JOINT CANADA-UNITED STATES
NATIONAL STANDARD

ANSI/CAN/UL 510:2024

STANDARD FOR SAFETY

Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape

Approved American National Standard

ANSI/UL 510-2024

SCC FOREWORD

National Standard of Canada

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SCC is a Crown corporation within the portfolio of Innovation, Science and Economic Development (ISED) Canada. With the goal of enhancing Canada's economic competitiveness and social well-being, SCC leads and facilitates the development and use of national and international standards. SCC also coordinates Canadian participation in standards development, and identifies strategies to advance Canadian standardization efforts.

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UL Standard for Safety for Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape, ANSI/CAN/UL 510

Tenth Edition, Dated April 17, 2020

Summary of Topics

This revision of ANSI/CAN/UL 510 dated February 28, 2024 includes Clarification to result recording – Dielectric; 9.3, 22.7, and 23.3.

Text that has been changed in any manner or impacted by ULSE's electronic publishing system is marked with a vertical line in the margin.

The new and revised requirements are substantially in accordance with Proposal(s) on this subject dated July 28, 2023 and October 10, 2023.

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APRIL 17, 2020
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ANSI/CAN/UL 510:2024

Standard for Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape

The first, second, third, fourth, fifth, and sixth editions were titled Electrical Insulating Tape.

Fourth Edition – August, 1976
Fifth Edition – January, 1982
Sixth Edition – October, 1986
Seventh Edition – June, 1994
Eighth Edition – February, 2005
Ninth Edition – May, 2017

Tenth Edition

April 17, 2020

This ANSI/CAN/UL Safety Standard consists of the Tenth Edition including revisions through February 28, 2024.

The most recent designation of ANSI/UL 510 as an American National Standard (ANSI) occurred on February 28, 2024. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, Title Page, Preface or SCC Foreword.

The Department of Defense (DoD) has adopted UL 510 on October 10, 1979. The publication of revised pages or a new edition of this Standard will not invalidate the DoD adoption.

This standard has been designated as a National Standard of Canada (NSC) on February 28, 2024.

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Preface

This is the Tenth Edition of ANSI/CAN/UL 510 Standard for Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape.

ULSE is accredited by the American National Standards Institute (ANSI) and the Standards Council of Canada (SCC) as a Standards Development Organization (SDO).

This Standard has been developed in compliance with the requirements of ANSI and SCC for accreditation of a Standards Development Organization.

This ANSI/CAN/UL 510 Standard is under continuous maintenance, whereby each revision is approved in compliance with the requirements of ANSI and SCC for accreditation of a Standards Development Organization. In the event that no revisions are issued for a period of four years from the date of publication, action to revise, reaffirm, or withdraw the standard shall be initiated.

In Canada, there are two official languages, English and French. All safety warnings must be in French and English. Attention is drawn to the possibility that some Canadian authorities may require additional markings and/or installation instructions to be in both official languages.

Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at http://csds.ul.com.

This Edition of the Standard has been formally approved by the Technical Committee (TC) on Insulating Tape, TC 510.

This list represents the TC 510 membership when the final text in this standard was balloted. Since that time, changes in the membership may have occurred.

TC 510 Membership

Name	Representing	Interest Category	Region
Barile, Alessandro	H-OLD S P A	Producer	Italy
Clevenger, Jason	Exponent, Inc.	General	USA
Colapietro, Nicholas	UL Solutions	Testing & Standards	USA
Deagazio, Mario	3M Canada Company	Producer	Canada
Ensign, Steve	Ensign Corp	Commercial / Industrial User	USA
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Jordan, Diana P.	UL Standards & Engagement	TC Chair – Non-voting	USA
Monsen, Megan	UL Standards & Engagement	TC Project Manager – Non-voting	USA
Murray, Nickolas	Consumer Association of Canada	Consumer	Canada

TC 510 Membership Continued on Next Page

TC 510 Membership Continued

Name	Representing	Interest Category	Region
Nelson, Gordon.	Florida Institute Of Technology College Of Science & Liberal Arts	General	USA
Savage, Michael	Marion County, Fl.	AHJ/Regulator	USA
Yung, Chuck	Electrical Apparatus Service Association	General	USA

International Classification for Standards (ICS): 29.035.20

This Standard is intended to be used for conformity assessment.

The intended primary application of this standard is stated in its scope. It is important to note that it remains the responsibility of the user of the standard to judge its suitability for this particular application.

CETTE NORME NATIONALE DU CANADA EST DISPONIBLE EN VERSIONS FRANÇAISE ET ANGLAISE

INTRODUCTION

1 Scope

1.1 In the US, this standard covers the following:

a) Thermoplastic and rubber tapes for use as electrical insulation at not more than 600 V and at 80 °C (176 °F) and lower temperatures on joints and splices in wires and cables in accordance with NFPA 70. It is intended that rubber tape on a joint or splice be mechanically protected by a covering such as friction, PE (thermoplastic polyethylene), or PVC (polyvinyl chloride or a copolymer of vinyl chloride and vinyl acetate)tape. Thermoplastic tape is acceptable without the additional mechanical protection.

b) The characteristic constituent of the thermoplastic tape covered in this Standard is either PVC (polyvinyl chloride or a copolymer of vinyl chloride and vinyl acetate), or PE (thermoplastic polyethylene).

1.2 In Canada, this standard covers the following:

a) Thermoplastic and rubber tapes for use as electrical insulation at not more than 600 V and 80 °C (176 °F) and lower temperatures on joints and splices in wire and cables in accordance with the CSA C22.1. It is intended that rubber tape on a joint or splice be mechanically protected by a covering such as friction, PE (thermoplastic polyethylene), or PVC (polyvinyl chloride or a copolymer of vinyl chloride and vinyl acetate) tape. Thermoplastic tape is acceptable without the additional mechanical protection.

b) The characteristic constituent of the thermoplastic tape covered in this Standard is PE (thermoplastic polyethylene). Requirements for PVC tape are covered by CSA C22.2 No. 197.

2 Units of Measurement

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

3 Referenced Publications

3.1 Any undated reference appearing in the requirements of this standard shall be interpreted as referring to the latest edition of the reference, including all revisions and amendments.

3.2 The following standards are referenced in this standard, and portions of these referenced standards may be essential for compliance.

American Society for Testing and Materials (ASTM) Standards

ASTM D297, *Standard Test Methods for Rubber Products – Chemical Analysis*

ASTM D412, *Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers – Tension*

ASTM D1000, *Standard Test Methods for Pressure-Sensitive Adhesive-Coated Tapes Used for Electrical and Electronic Applications*

ASTM D4325, *Standard Test Method for Nonmetallic Semi-Conducting and Electrically Insulating Rubber Tapes*

ASTM D5025, *Standard Specification for Laboratory Burner Used for Small-Scale Burning Tests on Plastic Materials*

ASTM D5207, *Standard Practice for Calibration of 20 mm (50 W) and 125 mm (500 W) Test Flames for Small-Scale Burning Tests on Plastic Materials*

ASTM D5374, *Standard Test Methods for Forced-Convection Laboratory Ovens for Evaluation of Electrical Insulation*

ASTM D5423, *Standard Specification for Forced-Convection Laboratory Ovens for Evaluation of Electrical Insulation*

ASTM G151, *Standard Practice for Exposing Nonmetallic Materials in Accelerated Test Devices That Use Laboratory Light Sources*

ASTM G155, *Standard Practice for Operating Xenon-Arc Light Apparatus for Exposure of Nonmetallic Materials*

CSA Group Standards

CSA C22.1, *Canadian Electrical Code, Part I Safety Standard for Electrical Installations*

CSA C22.2 No. 197, *PVC Insulating Tape*

National Fire Protection Association (NFPA) Codes and Standards

NFPA 70, *National Electrical Code*

UL Standards

UL 746A, *Polymeric Materials – Short Term Property Evaluations*

ALL TAPES

4 General

4.1 The requirements in Sections 4 – 6 and 23 apply to all of the tapes covered in this Standard and are supplemented by requirements in Sections 7 – 16 covering thermoplastic tape and in Sections 17 – 22 covering rubber tape.

4.2 Unless otherwise specified, lengths of 25 mm (1 inch) wide tape for use as specimens in any of the tests specified in this standard are to be taken from sample rolls of finished tape fitted snugly onto a horizontal rod or tube that is free to turn in its supports without wobbling or other extraneous motion whenever the tape is unrolled. The tape is to be in thermal equilibrium with the surrounding air at a temperature of 23.0 ±5.0 °C (73.4 ±9 °F) whenever being unrolled. The tape is always to be unrolled at an even rate of approximately 50 mm/second (2 inches/second). The first three layers of tape are to be discarded. Each length of tape intended as a specimen or from which a specimen is prepared is to be protected from dust and direct handling of the adhesive side and is to be placed adhesive side up on a smooth, clean surface or is to be suspended in air under the conditions specified in 4.3 after removal from a roll and before being used in a test.

Exception: Lengths of tape for use as adhesion test specimens are to be placed adhesive side up on a smooth, clean surface or are to be suspended in air for a minimum time corresponding to the conditions specified in 10.1.

4.3 Unless otherwise specified, all testing, except flammability, shall be conducted at 23 ±5 °C (73 ±9 °F) and a relative humidity of 50 ±10 %. Flammability testing shall be conducted in still air at a temperature of 15 – 35 °C (59 – 95 °F) and a relative humidity of < 75 %. All samples shall be preconditioned at 23 ±5 °C (73 ±9 °F) and a relative humidity of 50 ±10 % for a minimum of 30 minutes prior to test, or referred to as the As-Received condition.

4.4 Unless otherwise indicated for a specific test, testing of each construction in the unpigmented (natural) and heaviest pigmented loading of the darkest and lightest tapes (such as black and white) are considered to represent the range of colors for each test, if the performance characteristics are essentially the same. If the performance characteristics are not essentially the same for all specimens representing the range, acceptance shall be limited to the tape only in the colors tested, unless additional specimens in intermediate colors are provided for tests. If the tape is produced with the pigment in different layers, such as the backing, reinforcement and/or adhesive, each of those unique constructions will also require the applicable tests described within this standard. Tape constructed with a clear (transparent) overall color shall be considered a unique construction required for testing.

4.5 Each tape shall be considered a unique construction if the thickness of any individual layer varies by more than 10 %.

4.6 Unless otherwise specified in the individual test method, the average of the results for the specimens tested shall be used to determine compliance with the requirements of this standard.

4.7 Unless otherwise specified in the individual test method, tensile strength and elongation results for specimens that break at some obvious flaw or that do not break between the predetermined bench marks shall be discarded.

4.8 Another polymeric material, backing or adhesive, may be substituted in a tape having met the requirements of this standard only when the material meets the conditions in Annex B, Substitution of Materials, and compliance is determined through appropriate evaluation.

4.9 The apparatus for all the air-oven aging of specimens shall be in accordance with ASTM D5423, minimum of five air changes.

5 Flame Test

5.1 Insulating tape marked "Flame Retardant" in accordance with 23.2 shall not flame longer than 60 seconds following any of five 15 seconds applications of the test flame, the period between applications being:

a) 15 seconds if the specimen flaming ceases within 15 seconds; or

b) The duration of the specimen flaming if the specimen flaming persists longer than 15 seconds.

5.2 The tape shall not ignite combustible materials in its vicinity or damage more than 25 % of the indicator flag during, between, or after the five applications of the test flame. The test shall be conducted as described in 5.4 – 5.15.

5.3 The testing of the 19 mm (0.75 inch) specimen width is considered representative of the performance of all sizes (widths) of the tape. Sample set of three specimens shall be tested.

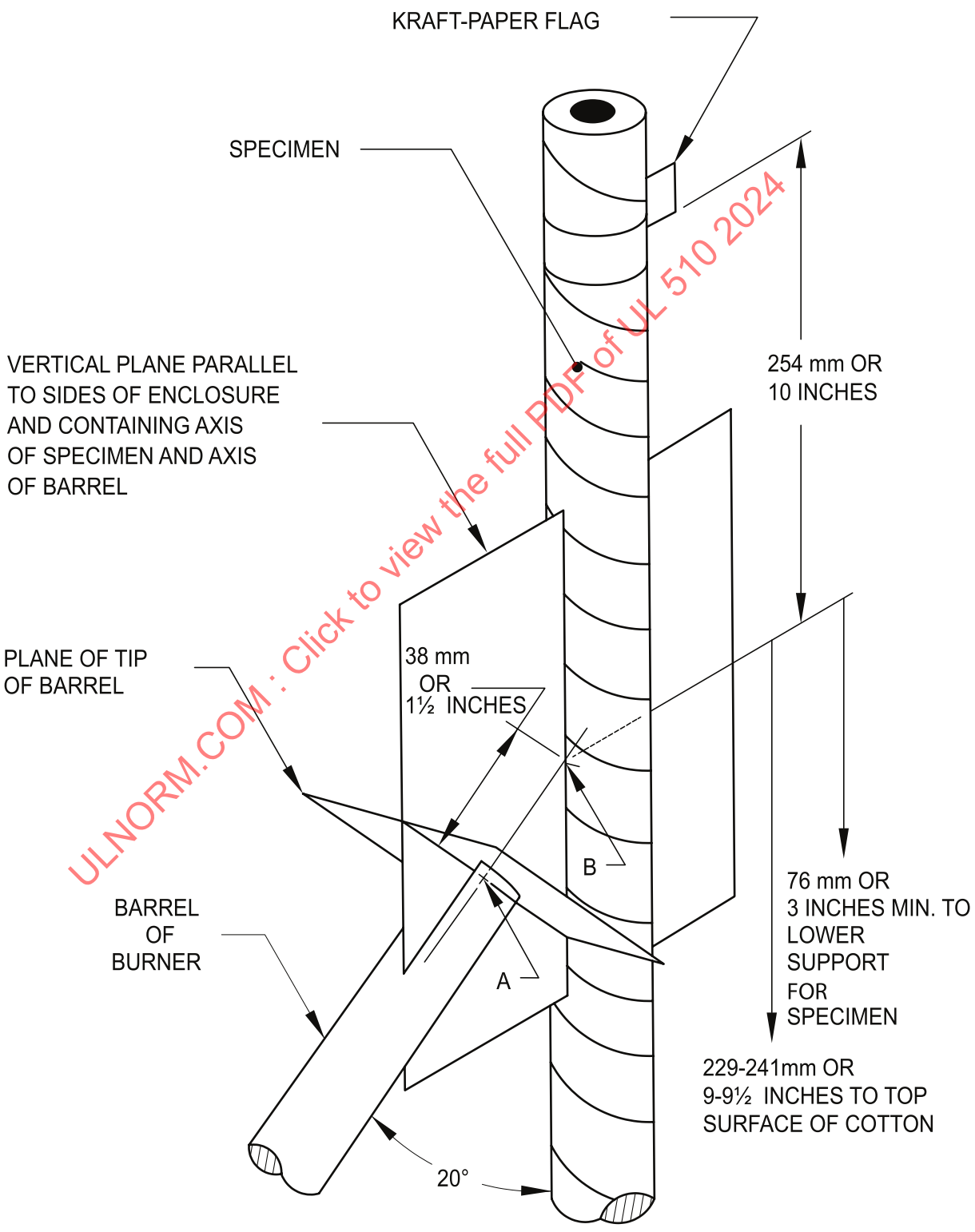
5.4 The test specimen is to be prepared as follows. A straight clean steel rod 460 mm (18 inches) long and 3.2 mm (0.125 inch) in diameter is to be supported in a winding jig. The winding jig is to support the rod at each end and have a crank for rotating the rod so that the tape can be wound thereon. The winding jig is to be attached to a rigid support in such a manner that it can be rotated, tilting the major axis of the rod to the horizontal. A 900 mm (3 feet) length of 19 mm (0.75 inch) tape is to be cut from a roll. The tape sample is to be secured, by overlapping the first turn of tape, to the rod held in a horizontal position. A weight exerting 2.0 kgf (4.4 lbf) is then to be attached to the free end of the 900 mm (3 feet) sample to provide tension. After 1 minute under tension, the rod is to be slowly rotated, and the fixture tilted so that the tape wraps with an overlap equal to one half the width of the tape. After wrapping is completed, the lower end of the tape is to be secured and the remaining length of tape is to be cut off. A second wrapping is to be similarly applied with the direction of advance of the turns of the tape reversed from that of the first wrapping. Finally, a third wrapping of tape is to be similarly applied with the direction of advance opposite to that of the second wrapping. Thus, six thicknesses of tape are to result at each point along the wrapped mandrel.

5.5 A strip of unreinforced 94 g/m^2 (60 lb) kraft paper that is 13 mm (0.5 inch) wide, approximately 0.1 mm (0.004 inch) thick, and is gummed on one side is to be used to make an indicator flag. The gumming is to be moistened but not more than necessary to facilitate adhesion. With the gum toward the specimen, the strip is to be wrapped around the specimen once with its lower edge 254 mm (10 inches) above B, the point at which the blue inner cone is to touch the specimen. The ends of the strip are to be pasted together evenly and trimmed to provide a flag that projects 19 mm (0.75 inch) from the specimen toward the rear of the enclosure with the flag parallel to the sides of the enclosure (see Figure 5.1). The lower clamp or other support for the specimen is to be adjusted vertically to keep it from being any closer than 76 mm (3 inches) to point B.

Figure 5.1

Essential dimensions for flame test

Proportions exaggerated for clarity of detail



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5.6 The test shall be conducted in a 3-sided metal enclosure positioned inside of a fume hood or cabinet. The 3-sided metal enclosure is to be 305 mm (12 inches) wide, 355 mm (14 inches) deep, 610 mm (24 inches) high, and the top and front are to be open. The test specimen detailed in 5.4 is to be secured with its longitudinal axis vertical in the center of the enclosure. A flat horizontal layer of absorbent 100 % cotton 6 to 25 mm (0.25 to 1 inch) thick is to cover the floor of the enclosure. The upper surface of the cotton is to be 229 to 241 mm (9 to 9.5 inches) below point B, which is the point at which the tip of the blue inner cone of the test flame touches the specimen. This is shown in Figure 5.1.

5.7 The fume hood or cabinet is to be a draft-free chamber having an air-tight, windowed sash, door, or other means for access and viewing. Each linear interior dimension of the chamber is to be at least 610 mm (24 inches). The actual dimensions are to result in an interior volume of the chamber of at least 4 m^3 (140 $feet^3$), including the volume of the exhaust transition. The size of the exhaust transition, if any, is not specified. At least 2 m^3 (70 $feet^3$) of this volume is to be above the area of the gas and specimen flames as space for the heat and smoke to accumulate and not influence the flames. The chamber volume at or below the level of the flames is not to contain obstructions to the natural flow of chamber air supplying oxygen to the flames.

5.8 The chamber is to have an air-tight glove box for arm-and-hand access to the apparatus or other means for adjusting the apparatus while the access is completely closed. The interior of the chamber is to be visible without obstruction while the access is closed. The chamber is to be fitted with an exhaust blower for pulling smoke and fumes out of the test area after the test. A tight-sealing damper is to be located between the chamber and the blower to prevent drafts while the blower is not operating. The exhaust blower is not to be operated during the test or during calibration. Immediately after each calibration and each test, the damper is to be opened and the blower is to be operated to purge the chamber of all smoke and fumes.

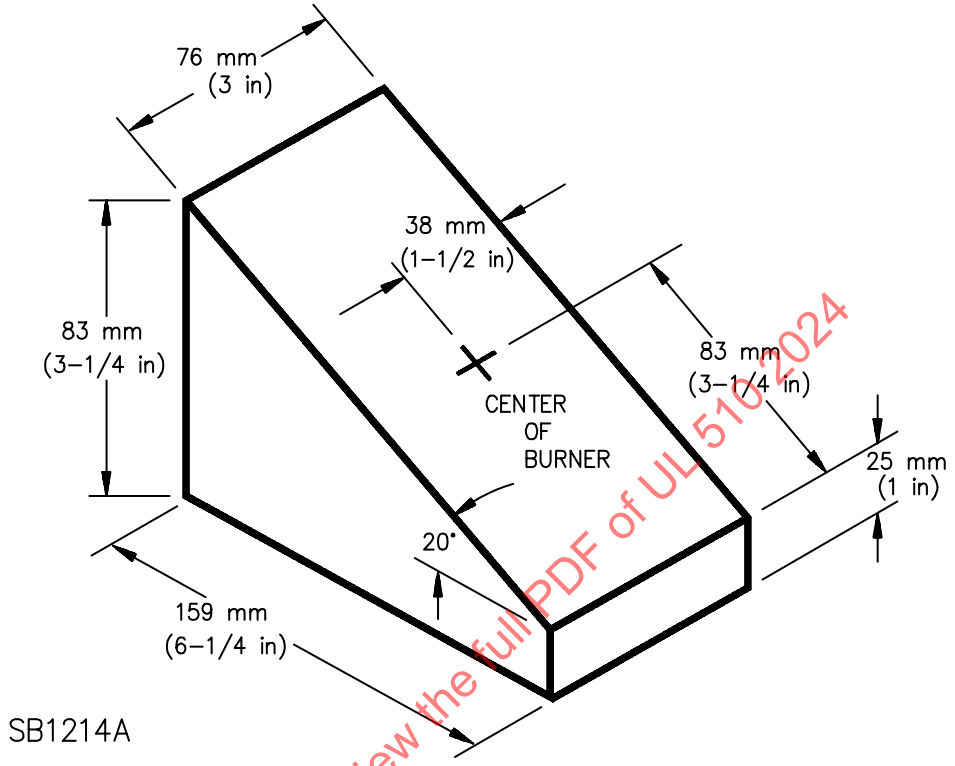
5.9 The flame test is to be conducted with a laboratory type burner having a tube with a length of 100 ±10 mm (3.9 ±0.39 inches) and an inside diameter of 9.5 ±0.3 mm (0.7 ±0.01 inches). The barrel is not to be equipped with an end attachment, such as a stabilizer. The burner shall be in compliance with ASTM D5025. The use of technical grade methane gas (minimum 98 % pure) with regulator and meter for uniform gas flow is to be used.

Note: Natural gas having a heat content of approximately 37 ±1 MJ/m^3 at 25 °C (77 °F) has been found to provide similar results. However, technical grade methane shall be used in case of dispute.

5.10 A wedge (acceptable dimensions are shown in Figure 5.2), to which the base of the burner can be secured, is to be provided for tilting the barrel 20° from the vertical while the longitudinal axis of the barrel remains in a vertical plane. The burner is to be secured to the wedge and the assembly is to be placed on an adjustable support jig. A layer of absorbent 100 % cotton 6 to 25 mm (0.25 to 1 inch) thick is to be placed on the wedge and around the base of the burner. The jig is to be adjusted toward one side or the other of the enclosure to place the longitudinal axis of the barrel in the vertical plane that contains the longitudinal axis of the specimen. The plane is to be parallel to the sides of the enclosure. The jig is also to be adjusted toward the rear or front of the enclosure to position the point A, (the intersection of the longitudinal axis of the barrel with the plane of the tip of the barrel) 38 mm (1.5 inches) from the point B at which the extended longitudinal axis of the barrel meets the outer surface of the specimen. Point B is the point at which the tip of the blue inner cone touches the center of the front of the specimen.

Figure 5.2

Acceptable dimensions of wedge in inches (millimeters)



5.11 The support for the burner and wedge is to be arranged to enable the burner to be quickly removed from and precisely returned to the position described in 5.5 without disturbing the layer of cotton on the floor of the enclosure or the cotton on the wedge and around the base of the burner.

5.12 Place the burner remote from the specimen, ignite, and adjust the gas flow. With the burner in a vertical position, adjust the overall height of the flame to approximately 125 mm (5 inches) and the height of the inner blue cone approximately 40 mm (1.5 inches).

5.13 The test flame shall be calibrated in accordance with the 125 mm (500 W) method in ASTM D5207 at least once a month and when the gas supply is changed, test equipment is replaced, or when data is questioned.

5.14 The burner is to be moved into position to the flame applied to the specimen for 15 seconds, and then removed for 15 seconds or longer if the flaming persists beyond the 15 seconds. If flaming persists for more than 15 seconds, the flame is reapplied as soon as the specimen ceases to flame. The procedure is repeated for a total of 5 applications of the flame.

5.15 The tape shall not be acceptable if the specimens show any of the following observations after any of the five applications of flame:

a) More than 25 % of the indicator flag is burned away or charred (soot that can be removed with a cloth or the fingers and brown scorching shall be ignored); or

b) Emits flaming or glowing particles or flaming drops at any time that ignite the cotton on the burner, wedge, or floor of the enclosure (flameless charring of the cotton shall be ignored); or

c) Continues to flame longer than 60 seconds after any application of the gas flame.

6 Sunlight Resistance Test

6.1 Insulating tape marked "Sunlight Resistant" in accordance with 23.2 shall retain at least 80 % of its as-received average tensile strength and elongation after 720 hours of UV exposure.

6.2 A set of tape specimens (at least five specimens) is to be vertically mounted in the specimen drum of the artificial weathering apparatus described in 6.3. After a total of 720 hours of exposure, the specimens are to be removed from the drum, 50 mm (2 inches) benchmarks are to be added to each specimen, and tested for tensile strength and elongation using the methods described in Section 8 for Thermoplastic tape and Section 20 for Rubber tape.

6.3 The specimens shall be exposed to ultraviolet light from a Xenon-arc lamp in accordance with ASTM G151 and ASTM G155. The spectral power distribution of the xenon-arc lamp shall conform to the requirement in Table 1 in ASTM G155 for a xenonarc lamp with daylight filters. A programmed cycle of 120 minutes consisting of a 102 minute light exposure and an 18-minute exposure to water spray with light shall be used. The apparatus shall operate with a spectral irradiance of 0.35 W/m^2 at 340 nm (0.00034 mm) and a black-panel temperature of 63 ±3 °C (145.4 ±5.4 °F).

THERMOPLASTIC TAPE

7 Thickness

7.1 The average thickness of a thermoplastic tape (backing plus adhesive) shall be at least 0.15 mm (0.006 inch).

7.2 Sample sets of five specimens shall be tested after being conditioned as described in Section 4. The average thicknesses shall be measured at different points on the tape or tape layer and the smallest of these shall be taken as the minimum thickness of the tape.

7.3 The average thickness of the tape shall be determined by means of a dead-weight dial micrometer having a presser foot 6.4 ±0.2 mm (0.25 ±0.010 inch) in diameter and weight of 1.67 ±0.02 N (6.0 ±0.1 oz-f), exerting a total pressure of 50 ±5 kPa (7.25 ±0.725 psi) on the specimens, the load being applied by means of a weight.

8 Physical Properties Tests

8.1 The tensile strength and elongation for thermoplastic tape constructions shall be evaluated in accordance with the Breaking Strength and Elongation method in ASTM D1000, as modified with benchmarks that are 50 mm (2 inches) apart on the specimen. Measurement of elongation is to be made with reference to the center of each mark, which is, halfway between the edges.

8.2 Single layer specimens of finished tape (backing plus adhesive) shall be used. Sample sets of five specimens shall be tested after being conditioned as described in Section 4.

8.3 The minimum average tensile strength and elongation values are shown in Table 8.1. The maximum load is to be noted from the dial or scale and recorded together with the original width and thickness of the specimen for use in calculating the tensile strength.

Table 8.1
Physical properties of thermoplastic tape

Condition of specimens at time of measurement	Minimum elongation		Minimum tensile strength	
	PVC tape	PE tape	PVC tape	PE tape
23 ±5 °C (73 ±9 °F) and 50 ±10 % RH	100 %	60 %	13.8 MN/m^2 (2000 lbf/in^2) (1379 N/cm^2) (1.41 kgf/mm^2)	10.3 MN/m^2 (1500 lbf/in^2) (1030 N/cm^2) (1.05 kgf/mm^2)

9 Dielectric Breakdown Test

9.1 The dielectric breakdown for thermoplastic tape constructions shall be evaluated in accordance with the Dielectric Breakdown Voltage short time method described in ASTM D1000.

9.2 Single layer specimens of finished tape (backing plus adhesive) shall be used. Sample sets of five specimens shall be tested after being conditioned as described in Section 4.

9.3 The maximum voltage is to be noted and recorded together with the original measured thickness of the specimen for use in calculating the dielectric strength. The average dielectric strength value shall be at least 39.37 kV/mm (1000 V/mil) of the tape thickness (backing plus adhesive).

10 Adhesion Strength Test

10.1 The adhesion strength for thermoplastic tape constructions shall be evaluated in accordance with the Adhesion Strength to Steel and Backing method described in ASTM D1000.

10.2 Single layer specimens of finished tape (backing plus adhesive) shall be used. Sample sets of three specimens shall be tested after being conditioned as described in Section 4.

10.3 The average adhesion strength shall be at least 0.175 N/mm (16 oz-f/in or 1 lb/in) when applied to the following surfaces:

a) Tape applied to steel; and

b) Tape applied to tape backing.

11 Moisture Absorption Test

11.1 The moisture absorption of thermoplastic tape shall be evaluated in accordance with 9.1.

11.2 Single layer specimens of finished tape (backing plus adhesive) shall be used. Sample sets of five specimens, taken from at least two rolls, shall be tested after being conditioned for 96 hours in air at 23.0 ±1.0 °C (73.4 ±1.8 °F) and 96 ±2 % relative humidity. Conditioned specimens are to be removed from the humidity chamber one at a time. The specimen is to be quickly placed between layers of dry cotton toweling, which is to be pressed gently over its entire surface and tested immediately thereafter. This shall be repeated for each of the five specimens per set, one at a time, to minimize misleading results because of further drying of the sample.

11.3 The average dielectric strength shall be at least 90 % of its unconditioned average dielectric strength after conditioning.

12 Exposure to Heat Test

12.1 Thermoplastic tape shall not be acceptable if the specimens show any of the following after conditioning and 24 hours after flexing:

a) Cracking when flexed, or otherwise be adversely affected; or

b) Conductor shows any corrosive or adverse effects from the tape after removal; or

c) Flagging greater than 2 mm (0.079 inch) (which is lifting of the terminating end of the wrapping).

12.2 Single layer specimens of finished tape (backing plus adhesive) shall be used. Sample set of four specimens shall be conditioned in a full-draft circulating-air oven for the applicable backing materials:

a) PVC backing material – 113.0 ±2.5 °C (235.4 ±4.5 °F) for seven days; or

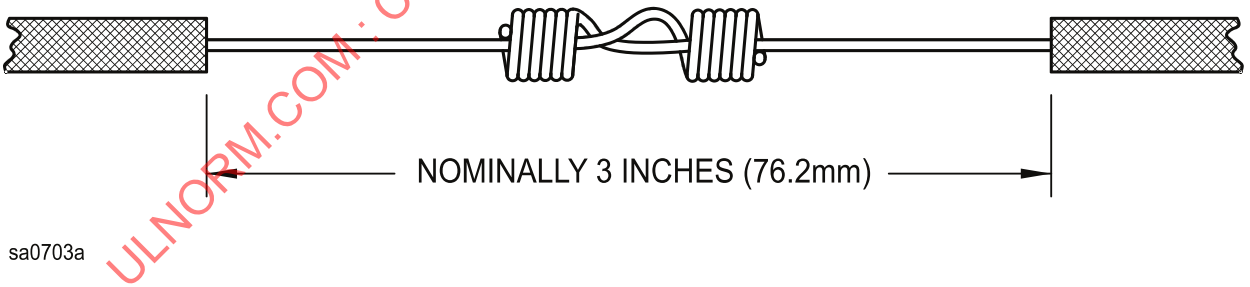
b) PE backing material – 87.0 ±2 °C (188.6 ±3.6 °F) for 60 days.

12.3 To determine whether a tape complies with 12.1, four tape-insulated splices made with Type T, TW, THW, THWN, THHN, RH, RHW, RHH, or XHHW wire as described in 12.4 are to be wrapped with the tape as indicated in 12.5 and conditioned, flexed, and examined as indicated in 12.6 and 12.7. The solid uncoated copper conductor shall have a diameter of 2.05 mm (12 AWG).

12.4 For each splice, two 300 mm (12 inches) lengths of insulated conductor are to be used, and a 50 mm (2 inches) length of insulation is to be stripped from one end of each conductor. The two bared conductors are to be connected together by means of an inline (Western Union) splice (see Figure 12.1). The spliced ends of the conductor are to be crimped with pliers to remove sharp projections.

Figure 12.1

Western union splice



12.5 While supporting a weight that exerts 11.1 N (1.13 kgf or 2.5 lbf), a strip of tape is to be held vertically with the upper end of the tape held against the insulated wire just adjacent to the splice. Initially, the major axis of the splice is to be located approximately horizontally, and the tape is to be caused to wrap around the wire and splice by rotating the splice around its major axis. The major axis of the splice is then to be tilted from the horizontal so that each turn of the tape overlaps the preceding turn by half of the width of the tape. After the bared conductors and approximately one tape width of the wire insulation have been completely wrapped in this manner, a second wrapping is to be similarly applied, with the direction of

advance of the turns of the tape reversed from that of the first wrapping. Finally, a third wrapping of tape is to be similarly applied with the direction of advance opposite to that of the second wrapping. Thus, six thicknesses of tape are to result at each point along the splice.

12.6 The insulated splices shall be placed in a full-draft circulating-air oven. After 24 hours, two of the splices are to be removed from the oven, cooled in still air at a room temperature of 23.0 ±5.0 °C (73.4 ±9 °F) for 16 to 96 hours, and subjected to flexing as described in 12.7. If the tape observes any of the items indicated in 12.1, the test shall be terminated and the seven day specimens shall be removed from the oven and discarded. If the tape does not observes any of the items under 12.1, the two remaining specimens are to stay in the oven for a total conditioning time specified in 12.2 and are then to be removed from the oven, cooled in still air at a room temperature of 23.0 ±5 °C (73.4 ±9 °F) for 16 to 96 hours, and subjected to flexing as described in 12.7.

12.7 After removal from oven conditioning, the wire splices are to be tightly wrapped around the mandrel. Each consecutive wrap around the mandrel shall be placed closely as possible to the prior wrap to provide the shortest winding distance. The flexing is to be performed by holding the wire of the assembly approximately 25 mm (1 inch) to the left of the splice firmly against a mandrel consisting of a solid steel rod with a diameter of 13 mm (0.5 inch) and is rigidly supported at one end with its longitudinal axis horizontal. The end of the assembly, which includes the splice, is then to be wrapped tightly, while contacting the prior wrap, around the mandrel in a clockwise direction until approximately 25 mm (1 inch) of the wire to the right of the splice is wrapped around the mandrel. The direction of wrap is then to be reversed and continued in the counterclockwise direction until approximately 25 mm (1 inch) of the wire to the right of the splice is wrapped around the mandrel. Five clockwise operations and five counterclockwise operations followed by a clockwise unwrap are to complete the flexing procedure. Each operation is to be conducted at a uniform rate such that the flexing procedure is completed in 15 to 25 seconds. After flexing, the tape is to be examined for cracking or other damage. In addition, upon examination, the conductor shall show no corrosion or other adverse effects from the tape after removal of the tape from the splices.

13 Exposure to Cold Test

13.1 A thermoplastic tape marked "Cold Resistant" in accordance with 23.3 shall not be acceptable if the specimens show any of the following after conditioning:

a) Cracking during the operations; or

b) Transfer of adhesive while being unwound; or

c) Inadequate adhesive strength to allow the splice to be wrapped with layers of tape that would equal the thickness of the insulation on the wire; or

d) Conductor affected adversely when examined after removal of the tape from the splices.

13.2 To determine whether a thermoplastic tape complies with the requirements in 13.1, two rolls of tape are to be conditioned at a temperature of minus 10.0 ±2.0 °C (14.0 ±3.6 °F) for two hours. While still being maintained at minus 10.0 ±2.0 °C (14.0 ±3.6 °F), a length of tape from each roll is subjected to the following:

a) Wrapped around a steel mandrel 3.2 mm (0.125 inch) in diameter for a distance of 127 mm (5 inches) using the method and apparatus referenced in 5.4. In wrapping the tape, the advance of each turn half of the tape width; and

b) Used to insulate a Western Union splice (reference 12.4) while the wire and tape are at minus 10.0 ±2.0 °C (14.0 ±3.6 °F), using a tension of 11.1 N (2.5 lbf) as described in 12.5.

14 Deformation Test

14.1 The thickness of the insulation (backing plus adhesive) on a splice covered with thermoplastic tape shall not decrease after conditioning, under pressure, as described in 14.3 – 14.5.

14.2 The tape thickness shall have a maximum decrease of:

a) PVC backing material – maximum decrease of 65 %; or

b) PE backing material – maximum decrease of 40 %.

14.3 A bare solid copper conductor with a diameter of 2.05 mm (12 AWG) is to be wrapped with successive layers of tape, with each layer of tape directly over the one below, until a thickness of tape equal to approximately 0.8 mm (0.031 inch) is in place over the conductor. The thickness of the insulation (tape) is to be measured by means of a dead-weight dial micrometer.

14.4 The apparatus for the determination of percentage deformation shall consist of:

a) A full draft air-circulating oven capable of maintaining the required air temperature specified in 4.9; and

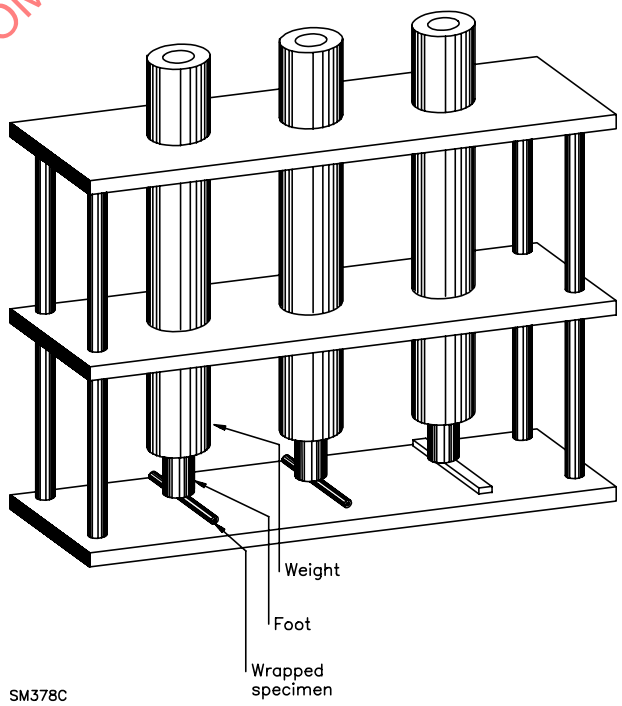
b) The necessary weights needed to exert a total force of 4.90 N (500 g-f) mounted in a metal frame so as to have free vertical movement, as illustrated in Figure 14.1. The weight shall be provided with a 9.5 ±0.2 mm (0.375 ±0.010 inch) diameter flat presser foot, slightly rounded at the edges, and intended to bear upon the specimen under test; and

c) Dial micrometer as specified in 7.3.

Figure 14.1

Weights and specimens in supporting frame for deformation test

(See 14.3 and 14.4)



14.5 The specimen is to be placed in the oven for one hour of preliminary heating at a temperature of 100.0 ±2.5 °C (212.0 ±4.5 °F) along with the weights and supporting frame:

a) At the end of one hour, the specimen is to be placed under the foot of one of the weights for an additional hour, and

b) At the end of the second hour, the sample is carefully removed from under the weight and the thickness is re-measured at the marked location within 15 seconds of removal from the oven, in the same manner as specified in 14.3. The percent decrease in the thickness of the insulation (tape) is to be calculated using the following formula.

$$D = \left[\frac{(T_1 - T_2)}{(T_1 - C)} \right] \times 100$$

In which:

D is the percent decrease in thickness;

T_1 is the overall sample diameter before aging;

T_2 is the overall sample diameter after oven aging; and

C is the conductor diameter.

15 Storage Test

15.1 A thermoplastic tape shall retain its adhesion strength after an unused roll of tape is conditioned.

15.2 An unused roll of tape is to be laid flat in a full-draft circulating-air oven operating at one of the following temperature and times:

a) 40.0 ±2 °C (104.0 ±3.6 °F) for 60 days; or

b) 65.0 ±2 °C (149.0 ±3.6 °F) for 10 days (Alternate condition, at the manufacturer's option).

15.3 Samples shall be evaluated in accordance with 10.1 and 10.2.

15.4 The tape shall comply with the adhesion strength requirements in 10.3.

16 Indirect Measurement of Conductor Corrosion Test (PVC Tape)

16.1 The insulation resistance in high humidity for PVC tape shall be evaluated in accordance with the Insulation Resistance at High Humidity method described ASTM D1000, using copper electrodes. The conditioning temperature of specimens with the copper electrodes shall be 23.0 ±5.0 °C (73.4 ±9 °F).

16.2 Single layer specimens of finished tape (backing plus adhesive) shall be used. Sample sets of five specimens shall be tested after being conditioned as described in Section 4.

16.3 The average resistance shall be at least 1.0 TΩ (1,000,000 MΩ) for a 25 mm (1 inch) width of tape.

RUBBER TAPE

17 Compound

17.1 A rubber insulating tape shall consist of a compound of unvulcanized or partially unvulcanized natural or synthetic rubber, or a blend thereof, that shall contain not more than 0.5 % of free sulphur by weight of the original compound when tested in accordance with ASTM D297.

18 Thickness

18.1 The average thickness of Rubber tape, as determined in 18.2, shall meet the following thickness measurements:

a) Rubber not derived from silicone shall be at least 0.46 mm (0.018 inch); or

b) Self-fusing silicone rubber shall be at least 0.18 mm (0.007 inch).

18.2 Sample sets of five specimens shall be tested after being conditioned as described in Section 4. The average thickness shall be measured at different points on the tape and the smallest of these shall be taken as the minimum thickness of the tape.

18.3 The average thickness of the tape shall be determined by means of a dead-weight dial micrometer having a presser foot 6.4 ±0.2 mm (0.25 ±0.010 inch) in diameter and weight of 0.84 ±0.02 N (3.0 ±0.1 oz-f), exerting a total pressure of 26.3 ±5 kPa (3.82 ±0.725 psi) on a specimen, the load being applied by means of a weight.

19 Separator

19.1 Material, position, and coverage

19.1.1 A separator of parchment paper, glazed sheeting, polyester film, or similar material shall be interposed between adjacent layers of a roll of tape and shall cover the outside of the tape.

19.2 Sticking and unraveling tendency

19.2.1 When a roll of tape is originally unwound, the separator shall not show undue tendency to stick or to unravel.

20 Physical Properties Tests

20.1 The tensile strength and elongation for rubber tape shall be evaluated in accordance with 20.2 – 20.9.

20.2 Sample sets of three specimens shall be assembled per 20.4 after being conditioned as described in Section 4.

20.3 The minimum average tensile strength and elongation values are shown Table 20.1. The maximum load is to be noted from the dial or scale and recorded together with the original width and thickness of the specimen for use in calculating the tensile strength.