UL 508A

STANDARD FOR SAFETY

Industrial Control Panels

UL Standard for Safety for Industrial Control Panels, UL 508A

Third Edition, Dated April 24, 2018

Summary of Topics

This revision of ANSI/UL 508A dated July 28, 2022 reissues the July 21, 2022 revisions to correct paragraph 1.1 by deleting the second paragraph which was erroneously included.

The topics of the July 21, 2022 revisions are noted below for reference:

- ***Limit for Ambient Temperature; 1.1, 52.1***

- ***Deletion of Requirements for Elevator Control Panels; 1.2, 1.25, Section 80***

- ***Include Reference in Scope to UL 67 Regarding Panelboard Construction; 1.12, 1.26, Appendix A***

- ***Clarification of Branch and Feeder Circuit Spacings; 10.2***

- ***Removal of SIS as an Example of Conductor Type Not Readily Available; 17.3, 17.4***

- ***Clarification of the Requirements for an Air Outlet from a Forced Ventilation System Located in the Area Occupied by an Operator; 21.2.2, Figure 21.1***

- ***Alignment with NFPA 79 for GFCI for Receptacles; 66.4.4***

- ***Alignment with NFPA 79 and NEC Regarding the Term Used to Indicate the Full-load Current; 2.26, 28.3.3, 29.6.1, 29.6.2, 31.3.1, Table 31.1, 31.4.1, 31.4.2, 33.2.1, 33.5.1, Table 33.2, 42.2.3.2, 45.2.1, 49.1, 49.2, 50.1, Table 50.1, Table 50.2, Table 52.1, 66.5.5, 67.1.1, 90.4.3, 98.1.2***

- ***Clarification of 31.3.3 for Self-protected Combination Motor Controllers; 31.3.3***

- ***Misprint in Paragraph 32.3.1***

- ***Revision of Requirements for Feeder Taps for Motor Loads; 32.5.1***

- ***Addition of Reactors Covered by UL 508; 36.3.1, 36.3.2***

- ***Manual Motor Starters as Overcurrent Protection for Control Transformers; 40.1.6, 40.2.3, 40.3.7***

- ***UPS with Supercapacitors; 47.3.2***

- ***Clarification of Overload Relay Heater Table Marking Requirement; 58.1***

- ***Alternate Enclosure Types; Table 19.2, 62.4, 62.5, 64.3***

- ***Enclosure Access; 66.1.2, 66.1.3, 66.1.3.1, 66.1.3.2, 67.4.2, 67.4.3***

- ***Deletion of Marking Requirement; 67.1.2***

- ***RFI/EMI Filters Rated Greater Than 400A; Table SB4.1***

- ***Power Monitoring Devices; SB4.2.1***

- ***Table SB4.2 Correction of Class RK1 I^2t Let-through Values at 50kA***

- ***SCCR Marking of Required Overcurrent Protective Device; SB4.2.3, SB5.1.1, SB5.1.3***

- ***Overload Protection Exemption for TP, IP, and EP Motor Circuits; 34.3.1, 50.4, 60.1***

- ***Alternative Testing of Component Bonding Connection; B.3.2***

- ***Interrupting Rating Versus Short-circuit Current Rating; 2.28B, SB3.2.1, Table SB4.1, SB4.2.1, SB4.4.1, SB4.4.2***

- ***Internal Conductor Ampacity Requirements for Power Circuits; 29.6.1***

- ***Schematic Wiring Diagrams; 61.1***

- ***Protection for Variable-Speed Drives; 31.3.2***

Text that has been changed in any manner or impacted by UL's electronic publishing system is marked with a vertical line in the margin.

The revised requirements are substantially in accordance with Proposal(s) on this subject dated July 16, 2021, February 11, 2022 and June 17, 2022.

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UL 508A

Standard for Industrial Control Panels

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This ANSI/UL Standard for Safety consists of the Third Edition including revisions through July 28, 2022.

The most recent designation of ANSI/UL 508A as an American National Standard (ANSI) occurred on July 21, 2022. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page. Any other portions of this ANSI/UL standard that were not processed in accordance with ANSI/UL requirements are noted at the beginning of the impacted sections.

Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at https://csds.ul.com.

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PART 1 – GENERAL USE INDUSTRIAL CONTROL PANELS

INTRODUCTION

1 Scope

1.1 These requirements cover industrial control panels intended for general industrial use, operating from a voltage of 1000 volts or less. This equipment is intended for installation in ordinary locations, in accordance with the National Electrical Code, ANSI/NFPA 70 and where the ambient temperature shall be between 5°C (41°F) and 40°C (104°F), unless marked with an ambient temperature rating.

1.2 These requirements also cover industrial control panel enclosures and industrial control panels primarily intended for flame safety supervision of combustible fuel type equipment, crane or hoist control, service equipment use, marine use, air conditioning and refrigeration equipment, equipment for load management applications, fountain control, irrigation equipment control, and for control of industrial machinery including metalworking machine tools, power press controls, and plastic injection molding machinery. Also covered are industrial control panels intended for control of permanently installed electrical equipment for aquatic playgrounds, permanently installed electrical equipment associated with commercial water park rides, wave pools and similar installations, and permanently installed electrical equipment associated with commercial and large residential swimming pools and in-ground spas.

1.3 This equipment consists of assemblies of two or more power circuit components, such as motor controllers, overload relays, fused disconnect switches, and circuit breakers, or control circuit components, such as pushbuttons, pilot lights, selector switches, timers, and control relays, or a combination of power and control circuit components, with associated wiring, and terminals. These components are mounted on, or contained within, an enclosure, or are mounted on a sub-panel.

1.4 An industrial control panel does not include an evaluation of the controlled equipment such as motors, heaters, lighting, and other loads connected to power circuits. Unless specifically noted on the wiring diagram of the industrial control panel, an industrial control panel does not include equipment mounted remotely from the panel and connected via a wiring systems or equipment field installed on or within the industrial control panel.

1.5 An evaluation of the adequacy of the controls and protective devices contained in an industrial control panel for supervision and proper functioning of the controlled loads or equipment is not covered by the requirements in this standard. Such evaluations are covered by the standards applicable to the complete piece of utilization equipment.

1.6 The evaluation of a pre-fabricated building, structure, or platforms supplied with industrial control panels are not covered by the requirements in this standard.

1.7 Fire pump controllers are covered by the Standard for Fire Pump Controllers, UL 218.

1.8 Equipment intended for use in hazardous locations, as defined in the National Electrical Code, ANSI/NFPA 70, are covered by the Standard for Explosion-Proof and Dust-Ignition-Proof Electrical Equipment for Use in Hazardous (Classified) Locations, UL 1203.

1.9 Industrial control panels incorporating intrinsic safety barriers and intended for connection to circuits residing in hazardous locations are covered by the Standard for Industrial Control Panels Relating to Hazardous (Classified) Locations, UL 698A.

1.10 Motor control centers, including motor control center sections and units, or equipment intended for field installation into a motor control center are covered by the Standard for Motor Control Centers, UL 845.

1.11 Assemblies of electrical control units or equipment containing electrical control units for fire-protective signaling systems are covered by the Standard for Control Units and Accessories for Fire Alarm Systems, UL 864.

1.12 A freestanding assembly of overcurrent protective devices and busses for control of electric light and power circuits or equipment intended for field installation in dead-front switchboards shall be evaluated to the Standard for Switchboards, UL 891.

1.13 Equipment intended to supply automatic illumination, power, or both, to critical areas and equipment essential to safety of human life is covered by the Standard for Emergency Lighting and Power Equipment, UL 924.

1.14 Control equipment for use with swimming pools and spas is covered by the Standard for Electric Spas, Equipment Assemblies, and Associated Equipment, UL 1563.

1.15 Portable control panels containing switches, overcurrent protection, and cord connected via attachment plugs and receptacles for use at carnivals, circuses, fairs, exhibition halls, motion picture and television studios, theaters, construction sites and similar locations are covered by the Standard for Portable Power-Distribution Equipment, UL 1640.

1.16 Equipment for the control of fuel cells, photovoltaic systems, or utility interactive systems are covered by the Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources, UL 1741.

1.17 Enclosures or pedestals containing terminals for connection of power circuit conductors are covered by the Standard for Termination Boxes, UL 1773.

1.18 Emergency alarm equipment or control panels containing emergency alarm equipment are covered by the Standard for General-Purpose Signaling Devices and Systems, UL 2017.

1.19 Equipment for gas or vapor detection or control panels containing gas or vapor detection equipment is covered by the Standard for Gas and Vapor Detectors and Sensors, UL 2075.

1.20 Control panels containing predominately communication equipment, such as telephone equipment and intended for installation in accordance with Chapter 8 of the NEC, is evaluated to the Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1.

1.21 Control equipment intended for use in physical access control systems, which provide an attended or unattended means of monitoring or controlling traffic through portals of a protected area for security purposes; or in key management systems, which regulate or control access to the use of a device by electrical, electronic or mechanical means, are covered by the Standard for Access Control System Units, UL 294.

1.22 Electrically operated or mechanically operated control equipment or enclosures intended for theft deterrent or warning purposes, such as detectors, security containers or alarms for merchandise or property, are covered by the Standard for Antitheft Alarms and Devices, UL 1037.

1.23 Equipment primarily intended to energize or de-energize electrical loads to achieve the desired use of electrical power is covered by the Standard for Energy Management Equipment, UL 916. Such equipment is intended to control electrical loads by responding to sensors or transducers monitoring power consumption, by sequencing, by cycling the loads through the use of preprogrammed data logic circuits, or any combination thereof.

1.24 Control panels, control units, and other various electrical circuits employed within a control circuit device intended for support functions, maintain operation and limiting safety control features for use in a Stationary Engine Driven Assembly or similar power production equipment (generator) control applications are covered by the Standard for Controllers for Use in Power Production, UL/ULC 6200.

1.25 Industrial control panels intended for control of elevators, dumbwaiters, escalators, moving walks, inclined lifts, and associated equipment are evaluated to the requirements contained in ANSI/ASME A17.1, American National Standard Safety Code for Elevators and Escalators, and ANSI/ASME A17.5, Elevator and Escalator Electrical Equipment.

1.26 An assembly of overcurrent protective devices and busses for control of electric light and power circuits, provided as part of an industrial control panel, shall be evaluated to the Standard for Panelboards, UL 67.

2 Glossary

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

2.2 APPLIANCE – A piece of utilization equipment that incorporates both controls and loads.

2.3 BRANCH CIRCUIT – The conductors and components following the last overcurrent protective device protecting a load.

2.4 BRANCH CIRCUIT PROTECTION – Overcurrent protection with an ampere rating selected to protect the branch circuit. For a motor branch circuit, the overcurrent protection is required for overcurrents due to short circuits and faults to ground only, see 2.5 and 2.23 and 2.29. For motor overload protection, see 2.39.

2.5 BRANCH CIRCUIT PROTECTIVE DEVICE – A fuse or circuit breaker that has been evaluated to a safety standard for providing overcurrent protection. See 2.23 and 2.30.

2.6 CLASS 1 CIRCUIT – A control circuit on the load side of overcurrent protective device where the voltage does not exceed 600 volts, and where the power available is not limited, or control circuit on the load side of power limiting supply, such as a transformer.

2.7 CLASS 1 WIRING – Conductors of a Class 1 Circuit.

2.8 CLASS 2 CIRCUIT – A control circuit supplied from a source having limited voltage (30 Vrms or less) and current capacity, such as from the secondary of a Class 2 transformer, and rated for use with Class 2 remote-control or signaling circuits.

2.9 CLASS 2 WIRING – Conductors of a Class 2 circuit.

2.10 COMBINATION MOTOR CONTROLLER – One or more devices assembled to provide disconnecting means, branch circuit protection, motor control, and motor overload protection for a single motor circuit.

2.11 CONTROL CIRCUIT – A circuit that carries the electric signals directing the performance of a controller, and which does not carry the main power circuit. A control circuit is, in most cases, limited to 15 amperes.

2.12 CONTROL TRANSFORMER – A transformer whose secondary supplies power to control circuit devices only (excluding loads).

2.13 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.

2.14 COVER – An unhinged portion of an enclosure that covers an opening.

2.15 DISCONNECT SWITCH – A device that disconnects all ungrounded conductors of a circuit from their electrical supply.

2.16 DOOR – A hinged portion of an enclosure that covers an opening.

2.17 DUTY, INTERMITTENT – Operation for alternate intervals of:

a) Load and no load; or

b) Load and rest; or

c) Load, no load, and rest.

2.18 ENCLOSED INDUSTRIAL CONTROL PANEL – An industrial control panel provided with an enclosure at the factory.

2.19 FEEDER CIRCUIT – The conductors and circuitry on the supply side of the branch circuit overcurrent protective device.

2.20 FIELD INSTALLED EQUIPMENT – Devices to be installed after an industrial control panel is built/labeled.

2.21 FIELD WIRING – Conductors to be installed by others to connect the industrial control panel to source(s) of supply, remote control devices, and loads.

2.22 FIELD WIRING TERMINAL – A terminal provided in an industrial control panel to terminate field wiring.

2.23 FUSE, BRANCH CIRCUIT TYPE – A fuse of Class CC, CF, G, H, J, K, L, R, and T. These fuses are able to provide branch circuit protection.

2.24 FUSE, SEMICONDUCTOR TYPE – A fuse designed for the protection of semiconductor devices. These fuses are able to provide branch circuit protection of motor circuits containing power conversion equipment as in 31.1.3.

2.25 FUSE, SUPPLEMENTARY TYPE – Miscellaneous type and miniature type fuses. These fuses are able to provide supplementary protection only.

2.26 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 current rating not exceeding the ampere rating of the device;

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

c) When dc rated, a load that is resistive (noninductive).

2.27 HEATER TABLE – Table supplied by the manufacturer of an overload relay having replaceable current elements that provides additional instructions as to the proper installation.

2.28 INDUSTRIAL CONTROL PANEL FOR GENERAL USE – A control panel intended to be installed in accordance with the general use requirements in Chapter 4 of the National Electrical Code, ANSI/NFPA 70.

2.28A INTERLOCK (for safeguarding of industrial machinery) – An arrangement that interconnects guard (s) or device (s) with the control system or all or part of the electrical energy distributed to the machine.

2.28B INTERRUPTING RATING – The highest current at rated voltage that a device is identified to interrupt under standard test conditions.

2.29 INSTANTANEOUS TRIP CIRCUIT BREAKER – A circuit breaker in which no delay is introduced into the tripping action of the circuit breaker. These circuit breakers are able to provide motor branch circuit protection when evaluated as a part of a combination motor controller as in 31.1.1.

2.30 INVERSE-TIME CIRCUIT BREAKER – A circuit breaker in which a delay is introduced into the tripping action of the circuit breaker. The delay decreases as the magnitude of the current increases. These circuit breakers are able to provide branch circuit protection.

2.31 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 evaluated as part of the primary circuit.

2.32 LOAD – A device external to the industrial control panel that is connected to the power circuit.

2.33 LOW-VOLTAGE LIMITED ENERGY CIRCUIT – A control circuit involving a peak open-circuit potential of not more than 30 volts ac rms, 42.4 volts peak, or 60 volts dc supplied by a primary battery or by an isolated secondary circuit, and where the current capacity is limited by an overcurrent device, such as a fuse, or by the inherent capacity of the secondary transformer or power supply, or a combination of a secondary winding and an impedance. A circuit derived from a line-voltage circuit by connecting a resistance in series with the supply circuit to limit the voltage and current is not identified as a low-voltage limited energy circuit.

2.34 MANUAL SELF-PROTECTED COMBINATION MOTOR CONTROLLER – A self-protected combination motor controller that is operable only by manual means.

2.35 MOTOR STARTER – An assembly of an overload relay and a contactor.

2.36 ONE-PORT SPD – An SPD having provisions (terminals, leads, plug) for connection to the ac power circuit but no provisions (terminals, leads, receptacles) for supplying current to ac power loads.

2.37 OPEN INDUSTRIAL CONTROL PANEL – An industrial control panel that includes internal wiring, field wiring terminals, and components mounted on a subpanel without a complete enclosure. The enclosure is intended to be supplied/completed at the installation.

2.38 OVERCURRENT PROTECTION – A device designed to open a circuit when the current through it exceeds a predetermined value. The ampere rating of the device is selected for a circuit to terminate a condition where the current exceeds the rating of conductors and equipment due to overloads, short circuits and faults to ground.

2.39 OVERLOAD PROTECTION – Protection required for motor circuits that will operate to prohibit excessive heating due to running overloads and failure to start.

2.40 PILOT DUTY RATING – A rating assigned to a relay or switch that controls the coil of another relay or switch.

2.41 POWER CIRCUIT – Conductors and components of branch and feeder circuits.

2.42 POWER TRANSFORMER – A transformer whose secondary winding supplies power to loads or a combination of loads and control circuit devices operating at the secondary voltage.

2.43 SELF-PROTECTED COMBINATION MOTOR CONTROLLER – A combination motor controller that contains coordinated overload and short circuit protection, and also provides disconnecting means and remotely-operable motor controller. Coordinated protection is able to be inherent or obtained by correct selection of components or accessory parts in accordance with the manufacturer's instructions.

2.44 SHORT CIRCUIT CURRENT RATING – The prospective symmetrical fault current at a nominal voltage to which an apparatus or system is able to be connected without sustaining damage exceeding the defined acceptance criteria.

2.45 SUPPLEMENTARY PROTECTION – A device intended to provide additional protection subsequent to branch circuit protection. They have not been evaluated for providing branch circuit protection.

2.46 SUPPLEMENTARY PROTECTOR – A manually resettable device designed to open the circuit automatically on a predetermined value of time versus current or voltage within an appliance or other electrical equipment. It is also able to be provided with manual means for opening or closing the circuit. These devices are able to provide supplementary protection only.

2.47 SURGE PROTECTIVE DEVICE (SPD) – A device composed of at least one non-linear component and intended for limiting surge voltages on equipment by diverting or limiting surge current and is capable of repeating these functions as specified. SPDs were previously known as Transient Voltage Surge Suppressors or secondary surge arresters.

2.48 SURGE PROTECTIVE DEVICE (SPD) ELECTRICAL RATINGS:

a) NOMINAL DISCHARGE CURRENT (In) – Peak value of the current, selected by the manufacturer, through the SPD having a current waveshape of 8/20 where the SPD remains functional after 15 surges.

b) MAXIMUM CONTINUOUS OPERATING VOLTAGE (MCOV) rating – The maximum continuous operating voltage that may be applied between the terminals of a surge protective device (SPD).

c) NORMAL OPERATING VOLTAGE RATING – The voltage rating assigned to an SPD by the manufacturer. For an SPD, other than a Component-SPD, it is generally equal to the nominal value of the voltage of the circuit (for example, 120, 208, 240, 347, 480, or 600 Vrms).

2.49 SURGE PROTECTIVE DEVICE (SPD) TYPE DESIGNATIONS – SPD Type designations are as follows:

TYPE 1 – Permanently connected SPDs intended for installation between the secondary of the service transformer and the line side of the service equipment overcurrent device, as well as the load side, including watt-hour meter socket enclosures and intended to be installed without an external overcurrent protective device.

TYPE 2 – Permanently connected SPDs intended for installation on the load side of the service equipment overcurrent device – including SPDs located at the branch panel.

TYPE 3 – Point of utilization SPDs, installed at a minimum conductor length of 10 meters (30 feet) from the electrical service panel to the point of utilization, for example cord connected, direct plug-in, receptacle type and SPDs installed at the utilization equipment being protected. The distance of 10 meters (30 feet) is exclusive of conductors provided with or used to attach SPDs.

TYPE 4 COMPONENT ASSEMBLIES – Component assembly consisting of one or more Type 5 components together with a disconnect (integral or external) or a means of complying with the limited current tests.

TYPE 1, 2, 3 COMPONENT ASSEMBLIES – Consists of a Type 4 component assembly with internal or external short circuit protection. These types are tested and rated based on the intended application as either Type 1, 2 or 3 SPD's.

TYPE 5 – Discrete component surge suppressors, such as MOVs that may be mounted on a PWB, connected by its leads or provided within an enclosure with mounting means and wiring terminations.

2.50 TUNGSTEN RATING – A rating assigned to devices intended to control incandescent lamp loads.

2.51 TWO-PORT SPD – An SPD having provisions (terminals, leads, plug) for connection to the ac power circuit and provisions [terminals, leads, receptacles(s)] for supplying current to one or more ac power loads. SPDs provided with a minimum of two adjacent terminals for each circuit conductor may be considered and tested as a two-port SPD.

2.52 WIRE BENDING SPACE – The amount of space required between a field wiring terminal and an enclosure wall directly opposite the terminal, to provide enough space for field wiring conductors.

3 Undated References

3.1 Any undated reference to a code or standard appearing in the requirements of this standard shall be interpreted as referring to the latest edition of that code or standard.

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 used in the products covered by this standard.

4.2 A component is not required to comply with a specific requirement that:

a) Involves a feature or characteristic not required 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 rating established for the intended conditions of use.

4.4 Specific components are 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.

4.5 A component that complies with the requirements of Appendix B, or Appendix D is able to be used in a product covered by this standard.

5 Units of Measurement

5.1 Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information.

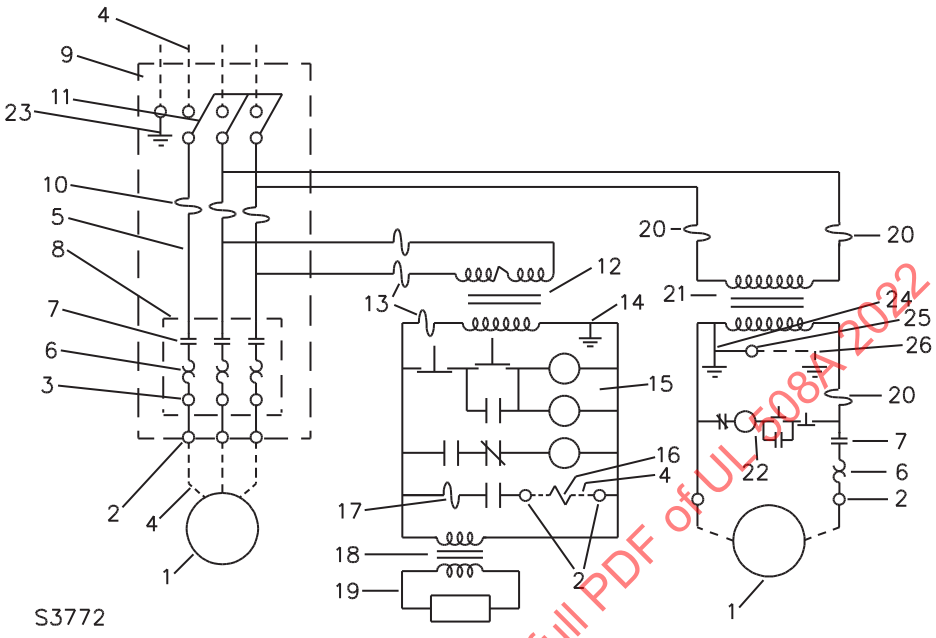
5.2 For calculations involving amperes, calculations resulting in a fraction of less than 0.5 shall be rounded down to the next whole number. Calculations resulting in a fraction of 0.5 or more shall be rounded up to the next whole number.

6 Terminology

6.1 For the purpose of this standard, the terms illustrated in Figure 6.1, Figure 6.2, and Figure 6.3 shall apply.

Figure 6.1

Description of terminology



1 Load (provided in field)

2 Field wiring terminals

3 Alternate field terminals

4 Field wiring

5 Power circuit internal wiring

6 Overload relay & heater elements

7 Contactor/Controller

8 Starter

9 Combination motor controller

10 Branch circuit protection

11 Fused disconnect switch or circuit breaker

12 Control transformer

13 Control transformer fuse/supplementary protection

14 Control transformer ground (for 1000 VA max control transformer)

15 Control circuit devices and wiring/Class 1 circuit/isolated secondary circuit

16 Solenoid or other control device – provided in field

17 Supplementary protection

18 Class 2 transformer

19 Class 2 circuit

20 Power transformer fuse/branch circuit protection

21 Power transformer – for motor load and control circuit

22 Control circuit/Class 1 circuit/common control circuit

23 Equipment ground and equipment ground terminal

24 Bonding conductor/bonding jumper

25 Grounding electrode conductor terminal

26 Grounding electrode conductor (provided in field)

Figure 6.2

Description of control circuits and power circuits

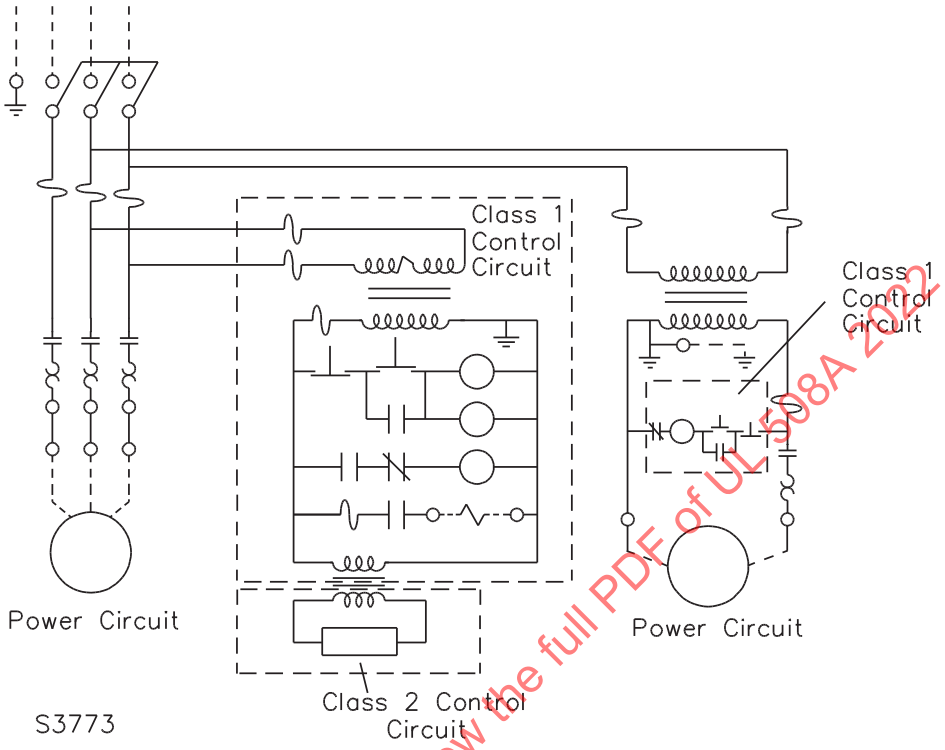
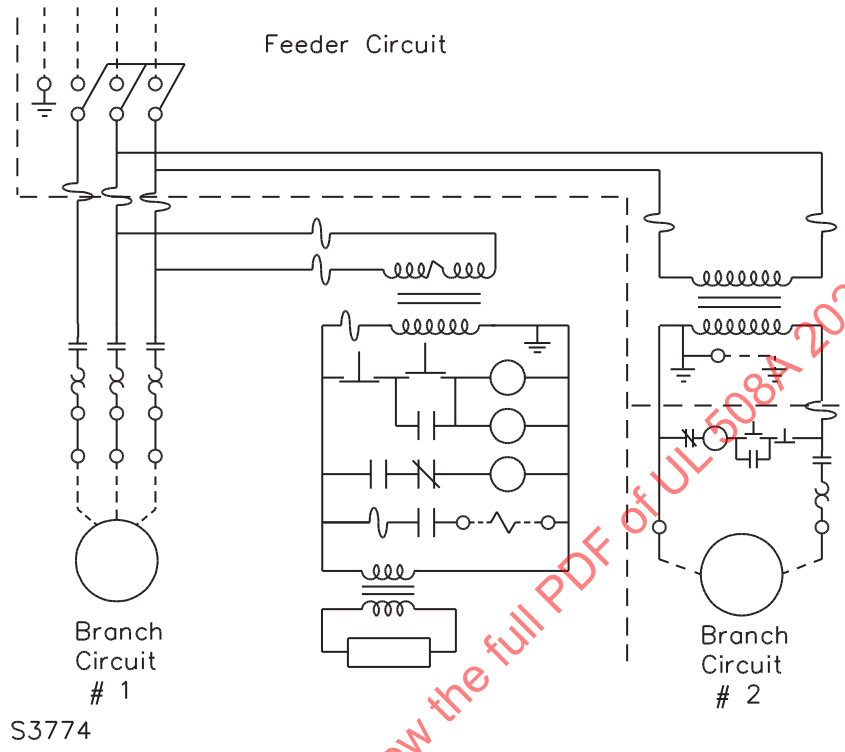


Figure 6.3

Description of branch circuits and feeder circuits



CONSTRUCTION

ALL PANELS

7 General

7.1 An industrial control panel 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; and

b) Employ materials and components that are determined to be usable in the application.

8 Protection Against Corrosion

8.1 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 required for proper mechanical operation.

Exception: This requirement does not apply to:

a) Bearings, thermal elements, sliding surfaces of a hinge, shaft, or similar part, where such protection is impracticable;

b) Small parts of iron or steel, such as washers, screws, bolts, or similar parts, when the parts are not current carrying or relied upon to support or maintain the relative position of uninsulated live parts or components; and

c) Parts made of stainless steel.

9 Support and Securement of Live Parts

9.1 Provisions shall be made for securely mounting components to a supporting surface. A bolt, screw, or other part used to secure a part of a component shall not also be used to secure the component to the supporting surface.

9.2 A live screwhead or nut on the underside of an insulating base shall be prohibited from loosening by means of a star or lock washer and shall be insulated from the mounting surface by an insulating barrier that complies with Section 12, Insulating Barriers, or by through air and over surface spacings specified in Section 10, Spacings.

9.3 An uninsulated live part, including a terminal, or a component with uninsulated live parts shall be secured to its supporting surface by a method other than friction so that it is prohibited from turning or shifting in position. Turning or shifting of a live part is able to be prohibited by the use of:

a) Two or more screws or rivets securing the component or part to the mounting surface;

b) Non-circular shoulders or mortises that abuts an adjacent part or mechanical stop member such as a mounting rail;

c) Non-circular shoulders or mortises that fit through an opening of the same shape cut into the mounting surface for a panel-mounted component or part;

d) A dowel, pin, lug, or offset that mates with a hole, recess or offset in the mounting surface; or

e) A connecting strap or clip fitted into an adjacent part.

9.4 For a live part or a component with uninsulated live parts that are secured by means other than as in 9.3, the part or component shall comply with the following:

a) The mounting screw or nut, when provided, is loosened (one component or part at a time) to allow movement;

b) Is subjected to typical operation of the device, such as switch operation, relamping operation or fuse replacement operation, or rotated to the extent limited by the mounting screw or other means; and

c) As a result of (a) and (b), the spacings between the uninsulated live parts shall not be reduced below the requirements in Section 10, Spacings, and the internal wiring shall not be damaged or strain transmitted to the terminals due to operation or rotation.

10 Spacings

10.1 Other than as required by 9.2, 9.4, 10.8, 12.1, 13.2, Exception to 21.3.4, 28.2.1(a), 28.2.2(a), 29.2.2(a), 29.3.7, 29.3.9, and 36.2.3, spacings at and within a component or device shall be investigated based on the requirements for that component or device.

10.2 Unless otherwise specified in this standard, spacings between uninsulated live parts of adjacent components, between uninsulated live parts of components and grounded or accessible dead-metal parts, between uninsulated live parts of components and the enclosure, and at field wiring terminals, shall be:

a) According to Table 10.1 or Table 10.1A for the following:

1) Field wiring terminals of a feeder tap terminating in a branch circuit protective device in a remote subpanel included on the panel schematic;

2) Field wiring terminals of a branch circuit, control circuit (including the control circuits of power circuit components), or an instrumentation circuit;

3) Factory wired terminals of feeder circuits, feeder tap circuits, branch circuits, control circuits, and instrumentation circuits;

4) Bus bars in a branch circuit constructed and rated according to the requirements in 29.6.2 or Appendix D of this standard.

b) According to Table 10.2 for the following:

1) Field wiring terminals for input or output of feeder circuits, except for voltages of 251 – 1000V, a 12.7mm (1/2 in) spacing through air to grounded parts is permitted; and

2) Bus bars in a feeder circuit constructed and rated according to the requirements in 29.6.2 or Appendix D of this standard.

Exception: Spacings at field wiring terminals for the supply connection to an industrial control panel, where the branch circuit protective device, protecting a branch circuit in the panel, is omitted and provided by the installer in accordance with 60.1, shall be permitted to comply with Table 10.1.

Table 10.1
Minimum required spacings in branch and control circuits

Potential involved in volts rms ac or dc		Minimum spacing, inch (mm)					
		A			B		C
		General industrial control equipment			Devices having limited ratings[a]		All circuits[d]
		51 – 150	151 – 300	301 – 600	51 – 300	301 – 600	0 – 50
Between any uninsulated live part and an uninsulated live part of opposite polarity, uninsulated grounded part other than the enclosure, or exposed metal part[f,g]	Through air or oil	1/8[b] (3.2)	1/4 (6.4)	3/8 (9.5)	1/16[b] (1.6)	3/16[b] (4.8)	1/16[b] (1.6)
	Over surface	1/4 (6.4)	3/8 (9.5)	1/2 (12.7)	1/8[b] (3.2)	3/8 (9.5)	1/16[b] (1.6)
Between any uninsulated live part and the walls of a metal enclosure including fittings for conduit or armored cable[c,e]	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)

NOTES –

1 A slot, groove, or similar gap, 0.013 inch (0.33 mm) wide or less in the contour of insulating material is to be disregarded for the purpose of measuring over surface spacings.

2 An air space of 0.013 inch (0.33 mm) or less between a live part and an insulating surface is to be disregarded for the purpose of measuring over surface spacings.

[a] See 10.5.

[b] 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 (6.4 mm) when short-circuiting or grounding of such terminals results from projecting strands of wire. For circuits involving no potential greater than 50 volts rms ac or dc, spacings at field wiring terminals are able to be 1/8 inch (3.2 mm) through air and 1/4 inch (6.4 mm) over surface.

Table 10.1 Continued on Next Page

Table 10.1 Continued

Potential involved in volts rms ac or dc		Minimum spacing, inch (mm)					
		A			B		C
		General industrial control equipment			Devices having limited ratings[a]		All circuits[d]
		51 – 150	151 – 300	301 – 600	51 – 300	301 – 600	0 – 50

[c] For the purpose of this requirement, a metal piece or component attached or mounted to the enclosure is evaluated as a part of the enclosure when deformation of the enclosure reduces the spacings between uninsulated live parts or between uninsulated live parts and metal parts.

[d] Spacings do not apply within a low-voltage limited energy circuit or a Class 2 circuit.

[e] 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).

[f] 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 with a limited rating complying with 10.5.

[g] 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.

Table 10.1A
Minimum required spacings in branch circuits rated 601 – 1000 V

Voltage, V rms ac or dc	Minimum Spacing, in (mm)			
	Between any uninsulated live part and an uninsulated live part of opposite polarity, uninsulated grounded part other than the enclosure, or exposed metal		Between any uninsulated live part and the walls of a metal enclosure including fittings for conduit or armored cable	
	Through Air	Over Surface	Through Air	Over Surface
601 – 1000	0.55 (14.0)	0.85 (21.6)	0.80[a] (20.3)[a]	1.00 (25.4)

[a] The through-air spacing shall not be less than 1/2 inch between live parts of a circuit breaker or fusible disconnecting means and grounded metal.

Table 10.2
Spacings in feeder circuit

Voltage involved	Minimum spacing, inch (mm)		
	Between live parts of opposite polarity		Between live parts and grounded metal parts, through air and over surface
	Through air	Over surface	
125 or less	1/2 (12.7)	3/4 (19.1)	1/2 (12.7)
126 – 250	3/4 (19.1)	1-1/4 (31.8)	1/2 (12.7)
251 – 1000	1 (25.4)	2 (50.8)	1[a] (25.4)[a]

NOTE – An isolated dead metal part, such as a screw head or a washer, interposed between uninsulated parts of opposite polarity or between an uninsulated live part and grounded dead metal is evaluated as reducing the spacing by an amount equal to the dimension of the interposed part along the path of measurement.

[a] The through-air spacing shall not be less than 1/2 inch between live parts of a circuit breaker or fusible disconnecting means and grounded metal, and between grounded metal and the neutral of an industrial control panel rated 277/480 volt, 3-phase, 4-wire.

10.3 Spacings between isolated circuits at different potentials shall be in accordance with those required for the higher potential circuit.

10.4 A through air spacing of 5/8 inch (15.9 mm) shall be provided between the terminals of an oil-filled capacitor and any uninsulated live part at opposite polarity, of a different (isolated) circuit, or to grounded metal parts. The spacing shall be measured in a direction perpendicular to the end cap.

10.5 The spacings specified in column B of Table 10.1 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 when 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.

10.6 The spacings between live parts and metal parts that are intended to be grounded, such as the heads of mounting screws that pass through an insulating panel, shall be evaluated as grounded parts within an enclosure.

10.7 For an enclosed panel without conduit openings or knockouts, spacings not less than the minimum specified in 11.1 shall be provided between uninsulated live parts and a conduit bushing installed at any location intended to be used during installation. A permanent marking on the enclosure, a template, or a full-scale drawing furnished with the equipment is able to be used to identify such locations as in 53.6.

10.8 The spacings for a discrete fuseholder shall be as follows:

a) A fuseholder used for fuses providing required branch circuit protection or feeder circuit protection shall comply with the spacings specified in column A of Table 10.1;

b) A fuseholder used for fuses providing supplementary protection within the branch circuit shall comply with the spacings specified in Table 10.1.

10.9 The spacings for connectors, receptacles, attachment plugs, inlets and cable assemblies described in 28.2.5, 28.6.1, 28.6.6 and 28.7.1 provided in a feeder circuit, branch circuit or control circuit and rated 600V or less shall be a minimum 3/64 inch (1.2 mm) for a device rated 250 V or less, and a minimum 1/8 inch (3.2 mm) for a device rated more than 250 V, between the following:

a) Uninsulated live parts of opposite polarity;

b) An uninsulated live part and a dead-metal part that is likely to be grounded or exposed to contact by persons when the device is installed as intended, including a metal surface on which the device is mounted in the intended manner or a metal face plate used with a flush receptacle.

11 Conduit Bushings

11.1 An enclosure with openings for wiring systems, where provided, shall have a flat surrounding surface for proper seating of a conduit bushing. Each opening shall be so located that installation of a bushing having dimensions as specified in Table 11.1 does not result in spacings between uninsulated live parts and the bushing of less than the minimum requirement. When multiple size knockouts are provided, spacings shall be determined using the largest bushing size accommodated unless the equipment is marked to specify maximum usable size.

Table 11.1
Dimensions of bushings

Trade size of conduit, inches	Bushing dimensions, inches (mm)			
	Overall diameter		Height	
1/2	1	(25.4)	3/8	(9.5)
3/4	1-15/64	(31.4)	27/64	(10.7)
1	1-19/32	(40.5)	33/64	(13.1)
1-1/4	1-15/16	(49.2)	9/16	(14.3)
1-1/2	2-13/64	(56.0)	19/32	(15.1)
2	2-45/64	(68.7)	5/8	(15.9)
2-1/2	3-7/32	(81.8)	3/4	(19.1)
3	3-7/8	(98.4)	13/16	(20.6)
3-1/2	4-7/16	(112.7)	15/16	(23.8)
4	4-31/32	(126.2)	1	(25.4)
4-1/2	5-35/64	(140.7)	1-1/16	(27.0)
5	6-7/32	(158.0)	1-3/16	(30.2)
6	7-7/32	(183.4)	1-1/4	(31.8)

12 Insulating Barriers

12.1 When an insulating material is used as a barrier in order to comply with the required over surface or through air spacings, or both, the required spacings in Section 10, Spacings, shall be applied by tracing over the surface of the insulator and through air to the edges of the insulator.

12.2 Insulating material used as specified in 12.1 shall comply with the following requirements:

a) The material shall be:

1) An insulating material described in Table 12.1; or

2) Tubing or sleeving complying with 29.2.3 and rated for the voltage involved;

b) The material is able to be in direct contact with uninsulated live parts; and

c) The material does not serve to physically support or maintain the position of an uninsulated live part.

Exception: A material that does not comply with 12.2 shall be investigated as an insulating barrier in accordance with the requirements in the Standard for Industrial Control Equipment, UL 508.

Table 12.1
Generic materials for use as barriers

Generic material	Minimum thickness	
	inches	(mm)
Aramid Paper	0.010	(0.25)
Electrical Grade Paper	0.028	(0.71)

Table 12.1 Continued on Next Page

Table 12.1 Continued

Generic material	Minimum thickness	
	inches	(mm)
Epoxy	0.028	(0.71)
Mica	0.006	(0.15)
Mylar (PETP)	0.007	(0.18)
RTV	0.028	(0.71)
Silicone Rubber	0.028	(0.71)
Vulcanized Fiber	0.028	(0.71)

13 Insulating Materials

13.1 An insulating material that is used for the direct support of an uninsulated live part, such as a standoff or insulating base for a bus bar, current shunt, or terminal, shall comply with 13.2. A material is in direct support of an uninsulated live part when:

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: A material in direct contact only with uninsulated live parts of a low-voltage limited energy circuit or a Class 2 circuit is not required to comply with 13.1.

13.2 Insulating material used as specified in 13.1 shall comply with the following requirements:

a) The material shall be an insulating material described in Table 13.1; and

b) The dimensions of the insulating material shall comply with the required spacings of Section 10, Spacings.

Exception: A material that does not comply with 13.2 shall be investigated as an insulating material in accordance with the requirements in the Standard for Industrial Control Equipment, UL 508.

Table 13.1
Generic materials for direct support of uninsulated live parts

Generic material	Minimum thickness	
	inches	(mm)
Diallyl phthalate	0.028	(0.71)
Epoxy	0.028	(0.71)
Melamine	0.028	(0.71)
Melamine-phenolic	0.028	(0.71)
Phenolic	0.028	(0.71)
Unfilled nylon	0.028	(0.71)
Unfilled polycarbonate	0.028	(0.71)
Urea formaldehyde	0.028	(0.71)
Ceramic, porcelain, and slate	no limit	no limit
Beryllium oxide	no limit	no limit

14 Grounding – General

14.1 An industrial control panel shall have provision for grounding all noncurrent carrying metal parts that are exposed or that are able to be contacted by persons during normal operation or adjustment of the equipment and that are able to become energized due to a breakdown of insulation, loose wiring connection, or electrical disturbance. Grounding (bonding) braids shall be listed according to UL 467 and sized according to 15.1.

14.2 An industrial control panel shall be provided with a field wiring terminal for the connection of an equipment grounding conductor. The terminal shall comply with:

a) The component requirements of a field wiring terminal in accordance with Section 28, Field Wiring; or

b) The requirements in the Standard for Grounding and Bonding Equipment, UL 467.

14.3 The equipment grounding terminal shall have electrical continuity with all metal parts of the enclosure, or subpanel for open type equipment, by means of metal-to-metal contact or by means of an internal bonding conductor that complies with 15.2.

14.4 An industrial control panel that is not intended to be permanently connected to the building power supply shall be provided with a flexible cord that:

a) Complies with 28.5;

b) Contains a grounding conductor that is connected to the grounding prong of the attachment plug; and

c) Has the grounding conductor connected to the enclosure as in 14.1 and 14.2 and terminated with wiring methods described in 29.3.1 – 29.3.9.

15 Grounding – Size of Terminal or Bonding Conductor

15.1 A field wiring terminal for connection of an equipment grounding conductor shall accommodate the conductor size required by Table 15.1 based upon the overcurrent protection provided for field wiring conductors supplying panel that is:

a) The rating of the branch circuit protection marked on the industrial control panel, or wiring diagram, or as calculated from the requirements in Section 31, Branch Circuit Protection, when branch circuit protection is not provided in the panel; or

b) An ampere rating equal to the ampacity of the anticipated field wiring size calculated from Section 28, Field Wiring, when the branch circuit and/or feeder protection is provided in the panel.

Exception: The terminal for the equipment grounding conductor is not required to retain a wire larger than the field wiring conductors supplying the panel.

Table 15.1
Size of equipment grounding conductor terminal

Maximum ampere rating of overcurrent protection for field wiring conductors supplying panel, see 15.1	Size of equipment grounding or bonding conductor, minimum			
	Copper		Aluminum	
	AWG or kcmil	(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	(107.2)
1200	3/0	(85.0)	250 kcmil	(127)
1600	4/0	(107.2)	350	(177)
2000	250 kcmil	(127)	400	(203)
2500	350	(177)	600	(304)
3000	400	(203)	600	(304)
4000	500	(253)	800	(405)
5000	700	(355)	1200	(608)
6000	800	(506)	1200	(608)

15.2 The size of an internal bonding conductor shall not be less than the size specified in Table 15.1 or the size of the field wiring conductor supplying the industrial control panel, whichever is smaller.

Exception: Where an internal over-current device is installed to protect control circuit conductors for door mounted equipment, the ampere rating of this over-current device can be used to size the bonding conductor for enclosure doors.

16 Transformer and Power Supply Secondary Grounding

16.1 A secondary circuit that contains field wiring terminals and is supplied from a power transformer, control transformer, or power supply shall have the secondary grounded under any of the following conditions:

a) When the secondary voltage is less than 50 volts; and

1) The supply to the primary is over 150 volts to ground; or

2) The supply to the primary at any voltage is ungrounded;

b) When the secondary voltage 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;

c) When the secondary is a 3-phase, 4-wire, wye connected in which the center point of the wye is used as a circuit conductor; or

d) When the secondary is a 3-phase, 4-wire, delta connected in which the midpoint of one phase winding is used as a circuit conductor.

16.2 For a transformer or power supply that is required to be grounded in accordance with 16.1, the secondary circuit shall be factory connected by a system bonding jumper to the enclosure and the grounding electrode conductor terminal. The size of the system bonding jumper shall be as specified in 75.1.4, based on the secondary rating. A grounding electrode conductor terminal sized to retain the required grounding electrode conductor in accordance with 75.1.4, based on the secondary rating, shall be provided in the enclosure containing the transformer or power supply and marked as specified in 54.10.

Exception No. 1: When the transformer or power supply is rated not more than 1000 volt-amperes and supplies only control circuits, the grounding electrode conductor terminal is able to be omitted and the system bonding jumper shall not be smaller than a 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.

Exception No. 2: Where multiple separately derived systems are provided within the same industrial control panel enclosure, a single grounding electrode conductor terminal suitable for a 3/0 AWG conductor is able to be supplied in the industrial control panel as the field wiring connection for the common grounding electrode conductor.

16.3 When components marked with a slash voltage rating, such as 120/240V, 480Y/277V, or 600Y/347V, are provided on the secondary side of a power transformer or power supply, the secondary shall be grounded as in 16.1(b), 16.1(c), or at the center point of the wye for a 3 phase, 3 wire secondary circuit, and 16.2.

16.4 For a power circuit or control circuit supplied from a secondary circuit voltage that is not required to be grounded as in 16.1 and is rated 100 V or more, the secondary circuit shall be provided with monitoring devices to provide an audible or visual indication when a ground fault occurs in any ungrounded conductor, such as a panel mounted indicator light or display, or one that interrupts the circuit in the event of a ground fault, such as a ground-fault protective device. For a monitoring device that does not interrupt the circuit, a ground fault shall not result in the bypassing of safety shutdown devices.

Exception: A control circuit supplied from a control transformer or power supply with secondary circuit voltage rated 100 V or more that has no provisions for field wiring connections is not required to comply with 16.4.

16.5 An industrial control panel that contains a transformer or power supply with a 3-phase, 4-wire delta secondary, as described in 16.1(d), and provided with field wiring terminals for loads to be connected between a phase and the neutral, shall comply with 29.3.14.

17 Identification of Grounding and Grounded Circuit Conductors and Terminals

17.1 A pressure wire connector intended for connection of a field-installed equipment grounding conductor shall be marked in accordance with 54.5.

17.2 A wire-binding screw terminal intended for connection of a field-installed equipment grounding conductor not larger than 10 AWG (5.3 mm^2) shall be colored green or marked in accordance with 54.5.

17.3 Insulated grounding and bonding conductors shall be identified by the color green with or without one or more yellow stripes and no other conductor shall be so identified.

Exception No. 1: Insulated conductors sized 4 AWG (21.2 mm^2) or larger and having insulation colored other than as in 17.3, and insulated conductors that are not manufactured in this color, shall be identified at each termination point by a green marking, such as tape wrapped around the conductor.

Exception No. 2: Integral leads of components are not required to meet this requirement.

17.4 Insulated grounded circuit conductors connected to the grounded side of a transformer secondary circuit containing field wiring terminals as in Section 16, Transformer and Power Supply Secondary Grounding, shall be identified by the color white or gray or by three continuous white stripes on other than green insulation along its entire length.

Exception No. 1: Insulated conductors sized 4 AWG (21.2 mm^2) or larger and having insulation colored other than as in 17.4, and insulated conductors that are not manufactured in this color, shall be identified at each termination point by a white marking, such as tape wrapped around the conductor.

Exception No. 2: Integral leads of components are not required to meet this requirement.

Exception No. 3: Insulated conductors of a multi-conductor cable colored other than as in 17.4 shall be identified at each termination point by a white marking, such as tape wrapped around the conductor.

17.5 Where more than one grounded circuit conductor is identified within an industrial control panel, each grounded circuit conductor shall be:

a) Identified by:

1) A means that complies with 17.4; or

2) An outer covering of white or gray with a colored stripe other than green running along the length of the insulation; and

b) Identified by means in (a) that is different than the grounded circuit conductors of another system and no other conductors in the industrial control panel shall be so identified.

17.6 A grounded circuit conductor of a flexible cord shall be identified by one of the following means:

a) A white or gray outer finish;

b) A braid with an outer finish colored white or gray; or

c) A white or gray tracer woven into the braid of contrasting color and no other conductor in the cord having a tracer.

ENCLOSED PANELS

18 Enclosures

18.1 An open industrial control panel intended to be installed completely within an enclosure in the field shall comply with the requirements in Sections 7 – 17 and Sections 28 – 61. Portions of an open industrial control panel that serve to complete an ultimate enclosure after installation shall additionally comply with Sections 18 – 27 and 62 – 64.

18.2 Two or more open type industrial control panels having partial enclosures intended to be assembled together in the field in order to form a completely enclosed industrial control panel shall be evaluated as an

enclosed device and comply with Sections 18 – 27. Each open type section shall be marked in accordance with 53.4.

18.3 An enclosed industrial control panel shall comply with Sections 18 – 27 and the enclosure shall comply with:

a) The requirements in the Standard for Enclosures for Electrical Equipment, Non-Environmental Considerations, UL 50, and the Standard for Enclosures for Electrical Equipment, Environmental Considerations, UL 50E; or

b) The industrial control panel enclosure requirements in Sections 62 – 64.

18.4 A door shall be provided on an enclosure that contains:

a) Power circuit fuses;

b) Circuit breakers located within power circuits which require renewal or resetting from inside the enclosure;

c) Motor overload protective devices which require renewal or resetting from inside the enclosure; or

d) Devices, such as timers or chart recorders, for which servicing or resetting is required.

Exception: A door is not required for an enclosure:

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

b) In which the only fuse enclosed is a control-circuit fuse, when the fuse and control-circuit load are within the same enclosure; or

c) In which a means is provided for resetting all overload-protective devices from outside the enclosure.

d) When the removable cover is flanged and is interlocked with the external operating handle of the disconnecting means so that power is removed from all components in the enclosure before the cover can be removed in order to replace fuses or to reset overload protective devices.

18.5 The enclosure shall be constructed so that all doors are able to be opened to a minimum of 90 degrees from the closed position.

19 Enclosure Openings

19.1 All openings provided for conduit connections in the field shall be of standard dimensions. When provided, conduit fittings shall comply with the Standard for Conduit, Tubing, and Cable Fittings, UL 514B. For enclosures other than Type 1, as noted in column 1 of Table 19.1, the conduit openings and fittings shall additionally comply with the requirements specified in column 2 of Table 19.1.

Exception: A conduit fitting that does not comply with Table 19.1 is able to be evaluated to the performance requirements in the Standard for Enclosures for Electrical Equipment, Environmental Considerations, UL 50E, corresponding to the required enclosure type rating.

Table 19.1
Openings for conduit connections in enclosures with environmental rating other than Type 1

Enclosure type (Column 1)	Conduit instructions (Column 2)
2, 3R, 3RX	a) All holes for conduit shall be below all uninsulated live parts; or b) Conduit openings above the lowest uninsulated live parts shall be provided with conduit fittings having an environmental rating that complies with Table 19.2; or c) The enclosure shall be marked as in 53.2 with instructions for the installer to apply fittings complying with (a) or (b).
3, 3S, 3SX, 3X, 4, 4X, 5, 12, 12K	d) All holes for conduit shall be provided with conduit fittings having an environmental rating that complies with Table 19.2 or as specified by the enclosure manufacturer; or e) The enclosure shall be marked as in 53.3 with instructions to apply fittings complying with (d).
6, 6P	f) All holes for conduit shall be provided with conduit fittings having an environmental rating that complies with Table 19.2.
13	g) All holes for conduit shall be provided with conduit fittings having an environmental rating that complies with Table 19.2; or h) No conduit openings shall be provided.

19.2 Openings for wireways shall be provided with a cover plate or supplied with the wireway. When provided, wireway shall comply with the Standard for Wireways, Auxiliary Gutters, and Associated Fittings, UL 870.

19.3 Openings provided in enclosures for mounting components shall be covered with components intended for such mounting. Openings provided for components, including ventilation openings, or observation windows, shall be closed with components that have been evaluated for one of the enclosure Types in the heading of column 2 of Table 19.2. The assembled enclosure is derated to the enclosure type rating indicated in the table corresponding to the type rating of the empty enclosure from column 1 and the type rating of the component from column 2 that results in the lowest rating.

Exception: A component that does not comply with Table 19.2 is able to be evaluated to the performance requirements in the Standard for Enclosures for Electrical Equipment, Environmental Considerations, UL 50E, corresponding to the required enclosure type rating.

Table 19.2
Enclosure rating/derating table

Enclosure Type (Column 1)	Component rating (Column 2)										
	1	**2**	**3R**	**Wet Loc**		**RainTight**	**RainProof**	**Weather Proof**	**3RX**	**3**	**3S**
1	1	1	1	1		1	1	1	1	1	1
2	2 or 1[a]	2	2	2		2	1	1	2	2	2
3R	1	2	3R	3R		3R	3R[b]	3R[b]	3R	3R	3R
3RX	1	2	3R	3R		3R	3R[b]	3R[b]	3RX	3R	3R
3	1	2	3R[e]	3R[e]		3R[e]	3R[b,e]	3R[b,e]	3R	3	3
3S	1	2	3R[e]	3R[e]		3R[e]	3R[b,e]	3R[b,e]	3R	3[c]	3S
3SX	1	2	3R[e]	3R[e]		3R[e]	3R[b,e]	3R[b,e]	3RX	3	3S
3X	1	2	3R[e]	3R[e]		3R[e]	3R[b,e]	3R[b,e]	3RX	3	3S[c]
4	1	2	3R[e]	3R[e]		3R[e]	3R[b,e]	3R[b,e]	3R	3	3
4X	1	2	3R[e]	3R[e]		3R[e]	3R[b,e]	3R[b,e]	3RX	3	3
4X Indoor Use Only	1	2	5[f]	5[f]		5[f]	1	1	5[f]	5[f]	5[f]
5	1	2	5	5		5	1	1	5	5	5
6	1	2	3R[e]	3R[e]		3R[e]	3R[e]	3R[e]	3R[e]	3	3
6P	1	2	3R[e]	3R[e]		3R[e]	3R[e]	3R[e]	3RX[e]	3	3
12	1	2	5[f]	5[f]		5[f]	1	1	5[f]	5[f]	5[f]
12K	1	1	1	5[f]		5[f]	1	1	1	5[f]	5[f]
13	1	1	1	5[f]		5[f]	1	1	1	5[f]	5[f]
	3SX	**3X**	**4**	**4X**	**4X Indoor Use Only**	**5**	**6**	**6P**	**12**	**12K**	**13**
1	1	1	1	1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	2	2	2	2	2
3R	3R	3R	3R	3R	1	1	3R	3R	1	1	1
3RX	3RX	3RX	3R	3RX	1	1	3R	3RX	1	1	1
3	3	3	3	3	5[f]	5[f]	3	3	1	1	1
3S	3S	3S[c]	3S[c]	3S[c]	5[f]	5[f]	3S[c]	3S[c]	1	1	1
3SX	3SX	3SX[d]	3[d]	3SX[d]	5[d,f]	5[d,f]	3S[c,d]	3SX[c,d]	1	1	1
3X	3X	3X	3	3X	5[f]	5[f]	3	3X	1	1	1

Table 19.2 Continued on Next Page

Table 19.2 Continued

Enclosure Type (Column 1)	Component rating (Column 2)										
4	3	3	4	4	5[f]	5[f]	4	4	1	1	1
4X	3RX	3RX	4	4X	4X Indoor Use Only	5[f]	4	4X	1	1	1
4X Indoor Use Only	5[f]	5[f]	5[f]	4X Indoor Use Only	4X Indoor Use Only	5[f]	5[f]	4X Indoor Use Only	1	1	1
5	5	5	5	5	5	5	5	5	5	5	5
6	3	3	4	4	5[f]	5[f]	6	6	1	1	1
6P	3X	3X	4	4X	4X Indoor Use Only	5[f]	6	6P	1	1	1
12	5[f]	5[f]	5[f]	5[f]	5[f]	5[f]	5[f]	5[f]	12	12	12
12K	1	1	5[f]	5[f]	5[f]	5[f]	5[f]	5[f]	12K	12K	12K
13	1	1	5[f]	5[f]	5[f]	5[f]	5[f]	5[f]	12	12	13

[a] Type 1 Components, ventilation openings, or windows under a drip shield are allowed to be used as Type 2.

[b] Components marked Weatherproof, or Rainproof are allowed to be installed below all other live parts in enclosure.

[c] Components with external operating mechanisms must be Type 3S or 3SX for use on 3S, otherwise rating becomes Type 3.

[d] Components with external operating mechanisms must be Type 3SX for use on 3SX, otherwise rating becomes Type 3.

[e] Must add drain, and locking mechanism or require tool entry.

[f] Must add locking mechanism or require tool entry.

19.4 *Deleted*

Table 19.3
Alternate enclosure ratings
Table deleted

19.5 No covering is required across the bottom of a floor-mounting enclosure when the lower edge of the enclosure is within 6 inches (152 mm) of the floor and when exposed live parts within the device are at least 6 inches above the highest portion of the lower edge of the enclosure.

19.6 Enclosures intended for use with conduit hubs, closure plates and other equipment intended to be field installed shall be marked or provided with instructions that identify the equipment necessary to maintain the environmental integrity of the enclosure. This may be accomplished by identifying the necessary environmental type designation or by identifying the specific manufacturer and models of the field installed equipment.

20 Accessibility of Live Parts

20.1 The minimum distance specified in Table 20.1 shall be provided between an opening in an enclosure and:

a) Uninsulated live parts of components inside of the enclosure where the circuit voltage is greater than 30 V ac or 42.4 V dc; and

b) Moving parts of components inside of the enclosure, such as a fan blade. The distance is measured in a straight line from any point around the edge of the opening to uninsulated live parts or moving parts.

Exception: A construction as described in 19.5 is not required to comply with this requirement.

Table 20.1
Minimum distance from an opening to a part involving risk of electric shock or personal injury

Minor dimension of opening[a]		Minimum distance from opening to uninsulated live part or moving part	
inches	(mm)	inches	(mm)
Less than 1/8	(Less than 3.18)	1/2	(12.7)
1/2	(12.7)	4	(101.6)
1[b]	(25.4)	6-1/2[b]	(165.0)
1-1/2[b]	(38.1)	8-3/8[b]	(212.7)
2[b]	(50.8)	11-5/8[b]	(295.3)
over 2 and not more than 3[b]	(over 50.8 and not more than 76.2)	30[b]	(762.0)

[a] The minor dimension of an opening is the diameter of the largest cylindrical probe having a hemispherical tip that is able to be inserted through the opening. The opening is evaluated without removable filters.

[b] Interpolation shall be used to determine intermediate distances between the table requirement and the previous entry specified in this table. Where the intermediate distance = (distance for previous entry) + (difference between intermediate minor dimension and minor dimension of previous entry) × (difference between required distance and distance of previous entry) / (difference between required minor dimension and minor dimension of previous entry).

Example: To find required distance for 3/4 inch opening (minor dimension) between 1/2 inch (12.7 mm) and 1 inch (25.4 mm) table values

Required distance = 4 inches + (3/4 − 1/2) × (6-1/2 − 4) / (1 − 1/2) = 5.25 inches

21 Ventilation Openings

21.1 General

21.1.1 A ventilation opening provided in an enclosure shall comply with the construction requirements in 21.3.1 – 21.3.5, and shall be evaluated as a Type 1 component with respect to 19.3. A ventilation opening that is an integral part of an enclosure or an accessory kit for an enclosure that complies with 18.3 complies with 21.3.1 – 21.3.5.

Exception: A ventilation opening for use in an enclosure with a Type 2 or 3R enclosure shall be evaluated to the performance requirements in the Standard for Enclosures for Electrical Equipment, Environmental Considerations, UL 50E, for the environmental rating.

21.1.2 The location of a ventilation opening with respect to components inside of the enclosure shall comply with 21.2.1 – 21.2.4.

21.2 Location of ventilation opening

21.2.1 A ventilation opening in the top of the enclosure shall be covered by a hood or protective shield spaced above the opening when there are uninsulated live components below the opening.

Exception: A hood or protective shield is not required over ventilation openings to a compartment of an industrial control panel where no uninsulated live parts are present.

21.2.2 A ventilation opening that serves as an air outlet of exhaust air from a forced ventilation system shall not direct air at the area occupied by the equipment operator. The area occupied by the operator in front of the industrial control panel shall be 30 inches wide (horizontal) centered on any operator control, display, or disconnect handle over the entire (vertical) height of the enclosure for wall mounted equipment or up to 6-1/2 feet above the floor for floor mounted equipment.

Exception No. 1: When an air outlet from a forced ventilation system is directed at the area occupied by an operator, a barrier or duct shall be provided to redirect the airflow by 90 degrees or greater so that the exhaust air is directed away from the operator area. See Figure 21.1 for permitted air directions. If a barrier is used, it shall be provided in addition to the barrier that may be required per 22.1. Redirecting airflow upward is only permitted if the construction ensures that water and/or solid objects cannot enter the enclosure.

Exception No. 2: Air filters which baffle the airflow are permitted, provided they meet the requirements in 22.4.