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SUBJECT 2736

OUTLINE OF INVESTIGATION

FOR

SINGLE POLE SEPARABLE INTERCONNECTING CABLE CONNECTORS

FOR USE WITH WIND TURBINE GENERATING SYSTEMS

Issue No. 1

May 28, 2010

Summary of Topics

This is the first issue of the Outline of Investigation for Single Pole Separable Interconnecting Cable Connectors for Use with Wind Turbine Generating Systems.

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INTRODUCTION

1 Scope

1.1 This outline covers single pole separable interconnecting cable connectors rated minimum 300 amperes up to a maximum of 1000 amperes and up to 750 volts ac or dc, intended for interconnection of individual power cables within tower sections of a Wind Turbine Generating System (WTGS).

1.2 This outline also covers single pole separable interconnecting cable connectors intended for connection to grounding circuit conductors in applications identified in 1.1.

1.3 For the purpose of this outline, separable interconnecting cable connectors consist of mating half devices.

1.4 These devices are not intended for connection or disconnection under load conditions.

1.5 Single pole separable interconnecting cable connectors have not been investigated for cables that are subject to movement, flexing, or twisting during operation of the wind turbine.

1.6 Single pole separable interconnecting cable connectors shall be supported at intervals to inhibit strain to individual terminals and interconnection of connections within the tower section or sections of a WTGS.

1.7 These devices are not intended for use in hazardous locations.

1.8 This outline does not cover:

- a) Plugs, Receptacles, and Cable Connectors, of the Pin and Sleeve Type covered by the Standard for Plugs, Receptacles, and Cable Connectors, of the Pin and Sleeve Type, UL 1682;
- b) Devices molded integrally with flexible cord or cable that are covered by the Standard for Cord Sets and Power-Supply Cords, UL 817;
- c) Single and multi-pole connectors, which may include 3 or more pilot contacts, intended for connection to copper conductors, for use in data, signal, control and power applications within and between electrical equipment, where exposed, that are covered by the Standard for Component Connectors for Use in Data, Signal, Control and Power Applications, UL 1977;
- d) Devices intended for use in hazardous (Classified) locations that are covered by the Standard for Receptacle-Plug Combinations for Use in Hazardous (Classified) Locations, UL 1010; or
- e) Devices such as wire connectors and soldering lugs that are covered by the Standard for Wire Connectors, UL 486A-486B; the Standard for Splicing Wire Connectors, UL 486C; or the Standard for Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors, UL 486E.

2 Definitions

- 2.1 For the purpose of this outline, the following definitions apply.
- 2.2 CIRCULAR MIL (CMIL) – The area of a circle with a diameter of 0.001 inch.
- 2.3 CONFIGURATION, KEYING – A deliberate means of the housing construction so that electrical continuity between respective and similarly marked terminals is established when mating connectors.
- 2.4 CONFIGURATION, LOCKING – A configuration that requires a deliberate mechanical action such as that required by a threaded collar, a mechanical lock or a latching-mechanism with audible indication of engagement or separation when used with its mating part.
- 2.5 CONNECTOR, FEMALE – A device consisting of a female contact and a housing, intended to be attached to one end of a cable.
- 2.6 CONNECTOR, MALE – A device consisting of a male contact and a housing, intended to be attached to one end of a cable.
- 2.7 CONTACT – A conductive element in a connector that mates with a corresponding component to provide an electrical path.
- 2.8 CRIMPING DIE – That part of a crimping tool, which forms the crimp(s) and usually incorporates the crimp anvil(s), the crimp indenter(s), and the positioner.
- 2.9 ENCLOSURE – The case or housing that renders inaccessible parts of the connector that may otherwise present a risk of electrical shock. It also provides protection to internal components against specified environmental conditions.
- 2.10 ENCLOSURE, RATING "IP" – Products in this category are marked with an ingress protection (IP) code, consisting of the letters "IP," followed by two characteristic numerals representing the level of protection from specified external conditions.
- 2.11 ENCLOSURE, "TYPE" NUMBER – Products in this category are marked with an operating environment type number or numbers representing the level of protection from specified external conditions.
- 2.12 GROUNDING PATH – A path between the grounding connector and the grounding terminal.
- 2.13 INSULATION, ELECTRICAL – The insulation necessary for the proper functioning of the device and for basic protection against electrical shock.
- 2.14 INSULATOR – That portion of a device that provides for support and insulation of live parts.
- 2.15 LOCKING MEANS – A mechanical arrangement that holds a male or female connector in position when it is in proper engagement and is intended to reduce the likelihood of its unintentional withdrawal. It may also facilitate environmental sealing.
- 2.16 RATED CURRENT (AMPERE RATING) – The maximum current rating assigned to a separable interconnecting cable connector by the manufacturer.
- 2.17 SEPARABLE INTERCONNECTING CABLE CONNECTOR – The complete assembly of both the male and female connectors.

2.18 TEMPERATURE RISE – Denotes the difference of the temperature of the interconnecting cable connector, measured under load, from the ambient temperature.

2.19 TERMINAL – A conductive part provided for the attachment of a conductor to either a male or female connector.

2.20 TERMINAL, CRIMP – A terminal in which the conductor is inserted into a hole or cavity, and compressed by a tool and permanently deformed to attach the conductor.

2.21 TERMINAL, MECHANICAL DOUBLE SET SCREW – A terminal in which the conductor is inserted into a hole or cavity where it is clamped under the shank of two set screws. The clamping pressure may be applied directly by the shank of the screws or through an intermediate clamping member or shim to which pressure is applied by the shank of the screws.

2.22 VOLTAGE RATING – The maximum voltage rating of a separable interconnecting cable connector assigned by the manufacturer.

3 Symbols and Abbreviations

3.1 Table 3.1 lists symbols and abbreviations used in this outline.

Table 3.1
Symbols and abbreviations

°	Degree
A	Amps, Amperes
Al	Aluminum
AWG/kcmil	American Wire Gage/gauge
C	Celsius
Cu	Copper
F	Fahrenheit
NH ₄	Moist ammonia
Hz	Hertz, cycles per second
in	Inch, Inches
WTGS	Wind Turbine Generating System
IP	Ingress Protection

4 Components

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

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 Outline; or
- b) Is superseded by a requirement in this Outline.

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 Components and subassemblies of the overall WTGS shall be evaluated and found suitable for operation over the normal range of electrical and environmental conditions as specified by the WTGS manufacturer.

5 Reference Publications

5.1 Where reference is made to standards, such reference shall be considered to refer to the latest edition and all amendments published to that edition up to the time when this standard was approved.

6 Units of Measurement

6.1 The values given in metric (SI) units shall be normative. Any other values given shall be for information purposes only.

CONSTRUCTION

7 General

7.1 The ratings mentioned throughout this outline represent the maximum current and voltage for a separable interconnecting cable connector under continuous duty. A separable interconnecting cable connector is considered to be for use with either alternating or direct current unless the rating includes a marking to restrict the use to alternating current. See 33.4.

7.2 Separable interconnecting cable connectors shall be rated in amperes and in volts, ac or dc, or both ac and dc. The maximum marked ampere rating of the connector shall not exceed the ampacity for the intended conductor size and type as shown in Table 7.1.

Table 7.1
Connector rating based upon conductor type and ampacity

Conductor size		Ampacity of single conductor cable, 90°C		Maximum connector rating, A	
AWG/kcmil	(mm ²)	Copper	Aluminum or copper-clad aluminum	Copper	Aluminum or copper-clad aluminum
2/0	(67.4)	300	—	300	—
3/0	(85.0)	350	—	350	—
4/0	(107)	405	315	405	315
250	(127)	455	355	455	355
300	(152)	505	395	505	395
350	(177)	570	445	570	445
400	(203)	615	480	615	480
500	(253)	700	545	700	545
600	(304)	780	615	780	615
700	(355)	855	675	855	675
750	(380)	855	700	855	700
800	(405)	920	725	920	725
900	(456)	985	785	985	785
1000	(507)	1000	845	1000	845
1250	(633)	1000	960	1000	960

7.3 Separable interconnecting cable connectors are intended for use with Type RHW-2 cable only, not exceeding the ampacity of insulated single conductor rated 90°C as shown in Table 7.1.

8 Mating and Intermateability

8.1 Separable interconnecting cable connectors shall be constructed so that electrical continuity between respective and similarly marked terminals is established when mating male and female connectors are connected together.

8.2 A female connector shall not permit a male connector other than one that is specifically intended for use with the female connector to be inserted to the extent that electrical contact is established.

8.3 Male and female connectors that have different electrical ratings or are produced by different manufacturers shall not be interchangeable with one another.

8.4 Separable interconnecting cable connectors shall:

- a) Have a mechanical means, such as a lock or latch, that prevents unintentional separation when mating halves are fully engaged in the mated condition and shall comply with the Secureness of Enclosure, Drop, and Latching Tests specified in Sections 28, 29, and 30, respectively, and
- b) Be keyed to limit interconnection to only the intended circuit, as specified by phase, voltage, and current.

8.5 Means shall be provided for retaining live parts within limits of alignment that ensure that male cable connectors will enter female cable connectors in the intended manner.

9 Insulating Material

9.1 A polymeric material used for electrical insulation, an internal barrier necessary to maintain electrical clearances and creepage distances, or an enclosure of live parts:

- a) Shall have a minimum flame class rating of V-1 in accordance with the requirements of the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94. The flammability classification shall be judged at the actual minimum thickness employed within 0.8 mm (1/32 inch) of live parts within the device, and
- b) Shall comply with the Hot Wire Ignition (HWI), High-Current Arc Resistance to Ignition (HAI), and Comparative Tracking Index (CTI) values indicated in Table 9.1.

Exception No. 1: Those materials without HWI Performance Level Category (PLC) values or with HWI PLC values higher (worse) than those required by Table 9.1 shall alternatively be subjected to the Glow-Wire Resistance to Ignition Test described in the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A with a glow wire at a temperature of 750°C. As a result of this test, there shall not be ignition of the insulating material during 30 seconds of application of the probe.

Exception No. 2: Those materials without HAI Performance Level Category (PLC) values or with HAI PLC values higher (worse) than those required by Table 9.1 shall alternatively be subjected to the end-product Special Arcing Test in accordance with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

Exception No. 3: Those materials without CTI Performance Level Category (PLC) values or with CTI PLC values higher (worse) than the CTI required by Table 9.1 shall alternatively be subjected to the end-product Special Arcing Test in accordance with the Standard for Polymeric Materials – Electrical Equipment Evaluations, UL 746C.

Table 9.1
Hot wire ignition (HWI), high-current arc resistance to ignition (HAI) and comparative tracking index (CTI) ratings of insulating materials

Flammability classification ^a	HWI ^b		HAI ^c		CTI	
	Mean ignition time, s	PLC ^d	Mean no. of arcs	PLC ^d	Tracking index, volts	PLC ^d
V0	7-15	4	15-30	3	175-249	3
V1	15-30	3	15-30	3	175-249	3
V5	15-30	3	15-30	3	175-249	3
^a Flammability Classification – Described in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94. ^b Hot Wire Resistance to Ignition – Described in the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A. ^c High-Current Arc Resistance to Ignition – Described in the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A. ^d Performance level class.						