



Designation: ~~D1351 – 14~~ D1351 – 20

Standard Specification for Thermoplastic Polyethylene Insulation for Electrical Wire and Cable¹

This standard is issued under the fixed designation D1351; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reappraisal. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reappraisal.

1. Scope*

1.1 This specification covers a thermoplastic insulation which consists substantially of polyethylene.

1.2 This type of insulation is considered suitable for use on wire or cable that will be used for continuous operation at conductor temperatures up to ~~75°C~~ 75 °C with a maximum conductor size of 1000 kcmil (507 mm²). The maximum voltage rating shall not exceed 35 000 V for power application or 9 000 V for series lighting.

1.3 In many instances the insulation material cannot be tested unless it has been formed around a conductor. Therefore, tests done on insulated wire or cable in this specification are solely to determine the relevant property of the insulation material and not to test the insulated conductor or completed cable.

1.4 Whenever two sets of values are presented, stated, in different units, the values in the ~~first~~ first set are ~~the~~ regarded as standard, while ~~those~~ the values in parentheses are provided for information ~~only~~ only and are not considered standard.

1.5 This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee. [a7b4-68fbfd4ffbdb/astm-d1351-20](https://standards.iteh.ai/document/standards/astm-d1351-20)

2. Referenced Documents

2.1 ASTM Standards:²

[D1248 Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable](#)

[D1711 Terminology Relating to Electrical Insulation](#)

[D2308 Specification for Thermoplastic Polyethylene Jacket for Electrical Wire and Cable](#)

[D2633 Test Methods for Thermoplastic Insulations and Jackets for Wire and Cable](#)

[D3349 Test Method for Absorption Coefficient of Ethylene Polymer Material Pigmented with Carbon Black](#)

2.2 ICEA Standard:³

[T-24-380 Guide for Partial-Discharge Procedure](#)

3. Terminology

3.1 Definitions:

¹ This specification is under the jurisdiction of ASTM Committee [D09](#) on Electrical and Electronic Insulating Materials and is the direct responsibility of Subcommittee [D09.07](#) on Electrical Insulating Materials.

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² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

³ Available from The Insulated Cable Engineers Association, Inc. (ICEA), P.O. Box ~~1568, Carrolton, 2694~~ 1568, Carrolton, 2694, Alpharetta, GA ~~30112, 30023~~ 30112, 30023, <http://www.icea.net>.

*A Summary of Changes section appears at the end of this standard

3.1.1 Refer to Terminology **D1711** for definitions of terms used in this specification.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *aging (act of), n*—exposure of materials to air at a temperature of 100°C – 100°C for 48 h.

4. High Voltage Hazard

4.1 *High Voltage:*

4.1.1 Lethal voltages are a potential hazard during the performance of this test. It is essential that the test apparatus, and all associated equipment electrically connected to it, be properly designed and installed for safe operation.

4.1.2 Solidly ground all electrically conductive parts which it is possible for a person to contact during the test.

4.1.3 Provide means for use at the completion of any test to ground any parts which were at high voltage during the test or have the potential for acquiring an induced charge during the test or retaining a charge even after disconnection of the voltage source.

4.1.4 Thoroughly instruct all operators as to the correct procedures for performing tests safely.

4.1.5 When making high voltage tests, particularly in compressed gas or in oil, it is possible for the energy released at breakdown to be sufficient to result in fire, explosion, or rupture of the test chamber. Design test equipment, test chambers, and test specimens so as to minimize the possibility of such occurrences and to eliminate the possibility of personal injury. If the potential for fire exists, have fire suppression equipment available. Design test equipment, test chambers, and test specimens so as to minimize the possibility of such occurrences and to eliminate the possibility of personal injury.

5. Conductor Shields

5.1 Conductor shields shall be used on solid and stranded conductors of power cables having rated circuit voltages above 2000 V. This requirement does not apply to series lighting cables. Conductor shielding is conducting material at least 0.0025 in. (0.06 mm) thick applied over the surface of the conductor. The options include conducting nonmetallic tape, conducting compound, or conducting cement.

6. Physical Properties

6.1 The polyethylene, before application to the conductor, shall comply with the requirements of Specification **D1248** for Type I; Class A, B₂ or C; Category 4 or 5; Grade E4 or E5. The requirements of Specification **D1248** do not apply to insulation removed from the conductor.

6.2 Insulation exposed to sunlight or weather requires Specification **D1248**, Class C compound or suitable protective coverings. Class C compound shall meet the minimum absorption coefficient requirement in **Table 1**.

TABLE 1 Physical Properties of Compound

Unaged Requirements:	
—Tensile strength, min, psi (MPa)	1500 (10.4)
—Tensile strength, minimum, psi (MPa)	1500 (10.4)
—Elongation at rupture, min, %	350
—Elongation at rupture, minimum, %	350
Aged Requirements:	
—After air oven aging at $100 \pm 1^{\circ}\text{C}$ for 48 h:	
—After air oven aging at $100 \pm 1^{\circ}\text{C}$ for 48 h:	
—Tensile strength, % retention, min	75
—Tensile strength, % retention, minimum	75
—Elongation at rupture, % retention, min	75
—Elongation at rupture, % retention, minimum	75
Absorption Coefficient, min, absorbance/nm	320
Absorption Coefficient, minimum, absorbance/nm	320

6.3 Specimens removed from the wire or cable and tested at 20 to 30°C (68 to 86°F) shall conform to the requirements for physical properties specified in Table 1. Alternatively, the insulation shall be air-oven aged without removal from the conductor.

6.4 Thickness of Insulation—The minimum average insulation thickness shall be as specified in Table 2 or Table 3 of this specification. The minimum thickness shall be at least 90 % of the specified minimum average thickness.

6.5 Absorption Coefficient—Test according to Test Method D3349. Alternatively, a certification by the manufacturer of the polyethylene compound that the requirement has been complied with shall suffice.

TABLE 2 Conductor Sizes, Insulation Thicknesses, and Test Voltages for Polyethylene-Insulated Power Cables^A

NOTE 1—Column A thicknesses (0 to 2000 V) are applicable to single-conductor power cables for general application when a black pigmented insulation is used without a further covering.

NOTE 2—Column B thicknesses (0 to 2000 V) are applicable to multiple-conductor cables with an outer covering and to single-conductor cables with an outer covering.

NOTE 3—To limit the maximum voltage stress on the insulation at the conductor to a safe value, the minimum size of the conductor shall be in accordance with Table 2.

For cables or conditions of service where mechanical stresses govern, such as in submarine cables or long vertical risers, it is possible that these minimum conductor sizes will not be strong enough.

NOTE 4—Polyethylene insulation used on nonshielded cable without an outer covering shall be black pigmented insulation meeting the requirements for both polyethylene insulation and polyethylene jacket.

NOTE 5—Polyethylene insulation used on nonshielded cable without an outer covering for rated circuit voltages of 2001 to 5000 V shall be ozone and discharge resistant when tested in accordance with Specification D2308.

NOTE 6—Carbon-black-pigmented polyethylene insulation shall not be used on power cable rated over 5000 V.

Rated Circuit Voltage, Phase to Phase, V ^B	Conductor Size, Awg or kcmil (mm ²)	Insulation Thickness for 100 and 133 Percent Insulation Levels, ^C Grounded and Ungrounded Neutral				a-c Test Voltage, kV, for 100 and 133 Percent Insulation Levels, ^C Grounded and Ungrounded Neutral		d-c Test Voltage, kV, for 100 and 133 Percent Insulation Levels, ^C Grounded and Ungrounded Neutral	
		Column A		Column B		A	B	A	B
		mils	mm	mils	mm				
0 to 600	14 to 9 (2.08 to 6.63)	45	1.14	30	0.76	4.0	3.5	12.0	10.5
	8 to 2 (8.37 to 33.62)	60	1.52	45	1.14	5.5	5.5	16.5	16.5
	1 to 4/0 (42.41 to 107.2)	80	2.03	55	1.40	7.0	7.0	21.0	21.0
	225 to 500 (114 to 253)	95	2.41	65	1.65	8.0	8.0	24.0	24.0
601 to 2000	525 to 1000 (266 to 507)	110	2.79	80	2.03	10.0	10.0	30.0	30.0
	14 to 9 (2.08 to 6.63)	60	1.52	45	1.14	5.5	5.5	16.5	16.5
	8 to 2 (8.37 to 33.62)	70	1.78	55	1.40	7.0	7.0	21.0	21.0
	1 to 4/0 (42.41 to 107.2)	90	2.29	65	1.65	8.0	8.0	24.0	24.0
2001 to 5000	225 to 500 (114 to 253)	105	2.67	75	1.90	9.5	9.5	28.5	28.5
	525 to 1000 (266 to 507)	120	3.05	90	2.29	11.5	11.5	34.5	34.5
		100 Percent Insulation Level, ^D Grounded Neutral		133 Percent Insulation Level, Ungrounded Neutral		100 Percent Insulation Level, ^D Grounded Neutral	133 Percent Insulation Level, Ungrounded Neutral	100 Percent Insulation Level, Grounded Neutral	133 Percent Insulation Level, Ungrounded Neutral
		NONSHIELDED ^E							
2001 to 5000	8 to 4/0 (8.37 to 107.2)	110	2.79	110	2.79	13	13	35	35
	225 to 500 (114 to 253)	120	3.05	120	3.05	13	13	35	35
	525 to 1000 (266 to 507)	130	3.30	130	3.30	13	13	35	35
		100 Percent Insulation Level, ^D Grounded Neutral		133 Percent Insulation Level, Ungrounded Neutral		100 Percent Insulation Level, ^D Grounded Neutral	133 Percent Insulation Level, Ungrounded Neutral	100 Percent Insulation Level, Grounded Neutral	133 Percent Insulation Level, Ungrounded Neutral
		SHIELDED							
2001 to 5000	8 to 1000 (8.37 to 507)	90	2.29	90	2.29	13	13	35	35
5001 to 8000	6 to 1000 (13.30 to 507)	115	2.92	140	3.56	18	22	45	45
8001 to 15000	2 to 1000 (33.62 to 507) ^F	175	4.45	215	5.46	27	33	70	80
15001 to 25000	1 to 1000 (42.41 to 507)	260	6.60	345	8.76	38	49	100	125
25001 to 28000	1 to 1000 (42.41 to 507)	280	7.11			42		105	
28001 to 35000	1/0 to 1000 (53.49 to 507)	345	8.76			49		125	

TABLE 2 Conductor Sizes, Insulation Thicknesses, and Test Voltages for Polyethylene-insulated Power Cables^A

NOTE 1—Column A thicknesses (0 to 2000 V) are applicable to single-conductor power cables for general application when a black pigmented insulation is used without a further covering.

NOTE 2—Column B thicknesses (0 to 2000 V) are applicable to multiple-conductor cables with an outer covering and to single-conductor cables with an outer covering.

NOTE 3—To limit the maximum voltage stress on the insulation at the conductor to a safe value, the minimum size of the conductor shall be in accordance with **Table 2**.

For cables or conditions of service where mechanical stresses govern, such as in submarine cables or long vertical risers, it is possible that these minimum conductor sizes will not be strong enough.

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NOTE 5—Polyethylene insulation used on nonshielded cable without an outer covering for rated circuit voltages of 2001 to 5000 V shall be ozone and discharge resistant when tested in accordance with Specification **D2308**.

NOTE 6—Carbon-black-pigmented polyethylene insulation shall not be used on power cable rated over 5000 V.

Rated Circuit Voltage, Phase to Phase, V ^B	Conductor Size, Awg or kcmil (mm ²)	Insulation Thickness for 100 and 133 % Insulation Levels, ^C Grounded and Ungrounded Neutral				a-c Test Voltage, kV, for 100 and 133 % Insulation Levels, ^C Grounded and Ungrounded Neutral		d-c Test Voltage, kV, for 100 and 133 % Insulation Levels, ^C Grounded and Ungrounded Neutral	
		Column A		Column B		A	B	A	B
		mils	mm	mils	mm				
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	525 to 1000 (266 to 507)	110	2.79	80	2.03	10.0	10.0	30.0	30.0
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		mils	mm	mils	mm	mils	mm	mils	mm
NONSHIELDED^E									
2001 to 5000	8 to 4/0 (8.37 to 107.2)	110	2.79	110	2.79	13	13	35	35
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28 001 to 35 000	1/0 to 1000 (53.49 to 507)	345	8.76			49		125	

^A For series lighting cables, see **Table 3**.

^B The actual operating voltage shall not exceed the rated circuit voltage by more than (1) 5 percent during continuous operation, or (2) 10 percent during emergencies lasting not more than 15 min.

^C The selection of the cable insulation level to be used in a particular installation shall be made on the basis of the applicable phase to phase voltage and the general system category as outlined below:

100 Percent Level—It is appropriate for cables in this category to be applied where the system is provided with relay protection such that ground faults will be cleared as rapidly as possible, but in any case within 1 min. While these cables are applicable to the great majority of cable installations which are on grounded systems, they are also potentially suitable on other systems for which the application of cables is acceptable provided the above clearing requirements are met in completely de-energizing the faulted section. In common with other electrical equipment, the use of cables is not recommended on systems where the ratio of the zero to positive phase reactance of the system at the point of cable application lies between -1 and -40 since excessively high voltages will be encountered in the case of ground faults.

133 Percent Level—This insulation level corresponds to that formerly designated for ungrounded systems. It is appropriate for cables in this category to be applied in situations where the clearing time requirements of the 100 percent level category cannot be met, and yet there is adequate assurance that the faulted section will be de-energized in a time not exceeding 1 h. They are also suitable for use when additional insulation strength over the 100 percent level category is desirable.

^D Where additional insulation thickness is desired, it shall be the same as for the 133 percent insulation level.

^E Where cable is provided with a protective covering, these insulation thicknesses shall be 90 mils (2.29 mm) for all conductor sizes listed.

^F For 133 percent insulation level (ungrounded neutral), the minimum conductor size is 1 Awg (42.41 mm²).