

APRIL 20, 2015

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UL 2237

**Outline of Investigation for Multi-Point Interconnection Power Cable
Assemblies For Industrial Machinery**

Issue Number: 4

April 20, 2015

Summary of Topics

This Fourth Issue of the Outline of Investigation for Multi-Point Interconnection Power Cable Assemblies for Industrial Machinery, UL 2237, has been published and now covers power cable assemblies that are rated 1000 V or less, when intended to be used on industrial machinery in accordance with the National Fire Protection Association Electrical Standard for Industrial Machinery, NFPA 79 that have system voltages up to and including 1000 V. Other editorial revisions have been made throughout to reflect present practice.

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INTRODUCTION

1 Scope

1.1 This outline of investigation covers multi-point interconnection power cable assemblies. They may consist of power cable assemblies, male and female power cable fittings, panel-mounted power cable/conductor fittings and feeder-tap power cable fittings used with industrial machinery in accordance with the National Fire Protection Association Electrical Standard for Industrial Machinery, NFPA 79 that have system voltages up to and including 1000 V.

1.2 These interconnection power cable assemblies may be used in an industrial environment to distribute the power to branch circuits, including motor branch circuits, of industrial machinery.

1.3 Devices covered under this outline of investigation are only intended for indoor use, unless otherwise identified.

1.4 The power cable assemblies covered under this outline of investigation are rated 1000 V or less, and are intended to be used on industrial machinery in accordance with the National Fire Protection Association Electrical Standard for Industrial Machinery, NFPA 79 that have system voltages up to and including 600 V. Each power cable assemblies and fittings are rated in volts and amperes. The electrical ratings are marked, on each device or on a flag label affixed to each individual power cable assembly.

1.5 The cable assembly fittings and panel-mount fittings are intended to be installed in accordance with the manufacturer's installation instructions. The cable assembly fittings are intended to be assembled or molded on flexible cord. The power cable assemblies and mating fittings are not intended to be used as a substitute for the fixed wiring of the building structure. The power cable assemblies and mating fittings may be connected to the fixed wiring of the building structure; using a feeder tap fitting or male/female cable fitting.

1.6 Power cable assemblies and fittings covered under this outline of investigation are not intended to make or interrupt current under load conditions. These power cable assemblies and fittings have been investigated to their marked short-circuit current rating. Power cable assemblies and fittings may specify a maximum ampere rating, type of overcurrent protective device, or both. Unless otherwise marked, the power cable assemblies and fittings are intended to be supplied from an overcurrent protective device of the maximum ampere rating permitted by the Relationship Between Conductor Size and Maximum Rating or Setting of Short-Circuit Protective Device for Power Circuits Table, Table 7.2.10.4, of the National Fire Protection Association Electrical Standard for Industrial Machinery, NFPA 79.

1.7 This outline of investigation does not cover male-to-male cable assemblies or multi-outlet fittings.

1.8 These devices are intended for use only with the manufacturer's same line of products covered under this outline of investigation.

1.9 These devices are not intended for disconnect use only not for current interrupting. Devices may be investigated for disconnecting means, if so requested and comply with the overload, temperature, resistance to arcing and dielectric voltage withstand testing as described in Table 19.1.

2 Glossary

2.1 For the purpose of this outline of investigation the following definitions apply.

2.2 FEEDER-TAP POWER CABLE FITTINGS – Feeder-tap fittings are intended for feed-through termination to tray cable or other appropriate cable together with either a female interconnection device to terminate to a cable assembly or to connect to flexible cord or cable suitable for hard use that is the same size and ampacity as the feeder cable.

2.3 FEED-THROUGH FITTING – A male and female device directly connected through the pins or contacts. This device is not assembled on a flexible cord, cable or AWM.

2.4 GROUNDED CONDUCTOR – The circuit conductor that is identified and intended for connection to the grounded circuit.

2.5 GROUNDING-CONDUCTOR – The circuit conductor that is identified and intended for connection to the grounding circuit.

2.6 GROUNDING-CONDUCTOR PATH – A path between the grounding pin or contact and/or terminal to the grounding conductor.

2.7 MALE AND FEMALE POWER CABLE FITTINGS – Fittings intended to be field-wired onto flexible cord or cable with either a male or female insert. The diameter and the wire size of the flexible cord or cable to which the fitting is intended to be assembled is marked on the individual fitting or on the smallest unit-shipping container.

2.8 PANEL-MOUNTED POWER CABLE/CONDUCTOR FITTINGS – These fittings consist of a panel-mounted assembly with either a male or female insert. Each assembly is provided with a means to secure to an enclosure, a panel, of the industrial machinery.

2.9 POLARIZED DEVICE – A device constructed for connection to a mating fitting only in the position that connects related poles of an electrical circuit.

2.10 POWER CABLE ASSEMBLIES – Cable assemblies consist of a length of cable or flexible cord with a molded-on or assembled-on male or female power cable fitting on at least one end of the cable.

2.11 SPLITTER – A male fitting that terminates in two or more female fitting which may or may not be cord connected.

2.12 SYSTEM VOLTAGE – The rated supply or line voltage to which the end product will be connected.

2.13 TERMINAL, CRIMP TYPE – A terminal in which an electro-mechanical connection is made between the terminal lug and a conductor by compressing the lug onto the conductors.

2.14 TERMINAL, INSULATION-DISPLACEMENT – A terminal having a contacting member that forces the conductor insulation aside and presses to contact the current-carrying conductor.

2.15 **TERMINAL, PIN TYPE (INSULATION-PIERCING)** – A terminal having a contact pin that punctures the conductor insulation to contact the current-carrying conductor.

2.16 **TERMINAL, PRESSURE WIRE** – A terminal that establishes a connection between one or more conductors and a terminal plate by means of mechanical pressure without the use of solder. The terminal is one of the following types:

a) **Clamp-type** – A terminal in which the conductor is held under a pressure plate or saddle clamp by one or more screws. This type of terminal may be provided in combination with a wire-binding screw terminal.

b) **Setscrew-type** – A terminal in which the pressure is applied by the end of the screw bearing on the conductor, either directly or through a wire-protecting pad.

2.17 **TERMINAL, WIRE-BINDING SCREW** – A terminal in which the conductor is bent around the screw and is clamped directly under the head of the screw when it is tightened.

2.18 **UNIT CONTAINER** – The smallest carton, package, or container, in which a fitting is packaged. A unit container may contain more than one fitting if the devices are not intended to be removed from the container for individual sale.

3 Components

3.1 Except as indicated in 3.2, a component of a product covered by this outline of investigation 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 outline of investigation.

3.2 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 outline of investigation, or

b) Is superseded by a requirement in this outline of investigation.

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

3.4 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 Units of Measurement

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

5 References

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

CONSTRUCTION

6 Accessibility of Uninsulated Live Parts

6.1 Uninsulated live parts, other than exposed wiring terminals, and internal wiring shall not be accessible to contact by the probe illustrated in Figure 6.1. The probe is to be applied with a force of 3 lbf (13.3 N). The probe is to be rotated, changed in configuration, or angled; before, during, and after application.

6.2 The probe is to be used as a measuring instrument to investigate the accessibility and not as an instrument to determine the strength of a material.

7 Insulating Materials

7.1 Insulating materials for devices rated 600 V or less

7.1.1 General

7.1.1.1 A part that functions as electrical insulation or as an enclosure of a device shall be made of insulating material rated for the particular application.

7.1.1.2 Vulcanized fiber shall not be used as the sole support of live parts. Vulcanized fiber is acceptable for insulating washers, separators, and barriers. Vulcanized fiber shall comply with Moisture Absorption Test, Section 21.

7.1.1.3 Tubing used to enclose live parts shall have a flammability rating of VW-1 in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94. The tubing shall be rated for voltage and temperature for the conditions of use.

7.1.2 Flammability

7.1.2.1 A polymeric material used for electrical insulation or enclosure of live parts shall have a flammability classification of HB, V-2, V-1, V-0, VTM-2, VTM-1, VTM-0, 5VA, or 5VB in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94. The flame class rating of the material shall be determined at the minimum thickness employed at the walls and barriers in the device, which are critical to the functioning of the insulation or enclosure of the device.

Exception No. 1: This requirement does not apply to a small part:

- a) With a volume that does not exceed 0.122 in³ (2 cm³),*
- b) With no dimension exceeding 1.18 in (3 cm), and*
- c) That is located such that the part does not propagate flame from one area to another or act as a bridge between a source of ignition and other ignitable parts.*

Exception No. 2: This requirement does not apply to fiber or similar material that is 0.010 in (0.25 mm) or less thick.

Exception No. 3: A polymeric material that complies with either the 12 mm or 20 mm (3/4-in) flame flammability test described in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, need not have a flammability class rating.

7.1.3 Electrical properties

7.1.3.1 General

7.1.3.1.1 A polymeric material used for electrical insulation or enclosure of live parts shall comply with 7.1.3.2, 7.1.3.3, and 7.1.3.4.

Exception No. 1: The requirements in 7.1.3.2, 7.1.3.3, and 7.1.3.4 do not apply to devices rated 8 A or less and 30 V (42 V_{peak}) or less.

Exception No. 2: Small parts that are made from polymeric or epoxy type materials that does not come into contact with live parts or are totally encapsulated due to their design and do not track between parts of opposite polarity and/or any other uninsulated parts of different polarities do not have to comply with the requirements of 7.1.3.2, 7.1.3.3, and 7.1.3.4. A small part is considered to be not more than 0.122 in³ (2 cm³) in volume.

7.1.3.2 Comparative tracking index (CTI)

7.1.3.2.1 A polymeric material used for electrical insulation of live parts shall have a comparative tracking index (CTI) performance level category (PLC) rating of 0, 1, 2, or 3 determined in accordance with the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A.

7.1.3.2.2 A polymeric material used for electrical enclosure of live parts shall have a comparative tracking index (CTI) performance level category (PLC) rating of 0, 1, 2, or 3 determined in accordance with the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A.

Exception: A polymeric material used for electrical insulation or enclosure of live parts is not required to comply with this requirement if it complies with the Comparative Tracking Index (CTI) Test in Section 45.2 or the Proof Tracking Test in accordance with the Method for the Determination of the Proof and the Comparative Tracking Indices of Solid Insulating Materials, IEC 60112.

7.1.3.3 Hot wire ignition (HWI)

7.1.3.3.1 A polymeric material used for electrical insulation of live parts shall have a hot wire ignition (HWI) performance level category (PLC) rating not less than specified in Table 7.1 determined in accordance with the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A. For a material with other than a VTM flammability classification, the acceptability of the material shall be determined using the material thickness employed in the end-use product or a nominal 1/8-in (3.2-mm) thickness, whichever is greater.

Exception No. 1: A polymeric material used in an enclosure of a molded-on fitting is not required to comply with this requirement.

Exception No. 2: A polymeric material used for electrical insulation or enclosure of live parts is not required to comply with this requirement if it complies with the Glow Wire Test in Section 45.1.

Table 7.1
Hot-wire ignition (HWI) ratings

Flammability classification ^a	HWI ^b	
	Mean ignition time ^c s	PLC ^d
V-0, VTM-0	7 and up to 15	4
V-1, VTM-1, 5VA, 5VB	15 and up to 30	3
V-2, VTM-2	30 and up to 60	2
HB	30 and up to 60	2
^a Flammability classification – Determined in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94. ^b HWI – Hot wire ignition (HWI) determined in accordance with the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A. ^c Mean ignition time is to be used to determine the acceptability of filament wound tubing, industrial laminates, vulcanized fiber, and similar polymeric materials only. All other materials are to be investigated using the performance level category values. ^d PLC – performance level category.		

7.1.3.4 High-current arc ignition (HAI)

7.1.3.4.1 A polymeric material used for electrical insulation or enclosure of live parts shall have a high-current arc ignition (HAI) performance level category (PLC) rating not less than specified in Table 7.2 as determined in accordance with the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A. For a material with other than a VTM flammability classification, the acceptability of the material shall be determined using the material thickness employed in the end-use product or a nominal 1/8-in (3.2-mm) thickness, whichever is greater.

Exception No. 1: This requirement does not apply to:

- a) A polymeric material used in over-mold applications to form the enclosure of live parts; and*
- b) A polymeric material used within contact with live parts not to exceed 0.04 in (1 mm) of contact area.*

Exception No. 2: A polymeric material used for electrical insulation or enclosure of live parts is not required to comply with this requirement if it complies with the High-Current Arc Resistance to Ignition Test in 45.3.

Table 7.2
High-ampere arc ignition (HAI) ratings

Flammability classification ^a	HAI ^b	
	Mean number of arcs ^c s	PLC ^d
V-0, VTM-0	15 and up to 30	3
V-1, VTM-1, 5VA, 5VB	30 and up to 60	2
V-2, VTM-2	30 and up to 60	2
HB	60 or more	1
^a Flammability classification – Determined in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94. ^b HAI – High-current arc ignition (HAI) determined in accordance with the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A. ^c Mean ignition time is to be used to determine the acceptability of filament wound tubing, industrial laminates, vulcanized fiber, and similar polymeric materials only. All other materials are to be investigated using the performance level category values. ^d PLC – Performance level category.		

7.1.4 Thermal properties

7.1.4.1 A polymeric material used for electrical insulation or enclosure of live parts shall have the relative thermal index ratings shown in Table 7.3 for the specific application of the insulating material. For materials with other than VTM flammability classifications, the material shall be evaluated using the specimen thickness employed in the end product or nominal 1/8-in (3.2-mm) thickness, whichever is greater.

Exception No. 1: The following generic materials having readings of 65 or less on the Shore Durometer D scale (when measured for 5 s at an ambient temperature of $73.4 \pm 3.6^\circ\text{F}$ ($23.0 \pm 2.0^\circ\text{C}$)) are acceptable for use at 140°F (60°C) based on their successful completion of the appropriate accelerated aging test described in the Accelerated Aging Tests, 44:

- a) Ethylene/Propylene/Diene (EPDM)*
- b) Natural Rubber (NR)*
- c) Neoprene (Chloroprene Butadiene) Rubber (CBR)*
- d) Nitrile Rubber (NBR)*
- e) Polyvinyl Chloride (PVC) and its copolymers*
- f) Silicone Rubber (SIR)*
- g) Styrene (Butadiene) Rubber (SBR)*
- h) Thermo Elastomeric [TEE; includes Thermoplastic Elastomers (TPE) and Ethylene Propylene Thermoplastic Rubber (EPTR)]*

Exception No. 2: A polymeric material that does not have a RTI value, see the Standard for Safety for Polymeric Materials – Long Term Property Evaluations, UL 746B Table for “Relative Thermal Indices Based Upon Past Field-Test Performance and Chemical Structure” for generic thermal index.

Exception No. 3: A polymeric material used in over-mold applications to form the enclosure of live parts or within contact with live parts not to exceed 0.04 in (1 mm) of contact area shall not require a comparative tracking index (CTI) rating.

Table 7.3
Minimum relative thermal indices (RTI)

Application	Minimum RTI ^a		
	Electrical °F (°C)	Mechanical with impact ^b °F (°C)	Mechanical without impact °F (°C)
Permanently-wired devices, panel-mounted fittings, multi-outlet fittings	176 (80)	140 (60)	176 (80)
Cord and cable fittings (including multi-outlet fittings, splitters, and feed-through fitting)	140 (60)	140 (60)	140 (60)
^a RTI – The relative thermal index determined in accordance with the Standard for Polymeric Materials – Long Term Property Evaluations, UL 746B. ^b For industrial laminates, vulcanized fiber, and similar polymeric materials, the material's minimum RTI for mechanical with impact shall comply with the values specified for mechanical without impact.			

7.2 Insulating materials for devices rated 601 – 1000 V

7.2.1 A device rated 601 – 1000 V shall comply with the applicable construction requirements in this standard in addition to the requirements for Insulating Materials for Devices Rated 600 V or Less, in 7.1.

7.2.2 An insulating material used as direct or indirect support of an uninsulated live part shall comply with 7.1 and the Inclined Plane Tracking Test specified in the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A. The insulating material shall not track beyond one inch in less than 60 min using the time to track method. The voltage for the Inclined Plane Tracking Test shall be not less than the rated voltage of the equipment.

7.2.3 Insulation material shall be subjected to the Mold Stress-Relief Distortion Test, Section 20. For the purpose of this outline of investigation, an insulation material is defined as a material which is in contact with or within 1/32 in (0.8 mm) to either uninsulated live parts of opposite polarity, or uninsulated live parts and either metal parts that are capable of being grounded in service, or any surface exposed to contact.

Exception: The Mold Stress-Relief Test is not required for rigid thermosetting materials, such as phenolic.

8 Live Parts

8.1 Iron or steel, plated or unplated, shall not be used for a current-carrying part. Stainless steel is acceptable for a current-carrying part that is not subject to arcing.

8.2 A current-carrying part shall be restrained from turning relative to the surface on which the part is mounted if such turning affects the performance of the device.

8.3 Uninsulated live parts shall be secured in place so that the spacings are not reduced below those specified in 12.1.1.

9 Grounding and Dead-Metal Parts

9.1 Grounding parts shall be copper or a copper-base alloy.

9.2 Steel or its equivalent is acceptable for a rivet, bolt, or clamp that is used to secure parts in the grounding path if the rivet, bolt, or clamp is not a conductor in the grounding path.

9.3 A copper-base alloy rivet that is used to secure parts in the grounding path, and forms a part of the grounding path, shall not contain less than 80% copper.

9.4 The requirements in 9.1 – 9.3 apply to the entire grounding-conductor path between the grounding pin or contact and the grounding terminal.

9.5 Grounding parts and dead-metal parts shall be secured in place so that the spacings are not reduced below those specified in 12.1.1.

9.6 A dead-metal part of a grounding device shall be conductively connected to the grounding-conductor path by means of the device unless the dead-metal part is isolated from current-carrying parts and wiring other than a complete flexible cord. A flexible cord is not complete if two insulated conductors of a parallel-type cord are split apart or where the jacket of a jacketed-type cord is removed from the insulated conductors.

9.7 The grounding path of a device fitting shall be located and formed in such a manner that makes grounding first and breaks the grounding circuit last.

9.8 The AWG sizing of the grounding conductor shall be the same or larger, as the other terminal conductors.

10 Terminals

10.1 When a device is intended for connection by conductors, the means for connection shall be a wiring terminal of the wire-binding screw construction, or pressure wire terminal construction that utilizes positive screw pressure on a bared conductor, or a factory assembled conductor attached by means of soldering, welding, riveting, or crimping.

Exception: Other forms of conductor connection meet the intent of the requirement if the mechanical features and current-carrying capability are equivalent to those of one of the connections described.

10.2 Each conductor shall be fastened to the terminals of fittings in a manner that:

- a) Prevents strands of any conductor from contacting uninsulated live parts of opposite polarity or dead-metal parts,
- b) Provides mechanical security in accordance with Conductor Secureness Test, Section 24,
- c) Provides ampacity for compliance with Temperature Test, Section 27, and
- d) Prevents strands from surfacing in a molded-on fitting.

10.3 A setscrew type terminal shall not be employed in other than a pressure wire connector as specified in 10.7.

10.4 A wire-binding screw shall thread into metal. The thickness of the metal shall provide two full threads for the screw.

10.5 Wire binding screws used in making electrical connections shall not be smaller than indicated in Table 10.1. The minimum size for a wire-binding screw shall be as indicated in Table 10.1.

Table 10.1
Minimum sizes of wire-binding screws

Contact rating A	Minimum size of screw	Minimum head diameter in (mm)	Maximum number of threads per inch
20 or less	No. 6 (M3.5) ^a	0.275 (7.0)	36
up to 35	No. 8 (M4) ^b	0.315 (8.0)	32
^a A No. 6 (M3) terminal screw, minimum head diameter of 1/4 in (6.3 mm), may be used on devices not intended for permanent installation and rated 15 A. ^b A No. 8 (M4) or larger screw having more than the number of threads per inch indicated may be used for terminals if the assembly is capable of withstanding a tightening torque of 16 lbf-in (1.8 N-m) applied to the wire-binding screw without stripping either the screw threads or the terminal plate threads, or damaging the slot in the head of the screw.			

10.6 A direct-bearing, setscrew pressure wire connector shall comply with the applicable requirements in the Standard for Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors, UL 486E.

10.7 The tightening torque for a field-wiring terminal shall be specified by the device manufacturer and the device shall be marked in accordance with 48.7. The tightening torque shall not be less than 90% of the value required for the Static Heating Test in the Standard for Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors, UL 486E, for the maximum wire size corresponding to the ampere rating of the device.

Exception: A lesser torque value meets the intent of the requirement if the connector complies with the Standard for Wire Connectors, UL 486A-486B, or the Standard for Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors, UL 486E, using the lesser torque value.

11 Strain Relief and Cord Entries

11.1 A strain-relief means shall be provided in a device intended for connection to a flexible cord so that a pull on the flexible cord is not transmitted to the binding-screw terminals, or connection between the conductors and the pins or contacts as determined in accordance with Strain-Relief Test, Section 25.

11.2 The cord-entry hole for a flexible cord in a metal enclosure shall be provided with an insulating bushing of porcelain, phenolic, cold-molded composition, or other insulating material with equivalent properties.

12 Spacings

12.1 Spacing for devices rated 600 V or less

12.1.1 The spacings maintained through air or over surface shall be a minimum 3/64 in (1.2 mm) for a device rated 250 V or less, and a minimum 1/8 in (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.

12.1.2 In measuring a spacing, an isolated dead-metal part interposed between live parts of opposite polarity, or between a live part and a grounded or exposed dead-metal part, is considered to reduce the spacing by an amount equal to the dimension of the isolated dead-metal part in the direction of the measurement.

12.2 Spacings for devices rated 601 – 1000 V

12.2.1 Other than as noted in Section 18, Clearance and Creepage Distances, the electrical spacings in cable assemblies and fittings rated 601 – 1000 V shall not be less than the applicable value specified in Table 12.1.

Table 12.1
Minimum spacings for cable assemblies and fittings rated 601 – 1000 V

Application	Potential involved V	Minimum spacings between uninsulated live parts of opposite polarity; and between an uninsulated live part and a grounded part including any mounting surface or exposed metal part			
		Through air		Over surface	
		in	(mm)	in	(mm)
Rated 601-1000 V	601 - 1000	0.55	(14.0)	0.85	(21.6)

12.3 Alternate spacings – clearance and creepage distances

12.3.1 As an alternative to the specified spacing requirements of Section 12, Spacings, the spacing requirements in the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840, are applicable.

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

a) For evaluating clearances:

- 1) A device which operates in the direct line of the source of power to the load device shall be evaluated for Overvoltage Category III.

Exception: Overvoltage category II can be applied if the device is marked as indicated in 48.13.

- 2) The Phase-to-Ground Rated System Voltage used in the determination of Clearances shall be the device rated supply voltage rounded to the next higher value (in the table for determining clearances for the device). The test is only required if using equivalency requirements.

b) For evaluation of creepage:

- 1) Any printed wiring board which complies with the requirements in the Standard for Printed Wiring Boards, UL 796, provides a Comparative Tracking Index (CTI) of 100, and when it complies with the requirements for Direct Support in UL 796, then it provides a CTI of 175;
- 2) A device shall be evaluated for pollution degree 3, but may be evaluated for pollution degree 2 when instructions are provided with the device indicating that it shall be installed in a pollution degree 2 macro-environment;

3) Printed wiring boards are evaluated as pollution degree 2 when adjacent conductive material is covered by any coating, such as a solder mask, which provides an uninterrupted covering over at least one side and the complete distance up to the other side of conductive material;

4) Printed wiring boards shall be evaluated as pollution degree 1 under one of the following conditions:

i) A coating which complies with the requirements for Conformal Coatings in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C; or

ii) At a specific printed wiring board location by application of at least a 1/32-in (0.79-mm) thick layer of silicone rubber or through potting, without air bubbles, in epoxy or potting material.

13 Assembly

13.1 General

13.1.1 An assembled-on or panel-mounted device shall be easily wired as intended so that the wires are not damaged.

13.1.2 Electrical contact shall be reliably maintained at any point at which a connection is made between current-carrying parts.

13.1.3 A live part of an outlet or cord connected device shall be protected against exposure to contact by persons when the device is assembled and installed as intended.

13.1.4 Where internal connections exist corresponding contacts of individual outlets shall be connected together.

13.1.5 A device having female contacts shall be constructed so that a mating attachment plug seats without exposure of the contacts of the plug between the plane of the face of the plug and the plane of the rim of the female device.

13.1.6 The insulation and braid on the individual conductors of a cord shall be removed only to the extent required to make the proper wire connection.

13.1.7 A fitting intended for securement to conduit shall also comply with the requirements contained in the Standard for Fittings for Cable and Conduit, UL 514B, as appropriate.

13.2 Polarization

13.2.1 A device shall be constructed so that the grounding member of the corresponding fitting plug or connector is not able to be inserted by hand into any outlet or inlet slot respectively to touch a live contact.

13.2.2 A device consisting of two or more pieces shall be such that any foreseeable assembly during installation does not defeat polarization.

13.3 Mating and interchangeability

13.3.1 A device shall be constructed so that electrical continuity between respective and similarly marked terminals is established automatically when the mating plug and outlet device are connected together.

13.3.2 An outlet shall not accommodate an attachment plug other than one that is specifically intended for use with the outlet.

13.4 Terminal identification

13.4.1 A terminal of a cable assembly, which is identified for the connection of either a grounded conductor or a grounding conductor, shall be connected to the corresponding identified conductor of the cord.

13.4.2 A terminal of a cable fitting or panel-mount fitting intended as a grounded conductor or a grounding conductor shall be identified in accordance with Table 13.1. No other terminals shall be so identified.

Table 13.1
Identification of wiring terminals

Identification	Grounded terminal	Grounding terminal
Wire-binding screw	White metal or plating on circular screw head	Hexagonal, green-colored nut or slotted screw head where screw is not readily removable
Pressure wire terminal, visible	White metal or plating on terminal	Green colored terminal, screw or appendage that is not readily removable
Terminal, concealed	Distinct white-colored area adjacent to wire entrance hole or the word "White" or letter "W" distinctively marked adjacent to wire entrance hole	Distinct green-colored area adjacent to wire entrance hole or the word "Green" or "Ground" distinctively marked adjacent to wire entrance hole, or the letters "G," "GR," or "GND", or the grounding symbol shown in Figure 13.1 distinctively marked adjacent to wire entrance hole in letters not less than 1/16 in (1.6 mm) high
Terminal plate (where all terminal screws are the same color)	White metal or plating	—
Insulating enclosure or terminal	The word "White" marked on or directly adjacent to terminal, or white metal or plating on terminal	The word "Green" marked on or directly adjacent to terminal, or green-colored terminal