ″CAUTION″ and the following or the equivalent, ″Bonding between conduit connections is not automatic and must be provided as a part of the installation″; or the word ″CAUTION″ and the following or equivalent, ″Nonmetallic enclosure does not provide grounding between conduit connection. Use grounding bushings and jumper wires.″

65.7 An overload relay that has a replaceable element or industrial control equipment incorporating an overload relay shall be marked with the word ″WARNING″ and the following or the equivalent: ″To provide continued protection against a risk of fire and electric shock, the complete overload relay must be replaced if burnout of the current element occurs.″

Exception No. 1: For an overload relay with replaceable type thermal elements, if the calibrated elements are within the replaceable thermal unit, then only the thermal unit need be replaced upon heater burnout.

Exception No. 2: For an overload relay with replaceable type thermal elements having the calibrated current sensing element in the basic nonreplaceable part of the overload relay, the marking is not required provided that subsequent to the short circuit tests conducted in accordance with Section 50, the overload relay is calibrated in accordance with Section 48.

Exception No. 3: For an overload relay with nonreplaceable type thermal elements, if the design of the overload relay is such that it prevents operation of the device in the event of burnout of any of the thermal units, the marking is not required.

65.8 Motor controllers intended for use on circuits having high available fault currents as indicated in 52.1.1 shall be marked with the word ″WARNING ″ and the following or equivalent, ″The opening of the branch-circuit protective device may be an indication that a fault current has been interrupted. To reduce the risk of fire or electric shock, current-carrying parts and other components of the controller should be examined and replaced if damaged. If burnout of the current element of an overload relay occurs, the complete overload relay must be replaced. ″

65.8 revised July 16, 1999

65.9 A control with direct-current motor ratings that does not comply with the requirements in 25.5.1 (d)(1) shall be marked with the word ″WARNING ″ and the following or the equivalent, ″Do not connect to a circuit supplied by a single-phase, half-wave rectifier ″; and a control that does not comply with the requirements in 25.5.1 (d)(2) shall be marked with the word ″WARNING ″ and the following or the equivalent, ″Do not connect to a circuit supplied by a single-phase rectifier of the half-wave or full-wave type.″

65.10 A device that requires a lower torque value than specified in Table 8.1 shall be marked with the following or the equivalent: ″Tighten to ____ pound-inches (____ N·m). Overtorquing may cause enclosure breakage.″

65.11 A knife switch complying with the Exception to 16.4, shall be marked with the word ″WARNING ″ and the following or equivalent: ″Risk of Electric Shock – The load side of this switch may be energized by backfeed when in the open position. ″

Exception: If there is not sufficient room on the switch for the marking, the marking may be on a separate pressure-sensitive label or equivalent. Instructions shall be provided to inform the installer to secure the marking adjacent to the switch in a location that will be visible after installation.

65.12 If required by the exception to 6.15.9, a marking shall be provided to instruct the installer to fill the opening with a Type 12 conduit fitting.

INSTRUCTIONS AND MARKINGS PERTAINING TO ACCESSORIES

66 Details

66.1 The equipment markings shall include identification of an accessory to be attached in the field, or a reference to a separate publication that identifies all such accessories. For equipment such as an open device for which the required marking may be on a separate sheet, the accessory information may also be on the separate sheet.

Exception: If a new accessory has been designed for an existing product, the accessory shall be marked with the identification of the equipment on which it is intended to be used.

66.2 An accessory that is not shipped from the factory in the same carton as the equipment with which it is intended to be used shall be plainly marked with:

a) The manufacturer's name, trademark, or other descriptive marking by which the organization responsible for the product may be identified;

b) The electrical rating; and

c) The catalog number or equivalent.

Exception: The electrical rating of the accessory need not be on the accessory if the accessory electrical rating is marked on the equipment for which it is intended.

66.3 An accessory shall be provided with installation and wiring instructions.

66.4 If an overload-protective device is provided within an enclosure that does not have a hinged cover, and a kit is available for resetting the device from outside the enclosure, in accordance with 6.4.2(c), the kit number shall be marked on the enclosure or in the installation instructions.

67 Marking Location

67.1 The required markings and the location for enclosed industrial control equipment and open industrial control equipment shall be in accordance with Table 67.1. The markings noted in Table 67.1 are a brief summary of the marking requirements given elsewhere in this Standard. For complete details on the required marking, see the marking reference specified in Table 67.1.

Table 67.1
Marking location for industrial control equipment

Revised Table 67.1 effective July 16, 2001

Marking reference	Required marking[a]	Location[b]	
		Enclosed	Open
	GENERAL		
63.1	Manufacturers name, trademark, or identifier, electrical rating, catalog number or equivalent	B	D
63.1.1	Ambient temperature rating or surrounding air temperature rating	G	G
		–	–
	Exception: No marking is required for 40°C (104°F) ambient temperature rating.		
63.2	Short circuit rating and fuse type/circuit breaker and size	B	G
63.2.1	Marking for group installation	B	G
63.3	Temperature rating of field installed conductors	G	G
		–	–
	Exception: Marking not required when intended for connection to control circuit conductors only		
63.4	Exception to 63.1	B	D
63.5	Marking for environmental type(s)	B	B
63.6	Marking for flat surface of type(s)	G	G
63.7	Specific load marking, indicating intended use	B	D
63.10	Marking for more than one factory	E	E
63.11	Oil tank mark for oil level	B	B
63.12	Guide to proper operation of device(s)	B	B
63.13	Use of ″ON″ and ″OFF″ markings (See Fig. 63.1)	A	–
63.14	Instructions for assembly in different combinations	G	G
63.15	Marking for use with other parts of a system	G	G
63.16	Marking for series resistor	G	G
63.17	Overload relay ″may start automatically″ when in automatic reset position	B	F
63.18	Devices provided with a protective device in an accessory kit	B	F
63.19	Maximum control circuit protective-device size corresponding to the size of control-circuit wire	B	G
63.20	Marking for supplementary fuse near fuseholder per 18.2.3	B	F
63.21	When fuseholder accepts higher fuse size per 18.2.4	B	F
63.22	″TV″ markings	B	D
63.23	Marking for replacement fuse per item 3 of Table 43.1	B	F
	WIRING TERMINAL MARKINGS		
64.1	Marking for proper connections	G	G
		–	–
	Exception No. 1: Marking not required for wire connections plainly evident		
		B	G
	Exception No. 2: Wiring diagram with multiple circuit arrangements		

Table 67.1 Continued on Next Page

Table 67.1 Continued

Marking reference	Required marking[a]	Location[b]	
		Enclosed	Open
64.2, 64.3	Terminal connection of ground supply conductor	G	G
64.4	Marking for low voltage wiring	G	G
64.5	Circuits capable of being connected to separate supplies but intended to be connected to common supply	G	G
64.6	Equipment with special fitting for connection	G	G
64.7	Equipment that is acceptable for nonmetal-enclosed wiring system	G	G
64.8	Field wiring terminal marking for wire type (Al, Cu)	G	G

Table 67.1 Continued on Next Page

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Table 67.1 Continued

Marking reference	Required marking[a]	Location[b]	
		Enclosed	Open
		–	–
	Exception: Marking not required when intended for connection to copper control circuit conductors		
64.9	Field wiring terminal not intended to receive conductor one size larger per 25.5.1	G	G
64.10	Marking for providing terminals separately in terminal kit	G	G
64.11	Torque values marking for field terminals per 25.5.9	G	G
		–	–
	Exception: Marking in 25.5.9 not required when field terminal connected to control circuit conductor if investigated for 7 lb-in.		
	CAUTIONARY MARKINGS		
65.1	Placement of cautionary markings	B	F
65.3	Instructing operator or servicing instructions	B	F
65.4, 65.5	Provided with more than one disconnect means	A	–
65.6	For enclosures that are intended for field assembly of the bonding means in accordance with 6.6.1	G	G
65.7	Replacement markings for overload relay that has replacement elements	B	F
		B	F
	Exception No. 1: Thermal unit replaced upon heater burnout		
		–	–
	Exception No. 2: Marking not required for overload relay with replaceable type thermal elements having calibrated current sensing element in nonreplaceable part of overload relay		
		–	–
	Exception No. 3: Marking not required for overload relay with nonreplaceable type thermal elements that prevents operation of the device		
65.8	Marking for motor controllers having indication that high available fault current interrupted	B	F
65.9	Control with direct-current motor ratings that does not comply with 25.5.1(d)(1)	G	G
65.10	Device which requires a lower torque value than Table 8.1	G	G
65.11	Knife switch complying with Exception to 16.4 where switch may be energized by back feed when in open position	A	–
		F	–
	Exception: Marking provided adjacent to switch and visible after installation		
	INSTRUCTIONS AND MARKINGS PERTAINING TO ACCESSORIES		
66.1	Accessories	H	H

Table 67.1 Continued on Next Page

Table 67.1 Continued

Marking reference	Required marking[a]	Location[b]	
		Enclosed	Open
		H	H
	Exception: New accessory on existing product		
66.2	Accessories	I	I
		B	D
	Exception: Rating of accessory		
66.3	Accessories provided with instructions	G	G
66.4	Kit available for overload protection device in accordance with 6.4.2 (c)	G	G
	MAGNETIC MOTOR CONTROLLERS		
71.1	See Sections 63 – 65		
	MANUAL MOTOR CONTROLLERS		
75.1	See Sections 63 – 65		
75.2	Manual motor controllers intended for use as motor disconnecting means, ″Suitable as Motor Disconnect″	B	F
	COMBINATION MOTOR CONTROLLERS		
88.1	See Sections 63 – 65		
	In addition, incorporating separate overload relay	B	F
		B	F
	Exception: Type E incorporating modules		
88.2	Marked with ″Combination Motor Controller ″ and short circuit current ratings	B	F
88.2.1	Type E construction, ″Self-Protected Combination Motor Controller″ and short circuit current ratings	B	F
88.3	Field conversion of fuses	B	F
88.5	Combination motor controllers incorporating instantaneous trip circuit breaker	B	F
88.6	Type D combination motor controllers	B	F
88.7	Type E combination motor controllers	B	F
	REDUCED VOLTAGE STARTERS		
92.2	Refer to rating details, Section 62	B	D
93.1	Marking ″Heavy or Medium Duty ″	B	F
	SOLID STATE AC MOTOR CONTROLLERS		
105.1	See Sections 63 – 65		
105.2	Replacement fuse near fuseholder	B	F
	FLOAT- AND PRESSURE-OPERATED SWITCHES		
115.1	Refer to Rating Details, Section 62. In addition, provide operating pressure rating	B	D
	SEMICONDUCTOR RELAYS AND SWITCHES		
126.1	See Sections 63 – 65		
	MERCURY SWITCHES		
132.1	See Sections 63 – 65		
	AUXILIARY DEVICES		
140.1	See Sections 63 – 65		
140.2	Indicate operators for intended use	D	G
140.3	Code markings	H	H
140.4	Indicate Use of Same Polarity	D	D

Table 67.1 Continued on Next Page

Table 67.1 Continued

Marking reference	Required marking[a]	Location[b]	
		Enclosed	Open
MECHANICAL OVERLOAD RELAYS			
146.1	See Sections 63 – 65		
146.2	Relay class designation	B	F

Table 67.1 Continued on Next Page

No Text on This Page

Table 67.1 Continued

Marking reference	Required marking[a]	Location[b]	
		Enclosed	Open
146.3	Alternative-Relay class designation on current element table	B	F
146.4	Ampere rating of overload relay	B	D
		B	F
	Exception: Tripping current on table		
146.5	Outside ambient temperature of 40°C and tripping current	B	F
		–	–
	Exception: Marking not required for ambient compensated devices		
146.6	Current elements of interchangeable type	B	F
146.7	Overload relay furnished with table	B	F
146.8	Current element rated for use at maximum marked rating	B	F
146.9	Ampere rating of controller with overload relay	–	–
146.10	Table referred to in Exception to 146.4 and 146.7	–	–
146.11	Combination of manual and automatic reset position	B	B
146.12	Adjustable overload relay	G	G
146.13	See 146.10	–	–
ELECTRONIC OVERLOAD RELAY			
154.1	See Section 146		
154.2	Overload relay not provided with current transformer	B	F
154.3	Marking for current transformer as indicated in 153.2	B	F
DEFINITE PURPOSE CONTROLLERS			
164.1	See 63.1 and 63.4		
LAMP DIMMERS			
172.1	See Sections 63 – 65		
MISCELLANEOUS DEVICES			
176.1	See Sections 63 – 65		
PROGRAMMABLE CONTROLLERS			
192.1	See Sections 63 – 65		
	Exception: Output device with more than one rating[c]		
192.2	Intended use in surrounding air greater than 25°C	G	G
193.1	Signal circuits	D	G
EQUIPMENT RATED 601 – 1500 VOLTS			
195.1	See Sections 63 – 65		
PROXIMITY SWITCHES[c]			
211.1	See Sections 63 – 65		
211.2	Code designation	H	H
211.3	For devices with conductors smaller than 18 AWG, indicate rating of over-current protection to be used	G	G

[a] These are a brief summary of marking requirements. For complete details see the specific Marking Reference.

Table 67.1 Continued on Next Page

Table 67.1 Continued

Marking reference	Required marking[a]	Location[b]	
		Enclosed	Open

[b] For marking locations identified below, ″A″ is the highest order of location, and ″I″ is the lowest order of location. At the option of the manufacturer, a higher order of location category is able to be used.

A. Marking shall be visible when the enclosure cover is on and the door is closed.

B. Marking shall be visible:

1. When the enclosure cover is removed or the door is open;

2. When other devices are mounted nearby as intended; and

3. When devices are installed side by side.

The marking shall not be obscured by attachments such as a disconnect switch operating handle.

C. Marking is on live parts which appear to be grounded.

D. Marking is visible when the device is mounted singularly. The marking may be on the side of the device, and is not required to be visible when the device is mounted next to other devices.

E. Marking is able to be anywhere on the device and is not required to be visible after installation.

F. Marking is on a separable, self-adhesive permanent label that is shipped with the device. For a device that will be installed in an enclosure, the marking shall be on the inside of the enclosure.

G. Marking is shipped separately with the device.

H. Marking is provided on a separate sheet which is available from the manufacturer, and not shipped with the product.

I Marking is shipped separately with kit.

[c] Small devices, such as proximity or photoelectric switches, are able to be marked with only one electrical rating, and all other markings are provided on a separate sheet or on the device carton.

PART II – MAGNETIC MOTOR CONTROLLERS

CONSTRUCTION

68 General

68.1 Magnetic motor controllers shall comply with the construction requirements in Sections 13 – 40.

68.2 A limiting impedance consisting of any number of components used to reduce the available voltage and current at an accessible live part to below the levels specified for risk of electric shock in Section 28 shall comply with the requirements specified in 68.3 and 68.4.

68.3 A single malfunction (short or open) of any circuit component, such as a resistor, capacitor, solid-state device, and the like, shall not cause the available voltage or current to exceed the limits specified in Section 28. For a discrete, multiple (more than two) terminal device, such as a transistor, SCR, triac, or similar device, any combination of terminals taken two at a time shall be open- or short-circuited. For an integrated circuit device, the following combinations of terminals shall be tested:

a) Each pair of adjacent terminals shorted;

b) Each input terminal shorted to (referenced) ground terminal;

c) Each output terminal shorted to (referenced) ground terminal;

d) Each input terminal shorted to each power supply;

e) Each output terminal shorted to each power supply;

f) Each terminal open-circuited.

Exception No. 1: A carbon resistor or a resistor investigated for its acceptability with respect to end use conditions and incorporating acceptable insulation, spacings, or both to prevent a short circuit or reduction in resistance need not be open- or short circuited.

Exception No. 2: A capacitor, capristor (parallel combination of a capacitor and resistor), or similar circuit component, complying with requirements for antenna coupling and line bypass components in the Standard for Across-the-Line, Antenna Coupling and Line-By-Pass Capacitors for Radio and Television Type Appliances, UL 1414, and investigated for its acceptability with respect to end use conditions need not be short-circuited.

Exception No. 3: Electronic circuit elements complying as part of a circuit assembly with a complete component evaluation program need not be open- or short-circuited.

Exception No. 4: For a line-connected circuit, if redundant circuit components are relied upon to limit the voltage or current, then one or more of such components may be open- or short-circuited simultaneously, except that components of a different type (for example, metal film resistors versus carbon resistors, electrolytic versus ceramic capacitors, silicon versus germanium diodes, and the like) are not to be open- or short-circuited simultaneously. When applying this exception, consideration shall also be given to the other exceptions.

68.4 A circuit element relied upon to limit the voltage, current, or both to the values specified in Section 28 shall not experience an electrical stress factor:

a) Greater than 0.5 during all conditions of normal operation; or

b) Greater than 1.0 after single component failure with respect to rated voltage, current and dissipated wattage.

The electrical stress factor is defined as ratio of applied electrical characteristic to rated electrical characteristic (applied current to rated ampacity).

PERFORMANCE

69 General

69.1 Magnetic motor controllers shall comply with the performance requirements in Sections 42 – 56.

RATING

70 Details

70.1 Magnetic motor controllers shall comply with the rating requirements in Section 62.

MARKING

71 Marking

71.1 Magnetic motor controllers shall comply with the marking requirements in Sections 63 – 65.

PART III – MANUAL MOTOR CONTROLLERS

CONSTRUCTION

72 General

72.1 Manual motor controllers shall comply with the construction requirements of Sections 13 – 40 and the requirements in 72.2 – 72.4.

72.1 revised July 16, 1999

72.2 The automatic tripping of a manually operated controller provided with an overload relay shall be independent of manipulation of the operating handle; and the controller shall not recycle while the operating handle is held continuously in the on position.

72.3 When a manual motor controller is provided with an overload relay, the overload relay shall comply with all applicable requirements in this standard or have been previously evaluated.

72.3 added July 16, 1999

72.4 The operating means of a manual motor controller intended for use as a motor disconnecting means shall be provided with a method of being locked in the off position.

Added 72.4 effective July 16, 2001

PERFORMANCE

73 General

73.1 A manual motor controller is to be subjected to the applicable tests described in this section. Tests that are to be conducted in sequence are specified in Table 73.1.

73.1 revised July 16, 1999

73.1.1 A manual motor controller additionally intended for use as a motor disconnecting means shall be subjected to the tests specified in Table 73.2. Tests required to be conducted in sequence are specified in Table 73.2.

Added 73.1.1 effective July 16, 2001

73.2 Relocated as 73A.1 July 16, 1999

Table 73.1
Sequence of tests

Revised Table 73.1 effective July 16, 2001

Standard reference section	Test	Sample number[a]			
		1	2	3	4
		Sequence	Sequence	Sequence	Sequence
73A	Temperature	1			
45	Overload		1		
46	Endurance		2		
73C	Dielectric Voltage Withstand	2	3		
48	Calibration[c]			1	
50	Short Circuit – General				1
73F	Magnetic Trip Out[b]				2
73G	Calibration – 200 Percent[c]				3

[a] All tests or any combination of test sequences are able to be conducted on a single sample when agreeable to those concerned. More than one sample are able to be used when more than one rating is being tested. One sequence is not required to be completed as a prerequisite to the starting of another.

[b] Required when contacts of manual motor controller with instantaneous trip operate to terminate short circuit test. See Section 73F.

[c] Required when manual motor controller is provided with mechanical overload relay.

Table 73.2
Sequence of tests for manual motor controllers used as disconnecting means

Added Table 73.2 effective July 16, 2001

Standard reference section	Test	Sample number[a]		
		1	2	3
		Sequence	Sequence	Sequence
73A	Temperature	1		
45	Overload		1	
73B	Endurance		2	
73C	Dielectric Voltage Withstand	2	3	
73D	Short Circuit			1
73E	Voltage Withstand			2

[a] All tests or any combination of test sequences is able to be conducted on a single sample when agreeable to those concerned. More than one sample is able to be used when more than one rating is being tested. One sequence is not required to be completed as a prerequisite to the starting of another.

73A Temperature Test

73A.1 In addition to complying with the Temperature Test, Section 43, the temperature rises shall not exceed those given in Table 77.3.

73.2 relocated as 73A.1 July 16, 1999

73A.2 A manual motor controller additionally intended for use as a motor disconnecting means shall be subjected to the Temperature Test, Section 43, while carrying a test current equal to the rated current or 115 percent of the maximum motor FLA corresponding to the horsepower rating, whichever is greater.

Added 73A.2 effective July 16, 2001

73B Endurance Test (Motor Disconnect)

73B.1 A manual motor controller additionally intended for use as a motor disconnecting means and its manual operating means shall comply with the Endurance Test, Section 46, for across-the-line motor starting, except the endurance test cycles, cycle rate, and test parameters shall be as specified in Table 73B.1.

Added 73B.1 effective July 16, 2001

Table 73B.1
Endurance test cycles for manual motor controllers used as a disconnecting means

Added Table 73B.1 effective July 16, 2001

Controller rating in amperes[a]	Number of cycles of operation per minute[b]	Number of cycles of operation		
		With current[c]	Without current	Total
100 or less	6	6000	4000	10,000
101 – 200	5	6000	2000	8000
201 – 400	4	1000	5000	6000
401 – 600	3	1000	4000	5000

[a] The controller rating is the larger of the ampere rating marked on the product or the maximum ampere rating equivalent to the marked horsepower ratings on the product as determined from Tables 45.2 and 45.3.

[b] The indicated number of cycles of operation per minute applies only to that part of the test performed with current. When no current is used, the manual motor controller is to be operated at any convenient speed.

[c] The first 1000 c tested with test current, power factor, and cycle rate as in Table 46.1 for AC Motor Starting, the remaining cycles ″with current″ tested at cycle rate indicated in this table, at 0.75 – 0.80 power factor, and at rated full load current.

73C Dielectric Voltage Withstand Test

73C.1 A manual motor controller shall comply with the Dielectric Voltage-Withstand Test, Section 49.

73C.1 added July 16, 1999

73C.2 A manual motor controller additionally intended for use as a motor disconnect shall comply with 73C.1 and shall also withstand without dielectric breakdown a test potential applied between line and load terminals of the manual motor controller with the controller contacts open.

Added 73C.2 effective July 16, 2001

73D Short Circuit Test (Motor Disconnect)

73D.1 A manual motor controller additionally intended for use as a motor disconnecting means on circuits capable of delivering standard fault currents shall comply with Section 51, Standard Fault Current Circuits, except the minimum short circuit current rating shall be 5 kA for motor ratings less than 50 hp, the power factor of the test circuit shall be 0.5 or less for short circuit current ratings of 10 kA or less, and the test procedure shall be in accordance with 73D.3 – 73D.5.

Added 73D.1 effective July 16, 2001

73D.2 A manual motor controller additionally intended for use as a motor disconnecting means on circuits capable of delivering high fault currents shall comply with Section 52, High-Available Fault Current Circuits (Optional), except the power factor of the test circuit shall be 0.5 or less for short circuit current ratings of 10 kA or less and the test procedure shall be in accordance with 73D.3 – 73D.5.

Added 73D.2 effective July 16, 2001

73D.3 The short circuit tests shall be conducted in accordance with 52.3.3 – 52.3.5 and the short circuit closing and withstand tests shall be conducted on the same samples.

Exception: The short circuit closing (″CO″) and the withstand (″O″) tests are able to be conducted on separate samples when the Voltage-Withstand Test is conducted after each short circuit test.

Added 73D.3 effective July 16, 2001

73D.4 Short Circuit Tests shall be performed on both a single phase, single-pole, and a three phase circuit for devices having single-phase and three-phase ratings.

Added 73D.4 effective July 16, 2001

73D.5 Following the short circuit closing (″CO″) and withstand (″O″) tests, a manual motor controller additionally intended for use as a motor disconnecting means shall be subjected to the test in Section 73E, Voltage-Withstand Test.

Added 73D.5 effective July 16, 2001

73E Voltage-Withstand Test (Disconnect)

73E.1 A manual motor controller additionally intended for use as a motor disconnecting means that has been subjected to the short circuit current test, Section 73D, shall comply with the Dielectric Voltage Withstand Test, Section 73C, except the test potential shall be twice the rated short circuit test voltage, or 900 volts, whichever is greater.

Added 73E.1 effective July 16, 2001

73F Magnetic Trip Out Test

73F.1 When required by item (h) of Table 53.1, a manual motor controller with instantaneous trip release is to be subjected to the magnetic trip out test described in 73F.2.

Added 73F.1 effective July 16, 2001

73F.2 The tripping current of a manual motor controller with an instantaneous trip release shall not exceed 130 percent of the marked maximum tripping current, when tested as described in 73F.3 and 73F.4.

Exception: As an option to the rate of increase defined in 73F.3, following a short circuit test, the tripping current is to be brought quickly to the level at the maximum trip setting for each pole.

Added 73F.2 effective July 16, 2001

73F.3 Each pole of a manual motor controller with instantaneous trip release is to be calibrated separately three times at each setting. When an adjustable short circuit trip setting mechanism is provided, the maximum, minimum, and one intermediate trip setting for each sample is to be calibrated. The test current is to be increased from zero or some value below the trip setting to the current at which the manual motor controller trips. The rate of increase is to be such that an accurate indication of the tripping current is established.

Added 73F.3 effective July 16, 2001

73F.4 The test method is to be impulsed type with synchronous closing or another method that has been found to give an accurate indication of the current at the tripping point.

Added 73F.4 effective July 16, 2001

73G Calibration – 200 Percent

73G.1 When required by item (j) of Table 53.1, a manual motor controller provided with a thermal overload relay shall operate automatically within 8 minutes when carrying 200 percent of rated tripping current in accordance with Section 48, Calibration Test.

Added 73G.1 effective July 16, 2001

RATING

74 Details

74.1 A manual motor controller shall comply with the rating requirements in Section 62.

MARKING

75 Details

75.1 A manual motor controller shall comply with the marking requirements in Sections 63 – 65.

75.2 A manual motor controller additionally intended for use as a motor disconnecting means shall be marked ″Suitable as Motor Disconnect.″

Added 75.2 effective July 16, 2001

PART IV – COMBINATION MOTOR CONTROLLERS

CONSTRUCTION

76 General

76.1 These requirements cover combination motor controllers which provide a disconnecting means and a load switching means within a device or assembly. In addition, overload and short-circuit protection may also be incorporated. The functions may be provided by individual discrete components or be combined in a single controller. Table 76.1 summarizes the applicable construction requirements for the various constructions of combination motor controllers.

Table 76.1
Construction of combination motor controllers

Construction type				
A	B	C	D	E
76.4 – 76.8	76.4 – 76.8	76.4 – 76.8	76.4 – 76.9	76.4 – 76.6 and 76.8 – 76.11

76.2 Typical constructions of combination motor controllers are indicated in Table 76.2. This table is for reference only.

Table 76.2
Various constructions of combination motor controllers

Component parts[a]	Construction type				
	A	B	C	D	E[b]
Disconnecting Means	Manual Disconnect (UL 98 or UL 1087)	Manual Disconnect (UL 98 or UL 1087)	Circuit Breaker (UL 489)	Circuit Breaker (UL 489)	Self-protected Control Device (UL 508)
Short-Circuit Protective Device	Fuse (UL 198)	Motor Short-Circuit Protector (UL 508)	Inverse Time Trip Circuit Breaker (UL 489)	Instantaneous Trip Circuit Breaker (UL 489)	
Motor Controller	Magnetic (UL 508)	Magnetic (UL 508)	Magnetic (UL 508)	Magnetic (UL 508)	
Overload Protection	Overload Relay (UL 508)	Overload Relay (UL 508)	Overload Relay (UL 508)	Overload Relay (UL 508)	

[a] Tests are conducted on the individual components per the applicable UL standards shown in the parentheses in the table following each component. The UL standards are as follows:

UL Number	Designation
98	Enclosed and Dead-Front Switches
198 series	Fuses
489	Molded Case Circuit Breakers
1087	Molded Case Switches

[b] See 76.11.

76.3 A combination motor controller shall comply with all of the applicable construction requirements in this standard. All combination motor controllers shall comply with 76.4 – 76.6. In addition, typical Type A – D construction devices as noted in Table 76.2 shall comply with 76.7 – 76.9 and Type E construction devices shall comply with 76.7 – 76.12.

Revised 76.3 effective July 16, 2001

76.4 The disconnecting means of an enclosed combination motor controller shall be provided with a method of being locked in the off position.

76.5 The disconnecting means employed in a combination motor controller shall open all ungrounded supply conductors and shall be constructed so that no pole will be independently operated under normal service conditions. One pole of the disconnecting means may disconnect a grounded conductor, provided that the disconnecting means is constructed so that the pole in the grounded conductor cannot be opened without disconnecting all conductors of the circuit in the same operation.

76.6 If an interlock is provided between the door or cover on the switching mechanism, provision is to be made for circumventing the interlock for inspection purposes while the switch is in the on position.

76.7 A combination motor controller using fuses, inverse-time or instantaneous-trip circuit breakers, or motor short-circuit protectors as the motor branch-circuit protection shall be evaluated in accordance with the applicable requirements for the specific protective device employed. In addition, a combination motor controller using motor short-circuit protectors shall be evaluated to determine if it is acceptable for the intended purpose. See Tables 77.2 – 77.4.

76.8 A disconnect switch or circuit breaker in a combination motor controller shall:

a) Have a short-circuit withstand rating not less than that specified in Table 77.6 for a Type E; or

b) Comply with the Standard for Enclosed and Dead-Front Switches, UL 98, the Standard for Molded Case Switches, UL 1087, or the Standard for Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures, UL 489 for all other devices.

76.8 revised July 16, 1999

76.9 An adjustable setting means of an instantaneous-trip circuit breaker or self-protected control device that is accessible without opening a door or removing a cover shall be constructed so that a stop to limit the maximum setting may be installed. Directions for the installation of the stop shall be included with the complete controller.

76.10 A Type E combination motor controller shall have a means that is visible with the device mounted as intended with the door or cover of the enclosure opened that indicates which function (overload or short-circuit) has operated.

76.11 A combination motor controller having nonreplaceable components – integral discriminating overload and short-circuit current sensors – and provided with one or more sets of contacts where the contacts cannot be isolated for separate testing, is considered to be a Type E device as specified in Table 76.2.

76.12 The field wiring terminals on the line side of a Type E combination motor controller shall comply with the spacing requirements in Table 76.3.

Added 76.12 effective July 16, 2001

Table 76.3
Minimum required spacings for Type E combination motor controller at field wiring terminals on the line side

Added Table 76.3 effective July 16, 2001

Voltage between parts involved	Minimum spacings in inches (mm)							
	Between uninsulated parts of opposite polarity on line side				Between uninsulated parts on line side and any grounded dead metal			
	Over surface		Though air		Over surface		Through air	
0 – 125	3/4	(19.1)	1/2	(12.7)	1/2	(12.7)	1/2	(12.7)
126 – 250	1-1/4	(31.8)	3/4	(19.1)	1/2	(12.7)	1/2	(12.7)
251	2	(50.8)	1	(25.4)	1	(25.4)	1/2	(12.7)

PERFORMANCE

77 General

77.1 A combination motor controller, constructed as Type A – D as specified in Table 76.2, and having individual replaceable components that comply with the appropriate requirements for that component or have been investigated in this application, shall also be subjected to the applicable tests specified in Table 77.2. See Table 77.4 for test sequence. Table 77.1 summarizes the applicable performance requirements for the various constructions of combination motor controllers.

Exception: Individual components are not required to be subjected to the tests in Table 77.4 if previously evaluated.

Table 77.1
Performance of combination motor controllers

References	Construction type				
	A	B	C	D	E
Tables	77.2 – 77.4	77.2 – 77.4	77.2	77.2	77.2
	–	–	76.2 and 77.4	76.2 and 77.4	76.2 and 77.4 – 77.6
	–	–	–	–	82.1
	–	–	–	–	83.1
Sections or paragraphs	–	–	–	78	–
	–	–	–	79	79
	80	–	80	80	80
	–	–	–	81	81
	–	–	–	82.1 – 82.4, 82.10 – 82.11	82
	–	–	–	–	83
	–	–	–	–	84
	85	85	85	85	85
	–	–	–	–	86

77.2 In addition to complying with the requirements of the Temperature Test, Section 43, the temperature rises shall not exceed those given in Table 77.3.

Table 77.2
Index of tests for combination motor controllers

Test No.	Test	Test reference section
1	Temperature	43
2	Overvoltage and Undervoltage	44
3	Overload	45
4	Calibration	48
5	Dielectric Voltage-Withstand	49
6	Short Circuit – General	50
7	Current Withstand	78
8	Contactor Overload	79
9	Voltage Withstand (Disconnect)	80
10	Magnetic Trip-Out	81
11	Combination Short Circuit	82
12	Endurance[a]	83
13	Calibration – 200 percent	84
14	High Available Short Circuit Currents	85
15	Coordination	86

[a] This test is to be conducted for each manual and electrical control that may be provided.

Table 77.3
Maximum acceptable temperature rises

Material and components		°C	°F
1.	Knife-switch blades and contact jaws	30	54
2.	Fuse clip for use with 60°C wire when tested with a dummy fuse that represents a fuse intended to provide branch circuit protection	30	54
3.	Fuse clip for use with 75°C wire when tested with a dummy fuse that represents a fuse intended to provide branch circuit protection	50	90
4.	Fuse clip when tested with a fuse intended to provide branch circuit protection[a]	85	153

[a] See 88.4.

77.3 For a device employing a fuseholder, an unplated copper bar, unplated copper tubing, or an equivalent material with negligible impedance is to be used during the test instead of a regular fuse.

Exception: A combination motor controller intended to be used with Class L fuses is to be tested with the fuse installed as intended in service. The fuse is to have the maximum ampere rating specified by the manufacturer's current-element tables. The device is to operate normally until constant temperatures are obtained at 100 percent rated current without:

a) The opening of any fuse; and

b) Without the temperature rise exceeding that specified in Table 77.3.

77.4 A combination motor controller, constructed as Type E, as specified in Table 76.2 and having individual replaceable components that comply with the appropriate requirements for that component shall be subjected to the specified tests in Table 77.2. See Table 77.4 for test sequence.

Exception: Modular trip units containing thermal or magnetic sensors, or both may be replaceable. The module may also contain load switching contacts. See 88.7(b).

Table 77.4
Sequence of tests for combination motor controllers

Construction type (See Table 76.2	Sequence number[a]										
	1	2	3[k]				4[k]				5
			Sample no.				Sample no.				
			1	2	3	4	1	2	3	4	
A	1 2 5	4	6 5	–			–	–			14 9
B	1 2 5	4 7 5	6 5	–			8 5	–			14 9
C	1 2 5	4	6 5	–			 –	–			14 9
D	1 2 5	4 7 5	11 5	–			8 5	–			14 9
E	1 4 15 10 8[l] 5[f]	3 1 2 12[d] 5[f]	13 11[b,m] 12[i] 13[e,h] 5[f]	13 11[b,n] 12[i] 13[e,h] 5[f]	13 12[i] 11[b,m] 13[e,h] 5[f]	13 12[i] 11[b,n] 13[e,h] 5[f]	13[e] 11[c,m] 12[i,j] 13[e,h] 5[f]	13[e] 11[c,n] 12[i,j] 13[e,h] 5[f]	13[e] 12[i,j] 11[c,m] 13[e,h] 5[f]	13[e] 12[i,j] 11[c,n] 13[e,h] 5[f]	13[e] 14 10 13 9

NOTE – See Table 77.2 for explanation of test numbers.

[a] All or any combination of a sequence may be conducted on a single sample if agreeable to those concerned. More than one sample may be used if more than one rating is being tested. One sequence need not be completed as a prerequisite to the starting of another.

[b] See Table 77.5 for test values and 82.6.

[c] See Table 77.6 for test values and 82.8.

[d] This test is to be conducted for each manual and electrical control that may be provided. If sample numbers 2 and 3 are combined then this test is not required.

[e] If an adjustable magnetic trip is provided also conduct test number 10.

[f] The dielectric voltage-withstand test shall additionally be conducted between the line and load terminals with the controller open, in the ″tripped″ and ″off″ positions.

[g] *Reserved.*

[h] This test may be conducted in lieu of the marking as noted in 88.7(b).

[i] This test is to be conducted using only the intended load switching control, unless samples are combined in which case the test is to be conducted for each manual and electrical control that may be provided.

[j] See note c in Table 83.1.

[k] Tests on sequence number 3 may be waived if the endurance test shown in Table 83.1 is used for sequence number 4.

[l] May be separate sample. If separate sample, must be followed by test 5.

[m] This test is to be conducted in accordance with 82.1(a).

[n] This test is to be conducted in accordance with 82.1(b).

Table 77.5
Low level short circuit interrupting test values for Type E combination motor controller in test sequence 3 of Table 77.4

Control rating, horsepower	rms Symmetrical	
	Volts	Circuit capacity, amperes[b]
0 – 5	125 maximum	1500
0 – 10	200 – 250	1500
0 – 50	600 maximum	3000
51 – 200	600 maximum	5000

NOTE – Sequence of operations shall be O-t-CO, where t is a minimum of 2 minutes and a maximum of 1 hour.

[a] The power factor for all test circuits other than dc is to be 0.4 – 0.5.

Table 77.6
Short circuit interrupting test values for Type E combination motor controllers in Test Sequence 4 of Table 77.4

Control rating, horsepower	rms Symmetrical		
	Volts	Circuit capacity, amperes[d]	
		Individual	Common
0 – 5	125 maximum	4,320[a,b]	5,000
0 – 10	200 – 250	4,320[a,b]	5,000
0 – 200	600 maximum	8,660[a,b,c]	10,000

[a] This value is the current available when using two legs of the 3-phase circuit indicated under ″Common.″

[b] For dc ratings the current indicated under ″Common″ shall be used for individual pole operation.

[c] For the 480Y/277 and 600Y/347 volt ratings the current indicated under ″Common″ shall be used.

[d] The power factor for all test circuits is to be 0.4 – 0.5 unless dc.

78 Current Withstand Test

78.1 A Type B or D combination motor controller having instantaneous-trip circuit breakers or motor short-circuit protectors shall withstand currents of 600 percent and 1000 percent of full-load motor current without damage to any parts or connected wires that would impair their function. Softening of wire insulation is acceptable but melting and dripping of wire insulation is not acceptable.

78.2 A sufficient number of representative samples is to be selected to cover the possible combinations of overload relays, current elements, and instantaneous-circuit-breaker trip coils or motor short-circuit protectors.

78.3 Each test sample is to be connected with wire sized in accordance with 45.8 based on the full-load, motor current rating. The instantaneous-trip circuit breaker is to be set to its maximum value or its trip mechanism is to be defeated – or may be jumpered if necessary – so that the test may be continued until operation of the overload relay opens the contactor. If a motor short-circuit protector is provided, it shall not open during the 600-percent test and is to be shunted out during the 1000-percent test. The test may be conducted using a low-voltage electrical supply source and with all poles connected in series. The test is to be conducted at normal room temperature. The 600-percent test is to be followed by the 1000-percent test as quickly as the overload mechanism can be reset.

79 Contactor Overload Test

79.1 A magnetic motor contactor that is intended for use in a Type B, D or E combination with an instantaneous-trip circuit breaker or motor short-circuit protector shall comply with the requirements of 45.1 after being subjected to a test consisting of breaking for three operations, a test current of 1000 percent of maximum full-load motor current, 40 to 50 percent power factor, at maximum rated volts for the overload test. The test is to cover conditions of maximum voltage, current, and power.

80 Voltage-Withstand Test

80.1 A combination motor controller shall withstand without breakdown a test potential of twice rated short circuit withstand test voltage, but not less than 900 volts applied as follows (a motor controller may be disconnected during these tests):

a) Between line and load terminals of the protective device assembly with the protective device open – that is, with a circuit breaker in the tripped position with current limiters in their holders, or with a disconnecting means open and the fuses or motor short-circuit protectors in their holders.

b) Between line and load terminals of the disconnecting means with the disconnecting means open – that is, between line terminals of the disconnecting means and the line side of the fuse, current limiter, or motor short-circuit protector.

c) Between terminals of opposite polarity with the disconnect switch or circuit-breaker contacts closed.

d) Between live parts and the overall enclosure with the disconnect switch or circuit-breaker contacts both open and closed.

Exception: This test need not be conducted if the same sample is to be subjected to the short-circuit-closing withstand test.

80.2 To determine whether a controller complies with the requirement in 80.1, the controller is to be tested using an acceptable 500 volt-ampere or larger capacity transformer, the output voltage of which is essentially sinusoidal and can be varied. The applied potential is to be increased from zero until the required test level is reached, and is to be held at that level for 1 minute. The increase in the applied potential is to be at a substantially uniform rate and as rapid as consistent with its value being correctly indicated by a voltmeter.

81 Magnetic Trip-Out Test

81.1 The tripping current of a controller provided with an instantaneous trip (release function) shall be in the range of 80 – 120 percent of the marked tripping current, when tested as described in 81.2 and 81.3.

Exception: Following a short circuit test the tripping current may be brought quickly to the 120 percent level at the maximum trip setting once for each pole.

81.2 Each pole is to be calibrated separately three times at each setting. If an adjustable short circuit trip setting mechanism is provided, the maximum, minimum, and one intermediate trip setting for each sample is to be calibrated. The test current is to be increased from zero or some value below the trip setting to the current at which the controller trips. The rate of increase is to be such that an accurate indication of the tripping current can be established.

81.3 The test method may be impulse tested with synchronous closing or another method that has been found to give an accurate indication of the current at the tripping point.

82 Combination Short Circuit Test

82.1 The Type D and E combination motor controller shall interrupt the circuit and have continuity in the closed position at rated voltage after being subjected to:

a) The short circuit tests in Section 50 (See also Section 54); and

b) The test described in 82.2 – 82.11.

Exception: If the instantaneous circuit breaker has already been evaluated with the Standard for Molded Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures, UL 489, then the test is not required.

82.1 revised July 16, 1999

82.2 Cotton indicators described in 82.10 and 82.11 shall not be ignited.

82.3 Combination short circuit tests on a combination controller incorporating an instantaneous-trip circuit breaker are to be conducted employing current elements of the minimum and maximum resistance for each size of circuit-breaker trip coil.

82.4 The applicable tests described in Section 50 and 82.3 are to be conducted at the maximum setting of the instantaneous-trip circuit breaker or self-protected control device (if adjustable).

Exception No. 1: If the maximum setting can exceed 13 times the maximum full load current setting specified on the device or in the current-element table, the instantaneous-trip circuit breaker or self-protected control device is to be set at not more than 13 times the maximum full-load current.

Exception No. 2: The instantaneous-trip circuit breaker or self-protected control device may be positioned at the maximum setting marked on the device or the current-element table.

82.5 The device is to be connected in accordance with the short circuit tests in Section 50, Short Circuit Test – General.

82.6 Self-protected control devices are to be subjected to the number and types of operations indicated in Table 77.5, and shall interrupt the current indicated.

82.7 As a result of the test, there shall be no electrical and mechanical breakdown of the device, and the fuse that is indicated in Figure 82.1 shall not have cleared. There shall be no damage to the insulation on the conductors used to wire the device.

82.8 Self-protected control devices are to be subjected to the number and type of operations indicated in Table 82.1 when connected as shown in Figure 82.1 and shall interrupt the current indicated in Table 77.6. Successive operations are to be conducted by alternately closing the circuit on the device (″O″ operation) by means of any appropriate switching device, using random closing, and closing the device on the circuit (″CO″ operation). At the option of the manufacturer the common or 3-phase operation may be conducted first, provided that ″O″ – ″CO″ – ″O″ alternate operations are maintained.

Table 82.1
Interrupting ability operations

Combination controller AC voltage rating	Letters indicate appropriate diagram in Figure 82.1					
	Operations on each pole		Common operations			Total number of operations
	O	CO	O	CO	O	
maximum 600	B[b]	B[b]	A	–	–	7
120/240[a]	–	–	D	D	D	3
480Y/277[a]	E	E	C	–	–	7
600Y/347[a]	E	E	C	–	–	7

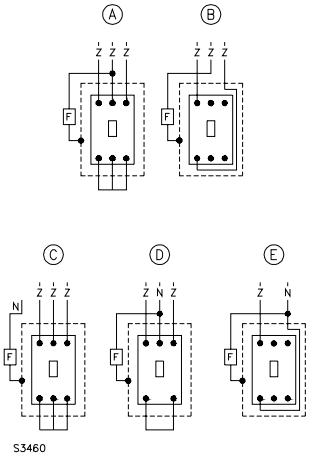
NOTE – For a 125/250 volt dc rating, the number of operations is the same as for a 120/240 volt ac rating. For a 250 volt dc rating, the number of operations is the same as for a 240 volt ac rating.

[a] This test is conducted if the combination motor controller rating is for a specific supply system having dual ratings and marked in accordance with 88.8.

[b] Figure 82.1 describes a test on one pole only. The remaining poles shall also be tested.

82.9 As indicated in Table 77.5, the time interval between the interrupting operation of a self-protected control device, Type E, is to be 2 minutes, except that the time interval may be extended to whatever is necessary to allow the self-protected control device, Type E, to reset, but not more than 1 hour.

Figure 82.1
Interrupting ability test connection diagrams



N – Neutral

Z – Limiting Impedance

F – 30 A ″ground″ Fuse-Enclosure

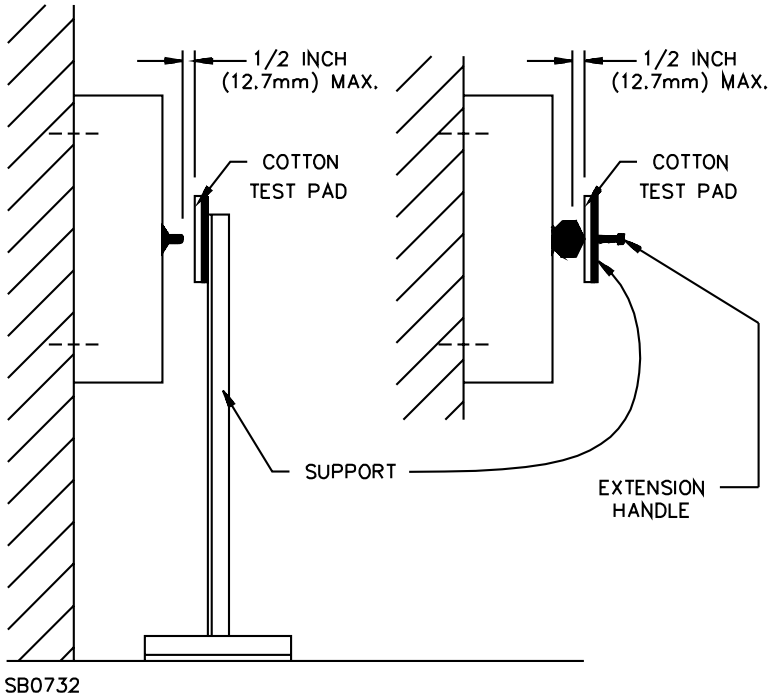
82.10 A cotton pad shall be provided when the operating handle extends through the enclosure. A cotton pad at least 1/2 inch (12.7 mm) thick, and having a length and width four times the handle opening but not less than 3 inches (76.2 mm) in either dimension is to be centered and secured not more than 1/2 inch from the end of the combination motor controller handle. If a handle extension longer than 1 inch

(25.4 mm) is used, the cotton pad is to be firmly supported and anchored to the extension as shown in Figure 82.2. The cotton pad may be supported on either a solid surface or on 1/2 inch mesh hardware cloth. A small opening is permitted in a cotton pad to pass a plunger to operate a push-type device.

Exception: The cotton indicator may be omitted, if, with the handle in any position, there is no opening around the handle through which a wire 0.010 inch (0.26 mm) in diameter can be inserted in a straight line to where it intersects any straight line connecting the separating contacts.

82.11 A device intended for use in a ventilated enclosure shall be tested in that enclosure. A cotton pad indicator at least 1/2 inch (12.7 mm) thick shall be attached to the outside of, and shall completely cover, any louvers or other openings which shall be constructed and located so that no flame or molten metal will be emitted. The ventilating openings shall comply with 6.9.2 – 6.10.4.

Figure 82.2
Location of cotton pad for interrupting ability test



83 Endurance Test

83.1 A Type E combination motor controller shall comply with the requirements described in Endurance Test, Section 46, for across-the-line starting. The tests shall be conducted as specified in Table 83.1.

Table 83.1
Endurance test

Test current, amperes	Power factor	Number of cycles when tested with values in Table		Test cycle times, seconds[a]	
		77.5	77.6	On	Off
Twice Full-Load Current[c]	0.4 – 0.5	1000	500	1/2	1/2
Full-Load Current[c]	0.75 – 0.80	5000	2500	1	9
No Load[d]	–	4000	0	b	b

NOTE – For an electrical control which operates load switching contacts, the tests as noted in Table 46.1 shall also be used.

[a] For test currents 200 amperes or more, the test on time is to be 1 second, and the maximum off time is to be 1 second for test currents of 200 – 499 amperes, and 120 seconds for test currents of 500 – 1499 amperes.

[b] Any convenient rate but not to exceed 20 operations per minute.

[c] To be conducted on the load switching contacts by any convenient means of actuation.

[d] To be conducted on the manual disconnect actuator if the actuator is used to operate the load switching contacts. If other means are used to operate the load switching contacts, then the number of cycles on the manual actuator shall be 10,000 cycles.

84 Calibration Test – 200 Percent

84.1 The overload function of a combination motor controller shall operate automatically within 8 minutes when carrying 200 percent of rated tripping current in accordance with Section 48 conducted at room ambient.

85 High Available Short Circuit Current Test

85.1 A combination motor controller shall comply with applicable performance requirements for controllers intended for use on circuits capable of delivering high fault currents if the controller short-circuit current marked rating is greater than indicated in Table 51.3. A combination motor controller shall comply with the tests described in Section 52, High-Available Fault Current Circuits.

85.2 Following the short-circuit-closing withstand test required by 52.3.3, a combination motor controller is to be subjected to the dielectric voltage-withstand test specified in Section 80, Voltage Withstand Test.

85.3 Components which serve as the disconnecting means are not to be replaced as these are required to complete the rest of the test program. Other components are to be replaced as needed.

86 Coordination Test

86.1 A Type E combination motor controller when tested in accordance with 86.2 – 86.4 shall result in the operation of one or both of the functions (overload or short-circuit) as intended at each test current as determined by a visual inspection of the device.

86.2 The test is to be conducted in accordance with the Calibration Test, Section 48, except as modified by the requirements in this section and conducted at room ambient.

86.3 Three poles are to carry current at any convenient voltage. If an adjustable overload function is provided, it is to be set at the lowest motor full load current setting. If an adjustable short-circuit function is provided, it is to be set at the maximum current setting but not more than 13 times the setting of the overload function.

86.4 The device is to be tested carrying 800 percent of the rated tripping current. Additional tests are to be conducted by increasing the test current in increments of 200 percent of the rated tripping current. No further tests are to be conducted after the short-circuit function has operated. The device is to be stabilized at room ambient before each test.

86.5 The test method is to be impulse tested with synchronous closing or another method that has been found to give an accurate indication of the current at the tripping point.

RATINGS

87 Details

87.1 A combination motor controller shall comply with the rating requirements in Section 56 except the controller shall be rated only in volts and horsepower, and shall indicate whether the equipment is for direct or alternating current. The rating of alternating current equipment shall include the number of phases and frequency.

MARKING

88 Details

88.1 A combination motor controller shall comply with the marking requirements in Sections 63 – 65. A combination motor controller incorporating a separate overload relay, shall additionally be provided with markings indicating the rating or other designation of the protective device to be used with each overload-relay current element, or the range of full-load motor current. Table 88.1 summarizes the applicable marking requirements for the various constructions of combination motor controllers.

Exception: If a self-protected control device incorporates interchangeable modules, a marking shall be provided which specifies the modules that can be used.

Table 88.1
Marking requirements for combination motor controllers

Construction types				
A	B	C	D	E
88.1	88.1	88.1	88.1	88.1
88.2	88.2	88.2	88.2	88.2
88.3	–	–	–	–
88.4	–	–	88.5	88.5
–	–	–	88.6	–
–	–	–	–	88.7
–	–	–	88.8	88.8

88.2 A combination motor controller shall be marked ″Combination Motor Controller″ and ″Short-Circuit Current Rating, ____ Amperes rms Symmetrical, ____ Volts Maximum″, or the equivalent. The ampere rating shall not be more than the value for which the controller was tested in accordance with 52.1.1 or Table 51.3, whichever is applicable.

88.2.1 A Type E combination motor controller shall be marked ″Self-Protected Combination Motor Controller″ in addition to the short circuit marking in 88.2.

Added 88.2.1 effective July 16, 2001

88.3 A combination motor controller intended for field conversion to accept Class G, J, L, R, or T fuses shall be marked with the word ″DANGER ″ and the following or the equivalent ″Unless Class ___ fuses are used, the switch may become a risk of fire, electric shock, and injury to persons if installed on circuits capable of delivering more than 10,000 rms symmetrical amperes. ″ The manufacturer is to insert the class of fuse when the product leaves the factory.

88.4 If the fuse used to determine compliance with item 4 of Table 77.3 is a Class G or K, the typical Type A construction shall be marked with a fuse replacement marking near the fuse holder specifying the class of fuse.

88.5 The marking on a combination motor controller incorporating an instantaneous-trip circuit breaker shall include complete instructions for breaker adjustment and overload-relay current element selection to provide protection in accordance with the National Electrical Code, ANSI/NFPA 70-1996.

88.6 A Type D, as specified in Table 76.2, combination motor controller shall be marked:

a) With the word ″WARNING ″ and the following or the equivalent: ″To maintain overcurrent, short-circuit, and ground-fault protection, the manufacturer's instructions for selecting current elements and setting the instantaneous-trip circuit breaker must be followed;″ and

b) With the word ″WARNING ″ and the following or the equivalent: ″Tripping of the instantaneous-trip circuit breaker is an indication that a fault current has been interrupted. Current-carrying components of the magnetic motor controller should be examined and replaced if damaged to reduce the risk of fire or electric shock. If burnout of the current element of an overload relay occurs, the complete overload relay must be replaced. ″

88.7 A Type E, as specified in Table 76.2, combination motor controller shall be marked:

a) With the word ″WARNING ″ and the following or equivalent: ″To maintain overcurrent, short-circuit, and ground-fault protection, the manufacturer's instructions for selection of overload and short circuit protection must be followed to reduce the risk of fire or electric shock;″ and

b) With the word ″WARNING ″ and the following or the equivalent: ″If an overload or a fault current interruption occurs, circuits must be checked to determine the cause of the interruption. If a fault condition exists, the current-carrying components should be examined and replaced if damaged, and the integral current sensors must be replaced to reduce the risk of fire or electric shock. ″

88.8 A Type D or E combination motor controller tested in accordance with Section 82 for a specific supply system voltage shall be marked accordingly: 120/240; 480Y/277; 600Y/347.

PART V – REDUCED-VOLTAGE STARTERS

CONSTRUCTION

89 General

89.1 A reduced voltage starter shall comply with the construction requirements in Sections 13 – 41 and 89.2 or 89.3, as applicable.

89.2 Reduced voltage starters incorporating semiconductor switching means shall be evaluated in accordance with the requirements in Part VI – Solid State AC Motor Controllers.

89.3 An autotransformer-starter switch shall be provided with an off position, a running position, and at least one starting position. An interlock shall be provided so that the starter switch cannot be thrown directly from the off to the run position. The starter switch shall be arranged so that it:

a) Will be held in the off and running positions;

b) Cannot be left in a starting position; and

c) Cannot be left unattended in any position that does not include the overload-protective devices in the circuit.

PERFORMANCE

90 Operation Test

90.1 After 100 operations under the most severe normal conditions for which it is intended, a rheostat, an autotransformer, a speed regulator, or a similar device, or a starter containing such a device shall show no serious burning of the contacts or other faults. The release mechanism of a motor-starting rheostat shall not be impaired by such a test.

90.2 The requirement in 90.1 is intended to demonstrate the ability of the device to close and interrupt the circuit under normal conditions of operation, including starting and operating with the motor loaded to full load at normal speed.

91 Duty Cycle Test

91.1 An autotransformer or reactor starter shall be identified as medium or heavy duty and shall not show resultant flaming or molten droppings when the maximum rated voltage is applied to line terminals, and when tested as indicated in 91.2 and 92.1. If the transformer windings are oil immersed, the oil shall not overflow its containing case.

91.2 The test may be terminated before the end of the period specified in Table 92.1 if the autotransformer is protected from overheating by a reliably operating, nonadjustable thermostat or similar device.

RATINGS

92 Details

92.1 Ratings for heavy and medium duty controllers shall be based on the duty cycles and load conditions specified in Table 92.1.

92.2 A reduced-voltage starter shall comply with the rating requirements in Section 62.

Table 92.1
Controller duty cycles and load conditions

1.	HEAVY DUTY	
	ON	1 minute
	OFF	1 minute
	REPEAT	4 times (for a total of five cycles)
	REST	2 hours
	ON	1 minute
	OFF	1 minute
	REPEAT	4 times (for a total of five cycles)
	TAP	lowest tap
	LOAD	motor with rotor locked or an equivalent inductive load
	POWER FACTOR	50 percent or less
2.	MEDIUM DUTY – MANUAL CONTROLLERS, 300 HORSEPOWER OR LESS	
	ON	15 seconds
	OFF	3 minutes 45 seconds
	REPEAT	3 times (for a total of four cycles)
	REST	2 hours
	ON	15 seconds
	OFF	3 minutes 45 seconds
	REPEAT	3 times (for a total of four cycles
	TAP	65 percent
	TAP CURRENT	300 percent of motor full-load current
	POWER FACTOR	50 percent or less
3.	MEDIUM DUTY – MAGNETIC CONTROLLERS FOR MOTORS, 200 HORSEPOWER OR LESS	
	ON	15 seconds
	OFF	3 minutes 45 seconds
	REPEAT	14 times (for a total of 15 cycles)
	REST	2 hours
	ON	15 seconds
	OFF	3 minutes 45 seconds
	REPEAT	14 times (for a total of 15 cycles)
	TAP	65 percent
	TAP CURRENT	300 percent of motor full-load current
	POWER FACTOR	50 percent or less
4.	MEDIUM DUTY – MAGNETIC CONTROLLERS FOR MOTORS, RATED MORE THAN 200 HORSEPOWER	

Table 92.1 Continued on Next Page

Table 92.1 Continued

ON	30 seconds
OFF	30 seconds
REPEAT	2 times (for a total of 3 cycles)
REST	1 hour
ON	30 seconds
OFF	30 seconds
REPEAT	2 times (for a total of 3 cycles)
TAP	65 percent
TAP CURRENT	300 percent of motor full-load current
POWER FACTOR	50 percent or less

MARKING

93 Details

93.1 An autotransformer and a reactor shall be marked ″Heavy Duty″ or ″Medium Duty″, as applicable for the intended use.

PART VI – SOLID-STATE AC MOTOR CONTROLLERS

CONSTRUCTION

94 General

94.1 The construction of a solid state controller incorporating a semiconductor switching means for on and off control of a motor load and with or without reduced voltage starting shall be in accordance with the requirements of Sections 13 – 41, inclusive.

PERFORMANCE

95 General

95.1 The performance of a solid state motor controller shall be investigated by subjecting a representative sample or samples in commercial form to the tests indicated in this section. Those tests to be conducted in a sequence are specified in Table 95.1. Consideration shall be given to heat sink capability, solid state device ratings, and other criteria in determining samples for testing representative of a line of similarly constructed controllers.

Table 95.1
Sequence of tests for solid state ac motor controllers

Standard reference section	Test	Sample number[a] 1 Sequence	2 Sequence	3 Sequence	4 Sequence
96	Temperature	1			
97	Dielectric Voltage-Withstand	3	3		
98	Overvoltage and Undervoltage	2			
99	Overload		1		
100	Endurance		2		
101	Short Circuit			1	
102	Breakdown of Components				1

[a] All or any combination of sequences may be conducted on a single sample if agreeable to those concerned. More than one sample may be used if more than one rating is being tested. One sequence need not be completed as a prerequisite to the starting of another.

Table 95.2
Sequence of tests for solid state motor controllers with reduced voltage starting feature

Test reference	Test	Sample number[a] 1 Sequence	2 Sequence	3 Sequence	4 Sequence	5 Sequence	6 Sequence	7 Sequence
96	Temperature	1						
97	Dielectric Voltage-Withstand	3			3	2	2	
98	Overvoltage and Undervoltage	2						
101	Short Circuit		1					
102	Breakdown of Components			1				
103.2	Controller Overload				1			
103.3	Single Phasing				2			
103.4	Inoperative Blower Motor					1		
103.5	Clogged Filter						1	
103.6	Current Limiting Control							1

[a] All of any combination of sequences may be conducted on a single sample if agreeable to those concerned. More than one sample may be used if more than one rating is being tested. One sequence need not be completed as a prerequisite to the starting of another.

95.2 Tests shall be conducted at rated frequency at a test potential not less than 120, 208, 240, 277, 480, or 600 volts as appropriate for the voltage rating, except that the tests in Section 96 may be conducted at a potential between 90 – 110 percent of the potential specified if the load current load is adjusted to produce the maximum normal heating, and if the power semiconductors are capable of conduction as intended at the test voltage.

96 Temperature Test

96.1 When operating in the normal mode resulting in maximum heating and as described in 96.2 and Section 43, solid state contactors shall not attain a temperature at any point sufficiently high to constitute a risk of fire, to adversely affect any materials or components employed in the device, or exceed, at stabilized temperature, the temperature rises specified in Table 43.1.

96.2 For the purpose of evaluating the temperature limit of the material, insulating material at the junction in lieu of required spacings is considered as being at the junction temperature. To determine the insulating material temperature, reference temperatures (case, tab, heat sink, or the like) are to be measured and the junction temperature is to be calculated based on the semiconductor manufacturer's power dissipation and thermal resistance data.

97 Dielectric Voltage-Withstand Test

97.1 The dielectric voltage-withstand test described in Section 49 is to be conducted immediately after the temperature test with the sample at stabilized temperature and, where necessary, having the power semiconductor (in power circuit) shorted. If placement of thermocouples could adversely affect the results of the dielectric voltage-withstand test, the test may be conducted on a sample without thermocouples that has been operated as defined for the temperature test until temperatures have stabilized.

Exception: The test between terminals of opposite polarity need not be conducted.

98 Overvoltage and Undervoltage Test

98.1 A control that employs an electromagnet shall comply with the overvoltage and undervoltage tests described in Section 44.

99 Overload Test

99.1 A solid-state motor controller shall comply with the appropriate overload test described in Section 45.

Exception: This test is not required for a motor controller having a reduced voltage starting feature.

100 Endurance Test

100.1 A solid-state motor controller shall comply with the appropriate endurance test described in Section 46.

Exception No. 1: This test is not required for a motor controller having a reduced voltage starting feature.

Exception No. 2: If the endurance test is to be conducted at rated current and there is no inrush current, the endurance test need not be conducted.

101 Short Circuit Test

101.1 Evaluation of short circuit test

101.1.1 Equipment rated 1-1/2 horsepower (1119 W output) or more shall comply with the following after the test described in 101.3.1 – 101.4.1. When no horsepower rating is marked, see Tables 45.2 and 45.3 for equivalent FLA ratings.

a) The cotton indicator shall not have ignited when tested without an enclosure as in 101.3.1.

b) When tested in an enclosure, the door or cover shall not be blown open and it shall be possible to open the door or cover. Deformation of the enclosure shall not result in the accessibility of live parts as determined by the requirments specified in 6.17.1.

c) Wires shall not be pulled out of connectors and the wire insulation shall not burn out.

d) The device is not required to be operational after testing.

101.1.1 revised July 16, 1999

101.2 Selection of samples

101.2.1 A sufficient number of samples considered to be representative of a product line are to be subjected to short circuit tests. Representative samples are to be selected on the basis of such features as configuration and ratings.

101.3 Test procedure

101.3.1 Open equipment is to be tested in an enclosure judged to be representative of that likely to be encountered in service except that tests may be conducted without an enclosure and considered representative of tests conducted using an enclosure if agreeable to those concerned. If tests are to be conducted without an enclosure, surgical cotton is to be placed on a wire cage surrounding and in close proximity to the equipment under test so as to closely simulate the intended enclosure.

101.3.2 Deleted July 16, 1999

101.3.3 Deleted July 16, 1999

101.3.4 The solid state motor controller is to be connected to a test circuit as noted in 101.4 and then loaded such that the output devices are actuated when the controller is energized.

101.3.4 added July 16, 1999

101.3.5 Actuation of the output device to a full ″on″ state is attainable by any one of the following methods of loading:

a) The connection of an actual motor to the motor output terminals such that enough loading is provided to actuate the output devices;

b) The connection of a resistive or resistive-inductive load to the motor output terminals such that enough loading is provided to actuate the output devices; or

c) The connection of a remote circuit to each controller such that the output devices are actuated to a full ″on″ state independent of any loading.

101.3.5 added July 16, 1999

101.3.6 Upon actuation of the output devices, a short is introduced across the motor output terminals and the controller is operated until the protective devices open the short circuit.

101.3.6 added July 16, 1999

101.3.7 For each sample selected, the controller is only required to be subjected to one short circuit test.

101.3.7 added July 16, 1999

101.4 Test circuit

101.4.1 The requirements in Sections 50 – 52A are to be applied except as noted in 101.3 and the test circuit is to be calibrated as described in Section 54, Calibration of Test Circuits, at the maximum available short circuit current for which the motor controller is rated.

101.4.1 revised July 16, 1999

102 Breakdown of Components Test

102.1 A solid state contactor shall comply with the requirements in 57.1.

102.2 With reference to 102.1, each of the following conditions is considered as resulting in abnormal operation of an ac rated controlled load. These conditions are considered to be unacceptable.

a) Asymmetrical switching other than half-wave;

b) Half-wave operation for a single-phase controller rated less than 5 horsepower; or

c) Transmitting 1 cycle or more of voltage source to the motor with the control in the off position thus permitting possible rotation of a de-energized motor.

103 Operation Tests

103.1 General

103.1.1 A solid state motor controller with a reduced voltage starting feature is to be subjected to the test sequence as described in Table 95.2.

103.1.2 During and upon completion of the operation tests, the solid state motor controller with reduced voltage starting features shall be electrically and mechanically operable and there shall be no evidence of a risk of fire or electric shock. The fuse specified in 103.1.3 shall not open and the surgical cotton specified in 103.1.3 shall not glow or flame.

103.1.3 To asses the risk of electric shock, the outer enclosure (if any) and grounded or exposed dead metal parts are to be connected through a 30-ampere fuse to the supply circuit pole least likely to arc to ground. For grounded control circuits, the enclosure and grounded or exposed dead metal parts are to be connected through the 30-ampere fuse to ground. Surgical cotton is to be placed at all openings, handles, flanges, joints, and the like on the outside of the enclosure.

Exception: The cotton is not required to be provided when circuit breakers (either inverse-time or instantaneous trip types) complying with the Standard for Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures, UL 489, are being relied upon to provide branch circuit short circuit protection.

103.1.3 revised July 16, 1999

103.1.4 Before all operation tests, the test sample is to be mounted, connected, and operated as described in the Temperature Test, Section 43.

103.1.5 A solid state circuit intended to provide short circuit or overload protection is to be defeated during the operation tests unless specifically evaluated. These tests are to be conducted with the voltage ramp setting adjusted for the minimum ramp time.

103.2 Controller overload

103.2.1 A motor controller having the coil circuit interlocked or sequenced such that in normal operation the contactor does not make or break load current is to be tested at the maximum current permitted by the current limiting control, if provided, but at least 150 percent of full-load current. Five operations are to be conducted.

No Text on This Page

103.3 Single phasing

103.3.1 A three-phase solid state motor controller with reduced voltage starting features is to be operated with one line disconnected at the input. The test is to be conducted by disconnecting one line with the controller operating at maximum normal load and is to be repeated by initially energizing the device with one disconnected. The test is to continue until the temperature stabilizes.

103.4 Inoperative blower motor

103.4.1 A solid state motor controller with a reduced voltage starting feature having forced ventilation is to be operated at rated load with an inoperative blower motor or motors until the test is terminated by a protective device or until the temperature stabilizes.

103.5 Clogged filter

103.5.1 An enclosed solid state motor controller with a reduced a voltage starting feature having filtered ventilation openings is to be operated with the openings blocked to represent clogged filters. The test is to be conducted initially with the ventilation openings blocked approximately 50 percent. The test is then to be repeated under a full blocked condition until terminated by a protective device or until temperature stabilizes.

103.6 Current limiting control

103.6.1 A solid state motor controller with a reduced voltage starting feature incorporating a current limiting control is to be operated with the load increased to cause the device to operate in the current limiting mode. When the current limiting control is adjustable, it is to be adjusted to the setting producing the most severe results. The duration of the test is not to exceed the maximum time required for operation of the overload protective device or system supplied.

RATING

104 Details

104.1 A solid-state motor controller shall be rated as described in Section 62 except a solid state motor controller with reduced voltage starting features shall be rated in horsepower (hp) and FLA (full load current) and shall indicate whether equipment is for direct current or alternating current. The rating for alternating current shall include the number of phases and frequency.

MARKING

105 Details

105.1 Marking shall be in accordance with the requirements in Sections 63 – 65.

105.2 A marking shall be provided specifying that a replacement fuse is to be of the same type and rating as originally supplied. The marking shall be located on or adjacent to the fuseholder or the mounting studs of a fuse that is required to comply with the requirements in Section 101.

PART VII – FLOAT- AND PRESSURE-OPERATED SWITCHES

CONSTRUCTION

106 General

106.1 Float and pressure operated switches shall comply with the construction requirements of Sections 13 – 41 and 107.1 – 107.3.

106.2 A float and pressure operated switch shall comply with the requirements in Section 107, Supply-Connections – Permanently-Connected Devices, or in Section 108, Supply Connections – Cord- and Plug-Connected Devices, as appropriate.

107 Supply Connections – Permanently-Connected Devices

107.1 A pressure switch or similar equipment intended to be supported only by rigid conduit shall be provided with a conduit hub or nipple.

107.2 A pressure switch employing a flare or compression fitting as the pressure connection shall have provision for fastening a conduit hub or nipple unless mounting brackets or holes are provided.

107.3 A conduit hub or nipple attached to the enclosure of a pressure switch or similar equipment by swaging, staking, or similar means shall comply with the pullout, bending, and torque test requirements described in Section 113.

107.4 The effective lead length outside of the float-operated device shall not be less than 4 inches (102 mm).

107.5 The length of a grounding lead, if provided, shall not be less than 6 inches (152 mm). See also 40.2.1 if the lead is insulated.

108 Supply Connections – Cord- and Plug-Connected Devices

108.1 A float-operated, cord-connected device shall be provided with a length of flexible cord and shall be provided with an attachment plug for connection to the branch circuit supply.

108.2 The attachment plug mentioned in 108.1 shall comply with the Standard for Attachment Plugs and Receptacles, UL 498. It shall be of a type suitable for use with a current at least equal to the rated current, and a voltage at least equal to the rated voltage of the device.

PERFORMANCE

109 General

109.1 Float and pressure operated switches shall be subjected to the applicable tests specified in this section. The tests are to be conducted in the sequence indicated in Table 109.1.

Table 109.1
Sequence of tests

Standard reference section	Test	Sample number[a]				
		1	2	3	4	5 – 16
		Sequence	Sequence	Sequence	Sequence	Sequence
43	Temperature	1				
110	Overload		1			
111	Endurance		2			
49	Dielectric Voltage-Withstand	2	3			
112	Pressure			1		
113	Hub and Nipple				1	
114	Sewage Applications					1

[a] All or any combination of sequences may be conducted on a single sample if agreeable to those concerned. More than one sample may be used if more than one rating is being tested. One sequence need not be completed as a prerequisite to the starting of another.

110 Overload Test

110.1 A float- or pressure-operated switch shall perform acceptably when subjected to a test as described in Section 45 on a test circuit having the parameters described in Table 110.1 for ac and dc motor loads and general use ratings. For other ratings, the test circuit shall have parameters described in Table 45.1.

Table 110.1
Parameters for overload test

Device used for	Amperes[a]	Closed test circuit voltage ratio[a]	Power factor	Operations		
				Number	Rate in seconds	
					On	Off
AC Motor Load[b,c]						
Part 1	6	1.1 – 1.0	0.4 – 0.5	50	1	9
Part 2	1.5	1.1 – 1.0	0.75 – 0.8	50	1	9
AC General Use	1.5	1.1 – 1.0	0.75 – 0.8	50	1	9
DC Motor Load[b,c]						
Part 1	10	0.55 – 0.5	d	50	1	9
Part 2	1.5	0.55 – 0.5	d	50	1	9
DC General Use	1.5	1.1 – 1.0	1.0	50	1	9

[a] Ratio of test value to rated value.

[b] If the switch is provided with an overload relay, an adjusting knob, or some similar means of using the switch to open the stalled rotor current of the motor, then the test current, voltage, power factor, operations rate, and number of operation are to be in accordance with Section 45 for an across-the line starter. A float-, lever-, or tool-operated adjustment of a float- or pressure-operated switch is not considered to be a similar means.

Table 110.1 Continued on Next Page

Table 110.1 Continued

Device used for	Amperes[a]	Closed test circuit voltage ratio[a]	Power factor	Operations		
				Number	Rate in seconds	
					On	Off

[c] For devices used for motor loads the overload test is to be conducted in two parts. For part 1, the device shall not be required to break current. Both parts 1 and 2 (100 operations total) shall be conducted on the same sample.
[d] Non-inductive resistance

111 Endurance Test

111.1 A float- or pressure-operated switch shall comply with the requirements of the endurance test as described in Section 46 on test circuits in accordance with Table 111.1 for ac and dc motor load and general use ratings. For other ratings, the test circuit shall have parameters as described in Table 46.1.

Table 111.1
Parameters for endurance test

Device used for	Closed test circuit voltage ratio[a]	Power factor
AC Motor Load[b]	1.1 – 1.0	0.75 – 0.8
AC General Use	1.1 – 1.0	0.75 – 0.8
DC Motor Load[b]	0.55 – 0.5	1.0
DC General Use	1.1 – 1.0	1.0

NOTE – For all devices the:

Make/break current is to be 100 percent of rated current,

Number of operations is to be 6000 cycles,

Each cycle is to be 1 second on and 9 seconds off.

[a] Ratio: test value/rated value.
[b] If the switch is provided with an overload relay, an adjusting knob, or some similar means of causing the switch to open the stalled-rotor current of the motor, then the test current voltage, power factor, operations rate, and number of operations are to be in accordance with Section 45. A float-, lever-, or tool-operated adjustment of a float- or pressure-operated switch is not considered to be a similar means.

112 Pressure Tests

112.1 Parts not contained in an enclosure

112.1.1 A device that is actuated by an external source of pressure and that employs a Bourdon tube, a flexible metal bellows, a diaphragm, or the like rated 300 psig (2069 kPa) or more and not contained within an enclosure, shall withstand for 1 minute, without rupturing, a hydraulic pressure equal to four times the maximum rated operating pressure of the device.

112.1.2 A sample is to be filled with water to exclude air and is to be connected to a hydraulic pump. The pressure is to be raised gradually to the required test pressure. Except as indicated in 112.1.3 – 112.2.3, the sample is to withstand the test pressure for 1 minute without leakage or rupture.

112.1.3 Leakage at a gasket or fitting during the hydrostatic pressure test is acceptable unless it occurs at a pressure that is 50 percent or less of the required test pressure.

112.1.4 If leakage occurs during the test, the test is to be continued to four times the maximum rated operating pressure of the device. If the leakage is due to external fittings, modifications may be made to permit completion of the test.

112.2 Parts contained in an enclosure

112.2.1 A Bourdon tube, a flexible-metal bellows, a diaphragm, or the like rated 300 psig (2069 kPa) or more that is contained within an enclosure shall comply with the requirement in 112.1.1 or shall:

a) Withstand for 1 minute without visible leakage a hydraulic pressure of two times the maximum rated operating pressure; and

b) Except as indicated in 112.2.3, withstand for 1 minute a pressure equal to four times the maximum rated operating pressure of the device without rupture that may result in a risk of injury to persons.

112.2.2 With reference to 112.2.1(b), a Bourdon tube, diaphragm, or bellows may rupture if no part is released outside the enclosure; a joint or a gasket may leak with acceptable results if the required pressure value is reached and maintained for 1 minute. A leaking gasket or flexible member may be replaced by a heavier material to permit the required pressure value to be reached.

112.2.3 With reference to 112.2.1, if leakage becomes excessive so that the four times the maximum operating pressure cannot be reached – that is, if the part functions as if it has a ruptured disc – the part is acceptable if:

a) A pressure of three times the maximum rated operating pressure is maintained;

b) No part capable of causing injury to persons is released outside the enclosure; and

c) It can be demonstrated by test – which may be at a low pressure – or otherwise, that the outer enclosure can either relieve a pressure equal to the maximum rated operating pressure of the device without rupture that presents a risk of injury to persons, or can withstand a pressure equal to the maximum rated operating pressure.

112.2.4 A pressure vessel, an air filter, a piston operator, or similar device shall withstand hydrostatic strength tests consistent with the intended use unless it is certified by the National Board of Boiler and Pressure Vessel Inspectors and bears an ASME Code inspection symbol other than the UM symbol.

113 Hub and Nipple Tests

113.1 General

113.1.1 A conduit hub or nipple shall withstand, without pulling apart, the tests described in 113.2.1 – 113.4.1, each applied in turn for 5 minutes. Some distortion of the enclosure under test is acceptable. The test may be discontinued when noticeable distortion occurs.

113.2 Pullout

113.2.1 The equipment is to be supported by rigid conduit in the intended manner and is to support a weight of 200 pounds (90 kg).

113.3 Bending

113.3.1 The equipment is to be rigidly supported by means other than the conduit fittings. A bending moment of 600 pound-inches (68 N·m) is to be applied to the conduit at right angles to its axis. The lever arm is to be measured from the wall of the enclosure in which the hub or stud is located to the point of application of the bending force.

113.4 Torque

113.4.1 The equipment is to be rigidly supported by means other than the conduit fitting. A torque of 600 pounds-inches (68 N·m) is to be applied to the conduit in a direction tending to tighten the connection. The lever arm is to be measured from the center of the conduit.

114 Sewage Application Tests

114.1 General

114.1.1 A float switch intended for use in a sewage application shall comply with the requirements of this section if the switching mechanism is located where the mechanism may come in contact with the liquid, such as inside the float.

Exception: A float switch having no electrical parts in the float and constructed so that only the float comes in contact with the liquid need not comply with the requirements in this section.

114.2 Immersion

114.2.1 Eleven float switches in the as-received condition are to be conditioned as described in 114.2.2. Within 1 minute after being removed from the conditioning liquid, each switch body and power supply cord is to be examined. The switch body shall not have a visible exposed live part. The power supply cord insulation shall have no visible damage when hand flexed.

114.2.2 One float switch and integral power supply cord, except for the field wiring end of the supply cord, is to be completely submerged in each of the conditioning solutions specified in Table 114.1 for 90 days at 60°C (140°F). If agreeable to those concerned, the samples may be conditioned for 45 days at 70°C (158°F).

Table 114.1
Conditioning liquids

Acetic Acid Solution
Detergent Solution[a]
Distilled Water
Soap Flake Solution[b]
Lard[c]
Corn Oil[c,d]
Sodium Carbonate Solution
Sodium Chloride Solution
Sodium Hydroxide Solution
Sodium Sulfate Solution
Synthetic Urine[e]

NOTE – Unless otherwise stated, conditioning solutions are to contain 5 percent of the specified conditioning liquid and 95 percent distilled or deionized water by weight.

[a] Solution is to contain 2.5 percent powder laundry detergent, 2.5 percent powder dishwashing detergent and 95 percent distilled or deionized water by weight. Tide detergent is an acceptable powder laundry detergent. Any other detergent having the properties of this detergent is also acceptable. Cascade detergent is an acceptable powder dishwashing detergent. Any other detergent having the properties of this detergent is also acceptable.

[b] Ivory is an acceptable soap flake. Any other soap flake having the properties of this soap is also acceptable.

[c] The conditioning solutions containing lard and corn oil shall be continuously moving or mixing so the lard and corn oil do not separate from the water.

[d] Mazola is an acceptable corn oil. Any other corn oil having the properties of this corn oil is also acceptable.

[e] Composed of the following:

Conditioning agent[f]	**Grams per 100 mL of conditioning liquid**
Urea	20.00
Sodium Chloride	10.00
Potassium Chloride	4.20
Sulfuric Acid	1.67
Phosphoric Acid	1.67
Creatinine	0.67
Ammonia	0.47
Uric Acid	0.47
Hippuric Acid	0.47
Magnesium Sulfate	1.63
Calcium Chloride	0.55

[f] Distilled or deionized water is to be added as needed to the conditioning agents listed above to complete the volume of the conditioning liquid.

114.3 Dielectric voltage-withstand

114.3.1 Each float switch tested as described in 114.2.1 and one float switch in the as-received condition with the float removed is to be tested as described in 114.3.2 and 114.3.3. As a result of the test described in 114.3.2, dielectric breakdown shall not occur. As a result of the test described in 114.3.3, the voltage at which dielectric breakdown occurs on the conditioned samples shall not be less than 60 percent of the voltage at which dielectric breakdown occurs on the unconditioned sample. The tests on the conditioned samples are to be completed within 5 minutes after being removed from the conditioning liquid.

114.3.2 A 60 hertz essentially sinusoidal test potential of 1000 volts plus twice rated voltage is to be applied for 1 minute between the conductors of the power supply cord and aluminum foil wrapped tightly around the switch body.

114.3.3 Immediately after the application of the 1 minute test potential specified in 114.3.2, the voltage is to be gradually increased until dielectric breakdown occurs.

114.4 Tensile strength and ultimate elongation

114.4.1 The power supply cord insulation of each float switch tested as described in 114.2.1 is to be subjected to tensile strength and ultimate elongation tests conducted in accordance with the Standard for Gaskets and Seals, UL 157. The tensile strength of each conditioned sample shall not be less than 45 percent of the tensile strength of the unconditioned sample. The ultimate elongation of each conditioned sample shall not be less than 45 percent of the ultimate elongation of the unconditioned sample. The tests on a conditioned sample are to be completed within 20 minutes after being removed from the conditioning liquid.

RATING

115 Details

115.1 A pressure switch shall have the rating required in Section 62, and an operating-pressure rating.

MARKING

116 Details

116.1 A device shall be marked in accordance with the requirements of Sections 63 – 65. In addition, a float switch intended to be used in a sewage application shall be marked with the following or the equivalent: ″SWITCH/CORD ASSEMBLY SUITABLE FOR EXPOSURE TO SEWAGE ENVIRONMENTS.″

PART VIII – SEMICONDUCTOR RELAYS AND SWITCHES

CONSTRUCTION

117 General

117.1 The construction of semiconductor relays and switches shall be in accordance with the requirements of Sections 13 – 41, inclusive.

PERFORMANCE

118 General

118.1 The performance of industrial control relays or switches incorporating semiconductor switches shall be investigated by subjecting a representative sample or samples in commercial form to the tests described in this section. Those tests to be conducted in sequence are specified in Table 118.1. Consideration shall be given to heat sink capability, solid state device ratings, and other criteria in determining representative samples for testing a line of similarly constructed devices.

118.2 Tests are to be conducted at rated frequency and a test potential not less than 120, 208, 240, 277, 480, or 600 volts as appropriate for the voltage rating except that the tests in Section 119 may be conducted at a potential between 90 – 110 percent of the potential specified if the ampere load is adjusted to produce the maximum normal heating, and if the power semiconductors are capable of conduction as intended at the test reduced voltage.

118.3 For the purposes of these requirements, an output section of a programmable control or the like is considered to be a control relay.

Table 118.1
Sequence of tests for semiconductor relays and switches

		Sample number[a]	
		1	2
Standard reference section	Test	Sequence	Sequence
119	Temperature	1	
120	Overvoltage and Undervoltage	2	
121	Overload		1
122	Endurance		2
123	Dielectric Voltage-Withstand	3	3

[a] All or any combination of sequences may be conducted on a single sample if agreeable to those concerned. More than one sample may be used if more than one rating is being tested. One sequence need not be completed as a prerequisite to the starting of another.

119 Temperature Test

119.1 When operating in the normal mode resulting in maximum heating, a semiconductor relay or switch shall not attain a temperature at any point sufficiently high to constitute a risk of fire, to adversely affect any materials or components employed in the device, or exceed, at stabilized temperatures, the temperature rises specified in Table 43.1.

119.2 Insulating material at the junction in lieu of required spacings is considered as operating at the junction temperature. To determine the insulating material temperature, reference temperatures (case, tab, heat sink, or the like) are to be measured and the junction temperature is to be calculated based on the semiconductor manufacturer's power dissipation and thermal resistance data.

119.3 A semiconductor relay or switch is to be tested while carrying the maximum rated current, and while mounted in a normal operating position. Other test conditions are to be as described in Section 43.

120 Overvoltage and Undervoltage Test

120.1 A control that employs an electromagnet shall comply with the Overvoltage and Undervoltage Test, Section 44.

121 Overload Test

121.1 A control relay or switch employing semiconductor switching shall be tested as described in 121.2 and 121.3. There shall be no mechanical or electrical malfunction.

121.2 The control is to be mounted and connected as described in Section 119. The supply voltage is to be 100 to 110 percent of rated voltage, the load current is to be as described in 121.3, and the control is to be operated for 50 operations without mechanical or electrical malfunction at a rate of 6 cycles per minute and with a minimum on time of 1 second. For controls with multiple ratings, a sufficient number of tests are to be conducted to cover the conditions of maximum voltage, maximum current, and maximum power ratings.

Exception: The test may be conducted at a faster rate if agreeable to all concerned parties and if the minimum on time is 1 second.

121.3 With reference to 121.2, the test load is to be in accordance with the following appropriate for the rating:

a) General Use Ampere Rating and Tungsten Lamp Rating – The load is to be 150 percent of rated current with a 0.75 to 0.80 power factor at rated voltage.

b) Resistive Ampere Rating – The load is to be 150 percent of rated current with power factor of 1.0 at rated voltage.

c) Pilot Duty Rating – See Section 137.

d) Electric Discharge Lamp Rating – The load is to be three times rated current at a power factor of 0.40 to 0.50.

122 Endurance Test

122.1 The equipment shall comply with the applicable endurance test requirements in Section 46.

Exception: If the endurance test is to be conducted at rated current and there is no inrush current, the endurance test need not be conducted.

123 Dielectric Voltage-Withstand Test

123.1 The equipment shall comply with the dielectric voltage withstand test requirements described in Section 97.

124 Breakdown of Components Test

124.1 A semiconductor relay or switch shall comply with the requirements in Section 57.

RATING

125 Details

125.1 Industrial control relays or switches incorporating semiconductor switching shall be rated in volts; and in amperes, volt-amperes, watts, or any combination thereof; and frequency if frequency sensitive.

MARKING

126 General

126.1 The equipment shall be marked in accordance with the requirements of Sections 63 – 65.

PART IX – MERCURY TUBE SWITCHES

CONSTRUCTION

127 General

127.1 A mercury tube switch shall comply with the requirements in Sections 13 – 41.

127.2 A mercury tube switch shall be acceptable for the intended application. The tube shall be firmly supported and mounted inside an acceptable material. Wire leads shall be as short as possible and shall be terminated with eyelets, or the equivalent, at terminal plates on the supporting base.

PERFORMANCE

128 General

128.1 A mercury tube switch shall be subjected to the tests specified in this section. Tests that are to be conducted in sequence are specified in Table 128.1.

Table 128.1
Sequence of tests for mercury tube switch

Standard reference section	Test	Sample number[a]		
		1	2	3
		Sequence	Sequence	Sequence
43	Temperature	1		
44	Overvoltage and Undervoltage	2		
45	Overload		1	
46	Endurance		2	
49	Dielectric Voltage – Withstand	3	3	
50	Short Circuit – General			1

[a] All or any combination of sequences may be conducted on a single sample if agreeable to those concerned. More than one sample may be used if more than one rating is being tested. One sequence need not be completed as a prerequisite to the starting of another.

129 Overvoltage and Undervoltage Test

129.1 A device using electromagnetic switching components shall comply with the Overvoltage and Undervoltage Test, Section 44.

130 Short Circuit Test

130.1 When short circuit tested as described in 130.2 – 130.4, equipment employing a mercury tube switch intended for connection to a line-voltage circuit shall not:

a) Ignite the cotton indicator or insulation on circuit conductors;

b) Emit flame or molten metal except for mercury from the enclosure housing the switch; or

c) Sustain damage to wiring except for the tube leads.

130.2 The equipment is to be in series with a standard, nonrenewable cartridge fuse on a direct-current circuit, except that alternating current with a resistive load may be employed if the device is intended for use on alternating current only. The fuse rating and capacity of the test circuit are to be as specified in Table 130.1.

Table 130.1
Mercury switch short-circuit test conditions

Volts	Maximum rating	Short-circuit current, amperes	Minimum fuse current rating in amperes at least equal to switch ampere rating, or the nearest standard fuse[a] not exceeding four times motor full-load ampere rating but not less than:		
			Volts		
			0 – 125	126 – 250	251 – 600
0 – 250	2000 volt-ampere	1000	20	15	–
0 – 250	30 ampere	3500	30	30	–
0 – 250	60 ampere	3500	60	60	–
0 – 250	Over 60 ampere	5000	b	b	–
251 – 600	Unlimited	5000	–	–	30

[a] For the purpose of this test, standard ampere ratings for fuses are 15, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, 90, 100, 110, 125, 150, 175, 200, 225, 250, 300, 350, 400, 450, 500, 600, 601, 700, 800, 1000, and 1200.
[b] Fuse size as specified in heading.

130.3 To determine if a mercury tube switch complies with the requirements in 130.1, each of three samples is to be operated three times with sufficient time between successive operations on any one sample to permit cooling to room temperature, unless the switch is damaged so as to open the circuit permanently before the specified number of tests is conducted. The switch need not operate as intended after the tests.

130.4 The enclosure and any other exposed metal are to be grounded, and the cotton is to be placed around all openings in the enclosure. Successive operations are to be conducted by alternatively closing the short circuit on the mercury-tube switch and closing the mercury-tube switch on the short circuit by means of a switching device.

RATING

131 Details

131.1 A mercury-tube switch shall be rated in accordance with the applicable requirements in Section 64.

MARKING

132 Details

132.1 A mercury-tube switch shall be marked in accordance with the applicable requirements in Sections 63 – 65.

PART X – AUXILIARY DEVICES

CONSTRUCTION

133 General

133.1 An auxiliary device shall be constructed in accordance with Sections 13 – 41. See 133.2.

133.2 A cord-connected auxiliary device shall comply with the requirements in 25.6.

Exception: A power-supply cord intended for outdoor use other than an application in a 6 or 6P environment is acceptable if the cord complies with the Power-Supply Cord Tests, Section 206.

PERFORMANCE

134 General

134.1 An auxiliary device shall be subjected to the tests specified in Table 134.1 in the sequence indicated.

Table 134.1
Sequence of tests for auxiliary devices

		Sample number[a]	
		1	2
Standard reference section	Test	Sequence	Sequence
135	Temperature	1	
44	Overvoltage and Undervoltage	2	
137	Overload		1
138	Endurance		2
49	Dielectric Voltage-Withstand	3	3

[a] All or any combination of sequences may be conducted on a single sample if agreeable to those concerned. More than one sample may be used if more than one rating is being tested. One sequence need not be completed as a prerequisite to the starting of another.

134.2 An auxiliary device that complies with the requirements for across-the-line motor starting of an alternating-current motor is acceptable for alternating-current pilot duty without further tests provided that the overload test current is at least 150 percent of the pilot-duty inrush current at the same voltage and the power factor is 0.5 or less. For Codes A, B, and C, and for devices with ratings not expressed using

codes, the pilot-duty inrush current (make) is ten times the steady state current value (break); and, for Codes D and E, the pilot-duty inrush current (make) is six times the steady state current value (break). The relationship between horsepower ratings and equivalent control circuit contact ratings is shown in Table 134.2.

Table 134.2
Horsepower rated switches used in control circuits

Switch rating single phase horsepower	Maximum rating of coil, volt-amperes	Equivalent control circuit contact rating code[a]
1	720	A150, A300, A600
1/2	360	B150, B300, B600
1/8	180	C150, C300
1/10	72	D150, D300

[a] See Section 134.

134.3 A supplementary fuse that is to be used to protect the power switching semiconductor of a solid state output device may be replaced with a copper dummy fuse for the overload and endurance tests in Sections 137 and 138.

134.4 For the overload and endurance tests in Sections 137 and 138, a four terminal device marked for use at the same polarity (see 140.4) is to be connected for test as specified in the top illustration in Figure 134.1 and a four terminal device not marked for use at the same polarity is to be connected for test as specified in the bottom illustration in Figure 134.1 with opposite polarity applied between poles. Two separate tests are to be conducted. The first test is to be conducted with only load A connected to the device followed by a second test with only load B connected.

135 Temperature Test

135.1 An auxiliary device shall carry continuously a current of 10 amperes without showing the temperature rises greater than those specified in Table 43.1.

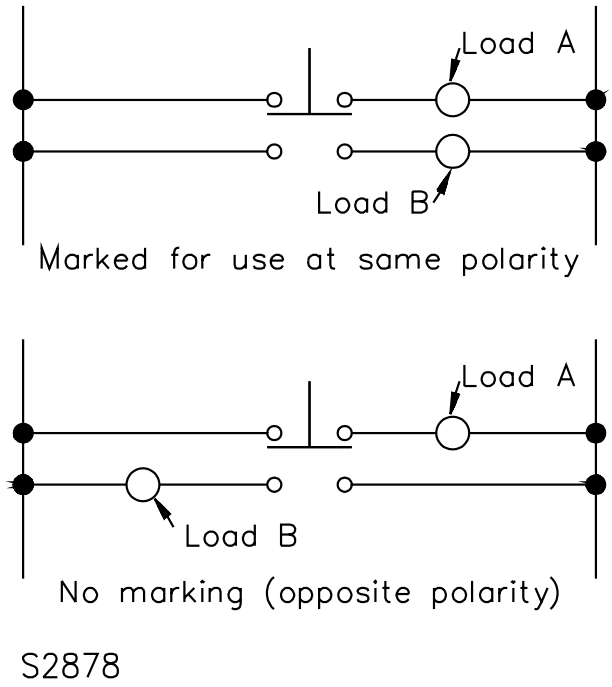
Exception No. 1: A device intended for standard duty applications as shown in Table 137.1 is to be tested using a current of 5 amperes if it is marked to indicate a 5-ampere thermal continuous test current rating as defined in Table 139.1.

Exception No. 2: A control device marked with a code designation is to be tested at the thermal continuous test current for the contact rating designation given in Tables 139.1 and 139.2.

Exception No. 3: A pushbutton station or other auxiliary device that is marked with a minimum as well as a maximum voltage rating along with a volt-ampere rating, or the equivalent, may be tested at its highest calculated steady-state-current value, which is the volt-ampere rating divided by the minimum voltage rating.

135.2 The temperature test is to be in accordance with Section 43, except that the test current is to be determined in accordance with 135.1.

Figure 134.1
Four terminal device connection



136 Overvoltage and Undervoltage Test

136.1 A device using electromagnetic switching components shall comply with the Overvoltage and Undervoltage Test, Section 44.

137 Overload Test

137.1 As a result of an overload test consisting of 50 operations of making and breaking a circuit of 110 percent of the maximum rated voltage, there shall be no:

a) Electrical or mechanical breakdown of the device;

b) Undue burning or pitting of the contacts; or

c) Welding of the contacts.

137.2 A load representative of the load that the device is intended to control shall be one of the following types:

a) An electromagnetic load that is to be the applicable value specified in Table 137.1, 139.1, or 139.2; or

b) An electromagnetic load other than one of those specified in the tables, the value to be based upon consideration of the need for a device to control an electromagnet having other characteristics, the means utilized for matching the rating of the device to that of the load, and the completeness of the rating marking. Unless known, the ac pilot-duty inrush current is to be ten times the steady state current.

137.3 In lieu of the electromagnetic loads described in 137.2, an air core inductive load may be used to produce the normal (break) and inrush (make) currents as required in Table 137.1, 139.1, or 139.2 provided the duration of the inrush (make) current is at least 2 cycles at 50 or 60 hertz.

137.4 An air-core inductive load in any phase may be connected in parallel with a resistor if the resistor (R_{SH}) power consumption is approximately 3 percent of the total power consumption in that phase calculated in accordance with the following formula:

$$R_{SH} = 33.3\left(\frac{1}{PF} - PF\right)\frac{E}{I}$$

in which:

PF is the power factor;

E is the closed-circuit phase voltage; and

I is the phase current.

137.5 If an auxiliary device is integral with a controller, the test is to be conducted with the intended electromagnet as the load.

137.6 The overload test on an overload relay is to consist of 50 cycles of operation at 110 percent of the maximum voltage specified in Table 42.2 on the control-circuit contacts, using the largest electromagnet of the contactor with which the relay will be used, or the manufacturer's marked rating, whichever is greater.

Table 137.1
Standard loads for control-circuit devices

Normal potential	Standard duty codes B & P		Heavy duty codes A & N	
	Normal current	Current inrush	Normal current	Current inrush
110 – 120 a-c[a] volts	3.0	30	6.0	60
220 – 240 a-c[a]	1.5	15	3.0	30
440 – 480 a-c[a]	0.75	7.5	1.5	15
550 – 600 a-c[a]	0.6	6	1.2	12
115 – 125 d-c[b]	1.1	–	2.2	–
230 – 250 d-c[b]	0.55	–	1.1	–
550 – 600 d-c[b]	0.2	–	0.4	–

[a] Power factor 0.35 or less.

[b] Inductive loads as specified in Section 125 of Industrial Control Devices, Controllers, and Assemblies, ANSI/NEMA ICS2-1993.

137.7 Each test cycle is to be 1 second on and 9 seconds off if the operation of the device is such that the test can be so conducted.

137.8 The load is set to conform with Table 137.1, 139.1, or 139.2 at rated potential and then the voltage is increased 10 percent without further adjustment of the load.

138 Endurance Test

138.1 As a result of an endurance test consisting of 6000 cycles of operation of making and breaking a test circuit of maximum rated voltage, there shall be no:

a) Electrical or mechanical breakdown of the device;

b) Undue burning or pitting of the contacts; or

c) Welding of the contacts.

138.2 The first 1000 cycles are to be at the rate of 1 cycle per second, except that the first 10 to 12 operations are to be made as rapidly as possible; and the remaining 5000 cycles are to be at the rate of 6 cycles per minute, with the device closed for approximately 1 second each cycle. The load is to consist of an electromagnet representative of the load that the device is intended to control. The load characteristics are to be as specified in 137.2.

Exception No. 1: If a control device is integral with the controller, the endurance test may be conducted with the intended electromagnet of the controller as the load.

Exception No. 2: To allow acceleration of the test, and with agreement of all concerned, the remaining 5000 cycles may be conducted at a rate of 1 cycle per second, or at any other rate that can be shown to be at least as severe on the switch as the normal rate of 6 cycles per minute.

RATING

139 Details

139.1 The rating of an auxiliary device shall indicate the voltage and whether it is intended for standard or heavy duty.

Exception No. 1: The rating may be in the form of a code designation in accordance with Table 139.1 or 139.2, as applicable.

Exception No. 2: The rating of an auxiliary device may be in volts, amperes, and inrush amperes; volts and volt-amperes; or volts, amperes, and the words "pilot duty".

Table 139.1
Rating codes for a-c control-circuit contacts at 50 and 60 hertz

Contact rating code designation[a]	Thermal continuous test current amperes	Maximum current, amperes[b]								Maximum volt-amperes	
		120 Volt		240 Volt		480 Volt		600 Volt			
		Make	Break	Make	Break	Make	Break	Make	Break	Make	Break
A150	10	60	6.00	–	–	–	–	–	–	7200	720
A300	10	60	6.00	30	3.00	–	–	–	–	7200	720
A600	10	60	6.00	30	3.00	15	1.50	12	1.20	7200	720
B150	5	30	3.00	–	–	–	–	–	–	3600	360
B300	5	30	3.00	15	1.50	–	–	–	–	3600	360
B600	5	30	3.00	15	1.50	7.50	0.75	6	0.60	3600	360
C150	2.5	15	1.5	–	–	–	–	–	–	1800	180
C300	2.5	15	1.5	7.5	0.75	–	–	–	–	1800	180
C600	2.5	15	1.5	7.5	0.75	3.75	0.375	3.00	0.30	1800	180
D150	1.0	3.60	0.60	–	–	–	–	–	–	432	72
D300	1.0	3.60	0.60	1.80	0.30	–	–	–	–	432	72
E150	0.5	1.80	0.30	–	–	–	–	–	–	216	36

[a] The numerical suffix designates the maximum voltage design values, which are to be 600, 300, and 150 volts for suffixes 600, 300, and 150, respectively. The test voltage is to be 600, 240, or 120 volts.

[b] For maximum ratings at voltages between the maximum design value and 120 volts, the maximum make and break ratings are to be obtained by dividing the volt-amperes rating by the application voltage. For voltages below 120 volts, the maximum make current is to be the same as for 120 volts, and the maximum break current is to be obtained by dividing the break volt-amperes by the application voltage, but these currents are not to exceed the thermal continuous test current.

Table 139.2
Rating codes for d-c control-circuit contacts

Contact rating code designation[a]	Thermal continuous test current, amperes	Maximum make or break[b] current, amperes			Maximum make or break volt-amperes at 300 volts or less
		125 Volt	250 Volt	301 to 600 Volt	
N150	10	2.2	–	–	275
N300	10	2.2	1.1	–	275
N600	10	2.2	1.1	0.40	275
P150	5.0	1.1	–	–	138
P300	5.0	1.1	0.55	–	138
P600	5.0	1.1	0.55	0.20	138
Q150	2.5	0.55	–	–	69
Q300	2.5	0.55	0.27	–	69
Q600	2.5	0.55	0.27	0.10	69
R150	1.0	0.22	–	–	28
R300	1.0	0.22	0.11	–	28

[a] The numerical suffix designates the maximum voltage design values, which are to be 600, 300, and 150 volts for suffixes 600, 300, and 150 respectively. Test voltage shall be 600, 250, or 125 volts.

[b] For maximum ratings at 300 volts or less, the maximum make and break ratings are to be obtained by dividing the volt-ampere rating by the application voltage, but the current values are not to exceed the thermal continuous test current.

MARKING

140 Details

140.1 Marking shall be in accordance with the requirements in Sections 63 – 65 and this section.

140.2 Individual contact blocks of a pushbutton or selector switch unit shall be marked to indicate the operators with which they are intended to be used unless the switch unit has been found acceptable for use with all operators to which they may be assembled that are made available by the manufacturer.

140.3 If the marked ratings are the code designations specified in Tables 139.1 and 139.2, the information concerning the voltage and overload current ratings for each code designation shall be published in a catalog, contained on a marking sheet packed with the product, or be otherwise available to the user.

140.4 A four terminal device intended to be used at the same polarity shall be marked to indicate this intent.

PART XI – MECHANICAL OVERLOAD RELAYS

CONSTRUCTION

141 General

141.1 An overload relay shall be constructed in accordance with the requirements of Sections 13 – 41 and 141.2.

141.2 The tripping of an overload relay shall be independent of the manipulation of the operating handle and, when tripped, it shall not be possible to close the contacts by operating the reset mechanism.

PERFORMANCE

142 General

142.1 Overload relays shall be subjected to the tests described in this section. Tests to be conducted in sequence are as specified in Table 142.1. The calibration test described in Section 48 and the short circuit test described in Section 50 are to be conducted.

Table 142.1
Sequence of test for mechanical overload relays

Table 142.1 revised July 16, 1999

Standard reference section	Test	Sample number[a]			
		1	2	3	4
		Sequence	Sequence	Sequence	Sequence
43	Temperature	1			
143	Overload		1		
144	Endurance		2		
49	Dielectric Voltage-Withstand	2	3		
50	Short Circuit – General			1	
48	Calibration				1

[a] All tests or any combination of test sequences are able to be conducted on a single sample when agreeable to those concerned. When more than one rating is being tested, more than one sample is able to be used. One sequence is not required to be completed as a prerequisite to the starting of another.

143 Overload Test

143.1 There shall be no electrical or mechanical breakdown of the device nor any undue burning or undue pitting or welding of the contacts as a result of an overload test as described in 143.2 – 143.9.

143.2 The test specified in 142.1 is to consist of 50 operations, making and breaking a circuit of 110 percent of the maximum rated voltage. The load is to consist of an electromagnet representative of the load that the device is intended to control. The loads are to be those specified in Table 137.1, 139.1, or 139.2, as applicable.

Exception: A load other than one of those specified in the tables may be used after consideration of the need for a device to control an electromagnet having other characteristics, the means utilized for matching the rating of the device to that of the load, and the completeness of the rating marking.

143.3 The device is to be thermally operated, unless the contacts are snap acting and the construction is such that mechanical operation is possible.

143.4 A device that has been found to comply with the requirements for across-the-line motor starting of an alternating-current motor is acceptable for alternating-current pilot duty without further tests provided that the overload test current is at least 150 percent of the pilot-duty inrush current at the same voltage and the power factor is 0.5 or less. For Codes A, B and C, the pilot-duty inrush current (make) is ten times the steady state current value (break); and for Codes D and E, the pilot-duty inrush current (make) is six times the steady state current value (break).

143.5 If a device is integral with a controller, the test is to be conducted with the electromagnet as the load.

143.6 The overload test on an overload relay is to consist of 50 cycles of operation at the applicable voltage specified in Table 42.2 on the control-circuit contacts, using the largest electromagnet of the contactor with which the relay will be used, or the manufacturer's marked rating, whichever is greater.

143.7 The test cycle rate is to be 1 second on and 9 seconds off if the operation of the device is such that the test can be so conducted.

143.8 The load is to be set to conform with Table 137.1, 139.1, or 139.2 at the rated potential and then the voltage is to be increased 10 percent without further adjustment of the load.

143.9 Four terminal devices are to be connected for test as indicated in Figure 134.1.

144 Endurance Test

144.1 If the control-circuit contacts of an overload relay may be automatically reset, the contacts shall perform acceptably when subjected to a 6000-cycle endurance test at rated voltage following the overload test methods described in 143.1 and Section 137.

RATING

145 Details

145.1 The rating of the contacts of an overload relay shall indicate the voltage and whether it is intended for standard or heavy duty.

Exception No. 1: The rating may be in the form of a code designation in accordance with Table 139.1 or 139.2, as applicable.

Exception No. 2: The rating of the device may be in volts, amperes, and inrush amperes.

MARKING

146 Details

146.1 Overload relays shall be marked in accordance with Sections 63 – 65, and as described in 146.2 – 146.12.

146.2 With reference to 48.2(c), an overload relay or the controller with which an overload relay is used shall be marked to indicate the relay class designation in accordance with Table 146.1.

Table 146.1
Marking designation for tripping time at 600 percent of the current element rating

Class designation[a]	Tripping time, seconds
Class 10	10
Class 20[b]	20
Class 30	30

[a] Class designations in excess of 30 seconds may be used, with the tripping time in seconds equal to the numerical class marking.
[b] Class 20 need not be marked.

146.3 Marking of overload relays required by 146.2 may be provided on the current element table that is provided on or with the product.

146.4 The ampere rating – tripping current – of an overload relay shall be marked on the relay if a noninterchangeable element is employed.

Exception: The tripping current may be marked on a table furnished with the relay if the relay is marked with a code designation, and the tripping current is specified for the code designation of the relay. See 146.6 – 146.10.

146.5 The outside ambient temperature of 40°C (104°F) on which the rating of an overload relay is based shall be marked along with the tripping current.

Exception: This requirement does not apply to an ambient-compensated overload relay.

146.6 For an overload relay intended to accommodate current elements of the interchangeable type, each element shall be marked with the ampere rating – tripping current – of the relay, or shall bear a code marking as described in 146.7 – 146.10.

146.7 If code markings are employed on current elements, the overload relay shall be furnished with the table that includes a column giving full-load motor currents, with an explanation of the protection afforded, such as 115 or 125 percent; a column giving the corresponding code markings that appear on the elements; and a column giving ampere ratings – tripping currents – for the complete device corresponding to the various elements available, or an explanation as to how the tripping currents may be determined from full-load motor current values.

146.8 The table referred to in the exception to 146.4 and in 146.7 shall include information for a current element rated for use at the maximum marked rating of the associated controller.

146.9 If an ampere rating is provided as a part of the marking on the controller, the overload relay rating shall be equal to or greater than the ampere rating.

146.10 The table referred to in the exception to 146.4 and in 146.7 shall not include any current element or overload relay that is not intended to be used with the associated controller.

Exception No. 1: A table may cover more than one size of controller or may cover the use of one, two, or three overcurrent relays or heater elements when that table is clearly marked to indicate the limits of its use.

Exception No. 2: A resistance- or autotransformer-type controller, a combination controller, or a similar device intended for limited horsepower rating may be provided with a table covering the elements furnished as if the limiting feature were not present.

146.11 A combination manual or automatic-reset overload relay shall be marked to indicate whether the relay is set in either the manual or automatic position.

146.12 An adjustable overload relay shall be provided with instructions for such adjustment.

146.13 The table referred to in the exception to 146.4 and in 146.7 shall be secured to enclosed equipment and shall be furnished with open types.

PART XII – ELECTRONIC OVERLOAD RELAYS

CONSTRUCTION

147 General

147.1 An electronic overload relay shall comply with the applicable requirements in Sections 12 – 41.

147.2 An overload relay shall be complete. A current transformer intended for use with an overload relay shall be supplied with it or the relay shall be marked as specified in 154.2.

147.3 An overload relay providing ground-fault sensing shall comply with the applicable requirements in the Standard for Ground-Fault Sensing and Relaying Equipment, UL 1053.

PERFORMANCE

148 General

148.1 An overload relay shall comply with the applicable performance requirements in Sections 42 – 60 of this standard in addition to the tests described in 149.1 – 152.1. See Table 148.1.

148.1 revised July 16, 1999

Table 148.1
Sequence of tests – electronic overload relays

Table 148.1 added July 16, 1999

Standard reference section	Test	Sample number[a]			
		1	2	3	4
		Sequence	Sequence	Sequence	Sequence
43	Temperature	1			
49	Dielectric Voltage-Withstand	2	3		
143	Overload		1		
144	Endurance		2		
149 or 150	Short Circuit for Devices Provided with a Current Transformer or Short Circuit for Devices not Provided with a Current Transformer			1	
151	Calibration			2	
152	Breakdown of Components				1

[a] All tests or any combination of test sequences are able to be conducted on a single sample when agreeable to those concerned. When more than one rating is being tested, more than one sample is able to be used. One sequence is not required to be completed as a prerequisite to the starting of another.

149 Short-Circuit Test for Devices Provided with a Current Transformer

149.1 An overload relay shall comply with the short circuit test specified in Section 50. If the overload relay current transformer can be shown to saturate at less than the specified short-circuit current, the short-circuit test specified in Section 50 may be conducted at the level at which the current transformer saturates.

150 Short-Circuit Test for Devices Not Provided with a Current Transformer

150.1 An overload relay not provided with a current transformer – see 154.2 – shall comply with the short circuit test specified in Section 50 using the maximum current that can be applied to the input of the overload relay that is specified by the manufacturer.

151 Calibration Test

151.1 After the short-circuit tests in 149.1 and 150.1, the device shall comply with the calibration test specified in Section 48.

152 Breakdown of Components Test

152.1 There shall be no emission of flame or molten metal nor ignition of cheesecloth indicators that have been loosely draped over all openings of ventilated devices or totally around open devices when capacitors, diodes, or other solid-state components are short-circuited or open-circuited individually.

RATING

153 Details

153.1 The rating of an electronic overload relay shall comply with the applicable requirements in Section 145.

153.2 The rating of the current transformer shall be expressed in amperes and frequency, and the turns ratio.

No Text on This Page

MARKING

154 Details

154.1 An electronic overload relay shall be marked in accordance with the applicable requirements in Section 146.

154.2 If the overload relay is not provided with the intended current transformer, the overload relay shall be marked with the model or catalog number, turns ratio, maximum signal (current) that can be applied to the input of the overload relay, and the name of the manufacturer of the intended current transformer.

154.3 A current transformer of an overload relay shall be marked with a model or catalog number, the rating as indicated in 153.2, and the name of the manufacturer. The marking shall be visible after installation.

PART XIII – DEFINITE PURPOSE CONTROLLERS

CONSTRUCTION

155 General

155.1 A controller for special use such as for heating and air conditioning equipment shall comply with the applicable requirements in Sections 13 – 41. See 159.1.

PERFORMANCE

156 General

156.1 The performance requirements for a definite purpose controller will vary in accordance with the intended use.

156.2 Definite purpose controllers shall be subjected to the test indicated in Table 156.1. The table indicates those tests which are to be conducted in a particular sequence.

Table 156.1
Sequence of tests for definite purpose controllers

Standard reference section	Test	Sample number[a]					
		1	2	3	4	5	6
		Sequence	Sequence	Sequence	Sequence	Sequence	Sequence
43	Temperature	1					
44	Overvoltage and Undervoltage	2					
158	Overload		1				
159	Endurance		2				
160	Locked-Rotor Endurance			1			
161	Part Winding Endurance				1		
49	Dielectric Voltage-Withstand	3	3	2	2		

Table 156.1 Continued on Next Page

Table 156.1 Continued

Standard reference section	Test	Sample number[a]					
		1	2	3	4	5	6
		Sequence	Sequence	Sequence	Sequence	Sequence	Sequence
48	Calibration					1	
162	Short Circuit						1

[a] All or any combination of sequences may be conducted on a single sample if agreeable to those concerned. More than one sample may be used if more than one rating is being tested. One sequence need not be completed as a prerequisite to the starting of another.

157 Overvoltage and Undervoltage Test

157.1 A device using electromagnetic switching components shall comply with the Overvoltage and Undervoltage Test, Section 44.

158 Overload Test

158.1 A definite purpose controller shall perform acceptably when subjected to a test consisting of making and breaking a test circuit having the parameters described in Table 45.1 for Across-the-Line AC Motor Starting devices, except the make and break test currents are to be the rated locked rotor ampere current rating (LRA). All other test methods and conditions are to be as described in Overload Test, Section 42.

159 Endurance Test

159.1 A definite purpose controller shall perform acceptability when subjected to a test consisting of making and breaking a test circuit having the parameters described in Table 46.1 for AC General Use devices, except the make and break test currents are to be the rated full load ampere current rating (FLA). All other test methods and conditions are to be as described in Endurance Test, Section 46.

159.2 The endurance test for a definite purpose controller intended for use in electric heating applications shall be the same as described in 159.1 except they shall be operated for 100,000 cycles.

159.3 If a device requiring an endurance test of 30,000 cycles has two or more electrical ratings, it may be tested for at least 7500 cycles at each rating, but any one sample is not to be subjected to more than 30,000 cycles. At least one sample is to be tested for 30,000 cycles.

159.4 The endurance test for a definite purpose controller intended for use in air conditioning applications shall be the same as described in 159.1 except they shall be operated for 30,000 cycles.

159.5 If a device requiring an endurance test of 100,000 cycles has two or more electrical ratings – for example, different currents at different voltages – it may be tested for not less than 25,000 cycles at each rating, but the total number of cycles on any one sample is not to be more than 100,000. At least one sample is to be tested for 100,000 cycles.

160 Locked Rotor Endurance Test

160.1 A controller cycled by the operation of an automatic-reset overload device shall perform acceptably when subjected to a locked rotor endurance test consisting of 6000 cycles of making and breaking the locked rotor current specified by the manufacturer at a test voltage of 120, 240, 480, or 600 volts, depending upon the rating of the control. The remainder of the test conditions is to be as specified in Overload Test, Section 45.

160.2 For the first 5900 cycles, the on time is to be 1 second with an off time to provide the on/off ratio specified by the manufacturer. For the last 100 cycles, the on time is to be the maximum on time specified by the manufacturer and a corresponding off time to provide the specified on/off ratio.

160.3 The power factor is to be 0.40 – 0.50.

161 Part Winding Endurance Test

161.1 A controller for a 3-phase hermetic refrigerant motor-compressor equipped with a part winding motor of the type in which one-half of the winding is energized through a controller and, subsequently or simultaneously through a second controller, the remaining half is energized so that both halves carry the same running current, shall be tested for the application as shown in Table 161.1 or 161.2. If the circuit does not contain a feature to delay the energization of the second controller, Table 161.1 shall be used for both controllers. If the circuit is provided with a feature to delay the energization of the second controller, Table 161.2 shall be used for the first controller and Table 161.1 shall be used for the second (delayed) controller. The controller shall comply with these requirements in addition to the requirements for the device.

Exception: Table 161.1 may be used in lieu of Table 161.2 if the controller is in compliance with the Locked Rotor Endurance Test, Section 160.

Table 161.1
Endurance test for simultaneously energized controllers

Make amperes	Break amperes	Power factor		Number of test operations	Operation rate, seconds	
		Make	Break		On	Off
FLA[a]	LRA[a]	0.75 – 0.80	0.4 – 0.5	30,000	1	9

[a] Rating of the winding controlled.

Table 161.2
Endurance test for second controller delayed applications

Make amperes	Break amperes	Power factor		Number of test operations	Operation rate, seconds	
		Make	Break		On	Off
LRA[a]	LRA[a]	0.4 – 0.5	0.4 – 0.5	30,000	1	9

[a] Rating of winding controlled.

162 Short Circuit Test

162.1 Short circuit tests are to be conducted in accordance with Section 50.

Exception: The protective device used for the tests need not exceed 225 percent of the full load current and fuses need not be of the time delay type.

162.2 The short circuit test current is to be as specified in Table 162.1. If the locked rotor current falls between the values in the table, the higher current, horsepower rating, and corresponding short circuit test current are to be used.

Table 162.1
Short circuit test current

Motor locked rotor current, amperes						Maximum horsepower rating (kW)		Short-circuit test current amperes
Single phase voltage		Two or three phase voltage						
110 – 120	220 – 240	10 – 120	220 – 240	440 – 480	550 – 600			
58.8	29.4	24	12	6	4.8	1/2	(0.4)	1000
82.8	41.4	33.6	16.8	8.4	6.6	3/4	(0.6)	1000
96.0	48	43.2	21.6	10.8	8.4	1	(0.7)	1000
120	60	62	31.2	15.6	12.6	1-1/2	(1.1)	5000
144	72	81	40.8	20.4	16.2	2	(1.5)	5000
204	102	–	58	26.8	23.4	3	(2.2)	5000
336	168	–	91	45.6	36.6	5	(3.7)	5000
480	240	–	132	66	54	7-1/2	(5.6)	5000
600	300	–	168	84	66	10	(7.5)	5000
–	–	–	252	126	102	15	(11.2)	5000
–	–	–	324	162	132	20	(14.9)	5000
–	–	–	408	204	162	25	(18.6)	5000
–	–	–	480	240	192	30	(22.4)	5000
–	–	–	624	312	246	40	(29.8)	5000
–	–	–	780	390	312	50	(37.3)	5000
–	–	–	924	462	372	60	(44.7)	10,000
–	–	–	1152	576	462	75	(55.9)	10,000
–	–	–	1488	744	594	100	(74.6)	10,000
–	–	–	1872	936	750	125	(93.2)	10,000
–	–	–	2160	1080	864	150	(111.9)	10,000
–	–	–	2880	1440	1152	200	(149.1)	10,000

[a] For 200 and 208 volt motor ratings, increase the locked rotor current by 15 and 10 percent, respectively, of the values in the 220 – 240 volt column.

RATING

163 Details

163.1 A definite purpose controller shall be rated in full load and locked rotor amperes or nonmotor load amperes, volts, and frequency. The rating shall include the number of phases unless the controller is obviously intended for single phase use.

MARKING

164 Details

164.1 The marking shall comply with 63.1 and 63.4.

PART XIV – SERVICE EQUIPMENT

165 General

165.1 Enclosed industrial control equipment intended for use as service equipment shall comply with the applicable construction requirements in Sections 13 – 41 and in addition shall comply with the requirements in the Reference Standard for Service Equipment, UL 869A.

165.2 Industrial control equipment intended for use as service equipment shall comply with the requirements for the size of a grounding electrode conductor and main bonding jumper contained in the appropriate table in the Reference Standard for Service Equipment, UL 869A, and in addition, 100, 310, and 600 service equipment ampere ratings shall be included which use the same conductor and jumper sizes as the 125, 400, and 800 ampere ratings, respectively.

165.3 The value of the service equipment ampere rating for determining the size of a grounding electrode conductor and main bonding jumper contained in the appropriate table of the Reference Standard for Service Equipment, UL 869A shall be determined in accordance with 25.5.1 of this standard.

PART XV – LAMP DIMMERS

CONSTRUCTION

166 General

166.1 A lamp dimmer shall be constructed in accordance with the requirements in Sections 13 – 41.

PERFORMANCE

167 General

167.1 The performance of an industrial lamp dimmer shall be investigated by subjecting a representative sample or samples in commercial form to the tests specified in Table 167.1. Some tests are required to be conducted in sequence as specified in Table 167.1. Consideration shall be given to such items as heat sink capability and solid state device ratings in determining samples for representative testing of a line of similarly constructed dimmers.

167.2 Tests shall be conducted at rated frequency and a test potential not less than 120, 208, 240, 277, 480, or 600 volts as appropriate for the voltage rating except that the tests in 168.1 – 168.3 may be conducted at a potential between 90 – 110 percent of the potential specified if the ampere load is adjusted to produce the maximum normal heating, and if the power semiconductors are capable of conduction as intended at the reduced test voltage.

Table 167.1
Sequence of tests for lamp dimmers

Test reference	Test	Sample number[a]	
		1	2
		Sequence	Sequence
168.1 – 168.3	Temperature	1	
170.1 and 170.2	Overload		1
Section 97	Dielectric Voltage-Withstand	2	2

[a] All or any combination of sequences may be conducted on a single sample if agreeable to those concerned. More than one sample may be used if more than one rating is being tested. One sequence need not be completed as a prerequisite to the starting of another.

168 Temperature Test

168.1 When operating in the normal mode resulting in maximum heating and as described below, a lamp dimmer shall not attain a temperature at any point sufficiently high to constitute a risk of fire, to adversely affect any materials or components employed in the device, or exceed, at stabilized temperatures, the temperature rises specified in Tables 43.1 and 174.1. The temperatures shall be adjusted for a 40°C (104°F) ambient.

168.2 An industrial dimmer intended to control an incandescent lamp load is to be tested controlling a resistive or tungsten filament lamp load adjusted to result in maximum rated dimmer current.

168.3 An industrial dimmer intended for fluorescent or high intensity electric discharge lamps shall be tested controlling ballast loads of rated voltage and maximum rated current.

Exception: A resistive or tungsten lamp load may be used if investigation indicates that the inductive characteristic of a ballast has no heating effect on the dimmer control.

169 Operation Test

169.1 A lamp dimmer shall be operated under rated load for 100 operations without mechanical damage. The lamp dimmer shall perform acceptably at the conclusion of this test. Turning the lamp dimmer from the off position to the maximum on position and back to the off position is considered one operation.

169.2 The test specified in 169.1 is to be conducted to allow for 1 minute of cooling of the lamp during the first 15 operations and then cycled at a moderate speed for the remaining 85 cycles of operation.

170 Overload Test

170.1 An industrial dimmer control intended for incandescent lamps is to be mounted, connected, and operated as described in 168.1 – 168.3 except that the load is to be increased to 150 percent of maximum rated normal current and operation is to be continued until ultimate results are observed. There shall be no evidence of a risk of fire or electric shock as a result of this test. The fuse and surgical cotton indicators are to be applied as specified in Short Circuit Test – General, Section 50.

Exception: If an overcurrent device is provided integral with the control, the load is to be 125 percent of the maximum rated normal current. The overcurrent device may be defeated if necessary to conduct this test.

170.2 An industrial lamp dimmer intended for fluorescent or high-intensity electric discharge lamps is to be mounted, connected, and operated as described in 168.1 – 168.3 except that the load is to be 125 percent of maximum rated normal current. Operation is to be continued until ultimate results are observed. There shall be no evidence of a risk of fire or electric shock as a result of this test. Integral overcurrent devices may be defeated if necessary to conduct this test. The fuse and surgical cotton indicators are to be applied as specified in Short Circuit Test – General, Section 50.

RATING

171 Details

171.1 An industrial lamp dimmer shall be rated in volts, and also in amperes, watts, or a combination of amperes and watts. The control shall be rated in frequency and number of phases if other than single phase.

MARKING

172 Details

172.1 A lamp dimmer shall be marked in accordance with the requirements in Sections 63 – 65.

PART XVI – MISCELLANEOUS DEVICES

GENERAL

173 Details

173.1 The requirements in this Part XVI cover devices, such as resistors.

PERFORMANCE

174 General

174.1 A continuous-duty resistor shall not be burned out nor depreciated by carrying the full normal current on any step continuously.

174.2 A resistor intended for intermittent use, such as on electric cranes, elevators, or the like, shall be capable of carrying its rated current on any step for as long a time as the apparatus that it controls will permit it to be used.

174.3 A starting duty resistor for direct current motors shall be constructed so that when tested as described in 174.4 no flaming or molten droppings shall result; and, if the resistance conductor is fused, the arc or any attendant flame or molten droppings shall be confined within the enclosure.

174.4 A voltage between 100 and 110 percent of maximum rated voltage is to be applied across the variable voltage autotransformer, motor starting transformer, or the entire resistor and the starting mechanism connected to the first step of resistance. If greater than rated motor current results, external resistance is to be added to reduce the current to rated value. If less than rated current results, the starting mechanism is to be adjusted to the subsequent step of resistance that results in not more than rated current, with or without added resistance. In either case, the device is to be left in the resulting position for 3 minutes in the case of a resistor, or until constant temperatures are obtained in the case of an autotransformer or motor start transformer. The autotransformer or motor starting transformer tap shall be set at the point which gives the maximum wattage loss. See 174.9.

174.5 Temperature rises shall not exceed the temperature rises specified in Tables 43.1 and 174.1.

Table 174.1
Maximum acceptable temperature rises

Materials and components		°C	°F
1.	On the embedding material of a resistor, a rheostat, and a wall-mounted dimmer with an embedded resistive element	300	540
2.	On the embedding material of a rheostatic dimmer having embedded resistive conductors, and arranged for mounting on a switchboard, or in a noncombustible frame	350	630
3.	On bare resistor materials, thermocouple method	375	675

174.6 A starting duty resistor for polyphase alternating current motors of other than the squirrel cage type or variable voltage autotransformer or motor starting transformer shall be tested as specified in 174.4. A starter intended for single phase or squirrel cage motors shall be constructed so that, when tested as described as follows, no flaming or molten droppings shall result; and, if the resistance conductor is fused, the arc or any attendant flame or molten droppings shall be confined within the enclosure. A voltage between 100 and 110 percent of maximum rated voltage shall be applied to the line terminals, and 300 percent of full-load current of the motor shall be applied through each leg for the first 15 seconds of each 15 consecutive 4-minute periods. See 174.9.

174.7 A continuous duty resistor shall be constructed so that when subjected for 2 hours to a current flow of 125 percent rated current throughout the whole or any part of the resistance elements, no flaming or molten droppings shall result; and, if the resistance conductor is fused, the arc or any attendant flame or molten droppings shall be confined within the enclosure.

174.8 A variable voltage autotransformer or motor starting transformer shall be subjected to an abnormal test specified in 174.7 except operation shall be continued until constant temperatures are obtained and the device shall not be damaged.

174.9 The tests described in 174.3 – 174.8 may be terminated before the end of the specified period if the resistor or autotransformer is protected from overheating by an operating, nonadjustable thermostat or similar device.

174.10 A rheostat, an autotransformer, a speed regulator, or a similar device, or a starter containing such devices shall, after 100 operations under the most severe normal conditions for which it is intended, show no serious burning of the contacts or other faults; and the release mechanism of a motor-starting rheostat shall not be impaired by such a test.

174.11 The requirements in 174.10 are designed to demonstrate the ability of the device to close and interrupt the circuit under normal conditions of operation. For motor loads, this includes starting and running with the motor loaded to full load at normal speed.

174.12 A variable voltage autotransformer or motor starting transformer shall be subjected to the normal operation test in 90.1. If tungsten lamp loads are used, the first fifteen operations shall be conducted at 1 minute intervals, the remaining 85 operations at moderate speed.

174.13 Immediately following the normal operation test, a dielectric voltage-withstand test shall be conducted in accordance with Section 49.

174.14 A variable voltage autotransformer or motor starting transformer shall be subjected to a burnout test as described in 174.6 except the operation shall be continued until ultimate results are observed.

RATING

175 Details

175.1 A miscellaneous device shall comply with the rating requirements in Section 62.

MARKING

176 Details

176.1 A miscellaneous device shall be marked in accordance with the applicable requirements in Sections 62 – 65.

PART XVII – PROGRAMMABLE CONTROLLERS

GENERAL

177 Details

177.1 The requirements specified in this Part XVII over programmable industrial control systems that use a programmable memory for the internal storage of user-oriented instructions for implementing specific functions such as logic, sequencing, timing, counting, and arithmetic, and to control, through digital or analog inputs or outputs, various industrial processes. The system may include a power supply, a central processing unit, input and output devices, assemblies to accept input and output devices, peripheral interface accessories, and programming and diagnostic units.

177.2 An open type device is intended for use in a controlled environment.

178 Glossary

178.1 CONTROLLED ENVIRONMENT – A heated, indoor location that is relatively free of moisture and conductive contaminants such as condensation, carbon dust, and the like (for example, a computer room or office). An equivalent environment may be provided by means of:

a) A hermetically-sealed enclosure;

b) Encapsulation;

c) A conformal coating;

d) A gasketed, tight-fitting enclosure with an internal heater or equivalent to protect against the formation of condensation.

CONSTRUCTION

179 General

179.1 The construction of a programmable controller shall comply with the requirements in Sections 12 – 41, inclusive supplemented by and in some cases amended by the requirements in this Part XVII.

180 Spacings

180.1 The spacing (creepage) between traces of opposite polarity on a printed wiring board may be as specified in Table 180.1.

Table 180.1
Minimum spacings between traces of opposite polarity on printed wiring boards

Volts,[a] ac rms or dc	Transient voltage not limited		Transient voltage limited[b]	
	Coated[c] mm	Uncoated mm	Coated[c] mm	Uncoated mm
50	0.18	0.85	0.025	0.04
100	0.25	1.0	0.1	0.16
125	0.28	1.05	0.16	0.25
160	0.32	1.1	0.25	0.4
200	0.42	1.4	0.40	0.63
250	0.56	1.8	0.56	1.0
320	0.75	2.2	0.75	1.6
400	1.0	2.8	1.0	2.0
500	1.3	3.6	1.3	2.5
630	1.8	4.5	1.8	3.2
800	2.4	5.6	2.4	4.0
1000	3.2	7.1	3.2	5.0

NOTES

1 Table derived from Table IV of International Electrotechnical Commission Publication 664A.

2 Linear interpolation of values is permitted.

[a] Between the traces where spacing is measured.

[b] The maximum recurring peak voltage shall not exceed the applicable value specified in Table 6.3 of the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840, when tested in accordance with the Recurring Peak Voltage Determination Test, Section 9 in UL 840, except a coated printed wiring board is tested in the uncoated condition.

[c] The coating shall comply with the requirements of the Printed Wiring Board Coating Performance Test, Section 11, in UL 840, or another equivalent method.

181 Separation of Circuit Barriers

181.1 A barrier provided for compliance with the separation of circuit requirements – see Section 34 – shall be of adequate mechanical strength, reliably held in place, and constructed in accordance with 181.2 – 181.5.

181.2 A barrier of sheet metal shall have the same thickness as that required for an enclosure as specified in Table 6.1.

181.3 A barrier of insulating material shall not be less than 0.028 inch (0.71 mm) thick.

Exception: Insulating material may have a thickness less than 0.028 inch (0.71 mm) if it is investigated and found to be acceptable for the application.

181.4 An unclosed opening in a barrier for the passage of a conductor shall have a maximum dimension no larger than 1/4 inch (6.4 mm), and the number of unclosed openings shall not exceed one per required conductor.

181.5 An opening in a barrier for a wire or a closure for an unused opening shall present a smooth surface wherever an insulated wire may be in contact with it.

182 Bonding

182.1 A withdrawable chassis or a plug-in subsidiary board required to be grounded by 40.1.1 and in a device provided with overcurrent protection shall comply with the Impedance Test, Section 190, except that the test current is to be at least 10 amperes.

182.2 A barrier that is provided for compliance with the separation of circuit requirements – see Separation of Circuits, Section 34 – and is required to be grounded (bonded to the equipment-grounding means) – see Grounding, Section 40 – shall comply with the Impedance Test, Section 190.

PERFORMANCE

183 General

183.1 A representative sample or samples in commercial form of a programmable controller shall be subjected to the tests described in Sections 184 – 189. Those tests that are to be conducted in sequence are specified in Table 183.1.

Table 183.1
Sequence of tests

Standard reference section	Test	Sample number[a]			
		1		2	
		Test required	Sequence	Test required	Sequence
43	Temperature	X	1		
44	Overvoltage and Undervoltage	X	2		
186	Overload			X	1
187	Endurance			X	2
49	Dielectric Voltage-Withstand	X	3	X	3

[a] All or any combination of sequences may be conducted on a single sample if agreeable to those concerned. More than one sample may be used if more than one rating is being tested. One sequence need not be completed as a prerequisite to the starting of another sequence.

[b] Sequence No. 2 is intended to apply to programmable controller outputs.

183.2 A programmable controller having outputs intended to control solenoids or similar coil loads shall be rated for pilot duty.

183.3 Tests are to be conducted at rated frequency and at a test potential not less than 120, 208, 240, 277, 480, or 600 volts, as appropriate for the voltage rating.

Exception: Tests for a solid state output device may be conducted at a potential between 90 – 100 percent of the potential specified in the ampere load if adjusted to produce the maximum normal heating, and if the power semiconductors are capable of the intended conduction at the reduced potential.

184 Temperature Test

184.1 A programmable controller is to be subjected to the requirements in 184.2 and 184.3 while carrying the maximum rated current, and while mounted in a normal operating position in a temperature controlled environment. The test ambient in the temperature controlled environment is to be the higher of 25°C or the marked surrounding air temperature – see 192.2. The temperature rise of a material or component is the difference between its stabilized test temperature and the test chamber ambient. All other test conditions are to be as described in Section 43. As an alternative, the test is able to be conducted at a lower test ambient as in 42.4.

184.1 revised July 16, 1999

184.2 During the test, a programmable controller shall not attain a temperature at any point sufficiently high to constitute a risk of fire, to adversely affect any materials or components employed in the device, or exceed, at stabilized temperatures, the temperature rises specified in Table 43.1.

184.3 Insulating material at the junction of power switching semiconductors used in lieu of required spacings is considered to be operating at the junction temperature. To determine the insulating material temperature, reference temperatures (case, tab, heat sink, or the like) are to be measured and the junction temperature is to be calculated based on the semiconductor manufacturer's power dissipation and thermal resistance data.

185 Overvoltage and Undervoltage Test

185.1 A programmable controller that employs an electromagnet shall comply with the test requirements described in Section 44.

186 Overload Test

186.1 A programmable controller employing a control relay or semiconductor switch for an output device shall comply with the test described in 186.2 and 186.3. There shall be no mechanical or electrical malfunction.

186.2 The programmable controller or output device is to be connected as described in Section 183. The supply voltage is to be 100 to 110 percent of rated voltage, and the load current is to be as described in 186.3. The control shall be operated for 50 operations without mechanical or electrical malfunction at a rate of 6 cycles per minute and a minimum on time of 1 second. For output devices with multiple ratings, a sufficient number of tests are to be conducted to cover the conditions of maximum voltage, maximum current, and maximum power ratings.

Exception: The test may be conducted at a faster rate if agreeable to those concerned and if the minimum on time is 1 second.

186.3 With regard to 186.2, the test load corresponding to the appropriate rating shall be one of the following:

a) General Use Ampere Rating or Tungsten Rating – The load is to be 150 percent of rated current with a 0.75 to 0.80 power factor at rated voltage.

b) Resistive Ampere Rating – The load is to be 150 percent of rated current with a power factor of 1.0 at rated voltage.

c) Pilot Duty Rating – See Section 137.

d) Electric Discharge Lamp Rating – The load is to be three times rated current at a power factor of 0.40 to 0.50.

e) Horsepower Rating – See Section 45 for across-the-line motor starting.

187 Endurance Test

187.1 A programmable controller shall comply with the applicable requirements in the Endurance Test, Section 46.

Exception No. 1: Devices rated for pilot duty shall be tested as described in the Endurance Test, Section 138.

Exception No. 2: The endurance test need not be conducted on solid-state output devices for general-use ampere or resistive ampere ratings.

188 Dielectric Voltage-Withstand Test

188.1 A programmable controller shall comply with the applicable requirements in the Dielectric Voltage-Withstand Test, Section 49.

189 Breakdown of Components Test

189.1 A programmable controller shall comply with the applicable requirements in the Breakdown of Components Test, Section 57.

190 Impedance Test

190.1 A bonding circuit of a programmable controller if required in 182.1 or 182.2 shall be tested in accordance with 190.2 and 190.3. As a result of the test:

a) For cord-connected equipment and permanently connected equipment, with the provided or intended branch-circuit protective device not exceeding 500 amperes, the measured applied voltage shall not exceed 4 volts;

b) For permanently connected equipment, with the provided or intended branch-circuit protective device exceeding 500 amperes, the measured applied voltage multiplied by the numerical rating of the provided or intended branch-circuit protective device and divided by 250 shall not exceed 4 volts; and

c) There shall be no melting of any metal in the bond, and heating or burning that may result in a risk of fire.

190.2 One sample at normal operating temperature is to be tested. A 60 hertz current, at the applied voltage necessary to pass the amperage as specified in 190.3 for a time as specified in Table 190.1, is to be passed between the part to be bonded and the equipment-grounding means. The applied voltage is to be continuously readjusted to maintain the test current. The applied voltage is to be measured during the last 5 seconds of the test.

Table 190.1
Test time

Test current, amperes	Time in minutes
0 – 30	2
31 – 60	4
61 – 100	6
101 – 200	8
201 and greater	10

190.3 The test current is to be:

a) For cord-connected equipment, twice the rating of the attachment plug, but not less than 30 amperes; and

b) For permanently connected equipment, twice the rating of the provided or intended branch-circuit protective device, but not exceeding 500 amperes.

RATING

191 Details

191.1 The power supply to a programmable controller shall be rated in volts; and also in amperes, volt-amperes, watts, or any combination thereof; and the rating shall indicate whether the power supply is intended for direct or alternating current. The rating for alternating current shall also indicate the frequency.

191.2 Input devices shall be rated in volts and shall also indicate whether the input device is intended for direct or alternating current.

191.3 Output devices shall be rated in volts; and in amperes, volt-amperes, watts, horsepower, or any combination thereof; and the rating shall indicate whether the equipment is for direct or alternating current. The rating for alternating current shall also indicate frequency. See Section 139 for output devices rated for pilot duty.

MARKING

192 Details

192.1 Programmable control equipment shall be marked in accordance with the applicable marking requirements in Sections 63 – 65.

Exception: An output device having more than one rating in accordance with 191.3 shall have at least one rating marked on the device. Additional ratings may be marked either on the device or on a stuffer sheet referenced on the device and provided in each smallest shipping container.

192.2 A programmable controller intended for use in a surrounding air temperature greater than 25°C shall be marked with the maximum specified surrounding air temperature on the device or in the installation instructions.

193 Signal Circuits

193.1 If a programmable controller is provided with a signal circuit that is intended to be directly connected to a source greater than 30 volts or operated at greater then 30 volts, and the available current for such a source is greater than 5 milliamperes, the maximum rated voltage of all signal circuits shall be marked on the device or in the instruction manual supplied with the equipment.

PART XVIII – EQUIPMENT RATED 601– 1500 VOLTS

GENERAL

194 Details

194.1 These requirements cover industrial control equipment rated 601 – 1500 volts.

CONSTRUCTION

195 General

195.1 Industrial control equipment rated 601 – 1500 volts shall comply with the applicable construction and marking requirements specified elsewhere in UL 508 in addition to the construction requirements in Sections 196 and 197.

196 Insulating Material

196.1 An insulating material used as direct or indirect support of an uninsulated live part shall comply with 15.1.

Exception: The Inclined-Plane Tracking Test of the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, may be conducted at the application (rated) voltage.

197 Spacings

197.1 The electrical spacings in industrial control equipment rated 601 – 1500 volts shall not be less than the applicable value specified in Table 197.1.

Table 197.1
Minimum acceptable spacings

Potential involved, in volts	Location	Minimum spacings, inches (mm)	
		601 – 1000 V	1001 – 1500 V
Between any uninsulated live part and an uninsulated live part of opposite polarity, an uninsulated grounded part other than the enclosure, or an exposed metal part	Through air	0.55 (14.0)	0.70 (17.8)
	Through oil	0.45 (11.4)	0.60 (15.2)
	Over surface air	0.85 (21.6)	1.20 (30.5)
	Over surface oil	0.62 (15.7)	0.70 (17.8)
Between any uninsulated live part and the walls of a metal enclosure, including fittings for conduit or armored cable	Through air or oil	0.80 (20.3)	1.20 (30.5)
	Over surface	1.00 (25.4)	1.65 (41.9)

PERFORMANCE

198 General

198.1 Industrial control equipment rated 601 – 1500 volts shall comply with the applicable performance requirements specified elsewhere in this standard except as indicated in Sections 199 and 200.

199 Short Circuit Test

199.1 For the Short Circuit Test – General, Section 50, the test circuit is to be capable of delivering the current specified in Table 199.1 for a given full load current rating when the test circuit is short-circuited at the testing terminals to which the device under test is to be connected.

Table 199.1
Short circuit test values for devices rated 601 – 1500 volts

Full load current, amperes	Test current, symmetrical rms amperes	Power factor
0 – 50	5,000	0.7 – 0.8
51 – 200	10,000	0.7 – 0.8
201 – 400	18,000	0.25 – 0.3
401 – 600	30,000	0.20 or less
601 – 850	42,000	0.20 or less
851 – 1500	85,000	0.20 or less
1501 or more	100,000, 125,000, 150,000 or 200,000	0.20 or less

200 Dielectric Voltage-Withstand Test

200.1 Industrial control equipment rated 601 – 1500 volts shall comply with the requirements in Section 49 except that an alternating-current test potential shall be 2000 volts plus 2.25 times maximum rated voltage, or a direct-current test potential shall be 1.414 times the alternating-current test potential of 2000 volts plus 2.25 times the maximum rated voltage.

PART XIX – PROXIMITY SWITCHES

GENERAL

201 Details

201.1 These requirements cover electronic proximity switches for use on industrial machinery or mass-production industrial equipment as defined by the Electrical Standard for Industrial Machinery, NFPA 79.

202 Glossary

202.1 For the purpose of Part XIX of this standard, the following definition applies.

202.2 PROXIMITY SWITCH – An electronic switching device that is actuated by the position of an object without mechanical contact with the object. The device may be of the inductive, capacitive, magnetic, or photoelectric type. An inductive proximity switch produces an electromagnetic field in a predetermined sensing zone. A capacitive proximity switch produces an electric field in a predetermined sensing zone. A magnetic proximity switch produces a magnetic or electromagnetic field in a predetermined sensing zone. A photoelectric proximity switch may be light emitting or infrared, producing visible or invisible light, respectively, in a predetermined sensing zone.

CONSTRUCTION

203 General

203.1 The construction of a proximity switch shall comply with the applicable requirements in Sections 6 – 40, supplemented by and in some cases amended by the requirements in this Part XIX.

203.2 A cord-connected proximity switch shall comply with the requirements in 25.6.1 – 25.6.7.

Exception No. 1: The power-supply cord on a proximity switch is not required to terminate in an attachment plug.

Exception No. 2: The power-supply cord on a proximity switch shall not terminate in an attachment plug having a blade configuration covered by the Standard for Wiring Devices – Dimensional Requirements, ANSI/NEMA WD6-1988.

Exception No. 3: A power-supply cord of other than hard service or junior hard service flexible cord is acceptable if the cord complies with the Power-Supply Cord Tests in 206.1.1.

Exception No. 4: A power-supply cord without an oil resistant rating and used on a proximity switch having a Type 12, 12K, or 13 enclosure is acceptable if the cord complies with the Power-Supply Cord Tests in 206.1.2.

Exception No. 5: A power-supply cord intended for outdoor use other than an application in a 6 or 6P environment is acceptable if the cord complies with the Power-Supply Cord Tests, Section 206.

203.3 For a cord-connected proximity switch, the individual conductors of the power-supply cord shall not be smaller than No. 30 AWG (0.05 mm^2).

203.4 In lieu of complying with Grounding, Section 40, a proximity switch may use double insulation protection provided that it complies with all the applicable requirements in the Standard for Double Insulation Systems for Use in Electrical Equipment, UL 1097.

PERFORMANCE

204 General

204.1 A proximity switch shall comply with the applicable requirements in Sections 118 – 124, supplemented by and in some cases amended by the requirements in Sections 205 – 209.

205 Infrared Radiation

205.1 A proximity switch of the infrared type shall be investigated and found acceptable with respect to a risk of injury to persons from infrared radiation.

206 Power-Supply Cord Tests

206.1 General

206.1.1 A proximity switch with a power-supply cord of other than hard service or junior hard service cord is to be tested as described in 206.2.1 and 206.3.1. The tensile strength and elongation shall be a minimum of 1500 psi (10.3 MN/m^2) and 100 percent, respectively, on unconditioned samples of the insulation on the individual conductors or on the outer jacket of the power-supply cord. After the oven conditioning, the tensile strength shall be at least 70 percent of the value obtained on the unconditioned samples, and the elongation shall be at least 65 percent of the value obtained on the unconditioned samples. See 203.2, Exception No. 3.

206.1.2 A proximity switch having a Type 12, 12K, or 13 enclosure and a power-supply cord without an oil resistant rating is to be tested as described in 206.2.1 and 206.4.1. After the oil conditioning, the tensile strength and elongation of the insulation on the individual conductors or of the outer jacket of the power-supply cord shall be at least 50 percent of the values obtained on unconditioned samples. See 203.2, Exception No. 4.

206.1.3 A proximity switch intended for outdoor use and provided with a power-supply cord without an outdoor use rating is to be tested as described in 206.2, 206.5, and 206.6. After five samples are subjected to the ultraviolet light (UV) conditioning as specified in 206.5, the average tensile strength and ultimate elongation of the insulation on the individual conductors or of the outer jacket of the power-supply cord shall be at least 80 percent of the average values obtained on five unconditioned samples. See exception No. 5 to 203.2.

206.2 Tensile strength and elongation tests

206.2.1 The number of samples to be tested, the methods of selection and preparation of the samples, the testing of the samples, the making of the measurements, and the calculations for ultimate elongation and tensile strength are to be as indicated in the requirements for physical properties tests of insulation and jacket in the Reference Standard for Electrical Wires, Cables, and Flexible Cords, UL 1581.

206.3 Oven conditioning

206.3.1 Samples of the insulation on the individual conductors or the outer jacket of a power-supply cord are to be conditioned in a full draft circulating air oven. The duration of conditioning and the oven temperature are to be as specified in Table 206.1.

Table 206.1
Oven conditioning

Temperature rating of conductor insulation or outer jacket			Oven temperature	
°C	(°F)	Oven time, hours	°C	(°F)
60	140	168	100 ±1	212 ±2
75	167	240	100 ±1	212 ±2
90	194	168	121 ±1	250 ±2
105	221	168	136 ±1	277 ±2

206.4 Oil conditioning

206.4.1 Samples of the insulation on the individual conductors or the outer jacket of a power-supply cord are to be conditioned by immersion in IRM immersion oil No. 902 for 168 hours at a temperature at least equivalent to the intended rating of the insulation.

206.5 Ultraviolet light (UV) conditioning

206.5.1 Samples of the insulation on the individual conductors or the outer jacket of a power supply cord intended for outdoor use are to be tested as specified in the Sunlight Resistance evaluation in the Reference Standard for Electrical Wires, Cables, and Flexible Cords, UL 1581, for 720 hours of exposure.

206.6 Cold bend test

206.6.1 A jacket on an outdoor-use cord shall not crack on its inner or outer surface while specimens of the complete finished cord that have been cooled for 4 hours in air at a temperature of minus 35 ±2.0°C (minus 31.0 ±3.6°F) are wound onto a mandrel as described in the Cold Bend evaluation in the Reference Standard for Electrical Wires, Cables, and Flexible Cords, UL 1581. The diameter of the mandrel is to be as specified in the Standard for Flexible Cord and Fixture Wire, UL 62.

207 Cable Gland Connector Tests

207.1 General

207.1.1 A cord-connected proximity switch with a cable gland connector is to be tested as described in 207.1.2 – 207.5.1. After the flexing test, there shall be no displacement of the cord within the gland connector and the gland connector shall show no signs of cracking, warping, or shrinking. As a result of the strain relief test, both the cord and conductors shall not be damaged or displaced.

207.1.2 Five samples of a proximity switch with a cable gland connector are to be tested. One sample, in the as-received condition, is to be subjected only to the flexing and strain relief tests described in 207.4.1 and 207.5.1. The other four samples are to be subjected to the conditioning described in 207.2.1 if of rubber composition, or 207.3.1 if of thermoplastic composition prior to subjecting them to the flexing and strain relief tests.

207.2 Oven conditioning (rubber composition)

207.2.1 The samples are to be placed in an air oven for 70 hours at 100°C (212°F).

207.3 Oven conditioning (thermoplastic composition)

207.3.1 The samples are to be conditioned for 168 hours in an air circulating oven at a temperature 10°C (18°F) higher than the maximum temperature at the gland material measured under normal operating conditions, but not less than 70°C (158°F).

207.4 Flexing test

207.4.1 Each of the five samples are to be mounted vertically in a fixed position. Starting from the vertical position, the cord is to be flexed through a 90 degree angle, having a radius of 5 inches (127 mm) for a cord 3/4 inch (19 mm) in diameter or less, and 10 inches (254 mm) for a cord more than 3/4 inch in diameter. The cord is then flexed through a 180 degree angle of the same radius in the opposite direction, and then flexed to the vertical position. The flexing is repeated for a total of 500 cycles of operation.

207.5 Strain relief test

207.5.1 The test is to be conducted as described in 208.2 except that each of the five samples are to be tested.

208 Strain Relief Test

208.1 A cord-connected proximity switch that is not provided with a cable gland connector is to be tested as described in 208.2. As a result of the test, both the cord and conductors shall not be damaged or displaced.

208.2 One sample is to be tested. The cord is to be disconnected from the terminals of the proximity switch. A direct pull of 35 pounds (156 N) for cord size Nos. 18 AWG (0.82 mm^2) and larger, and 20 pounds (88.0 N) for cord sizes small than No. 18 AWG is to be applied to the cord for 1 minute.

209 Tests for Environmental Type Enclosures

209.1 A proximity switch that is provided with a cable gland connector and that is provided with other than a Type 1 enclosure, shall be subjected to the conditioning tests described in 207.2.1 if the cable gland connector is of rubber composition or 207.3.1 if the cable gland connector is of thermoplastic composition, prior to conducting the applicable tests required in Sections 6 – 9 for the type of enclosure involved.

RATING

210 Details

210.1 The rating of a proximity switch shall comply with the applicable requirements in Section 62, supplemented by and in some cases amended by the requirements in this section.

210.2 The rating of a proximity switch shall indicate the voltage and whether it is intended for standard or heavy duty use.

Exception No. 1: The rating may be in the form of a code designation in accordance with Table 139.1 or 139.2, as applicable.

Exception No. 2: The rating of a proximity switch may be in volts, amperes, and inrush amperes; volts and volt-amperes; or volts, amperes, and the words "pilot duty."

MARKING

211 Details

211.1 The marking of a proximity switch shall comply with the applicable requirements in Sections 63 – 65, supplemented by and in some cases amended by the requirements in this section.

211.2 If the marked ratings are the code designations specified in Tables 139.1 and 139.2, the information concerning the voltage and overload current ratings for each code designation shall be published in a catalog, contained on a marking sheet packed with the product, or be otherwise available to the user.

211.3 For devices that are provided with conductors smaller than No. 18 AWG (0.82 mm^2), the device or the installation instructions shipped with the device shall be marked to indicate the voltage and ampere rating of the overcurrent protection to be used. The ampere rating of the overcurrent protection shall be in accordance with Table 211.1.

Table 211.1
Overcurrent protection

Conductor size		Maximum ampere rating of the overcurrent protection
AWG	(mm^2)	
20	(0.52)	5
22	(0.32)	3
24	(0.20)	2
26	(0.13)	1
28	(0.08)	0.8
30	(0.05)	0.5

211.4 If the enclosure of a proximity switch is too small to accommodate the type designation either on the inside or outside surface as specified in 12.1 and 57.5, then the type designation may appear on the smallest unit package or information sheet included within the smallest unit package.

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SUPPLEMENT SA - INDUSTRIAL CONTROL EQUIPMENT FOR MARINE USE

SA1 Scope

SA1.1 These requirements cover industrial control equipment intended for use aboard vessels over 65 feet (19.8 m) in length as covered by USCG Electrical Engineering Regulations Subchapter J (46 CFR, Parts 110 – 113). These requirements add to the applicable requirements in this standard.

SA2 Enclosure

SA2.1 An enclosure shall comply with the requirements in this standard except as modified by this supplement.

SA2.2 An enclosure shall be of one of the following types:

a) Nonwatertight;

b) Dripproof; or

c) Watertight.

SA2.3 Dripproof equipment shall be constructed or protected so that its successful operation is not interfered with when subjected to falling moisture or dirt.

SA2.4 The enclosure is considered dripproof if there is no significant accumulation of water within the enclosure and no water has entered at a level higher than the lowest live part when subjected to the Drip Test, Section 31, in the Standard for Enclosures for Electrical Equipment, UL 50.

SA2.5 Watertight equipment shall be constructed so that water will not enter the enclosure when subjected to the Hose and Hosedown Test, Section 35, in the Standard for Enclosures for Electrical Equipment, UL 50.

SA2.6 Cable entrance plates, if provided, for watertight enclosures and at the top of dripproof enclosures shall be at least 1/8 inch (3.2 mm) thick and be fitted with gaskets. Watertight enclosures shall be provided with external feet or lugs for mounting.

SA2.7 A sheet metal enclosure shall not be employed for use in corrosive locations, that is, locations exposed to the weather on vessels operating in salt water, unless the enclosure complies with one of the following:

a) The enclosure is fabricated of corrosion-resistant material as indicated in 15.8 of the Standard for Enclosures for Electrical Equipment, UL 50;

b) The enclosure is fabricated of sheet steel not less than 1/8 inch (3.2 mm) thick and is hot-dip galvanized after fabrication; or

c) The enclosure is fabricated of sheet steel not less than 3/16 inch (4.9 mm) thick and has a corrosion-resistant finish in accordance with Section 15 in UL 50.

SA2.8 A controller having hinged doors that are either more than 45 inches (1.14 m) high or more than 24 inches (610 mm) wide shall be provided with door positioners and stops.

SA2.9 Equipment mounted on a hinged door shall be constructed or shielded so that no live parts of the equipment mounted on the door will be exposed to unintentional contact when the door is open and the circuit is energized.

SA3 Current-Carrying Parts

SA3.1 Current-carrying parts shall be copper or copper alloy.

SA4 Autotransformer Starters

SA4.1 An autotransformer starter with a case for oil shall not leak when tilted to an angle of 30 degrees and shall be constructed to prevent the oil from splashing out of the case due to normal motion of the vessel.

SA5 Heater Circuits

SA5.1 The heater circuit of a controller fitted with electric heaters located inside the enclosure shall be energized from a separate circuit.

SA6 Insulating Materials

SA6.1 Porcelain shall not be used for lamp sockets, switches, receptacles, fuse blocks, or the like, where the material is rigidly fastened by machine screws or the equivalent.

SA7 Overcurrent Devices

SA7.1 Plug fuses of the Edison-base type and renewable-link cartridge-type fuses shall not be used.

SA8 Temperature Rating

SA8.1 An ambient temperature of 40°C is to be assumed for all locations except 50°C is to be assumed as the ambient temperature for boiler and engine rooms.

SA9 Marking

SA9.1 A heat resistant, durable wiring diagram shall be permanently attached to the inside of the controller door.

SA9.2 Three samples of a test panel are to be conditioned for 240 hours in an air-oven maintained at 87°C) The label is considered to be permanent if after being exposed for 24 hours to room temperature following removal from the oven:

a) Each sample demonstrates good adhesion at all points and the edges are not curled;

b) The label resists defacement of removal as demonstrated by scraping across the test panel with a flat metal blade 1/16 inch thick, held at right angles to the test panel; and

c) The printing is legible and is not defaced by rubbing with thumb or finger pressure.

SA9.3 A dripproof or watertight enclosure shall be marked ″Dripproof″ or ″Watertight,″ as appropriate.

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APPENDIX A

Standards for Components

Standards under which components of the products covered by this standard are evaluated include the following:

Title of Standard − UL Standard Designation

Capacitors – UL 810
Circuit Breakers, Molded-Case, Molded-Case Switches, and Circuit-Breaker Enclosures –UL 489
Class 2 and Class 3 Transformers – UL 1585
Electrical Analog Instruments – Panel Board Types – UL 1437
Electrical Wires, Cables, and Flexible Cords, Reference Standard for – UL 1581
Enclosures for Electrical Equipment – UL 50
Equipment Wiring Terminals for Use With Aluminum and/or Copper Conductors – UL 486E
Fitting for Conduit and Outlet Boxes – UL 514B
Flexible Cord and Fixture Wire – UL 62
Fuseholders – UL 512
Fuses, Class R – UL 198E
Fuses for Supplementary Overcurrent Protection – UL 198G
Fuses, High-Interrupting-Capacity, Current-Limiting Types – UL 198C
Fuses, Plug – UL 198F
Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment – UL 840
Marking and Labeling Systems – UL 969
Plastic Materials for Parts in Devices and Appliances, Tests for Flammability of – UL 94
Polymeric Materials – Long Term Property Evaluations – UL 746B
Polymeric Materials – Short Term Property Evaluations – UL 746A
Polymeric Materials – Use in Electrical Equipment Evaluations – UL 746C
Power Units Other Than Class 2 – UL 1012
Printed-Wiring Boards – UL 796
Protectors, Supplementary, for Use in Electrical Equipment – UL 1077
Service Equipment, Reference Standard for – UL 869A
Speed Controls, Solid-State Fan – UL 1917
Switches, Clock-Operated – UL 917
Switches, Enclosed and Dead-Front – UL 98
Switches, Molded-Case – UL 1087
Systems of Insulating Materials – General – UL 1446
Temperature-Indicating and -Regulating Equipment – UL 873
Terminal Blocks – UL 1059
Terminals, Electrical Quick-Connect – UL 310
Tests for Safety-Related Controls Employing Solid-State Devices – UL 991
Transformers, Specialty – UL 506
Wire Connectors and Soldering Lugs for Use with Copper Conductors – UL 486A
Wire Connectors for Use With Aluminum Conductors – UL 486B
Wires and Cables, Machine-Tool – UL 1063
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Superseded requirements for

the Standard for

Industrial Control Equipment

UL 508, Seventeenth Edition

The requirements shown are the current requirements that have been superseded by requirements in revisions issued for this Standard. To retain the current requirements, do not discard the following requirements until the future effective dates are reached.

50.1.1 The requirements in this section are to be used in conjunction with Section 51, Standard Fault Current Circuits, Section 52, High Available Fault Current Circuits, Section 53, Standard and High Fault Acceptance Criteria, and Section 54, Calibration of Test Circuits.

50.4.1 As a result of the short circuit test, a motor controller incorporating an overload relay intended for group fusing shall not ignite the cotton indicator or show any manifestation of a risk of fire. Welding or complete disintegration of the contacts and burnout of the current element are acceptable. The controller need not operate after the test. Samples are to be investigated in accordance with 50.4.2 – 50.4.5 for specific types and ratings. However, the rating of the protective device is not limited to those values specified in Table 51.1.

50.4.2 Characteristics of the test circuit are to be as specified in 51.3.4.2.

50.4.3 The relay is to be tested in the controller with which it is intended to be used, with the enclosure connected solidly without any fuse to one side of the line as indicated in 50.3.2. Surgical cotton is to be placed at all openings, handles, flanges, joints, and the like, on the outside of the enclosure.

50.4.4 Three samples of an overload-relay current element that complies in all other respects with requirements in this standard are to be subjected to short circuit tests in an overload relay connected in series with nonrenewable cartridge fuses of the maximum standard rating with which the element is intended to be used. The short circuit test is to consist of the following:

a) The test of a 2- or 3-phase relay for group fusing is to consist of two operations on a 3-phase circuit, with two elements and three fuses in the circuit unless the relay has elements in each conductor to the motor, in which case, three elements and three fuses are to be in the test circuit; or

b) The test of a single-phase relay for group fusing is to consist of three operations on a single-phase circuit with one element and one fuse in the circuit.

50.4.5 If a group of current elements of the same construction and material is intended for use with one size of fuse, tests on the lowest and highest ratings may be considered to be representative of that group.

51.1.3.4 For an instantaneous circuit breaker, it shall be adjusted to its maximum setting but no more than 13 times the full load current.

Table 53.1
Maximum damage criteria

Protective device	Acceptance criteria reference
Standard Level Short Circuit	a through i
High Fault Circuit	b through l

Maximum Damage Criteria:

a) Damage to the overload-relay base, temperature sensing element, or other parts may occur if the current elements, used with a motor rated less than 0.25 amperes, burn out when subjected to the test described in Sections 50 – 52.

b) The motor control device may be inoperative at the conclusion of the test.

c) The contacts of the motor control device may weld or completely disintegrate.

d) Discharge of parts or any risk of a fire shall not occur.

e) The door or cover shall not be blown open, and it shall be possible to open the door or cover. Deformation of the enclosure is acceptable, but shall not result in the accessibility of live parts as determined by the use of the rods specified in 6.17.1.

f) Burnout of the current element is acceptable.

g) The solid AWG wire connected between the live pole and the enclosure shall not be open.

h) There shall be no damage to a conductor or terminal connector and no conductor shall pull out of a terminal connector.

i) There shall be no breakage or cracking of insulating bases to the extent that the integrity of the mounting of live parts is impaired.

j) The load switching function of the motor control device may be inoperative at the conclusion of the test. Contacts that serve as disconnection or branch circuit protection means shall not weld. A combination motor controller self-protected control device module may contain moad switching means that have welded provided that the module is located on the load side of the disconnection and branch circuit contacts and that the module can be replaced. Self-protected control devices shall be operable immediately after the test for compliance with the Magnetic Trip-Out Test, Section 81.

k) The disconnecting means of the combination motor controller shall be capable of being opened manually with the operating handle.

l) If provided as part of the equipment, neither end of a protective device – such as a fuse, current limiter, or motor short-circuit protector – shall be completely separated from the mounting means, and the line end of a fuse, current limiter, or motor short-circuit protector shall not bridge from the mounting means to dead metal.

Table 67.1
Marking location for industrial control equipment

Marking reference	Required marking[a]	Location[b]	
		Enclosed	Open
	GENERAL		
63.1	Manufacturers name, trademark, or identifier, electrical rating, catalog number or equivalent	B	D
63.2	Short circuit rating and fuse type/circuit breaker and size if needed	B	F
63.3	Temperature rating of field installed conductors	G	G
		–	–
	Exception: Marking not required when intended for connection to control circuit conductors only		
63.4	Exception to 63.1	B	D
63.5	Marking for environmental type(s)	B	B
63.6	Marking for flat surface of type(s)	G	G
63.7	Specific load marking, indicating intended use	B	D
63.10	Marking for more than one factory	E	E
63.11	Oil tank mark for oil level	B	B
63.12	Guide to proper operation of device(s)	B	B
63.13	Use of ″ON″ and ″OFF″ markings (See Fig. 63.1)	A	–

Table 67.1 Continued on Next Page

Table 67.1 Continued

Marking reference	Required marking[a]	Location[b]	
		Enclosed	Open
63.14	Instructions for assembly in different combinations	G	G
63.15	Marking for use with other parts of a system	G	G
63.16	Marking for series resistor	G	G
63.17	Overload relay ″may start automatically″ when in automatic reset position	B	F
63.18	Devices provided with a protective device in an accessory kit	B	F
63.19	Maximum control circuit protective-device size corresponding to the size of control-circuit wire	B	G
63.20	Marking for supplementary fuse near fuseholder per 18.2.3	B	F
63.21	If fuseholder can accept higher fuse size per 18.2.4	B	F
63.22	″TV″ markings	B	D
63.23	Marking for replacement fuse per item 3 of Table 43.1	B	F
	WIRING TERMINAL MARKINGS		
64.1	Marking for proper connections	G	G
		–	–
	Exception No. 1: Marking not required for wire connections plainly evident		
		B	G
	Exception No. 2: Wiring diagram with multiple circuit arrangements		
64.2, 64.3	Terminal connection of ground supply conductor	G	G
64.4	Marking for low voltage wiring	G	G
64.5	Circuits capable of being connected to separate supplies but intended to be connected to common supply	G	G
64.6	Equipment with special fitting for connection	G	G
64.7	Equipment that is acceptable for nonmetal-enclosed wiring system	G	G
64.8	Field wiring terminal marking for wire type (Al, Cu)	G	G
		–	–
	Exception: Marking not required when intended for connection to copper control circuit conductors		
64.9	Field wiring terminal not intended to receive conductor one size larger per 25.5.1	G	G
64.10	Marking for providing terminals separately in terminal kit	G	G
64.11	Torque values marking for field terminals per 25.5.9	G	G
		–	–
	Exception: Marking in 25.5.9 not required when field terminal connected to control circuit conductor if investigated for 7 lb-in.		
	CAUTIONARY MARKINGS		
65.1	Placement of cautionary markings	B	F
65.3	Instructing operator or servicing instructions	B	F
65.4, 65.5	Provided with more than one disconnect means	A	–
65.6	For enclosures that are intended for field assembly of the bonding means in accordance with 6.6.1	G	G

Table 67.1 Continued on Next Page

Table 67.1 Continued

Marking reference	Required marking[a]	Location[b]	
		Enclosed	Open
65.7	Replacement markings for overload relay that has replacement elements	B	F
		B	F
	Exception No. 1: Thermal unit replaced upon heater burnout		
		–	–
	Exception No. 2: Marking not required for overload relay with replaceable type thermal elements having calibrated current sensing element in nonreplaceable part of overload relay		
		–	–
	Exception No. 3: Marking not required for overload relay with nonreplaceable type thermal elements that prevents operation of the device		
65.8	Marking for motor controllers having indication that high available fault current interrupted	B	F
65.9	Control with direct-current motor ratings that does not comply with 25.5.1(d)(1)	G	G
65.10	Device which requires a lower torque value than Table 8.1	G	G
65.11	Knife switch complying with Exception to 16.4 where switch may be energized by back feed when in open position	A	–
		F	–
	Exception: Marking provided adjacent to switch and visible after installation		
	INSTRUCTIONS AND MARKINGS PERTAINING TO ACCESSORIES		
66.1	Accessories	H	H
		H	H
	Exception: New accessory on existing product		
66.2	Accessories	I	I
		B	D
	Exception: Rating of accessory		
66.3	Accessories provided with instructions	G	G
66.4	Kit available for overload protection device in accordance with 6.4.2(c)	G	G
	MAGNETIC MOTOR CONTROLLERS		
71.1	See Sections 63 – 65		
	MANUAL MOTOR CONTROLLERS		
75.1	See Sections 63 – 65		
	COMBINATION MOTOR CONTROLLERS		
88.1	See Sections 63 – 65		
	In addition, incorporating separate overload relay	B	F
		B	F
	Exception: Type E incorporating modules		

Table 67.1 Continued on Next Page

Table 67.1 Continued

Marking reference	Required marking[a]	Location[b]	
		Enclosed	Open
88.2	Marked with ″Combination Motor Controller ″ and short circuit current ratings	B	F
88.3	Field conversion of fuses	B	F
88.5	Combination motor controllers incorporating instantaneous trip circuit breaker	B	F
88.6	Type D combination motor controllers	B	F
88.7	Type E combination motor controllers	B	F
	REDUCED VOLTAGE STARTERS		
92.2	Refer to rating details, Section 62	B	D
93.1	Marking ″Heavy or Medium Duty ″	B	F
	SOLID STATE AC MOTOR CONTROLLERS		
105.1	See Sections 63 – 65		
105.2	Replacement fuse near fuseholder	B	F
	FLOAT- AND PRESSURE-OPERATED SWITCHES		
115.1	Refer to Rating Details, Section 62. In addition, provide operating pressure rating	B	D
	SEMICONDUCTOR RELAYS AND SWITCHES		
126.1	See Sections 63 – 65		
	MERCURY SWITCHES		
132.1	See Sections 63 – 65		
	AUXILIARY DEVICES		
140.1	See Sections 63 – 65		
140.2	Indicate operators for intended use	D	G
140.3	Code markings	H	H
140.4	Indicate Use of Same Polarity	D	D
	MECHANICAL OVERLOAD RELAYS		
146.1	See Sections 63 – 65		
146.2	Relay class designation	B	F
146.3	Alternative-Relay class designation on current element table	B	F
146.4	Ampere rating of overload relay	B	D
		B	F
	Exception: Tripping current on table		
146.5	Outside ambient temperature of 40°C and tripping current	B	F
		–	–
	Exception: Marking not required for ambient compensated devices		
146.6	Current elements of interchangeable type	B	F
146.7	Overload relay furnished with table	B	F
146.8	Current element rated for use at maximum marked rating	B	F
146.9	Ampere rating of controller with overload relay	–	–
146.10	Table referred to in Exception to 146.4 and 146.7	–	–
146.11	Combination of manual and automatic reset position	B	B
146.12	Adjustable overload relay	G	G
146.13	See 146.10	–	–
	ELECTRONIC OVERLOAD RELAY		
154.1	See Section 146		

Table 67.1 Continued on Next Page

Table 67.1 Continued

Marking reference	Required marking[a]	Location[b]	
		Enclosed	Open
154.2	Overload relay not provided with current transformer	B	F
154.3	Marking for current transformer as indicated in 153.2	B	F
DEFINITE PURPOSE CONTROLLERS			
164.1	See 63.1 and 63.4		
LAMP DIMMERS			
172.1	See Sections 63 – 65		
MISCELLANEOUS DEVICES			
176.1	See Sections 63 – 65		
PROGRAMMABLE CONTROLLERS			
192.1	See Sections 63 – 65 *Exception: Output device with more than one rating*[c]		
192.2	Intended use in surrounding air greater than 25°C	G	G
193.1	Signal circuits	D	G
EQUIPMENT RATED 601 – 1500 VOLTS			
195.1	See Sections 63 – 65		
PROXIMITY SWITCHES [c]			
211.1	See Sections 63 – 65		
211.2	Code designation	H	H
211.3	For devices with conductors smaller than 18 AWG, indicate rating of over-current protection to be used	G	G

[a] These are a brief summary of marking requirements. For complete details see the specific Marking Reference.

Table 67.1 Continued on Next Page

Table 67.1 Continued

Marking reference	Required marking[a]	Location[b]	
		Enclosed	Open

[b] For marking locations identified below, ″A″ is considered the highest order of location, and ″I″ is considered the lowest order of location. At the option of the manufacturer, a higher order of location category may be used.

A. Marking shall be visible when the enclosure cover is on and the door is closed.

B. Marking shall be visible:

1. When the enclosure cover is removed or the door is open;

2. When other devices are mounted nearby as intended; and

3. When devices are installed side by side.

The marking shall not be obscured by attachments such as a disconnect switch operating handle.

C. Marking is on live parts which may appear to be grounded.

D. Marking is visible when the device is mounted singularly. The marking may be on the side of the device, and need not be visible when the device is mounted next to other devices.

E. Marking may be anywhere on the device and need not be visible after installation.

F. Marking is on a separable, self-adhesive permanent label that is shipped with the device. For a device that will be installed in an enclosure, the marking shall be on the inside of the enclosure.

G. Marking is shipped separately with the device.

H. Marking is provided on a separate sheet which is available from the manufacturer, but not necessarily shipped with the product.

I Marking is shipped separately with kit.

[c] Small devices, such as proximity or photoelectric switches, may be marked with only one electrical rating, and all other markings are provided on a separate sheet or on the device carton.

Table 73.1
Sequence of tests

Standard reference section	Test	Sample number[a] 1 Sequence	2 Sequence	3 Sequence	4 Sequence
43	Temperature	1			
45	Overload		1		
46	Endurance		2		
49	Dielectric Voltage Withstand	3	3		
48	Calibration			1	
50	Short Circuit – General				1

[a] All or any combination of sequences may be conducted on a single sample if agreeable to those concerned. More than one sample may be used if more than one rating is being tested. One sequence need not be completed as a prerequisite to the starting of another.

76.3 A combination motor controller shall comply with all of the applicable construction requirements in Sections 12 – 41, inclusive. All combination motor controllers shall comply with 76.4 – 76.6. In addition, typical Type A – D construction devices as noted in Table 76.2 shall comply with 76.7 – 76.9 and Type E construction devices shall comply with 76.10.