**Designation: ~~D2220 – 17~~ D2220 – 21**

# Standard Specification for Poly(Vinyl Chloride) Insulation for Wire and Cable, ~~75°C~~75 °C Operation[1]

This standard is issued under the fixed designation D2220; 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 reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

## 1. Scope*

1.1 This specification covers a thermoplastic insulation of poly(vinyl chloride) or the copolymer of vinyl chloride and vinyl acetate.

1.2 This insulation is recommended for use in power and control circuits at temperatures not higher than ~~75°C.~~75 °C. At a thickness of 15 mils (0.38 mm), application is limited to voltage ratings below 300 V, and to dry locations. At a thickness of 30 mils, the application range is widened to dry or wet applications, and to a voltage rating of 600 V.

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

1.4 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.4.1 In come cases (including the title), temperatures are described in degrees Celsius only.

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.*

## 2. Referenced Documents

2.1 *ASTM Standards:*[2]

D1711 Terminology Relating to Electrical Insulation

D2633 Test Methods for Thermoplastic Insulations and Jackets for Wire and Cable

~~D2633~~D8354 Test ~~Methods for Thermoplastic Insulations and Jackets for Wire and Cable~~Method for Flammability of Electrical Insulating Materials Used for Sleeving or Tubing

G153 Practice for Operating Enclosed Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials

G155 Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials

[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.

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

## 3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of terms used in this specification, refer to Terminology D1711.

~~3.2 *Definitions of Terms Specific to This Standard:*~~

~~3.2.1 *aging (act of), n*—exposure of materials to air or oil at a temperature and a time as specified in Table 1.~~

## 4. Physical Properties

4.1 The insulation shall conform to the requirements for physical properties prescribed in Table 1. In terms of this specification, the act of aging is the response of materials to their exposure to air or oil at a temperature and a time as specified in Table 1. The vertical flame test shall be conducted in accordance with Test Method D8354.

## 5. Electrical Requirements

5.1 Perform the ac voltage, insulation resistance, and dc voltage tests in that order when any of these tests are required. The sequence for other testing is not specified.

5.2 *AC Voltage Test*—Test the insulated conductor at the ac withstand voltage as specified in Table 2. Unless otherwise specified, omit this test if the dc withstand voltage test described in 5.4 is performed.

**TABLE 1 Physical Properties Requirements**

| | |
|---|---|
| Unaged Requirements: | |
| ~~Tensile strength, min, psi (MPa)~~ | ~~2000 (13.8)~~ |
| Tensile strength, min, psi (MPa) | 2000 (13.8) |
| ~~Elongation at rupture, min, %~~ | ~~150~~ |
| Elongation at rupture, min, % | 150 |
| Aged Requirements: | |
| ~~After air oven test at 121± 1°C for 168 h:~~ | |
| After Air Oven Test at 121 ± 1 °C for 168 h: | |
| ~~Tubular Specimens—up to size AWG 6 (13.3 mm$^2$)~~ | |
| Tubular Specimens—Up to size AWG 6 (13.3 mm$^2$) | |
| ~~Tensile strength, min, % of unaged value~~ | ~~80~~ |
| Tensile strength, min, % of unaged value | 80 |
| ~~Elongation, min, % of unaged value~~ | ~~75~~ |
| Elongation, min, % of unaged value | 75 |
| ~~Buffed die-cut Specimens—sizes AWG 6 and larger~~ | |
| Buffed die-cut Specimens—sizes AWG 6 and larger | |
| ~~Tensile strength, min, % of unaged value~~ | ~~75~~ |
| Tensile strength, min, % of unaged value | 75 |
| ~~Elongation, min, % of unaged value~~ | ~~50~~ |
| Elongation, min, % of unaged value | 50 |
| ~~Heat shock, 121 ± 1°C~~ | ~~no cracks~~ |
| Heat Shock, 121 ± 1 °C | no cracks |
| ~~Heat distortion, 121 ± 1°C, max, % decrease~~ | ~~25~~ |
| Heat Distortion, 121 ± 1 °C, max, % decrease | 25 |
| ~~Vertical flame test, after~~ | ~~passes~~ |
| Vertical Flame Test, after | passes |
| ~~five 15-s applications~~ | |
| Five 15-s applications in accordance with Test Method D8354 | |
| Oil resistance test: | |
| ~~After oil immersion at 70± 1°C for 4 h:~~ | |
| After Oil Immersion at 70 ± 1 °C for 4 h: | |
| ~~Tubular Specimens—up to size AWG 6 (13.3 mm$^2$)~~ | |
| Tubular Specimens—Up to size AWG 6 (13.3 mm$^2$) | |
| ~~Tensile strength, min, % of unaged value~~ | ~~85~~ |
| Tensile strength, min, % of unaged value | 85 |
| ~~Elongation, min, % of unaged value~~ | ~~85~~ |
| Elongation, min, % of unaged value | 85 |
| ~~Buffed die-cut Specimens—sizes AWG 6 and larger~~ | |
| Buffed Die-cut Specimens—sizes AWG 6 and larger | |
| ~~Tensile strength, min, % of unaged value~~ | ~~80~~ |
| Tensile strength, min, % of unaged value | 80 |
| ~~Elongation, min, % of unaged value~~ | ~~60~~ |
| Elongation, min, % of unaged value | 60 |
| ~~Cold bend test, -30 ± 1°C for 1 h~~ | ~~no cracks~~ |
| Cold Bend Test, –30 ± 1 °C for 1 h | no cracks |

**TABLE 2 Conductor Sizes, Insulation Thicknesses, and Test Voltages for Poly(Vinyl ~~Chloride)-Insulated~~Chloride)-insulated Control and Power Cables**

| Rated Circuit Voltage, Phase-to-Phase, V | Conductor Size, AWG or cmil ($mm^2$) | Insulation Thickness, mils (mm) | AC ~~Test~~ Test Voltage, kV |
|---|---|---|---|
| 0 to 300 | 26 to 16 (0.13 to 1.31) | 15 (0.38) | 1.0 |
| 0 to 600 | 26 to 16 (0.13 to 1.31) | 30 (0.76) | 1.5 |
| | 14 to 9 (2.08 to 6.63) | 45 (1.14) | 3.0 |
| | 8 to 2 (8.37 to 33.6) | 60 (1.52) | 3.5 |
| | 1 to 0000 (42.4 to 10.7) | 80 (2.03) | 4.0 |
| | 225 000 to 500 000 (140 to 253) | 95 (2.41) | 5.0 |
| | 501 000 to 1 000 000 (254 to 507) | 110 (2.79) | 6.0 |
| | Over 1 000 000 (507) | 125 (3.18) | 7.0 |

5.2.1 For cables or conditions of service where mechanical stresses govern, such as in submarine cables or long vertical risers, it is possible that the minimum conductor sizes in Table 2 are not strong enough.

5.2.2 The thicknesses given in Table 2 apply to aerial cables and to single conductors installed in conduits above ground and to the individual conductors of all multiple-conductor cables having a common jacket metallic sheath or protective covering over the assembly, except as shown in 5.2.2.1.

5.2.2.1 For single-conductor cables for installation in underground ducts or direct earth burial, add 15 mils (0.38 mm) to the insulation thicknesses given in Table 2 when such cables do not have a thermoplastic jacket or metallic sheath over the assembly.

5.2.3 Where the thickness of the insulation is increased for mechanical reasons or for special service conditions, determine the test voltage in Table 2 by the size of the conductor and the rated voltage.



5.3 *Insulation Resistance:*

5.3.1 Insulated conductors in sizes AWG 14 (2.08 $mm^2$) and larger shall have an insulation resistance of at least that corresponding to a constant of 2000 M Ω-1000 ft at ~~60°F (15.6°C).~~60 °F (15.6 °C).

5.3.2 If the temperature at the time measurement was made differs from ~~60°F (15.6°C),~~ 60 °F (15.6 °C), correct the insulation resistance to ~~60°F~~ 60 °F by multiplying the measured value by the proper correction factor from Table 1, Temperature Correction Factors for Insulation Resistance at ~~60°F,~~ 60 °F, of Test Methods D2633.

5.4 *DC Voltage Test*—Upon completion of the insulation resistance test, test each non-shielded insulated conductor for 5 min at a dc withstand voltage which is three times the ac test voltage specified in Table 2. Unless otherwise specified, omit this test if the ac withstand voltage test described in 5.2 is performed.

5.5 *Accelerated Water Absorption*—The insulation shall meet the requirements in Table 3.

5.6 *Dielectric Strength Retention*— The insulation shall be capable of meeting a dielectric strength retention of at least 60 % of the original dielectric strength when tested at a temperature of 75 ± ~~1°C.~~ 1 °C.

## 6. Thickness of Insulation

6.1 The average thickness of the insulation shall be at least that prescribed in Table 2. The minimum thickness shall be at least 90 % of the thickness prescribed in Table 2.

**TABLE 3 Accelerated Water Absorption Requirements**

| | |
|---|---|
| ~~Electrical method 60 Hz at 75 ± 1°C:~~ | |
| Electrical method 60 Hz at 75 ± 1 °C: | |
| Permittivity after 24 h, max | 10.0 |
| Increase in capacitance, max, %: | |
| 1 to 14 days | 4.0 |
| 7 to 14 days | 2.0 |