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SUBJECT 508A
OUTLINE OF INVESTIGATION
FOR
INDUSTRIAL CONTROL PANELS

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FOREWORD

A. This Outline of Investigation 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 Outline of Investigation. They are subject to revision as further experience and investigation may show is necessary or desirable.

B. The observance of these requirements 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 Outline of Investigation will not necessarily be judged to comply with the Outline of Investigation 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 differing from those detailed in the requirements of this Outline of Investigation may be examined and tested according to the intent of the requirements and, if found to be substantially equivalent, may be judged to comply with the Outline of Investigation.

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 Outline of Investigation is processed. UL shall not be responsible to anyone for the use of or reliance upon this Outline of Investigation 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 Outline of Investigation.

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

INTRODUCTION

Scope

1.1 The industrial controls panels covered by these requirements are intended for general industrial use. They are not intended for metalworking machine tools, plastic injection molding, power press controls, flame safety supervision of combustible fuel type equipment, or elevator controls.

1.2 The industrial control panels covered by these requirements are assemblies consisting of components such as motor controllers, overload relays, fused disconnect switches, and/or circuit breakers and related control devices such as push button stations, selector switches, timers, switches, control relays and the like with associated wiring, terminal blocks, pilot lights, and the like. The enclosure may be provided or the assembly may be an open construction.

1.3 A product that contains features, characteristics, components, materials, or systems new or different from those in use when the outline was developed, 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 level of safety for the user of the product as originally anticipated by the intent of this outline.

1.3 added October 12, 1993

General

2.1 The combination of components and construction may vary as described in the following sections.

2.2 For convenience these requirements are divided into three parts. These are:

I Components

II Enclosure Construction

III Electrical Assembly

2.3 Definitions

2.3-1 RESTRICTED COMPONENT - A component or device that complies with the requirements of the applicable standard within its marked ratings and under certain conditions of acceptability.

2.3-2 UNEVALUATED COMPONENT - A component or device for which compliance with an applicable standard has not been determined.

2.3-3 UNRESTRICTED COMPONENT - A component or device that complies with the requirements of the applicable standard within its marked ratings.

PART I - COMPONENTS

Unrestricted Devices

3.1 Any unrestricted device can be used for its intended use not exceeding its marked rating.

Exception: Assemblies built up by the panel manufacturer to provide wye-delta, reversing, reduced voltage (part winding, autotransformer, primary reactor, primary resistor, and multispeed) can only be used when investigated for the intended use.

Restricted Devices

3.2 Restricted Oil Filled Capacitors, when used, shall comply with A through D below.

(A) The voltage rating of the capacitor shall be equal to or greater than the voltage rating of the circuit in which it is used.

(B) To permit the expansion of the head or terminal end of the capacitor the through air spacings between the live part of the capacitor and any uninsulated live part of opposite polarity or uninsulated grounded dead-metal part shall be 5/8 in. This distance is to be measured in a direction perpendicular to the end cap from the capacitor terminal to the other concerned part.

(C) The available fault current (AFC) marking of the capacitor shall be 10,000 A where the capacitor is used across the line. When used in series with other impedance the available fault current (AFC) marking of the capacitor shall at least equal the current rating of the connected load.

(D) When a panel is intended for use on circuits capable of delivering greater than 10,000 A (that is; employ Class G, J, R, or L fuses or circuit breakers whose interrupting rating is greater than 10,000 A) the capacitor shall be investigated for the intended use.

3.2A A restricted power supply may be used if:

(A) The control panel enclosure is nonventilated,

(B) The power supply is powered from the isolated secondary of a transformer (not autotransformer type),

(C) The components connected to the secondary of the power supply comply with paragraphs 3.1, 3.2, 3.3, and 3.4, as applicable, and

(D) The power supply is not used at more than 50 percent of the ampere output rating.

Exception: The output may be fused at 50 percent or less. If fused, a marking adjacent to the fuseholder shall indicate the size of the replacement fuse. See Table 20.1.

3.2A added October 12, 1993

3.3 Devices that are restricted in the category "Industrial Control Equipment" and that are not restricted to nonindustrial use (such as appliances, business machines, air-conditioning and refrigeration equipment, and the like) can be used within their marked load ratings.

Exception: Restricted solid state devices such as solid state relays, motor speed controllers, power conversion equipment and others can be used only when investigated for the intended use.

3.4 Where restricted devices are investigated for the intended use meeting certain conditions, any restricted device meeting all specified conditions can be used. Other restricted devices can be used only when investigated for the intended use.

Unevaluated Devices

3.5 Unevaluated nonelectrical and nonhydraulic devices mounted on the subpanel such as those operating on air pressure can be used. The term hydraulic shall be interpreted as any liquid, and only inert substances shall enter or exit the panel.

Class 2 Transformers

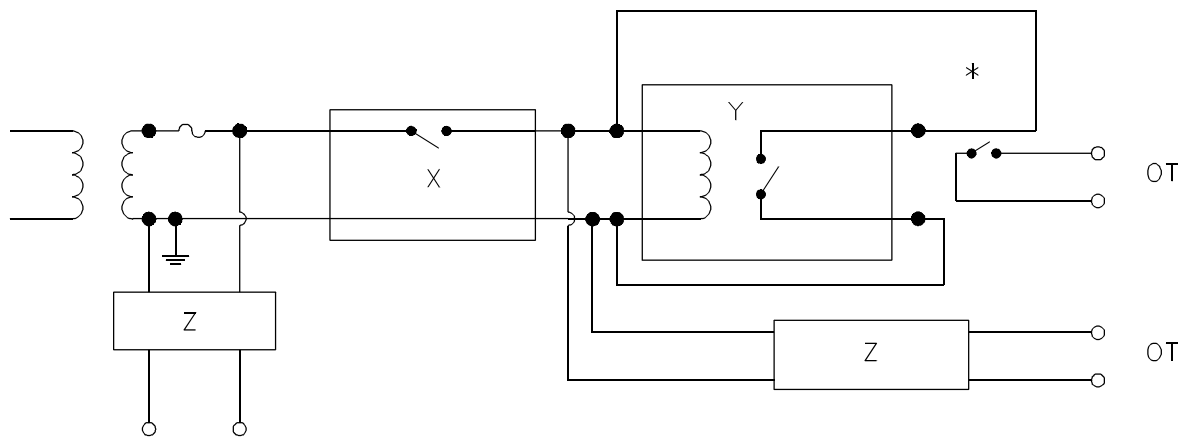
3.6 Unevaluated electrical devices totally within the circuit connected to the secondary of a Class 2 low-voltage transformer can be used. The CL 2 transformer must be unrestricted, restricted or investigated for the intended use. See paragraph 19 for CL 2 application.

Ground Fault Circuit Interrupters

3.7 Components that are neither unrestricted, restricted, or otherwise investigated for the intended use may be used if protected by an unrestricted ground fault circuit interrupter (GFCI). These components may be control switching devices, control or sensing equipment, or similar components but they shall not be power switching equipment (devices that control external "loads") or power consuming equipment (such as heaters or motors). A cathode ray tube may be used only if investigated for the intended use. These components shall be connected in a secondary circuit of a transformer, for example, as illustrated in Figure A. In addition, the GFCI circuit shall comply with the requirements specified in paragraphs 3.7-1 through 3.7-13.

3.7 revised October 12, 1993

**FIGURE A
UNEVALUATED COMPONENT CONNECTION**



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X - Ground-Fault Circuit-Interrupter
Y - Unevaluated Device
Z - Restricted or Unrestricted Control Equipment
* - Evaluated Component
OT - Output Terminals

Figure A added October 12, 1993

- 3.7- 1. The transformer is unrestricted, restricted, or investigated for the intended use.
- 3.7- 2. The transformer has an isolated secondary and the secondary load does not exceed the transformer rating.
- 3.7- 3. The maximum rating of the secondary is 240 V.
- 3.7- 4. One side of the secondary circuit is grounded.
- 3.7- 5. The transformer shall have overcurrent protection in accordance with paragraphs 13.7A — 13.7E, or 13.F.

3.7-5 revised October 12, 1993

3.7- 6. An unrestricted, Class A (6 mA trip) ground fault circuit interrupter is provided in the secondary circuit. If the ground fault circuit interrupter is a "receptacle-style" ground fault circuit interrupter of the feed through type, the load is connected to the terminals not plugged into the receptacle. Marking on or adjacent to the receptacle indicates that the receptacle is not to be used for external connections. The receptacle shall be mounted such that it is not accessible to the user from the outside of the enclosure.

3.7- 7. The panel has a marking as shown in A and B. All component parts within the secondary shall be tabulated.

(A) "WARNING - Use Of The Following Components Is Dependent Upon The Additional Protection Afforded By The Ground Fault Circuit Interrupter And The Overcurrent Protective Device Provided. Do Not Remove Or Defeat These Protective Components."

Component Identification

(B) "The Ground Fault Circuit Interrupter Should Be Checked Periodically For Proper Operation."

3.7- 8. The manufacturer also shall:

(A) Conduct appropriate tests to determine that the ground fault circuit interrupter will protect against all likely ground faults. This may be accomplished by energizing the control circuit and connecting a resistance between live parts of the unevaluated component and ground. The value of the resistance should be such that the current through it will be more than 6 mA but less than the rating of the secondary overcurrent protective device.

(B) Review the application to determine that the overcurrent protection will protect against possible short circuits; and

(C) Maintain records of the use of unevaluated components for periodic review by UL personnel so determination can be made when added detailed evaluation of the component will be required such as for those components having repeated use.

Records of unevaluated component usage shall be maintained in the following form, or the equivalent:

Component Designation	Component Manufacturer's Name	Catalog Designation	Number Used	Panel Identification	Ground Fault Date Testing

3.7- 9. The panel is enclosed and nonventilated. The unevaluated component and its controlled load or controlling device are within the panel. This may require the use of one or more acceptable component interfaces to input or output terminals.

Exception A: If unevaluated components are provided on an open panel, an acceptable subenclosure shall completely enclose the unevaluated components except for openings that comply with the requirements for ventilated enclosures below. In addition, the open panel is to be complete to such an extent that it would not be necessary to make any field connections to uninvestigated components inside the subenclosure and any component directly controlled by the unevaluated component must be mounted on the panel.

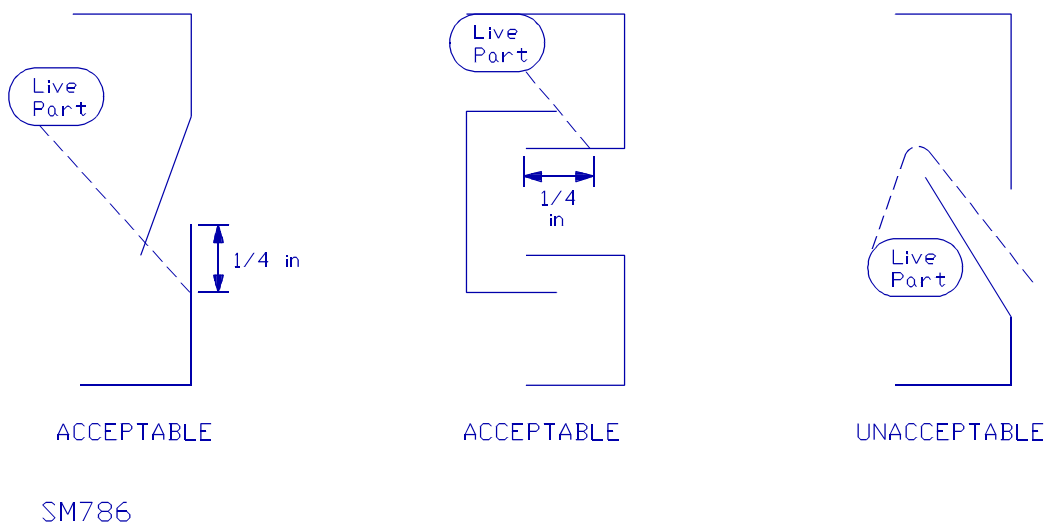
Exception B: In addition to complying with the provisions for ventilation openings that have been investigated for the intended use, the following criteria are also met.

(1) A barrier shall be interposed between the unevaluated component and all openings. The barrier shall be of such dimensions and so located that there shall be a 1/4 in. (6.4 mm) minimum overlap from a straight line drawn from the unevaluated component and the edges of the opening. The barrier shall be not less than 0.053 in. (1.35 mm) (No. 16 MSG) if uncoated sheet steel, or not less than 0.056 in. (1.42 mm) thick (No. 16 GSG) if zinc-coated sheet steel, or not less than 0.075 in. (1.91 mm) thick (No. 12 AWG) if aluminum.

(2) If the barrier is nonmetallic, it will be investigated for the intended use.

See Figure 1 for examples of possible constructions.

**FIGURE 1
BARRIERS FOR OPENINGS**



3.7-10. An unevaluated component may extend through an opening and enclose the opening such that the component housing serves the purpose of completing the enclosure (such as a door mounted meter), and as indicated below.

(1) The component housing material is polymeric (plastic) material and the area opening does not exceed 30 sq in. (194 sq cm), or

(2) The component housing material is metal and glass that has no exposed glass exceeding an area of 100 sq in. (645 sq cm).

3.7-11. An unevaluated component may be connected to an external device provided the voltage involves a potential of 30 V rms (42.4 V peak) or less, and all ungrounded conductors that extend beyond the enclosure shall be protected by a fuse rated no more than 0.5 A located within the panel and as close as practical to the field wiring terminals. Additionally, the area near the fuse shall be permanently marked with the wording "Caution: To Reduce The Risk Of Fire, Replace Only With Same Type And Rating Of Fuse," or equivalent.

3.7-12. An unevaluated component may be connected to an external source of supply (such as a signal source from a transducer) provided the voltage involves a potential of 30 V rms (42.4 V peak) or less, and is provided with marking at field wiring terminals provided for the connection of such circuits as follows or equivalent - "Caution: To Reduce The Risk Of Electric Shock, connections to these terminals shall not involve a potential of greater than 30 V rms or 42.4 V peak between live parts of opposite polarity and between a live part and ground."

All ungrounded conductors that extend beyond the enclosure shall be protected by a fuse rated no more than 0.5 A located within the panel and as close as practical to the field wiring terminals. The area near the fuse shall be permanently marked with the wording "Caution: To reduce the risk of fire, replace only with same type and rating of fuse," or equivalent.

Exception: Tachometers, transducers, thermocouples and similar feedback devices that are isolated from line voltage circuits may extend beyond the panel without fusing provided the input to the sensing device is protected as investigated for the intended use.

3.7-13. All other unevaluated devices shall be investigated for the intended use.

PART II - ENCLOSURE CONSTRUCTION

Enclosure Types

4.1 An enclosure constructed in accordance with the requirements specified in the following paragraphs is considered a Type 1 enclosure, and shall be marked Type 1. A Type 1 enclosure may be additionally marked indoor use only. All other types of enclosures are to be investigated for the intended use.

Exception: An unrestricted enclosure marked with other than a Type 1 designation may be used under the conditions described in Tables A1 and A2. Any deviations are to be investigated for the intended use.

4.1 revised October 12, 1993

**TABLE A1
TYPES OF ENCLOSURES**

Type of Enclosure	Holes
1	1. All holes cut by the panel manufacturer are to be covered with conduit fittings that comply with the Standard for Fittings for Conduit and Outlet Boxes, UL 514B
2, 3, 3R	1. All holes cut by the panel manufacturer for conduit are below live parts or conduit hubs as marked on the enclosure are used 2. No other openings are cut by the panel manufacturer unless the holes are closed with equipment marked for use with that type enclosure (see Table A2) and installed in accordance with the instructions provided with the closing equipment
3S, 4, 4X, 6, 6P, 11	1. All holes cut by the panel manufacturer for conduit are provided with conduit hubs as marked on the enclosure 2. No other openings are cut by the panel manufacturer unless the holes are closed with equipment marked for use with that type enclosure (see Table A2) and installed in accordance with the instructions provided with the closing equipment
12, 12K	1. Holes for electrical components mounted on the enclosure are to be sealed in accordance with the instructions on the enclosure 2. Any other holes cut by the panel manufacturer must be closed with equipment marked for use with the type enclosure (see Table A2) and installed in accordance with the instruction provided with the closing equipment.
13	1. No conduit openings or openings for components are provided. 2. Any other holes cut by the panel manufacturer must be closed with equipment marked for use with that type enclosure (see Table A2) and installed in accordance with the instructions provided with the closing equipment

TABLE A2 OPENINGS IN ENCLOSURE	
Enclosure Type	Openings May Be Closed By Equipment Marked
2	2, 3, 3R, 3S, 4, 4X, 6, 6P, 11, 12, 12K, 13
3	3, 3R, 3S, 4, 4X, 6, 6P
3R	3, 3R, 3S, 4, 4X, 6, 6P
3S	3, 3R, 3S, 4, 4X, 6, 6P
4	4, 4X, 6, 6P
4X	4X
6	6, 6P
6P	6P
11	11
12, 12K	12, 12K, 13
13	13

Table A2 revised October 12, 1993

4.2 A cover or door shall be hinged if it gives access to (1) power circuit fuses, (2) overload protective devices which require renewal or resetting from the inside (3) products such as timers or chart recorders where resetting is a normal function. A hinged cover is not required for an enclosure in which the only fuses are control circuit fuses, provided the control circuit loads are within the same enclosure. Also see Para. 4.7 dealing with fit of hinged covers or door.

4.3 The following enclosures may be used.

- A. Unrestricted industrial control panel enclosure.
- B. Unrestricted cabinet box with mating unrestricted cabinet front.
- C. Restricted industrial control panel enclosure.
- D. Unrestricted cutout box.
- E. Unrestricted junction (pull box).
- F. An enclosure constructed in accordance with the details in the following paragraphs, or investigated for the intended use.

Protection Against Corrosion

4.4 Corrosion protection of all ferrous metal parts is provided by plating or painting.

Enclosure With Openings for Wiring Systems

4.5 Where provided, such openings have a flat surrounding surface adequate for proper seating of a conduit bushing, and are so located that installation of a bushing at any opening likely to be used during installation will not result in spacings between uninsulated live parts and the bushing of less than the minimum requirements. See Table B below for bushing dimensions. Where multiple size knockouts are provided, spacings are to be determined using the largest bushing size accommodated unless the equipment is marked to specify maximum permitted size.

TABLE B DIMENSIONS OF BUSHINGS Bushing Dimensions, Inches(mm)			
Overall Diameter		Height	
1	(25.4)	3/8	(9.5)
1-15/64	(31.4)	27/64	(10.7)
1-19/32	(40.5)	33/64	(13.1)
1-15/16	(49.2)	9/16	(14.3)
2-13/64	(56.0)	19/32	(15.1)
2-45/64	(68.7)	5/8	(15.9)
3-7/32	(81.8)	3/4	(19.1)
3-7/8	(98.4)	13/16	(20.6)
4-7/16	(113.0)	15/16	(23.8)
4-31/32	(121.0)	1	(25.4)
5-35/64	(141.0)	1-1/16	(27.0)
6-7/32	(158.0)	1-3/16	(30.2)
7-7/32	(183.0)	1-1/4	(31.8)

Thickness

4.6 Sheet metal enclosures shall be formed of metal having thickness not less than that specified in Table C.

TABLE C						
MINIMUM THICKNESS OF SHEET METAL ENCLOSURES FOR CARBON STEEL OR STAINLESS STEEL						
Maximum Width in. (cm)		Maximum Length in. (cm)		Minimum Thickness, in. (mm) (Column 3)		
(Column 1)		(Column 2)		Uncoated		Zinc Coated
4.0	(10.2)	Not limited		0.020	(0.51)	0.023 (0.58)
4.75	(12.1)	5.75	(14.6)			
6.0	(15.2)	Not limited		0.026	(0.66)	0.029 (0.74)
7.0	(17.8)	8.75	(22.2)			
8.0	(20.3)	Not limited		0.032	(0.81)	0.034 (0.86)
9.0	(22.9)	11.5	(29.2)			
12.5	(31.8)	Not limited		0.042	(1.07)	0.045 (1.14)
14.0	(35.6)	18.0	(45.7)			
18.0	(45.7)	Not limited		0.053	(1.35)	0.056 (1.42)
20.0	(50.8)	25.0	(63.5)			
22.0	(55.9)	Not limited		0.060	(1.52)	0.063 (1.60)
25.0	(63.5)	31.0	(78.7)			
25.0	(63.5)	Not limited		0.067	(1.70)	0.070 (1.78)
29.0	(73.7)	36.0	(91.4)			
33.0	(83.8)	Not limited		0.080	(2.03)	0.084 (2.13)
38.0	(96.5)	47.0	(119.4)			
42.0	(106.7)	Not limited		0.093	(2.36)	0.097 (2.46)
47.0	(119.4)	59.0	(149.9)			
52.0	(132.1)	Not limited		0.108	(2.74)	0.111 (2.82)
60.0	(152.4)	74.0	(188.0)			
63.0	(160.0)	Not limited		0.123	(3.12)	0.126 (3.20)
73.0	(185.4)	90.0	(228.6)			

Instructions for Using Table C

4.6- 1. The width is the smaller dimension of a rectangular sheet metal piece which is part of an enclosure. Adjacent surfaces of an enclosure may have supports in common and be made of a single sheet.

4.6- 2. Determine if the portion of the enclosure is supported or nonsupported using the following criteria.

- (a) Supported - Supported edges flanged at least 1/2 in. or fastened to adjacent surfaces not normally removed in use. (Surfaces A and C of Figure 2 are considered supported.)

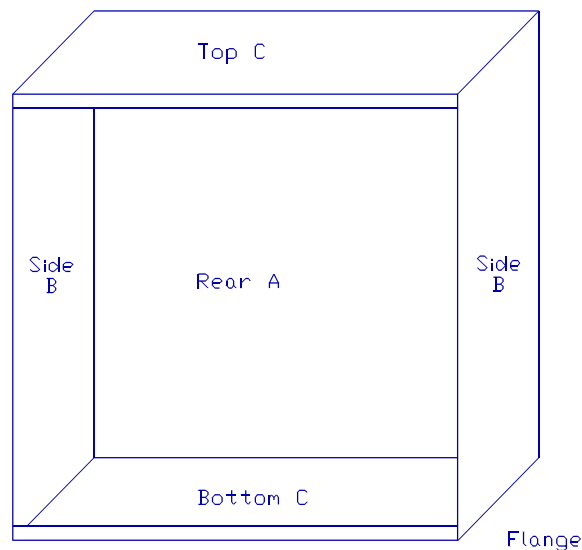
- (b) Nonsupported - Constructions considered to be without supporting frame include: (1) a single sheet with single formed flanges - formed edges, (2) a single sheet that is corrugated or ribbed, (3) an enclosure surface loosely attached to a frame, for example, with spring clips, and (4) an enclosure surface having an unsupported edge. (Surface B of example Figure 2 is unsupported.)

4.6- 3. For supported surfaces, measure width and enter table at Column 1. If dimension of Column 2 is "not limited" determine minimum thickness from Column 3. If dimension of Column 2 is numerical, the length may not exceed that value for the thickness of Column 3. If the length exceeds the numerical value, it is necessary to drop to the next line in the column to determine minimum thickness.

4.6- 4. For nonsupported surfaces, measure length. Enter table at Column 2. At the smallest numerical value not less than the measured length, determine minimum thickness from Column 3.

4.6- 5. If thickness determined is not provided, "Body Stiffeners," "Reinforcing Ribs," "Cross Frames," and the like may be used if investigated for the intended use.

FIGURE 2
ENCLOSURE SURFACES



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