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Standard Specification for PVC Insulating Sheeting [1]

This standard is issued under the fixed designation F 1742; 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.

ϵ^1 NOTE—Note 1 was added editorially in February 1999.

1. Scope

1.1 This specification covers acceptance testing of Poly Vinyl Chloride insulating sheeting for use as a covering for protection of workers.

1.2 The following safety hazards caveat applies only to the test method portion, Sections 17-19, of this specification: *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 149 Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies [2]

D 412 Test Methods for Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers— Tension [3]

D 570 Test Method for Water Absorption of Plastics [4]

D 747 Test Method for Apparent Bending Modulus of Plastics by Means of a Cantilever Beam [4]

D 1004 Test Method for Initial Tear Resistance of Plastic Film and Sheeting [4]

D 1048 Specification for Rubber Insulating Blankets [5]

D 1746 Test Method for Transparency of Plastic Sheeting [4]

D 2240 Test Method for Rubber Property—Durometer Hardness [3]

2.2 *American National Standard:* [6]

ANSI C84.1 Voltage Ratings for Electric Power Systems and Equipment (60 Hz)

3. Terminology

3.1 *Definitions:*

3.1.1 *voltage, maximum use*—the a-c voltage (rms) classification of the protective equipment that designates the maximum nominal design voltage of the energized system that may be safely worked. The nominal design voltage is equal to phase-to-phase voltage on multiphase circuits.

3.1.1.1 *Discussion*—If there is no multiphase exposure in a system area, and the voltage exposure is limited to phase (polarity on d-c systems) to ground potential, the phase (polarity on d-c systems) to ground potential shall be considered to be the nominal design voltage.

3.1.2 *Discusssion*—If electrical equipment and devices are insulated, or isolated, or both, such that the multiphase exposure on a grounded wye circuit is removed, then the nominal design voltage may be considered as the phase-to-ground voltage on that circuit.

3.1.3 *voltage, nominal design*—a nominal value consistent with the latest revision of ANSI C84.1, assigned to the circuit or system for the purpose of conveniently designating its voltage class.

4. Significance and Use

4.1 This specification covers the minimum electrical and physical properties guaranteed by the manufacturer and the detailed procedures by which such properties are to be determined. The purchaser may at his option perform or have performed any of these tests in order to verify the guarantee. Claims for failure to meet the specification are subject to verification by the manufacturer.

NOTE 1—This material is intended for a single use application.

4.2 The safe and proper field use of PVC sheeting is beyond the scope of this specification.

4.2.1 When authorizing use of PVC sheeting for personal protection, a margin of safety should be allowed between the maximum voltage at which it is used and the proof-test voltage at which it is tested. The relationship between proof-test and the maximum voltage at which sheeting shall be used is shown in Table 1.

5. Classification

5.1 PVC insulating sheeting covered under this specification shall be designated as Class 0 or Class 1.

5.1.1 The class designation shall be based on the electrical properties as shown in Table 2 or Table 3.

[1] This specification is under the jurisdiction of ASTM Committee F-18 on Electrical Protective Equipment for Workers and is the direct responsibility of Subcommittee F18.25 on Insulating Cover-Up Equipment.

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[2] *Annual Book of ASTM Standards*, Vol 10.01.

[3] *Annual Book of ASTM Standards*, Vol 09.01.

[4] *Annual Book of ASTM Standards*, Vol 08.01.

[5] *Annual Book of ASTM Standards*, Vol 10.03.

[6] Available from American National Standards Institute, 11 West 42nd St., 13th Floor, New York, NY 10036.

TABLE 1 Proof Test/Use Voltage Relationship

NOTE 1—The a-c voltage (rms) classification of the protective equipment designates the maximum nominal design voltage of the energized system that may be safely worked. The nominal design voltage is equal to:

(*a*) The phase to phase on multiphase circuits, or

(*b*) The phase to ground voltage on single phase grounded circuits.

Class of Insulating Sheeting	Maximum Use Voltage [A] Phase-Phase a-c rms, max	A-C Proof-Test Voltage, rms V	D-C Proof-Test Voltage, avg V
0	1000	5000	8500
1	7500	10 000	17 000

[A] Except for class 0 equipment, the maximum AC use voltage is based on the following formula: Maximum use voltage (maximum nominal design voltage) = 0.95 a-c proof-test voltage-2000.

TABLE 2 A-C Voltage Requirements

Class	Electrode Clearances Min [A]		Proof Test Voltage rms V	Dielectric Breakdown Test Voltage rms V
	mm	in.		
0	76	3	5000	10 000
1	76	3	10 000	20 000

[A] These nominal clearances are intended to avoid flashover and may be increased from the standard of 100 kPa (1 atm) barometric pressure and average humidity by no more than 51 mm (2 in.) when required by change in atmospheric conditions. These clearances may be decreased if atmospheric conditions permit.

TABLE 3 D-C Voltage Requirements

Class	Electrode Clearances Min [A]		Proof Test Voltage avg V	Dielectric Breakdown Test Voltage avg V
	mm	in.		
0	76	3	8500	17 000
1	76	3	17 000	44 000

[A] These nominal clearances are intended to avoid flashover and may be increased from the standard of 100 kPa (1 atm) barometric pressure and average humidity by no more than 51 mm (2 in.) when required by change in atmospheric conditions. These clearances may be decreased if atmospheric conditions permit.

6. Ordering Information

6.1 Orders for PVC insulating sheeting under this specification should include the following information:

6.1.1 Class,

6.1.2 Thickness,

6.1.3 Width, and

6.1.4 Length.

7. Manufacture and Marking

7.1 The insulating sheet shall consist of a clear PVC compound with a smooth, polished finish on each surface.

7.2 Each piece of sheeting shall be marked clearly and permanently at a maximum interval of 1 m (3 ft) with the name of the manufacture or supplier, ASTM D and class.

8. Physical Requirements

8.1 Insulating sheeting shall conform to the physical requirements in Table 4.

8.2 PVC insulating sheeting should remain flexible for use through normal temperature ranges.

8.3 PVC insulating sheeting is clear but may be tinted to aid in visual identification.

9. Electrical Requirements

9.1 The entire length of each roll of sheeting when new (unused) shall withstand the 60-Hz a-c proof-test voltage (rms value) specified in Table 2 or the d-c proof-test voltage (avg value) specified in Table 3. The test voltage shall be applied continuously for 1 min.

9.2 The sheeting material when tested between 51-mm (2-in.) disk electrodes with edges rounded to a radius of 6 mm (0.25 in.), shall show a 60-Hz dielectric strength of not less than the requirements shown in Table 2 or Table 3 for the thickness of each individual specimen.

TABLE 4 Physical Requirements

Tensile strength, min, MPa (psi)	2600
Elongation, min, %	300
Moisture absorption, max increase, [A] %	0.30
Hardness, max shore A	90
Specular transmission, [B] min, %	75
Tear resistance, min, lbf/in.	575
Stiffness, max, psi	25 000
20°F	
−7°C	
Puncture resistance, min, lbf/in.	900

[A] Distilled water − 23°C (75°F).

[B] 550 nm.

10. Dimensions and Permissible Variations

10.1 *Width*—Standard widths shall be 1220 ± 25 mm (48 ± 1 in.). Other widths may be negotiated with the manufacturer.Table 4

10.2 *Thickness*—The thickness of the sheeting shall be as specified in Table 5.

11. Workmanship and Finish

11.1 The sheeting shall be smooth and uniform and free of harmful physical irregularities, which can be detected by a thorough test or inspection.

11.1.1 *Nonharmful Irregularities*—Flow marks may be present on all PVC sheeting due to inherent difficulties in the manufacturing process. These irregularities may appear as waves in the sheeting which are acceptable provided that the sheeting thickness at any irregularity conforms to the thickness requirements of Table 5.

12. Guarantee

12.1 The manufacturer or supplier shall replace, without charge to the purchaser, unused sheeting which at any time within a period of nine months from date of initial delivery of shipment to the purchaser or his designee, fail to pass the tests in this specification. This guarantee will be binding on the manufacturer or supplier only if the sheeting has been properly stored and has not been subjected to more than an original acceptance test and one retest.

12.2 Any acceptance test made by the purchaser or the purchaser's designee, shall be performed within the first two months of the guarantee period unless otherwise specified.

TABLE 5 Thickness Measurements

Class	Thickness		Tolerance	
	mm	in.	mm	in.
0	1.02	0.040	0.12	±0.005
1	1.02	0.040	0.12	±0.005

NOTE 2—Proper storage means that the sheeting is stored without distortion and not stored directly above or in proximity to steam pipes, radiators, or other sources of artificial heat, or exposed to direct sunlight. It is desirable that the ambient storage temperature shall not exceed 65°C (150°F).

13. Sampling

13.1 Each roll of sheeting in a lot or shipment shall be subject to inspection and test by the manufacturer including electrical proof test to levels required in Table 2 or Table 3 of this specification.

13.2 An original sample of sufficient material shall be cut from the end of a roll or rolls selected from the lot for the test requirements of Sections 9and 8. A lot is defined as that quantity of material produced by a common manufacturing process during a consecutive time period not to exceed 24 h. If failure occurs in the first sample, a second sample of the same quantity shall be selected and tested.

14. Rejection

14.1 Individual rolls shall be rejected if they fail to meet the manufacturing and marking requirements of Section 7, the electrical requirements of 7, the width requirements of 10.1, the minimum thickness requirements of 10.2, or the workmanship requirements of Section 11.

14.2 The entire lot or shipment of sheeting shall be rejected under any of the following conditions:

14.2.1 If 5 % or more, but not less than two rolls of the sheeting in a shipment fail to meet the requirements of 9.1.

14.2.2 If two dielectric breakdowns that do not meet the dielectric strength value specified in 9.2 occur in five tests on the specimen.

14.2.3 If one dielectric breakdown of five tests on the original and one or more dielectric breakdowns of five tests on an additional specimen fail to meet the dielectric strength value specified in 9.2.

14.3 The testing shall be terminated and the manufacturer or supplier notified if, during the course of testing, 5 % or more, but not less than two rolls, of the sheeting in a lot or shipment, fail to meet the requirements of 9.1 or 9.2 as determined by the rejection criteria of 14.1, 14.2, 14.2.1, 14.2.2 or 14.2.3. The manufacturer or supplier may in such a case require the purchaser to submit proof that the test procedure and equipment conform to the appropriate paragraphs of Section 18. When such proof has been furnished, the manufacturer or supplier may request that his representative witness the testing of additional rolls from the shipment.

14.4 The entire lot or shipment of sheeting may be rejected at the option of the purchaser if two of the five specimens tested fail any of the separate requirements outlined in Section 8.

14.5 The entire lot or shipment of sheeting may be rejected at the option of the purchaser if 25 % of the sheeting in the lot or shipment fail to meet the requirements of Section 10 or 11.

14.6 All rejected material shall be returned unaltered except as required for sampling, as directed by the manufacturer at his or the supplier's request. Those sheets punctured when tested in accordance with 9.1 or 9.2, however, shall be stamped, punched, or cut prior to being returned to the supplier to indicate that they are unfit for electrical use.

15. Packaging

15.1 Sheeting shall be packaged in rolls and shall not be distorted mechanically.

16. Thickness Measurements

16.1 Thickness measurements should be made on complete sheeting samples with a caliper graduated to within 0.03 mm (0.001 in.). At least five thickness measurements shall be made at selected points uniformly distributed over the test area of the sheeting.

TEST METHODS

17. Sequence of Testing

17.1 The following order of procedure is suggested for testing PVC insulating sheeting.

17.1.1 Inspection of the surfaces in accordance with Section 11.

17.1.2 The dimensions in accordance with Sections 10 and 16.

17.1.3 Electrical proof test in accordance with the appropriate paragraphs of Section 18.

17.1.4 Breakdown voltage test in accordance with the appropriate paragraphs of Section 18.

17.1.5 Physical property tests in accordance with 19.

18. Electrical Tests

18.1 *Conditioning*—Prior to testing, the sheeting shall be placed in a flat position.

NOTE 3—**Precaution:** It is recommended that the test apparatus be designed to afford the operator full protection in the performance of his duties. Reliable means of deenergizing and grounding the high-voltage circuit should be provided.

18.2 *A-C Proof Test*:

18.2.1 *Electrodes*—Where electrodes are to be employed as part of the test apparatus, they shall be of such design so as to apply the electrical stress uniformly over the test area without producing mechanical strain in the material. The electrodes used in proof tests shall be of such dimensions that the flashover clearances specified in Table 2 are not exceeded. A satisfactory procedure for a-c proof testing utilizes electrodes that will provide intimate contact without undue pressure.

NOTE 4—Rectangular metal sheets approximately 3-mm (0.06-in.) thick, having smoothly rounded edges and corners, have been found to be satisfactory for this purpose. Also satisfactory are wet felt or sponge-top electrodes. Test platens made from grade 316L stainless steel 100 mesh screen material is also acceptable.

18.2.2 *Voltage Supply and Regulation*:

18.2.2.1 The test equipment used in both the proof-test voltage and dielectric breakdown voltage tests shall be capable of supplying an essentially stepless and continuously variable voltage to the test specimen. Motor-driven regulating equipment is convenient and tends to provide uniform rate-of-rise to the test voltage. The test apparatus should be protected by an automatic circuit-breaking device designed to open promptly on the current produced by breakdown of a specimen under test. This circuit breaking device should be designed to protect the test equipment under any conditions of short circuit.

18.2.2.2 The desired test voltage may be obtained most readily from a step-up transformer energized from a variable low-voltage source. The transformer and its control equipment shall be of such size and design that, with the test specimen in the circuit, the crest factor (ratio of maximum to mean effective) of the test voltage shall differ by not more than 5 % from that of a sinusoidal wave over the upper half of the range of test voltage.

18.2.2.3 The accuracy of the voltage-measuring circuit shall be within± 2 % of full scale. The correct rms value of the actual sinusoidal voltage wave-form applied to the sheeting may be measured by one of the following methods: (*1*) a voltmeter used in conjunction with a calibrated instrument transformer connected directly across the high-voltage circuit, (*2*) a calibrated electrostatic voltmeter connected directly across the high-voltage circuit, or (*3*) an a-c meter connected in series with appropriate high-voltage type resistors directly across the high-voltage circuit.

18.2.2.4 The crest factor may be checked by the use of a peak-reading voltmeter connected directly across the high-voltage circuit. If an electrostatic voltmeter or an rms voltmeter in conjunction with an instrument potential transformer is connected across the high-voltage circuit, a standard sphere gap may be sparked over and the corresponding voltage compared with the reading of the rms voltmeter.

18.2.3 *Test*—The proof-test voltage initially shall be applied at a low value, and then gradually increased at a constant rate-of-rise of approximately 1000 V/s ac until the prescribed test voltage level is reached or failure occurs. The test period starts at the instant that the prescribed testing voltage is reached. Reduce the applied voltage to at least half value, unless an electrical puncture has already occurred, at the end of the test period before opening the test circuit.

18.2.4 *Dielectric Breakdown Test*—The dielectric breakdown test shall be performed in accordance with Test Methods D 149. The voltage should be applied at the rate of 1000 V/s under the short-time procedure. The specimen shall be representative of the sheeting material to be tested. Sufficient material shall be available to permit making five tests.

18.3 *D-C Proof Test*:

18.3.1 *Electrodes*—The d-c proof test may be made with dry electrodes that consist of two flat metallic plates, at least one of which is sized so that the electrode clearances recommended in Table 4 are not exceeded. The edges of these plates should be rounded so as to eliminate sharp nicks and protuberances.

18.3.2 *Voltage Supply and Regulation*:

18.3.2.1 Obtain the d-c proof-test voltage from a d-c source capable of supplying the required voltage. The peak-to-peak a-c ripple component of the d-c proof-test voltage shall not exceed 2 % of the average voltage value under no-load conditions.

18.3.2.2 Measure the d-c proof-test voltage by a method that provides the average value of the voltage applied to the specimen. It is recommended that this voltage be measured by the use of a d-c meter connected in series with appropriate high-voltage type resistors across the high-voltage circuit. An electrostatic voltmeter of proper range may be used in place of the d-c meter-resistor combination. The accuracy of the voltage-measuring circuit shall be within ±22 % of full scale.

18.3.3 *Procedure*—The procedure shall be the same as the a-c proof test, except that the rate-of-rise shall be approximately 3000 V/s dc.

18.3.4 Perform the dielectric breakdown test in accordance with Test Methods D 149. Apply the voltage at the rate of 3000 V/s under the short-time procedure. The specimen shall be representative of the PVC Material to be tested. Sufficient material shall be available to permit making five tests.

19. Physical Tests

19.1 *Physical Tests*:

19.1.1 Physical tests should be performed to determine the physical requirements specified in Section 8. The sheeting samples should be conditioned by storing in a flat position for 24 h at room temperature.

19.1.2 The tensile strength and elongation tests shall be performed in accordance with Test Method D 412. The tensile strength and elongation specimens shall conform in dimensions to Die C. The elongation in the tensile set shall be as specified in Table 4.

19.1.3 The moisture absorption test shall be performed in accordance with Test Method D 570, using the 24 h immersion procedure at a temperature of 23°C (75°F).

19.1.4 The shore hardness A test shall be performed in accordance with Test Method D 2240.

19.1.5 The specular transmission test shall be performed in accordance with Test Method D 1746.

19.1.6 The stiffness test shall be performed in accordance with Test Method D 747.

19.1.7 The tear resistance test shall be performed in accordance with Test Method D 1004.

19.1.8 The puncture resistance test shall be performed in accordance with Specification D 1048.