JOINT CANADA-UNITED STATES
NATIONAL STANDARD

ANSI/CAN/UL 510A:2023

STANDARD FOR SAFETY

Component Tapes

ANSI/UL 510A-2023

SCC FOREWORD

National Standard of Canada

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UL Standard for Safety for Component Tapes, ANSI/CAN/UL 510A

Second Edition, Dated April 17, 2020

Summary of Topics

This revision of ANSI/CAN/UL 510A dated December 19, 2023 includes revisions to Table 5.1 and result recording clarifications; 11.1.3, 11.2.8, 12.6, 16.2.1, and 24.2.

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.

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1

ANSI/CAN/UL 510A:2023

Standard for Component Tapes

First Edition – May, 2017

Second Edition

April 17, 2020

This ANSI/CAN/UL Safety Standard consists of the Second Edition including revisions through December 19, 2023.

The most recent designation of ANSI/UL 510A as an American National Standard (ANSI) occurred on December 19, 2023. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, Title Page, Preface or SCC Foreword.

This standard has been designated as a National Standard of Canada (NSC) on December 19, 2023.

No Text on This Page

CONTENTS

Preface

This is the Second Edition of ANSI/CAN/UL 510A, Standard for Component Tapes.

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 510A 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.

Annex A is identified as Normative for Canada and Informative for the US. Informative text is for informational purposes only, and Normative text is considered to be mandatory.

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 at any time. Proposals should be submitted via a Proposal Request in the Collaborative Standards Development System (CSDS) at https://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
Fujioka, Hiroaki	Chemitox INC	Testing & Standards	Japan
Gegner, Hugo	Tecnologia Argentina EN Cintas S A	Producer	Argentina
Jordan, Diana P.	UL Standards & Engagement	TC Chair – Non-voting	USA

TC 510 Membership Continued on Next Page

TC 510 Membership Continued

Name	Representing	Interest Category	Region
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Murray, Nickolas	Consumer Association of Canada	Consumer	Canada
Nelson, G.	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 This standard covers tape having constructional features such as reinforcement, adhesive and non-adhesive, and metal foil backed tapes intended for use with finished electro-mechanical products.

1.2 Results obtained provide data with respect to the physical, electrical, flammability, thermal, adhesion and other properties of the tapes under consideration and are intended to provide guidance for tape manufacturers, end-product manufacturers, safety engineers, and other interested parties.

1.3 This standard also covers tapes which have only been subjected to thickness and flammability tests in accordance with Thickness, Section 9 and Flame Test, Section 20, respectively. Tapes subjected only to flammability tests in accordance with Section 20 may employ a conductive backing.

1.4 This standard does not cover the following:

a) In the US, adhesive coated polyvinyl chloride (PVC), adhesive coated polyethylene (PE) and rubber tapes intended for use on joints and splices in wires and cables in accordance with NFPA 70 at not more than 80 °C (176 °F) and 600 V. These types of tapes are covered by UL 510.

b) In Canada, adhesive coated polyethylene (PE) and rubber tapes intended for use on joints and splices in wire and cables in accordance with CSA C22.1 at not more than 600 V and 80 °C (176 °F). These tapes are covered by UL 510.

c) In Canada, adhesive coated polyvinyl chloride (PVC) tape, intended for use on joints and splices in wires and cables in accordance with CSA C22.1 at a maximum temperature of 60 °C (140 °F), 80 °C (176 °F), 90 °C (194 °F), or 105 °C (221 °F) and having voltage ratings up to 1,000 V. These types of tapes 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 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 D3638, *Standard Test Method for Comparative Tracking Index of Electrical Insulating Materials*

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 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*

IEC Standards

IEC 60112, *Method for the Determination of the Proof and the Comparative Tracking Indices of Solid Insulating Materials*

National Fire Protection Association (NFPA) Codes and Standards

NFPA 70, *National Electrical Code*

UL Standards

UL 94, *Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances*

UL 510, *Polyvinyl, Polyethylene, and Rubber Insulating Tape*

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

UL 840, *Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment*

UL 60950-1, *Information Technology Equipment – Safety – Part 1: General Requirements*

UL 61010-1, *Electrical Equipment for Measurement, Control, and Laboratory Use; Part 1: General Requirements*

4 Use of Tapes

4.1 The safety of electrical equipment often depends upon the correct selection of tapes, design, as well as the assembly, mounting, and relative positions of these parts.

4.2 The properties needed by individual applications are defined by the function or functions of the tape. A tape used as interwinding insulation in a transformer, for example, must ordinarily be designed to

withstand electrical stress at elevated use temperatures. Accordingly, a tape known to have suitable thermal endurance and substantial dielectric strength would normally be used although a material of lower dielectric strength used in multiple layers may also be satisfactory.

4.3 End products may employ many tapes that usually have divergent properties. The ability to match the demands of the application with the attributes of a tape as well as the ability to compare the properties of one tape with those of another can lead to the selection of an acceptable tape.

4.4 The information gained from the data obtained from these tests can be used as an aid in the evaluation of end products using tapes. Knowledge of a tape's performance can be obtained from an analysis of data from standard tests conducted on small specimens.

5 Tape Tests Based on Functional Use

5.1 According to the functional uses in the end product, each tape shall comply with the tests specified in Table 5.1. See also 8.1.

Table 5.1
Tape tests based on functional use[1)]

Functional Use	Required Test	Section	Performance Requirement
Tape is used as a dielectric insulator (in dry locations)	Tensile Strength (as-received and oven exposure)	11	Oven conditioned value retain 50 % of the as-received value
	Dielectric Breakdown (as-received and oven exposure)	12	Oven conditioned value retain 50 % of the as-received value
Tape is used as a dielectric insulator (in damp locations)[2)]	Dielectric Breakdown (humidity exposure)	12	Humidity conditioned value retain 90 % of the as-received value
	Insulation Resistance	13	1.0 TΩ (1,000,000 MΩ) for a 25 mm (1 inch) width
	Exposure to Heat	17	Conductor shows no corrosion
Tape is required to demonstrate resistance to electrical surface tracking due to the combined effects of electric stress and surface contamination	Comparative Tracking Index	14	Requirements vary depending on degree of contamination, voltage, and creepage distances in the end product. Refer to Table 14.1
Tape to tape (backing) adhesion provides sole means of securement to maintain position and/or spacings	Adhesion Strength and/or Roll Storage (tape to tape)	15, 16	0.175 N/mm (16 oz-f/inch, or 1 lb/inch) of width
Tape to steel adhesion provides sole means of securement to maintain position and/or spacings	Adhesion Strength and Roll Storage (tape to steel)	15, 16	0.175 N/mm (16 oz-f/inch, or 1 lb/inch) of width
Tape is required to be conformable and remain in complete contact with the surface to which it is applied (no lifting of the tape ends after application)	Exposure to Heat	17	Maximum flagging of 2 mm (0.079 inch)

Table 5.1 Continued on Next Page

Table 5.1 Continued

Functional Use	Required Test	Section	Performance Requirement
The tape will be flexed or subject to bending			No cracking
Tape is used in such a fashion as to be subjected to tensile forces which may result in elongation of the tape	Elongation	18	As-received value shall be at least 50 %; and Oven conditioned value retain 50 % of the as-received value
Tape is used in applications where it will be subjected to compression forces	Deformation	19	Maximum of 50 % decrease in thickness
Tape is used in applications where flammability is a concern	Flame	20	Maximum 25 % flag damage; or No ignition of cotton; or Maximum burn time of 60 seconds
Tape is used in applications where it will be subjected to UV light exposure	Sunlight Resistance	21	UV conditioned tensile strength and elongation values retain 80 % of respective as-received values
Tape is used in applications where the tape will be wrapped or installed at temperatures down to minus 10 °C	Expose to Cold	22	No cracking; or Transfer of adhesive; or Loss of adhesion; or Adverse effects to conductor

[1] Functional use determines tape properties which are relied upon to maintain the proper functioning of device with regard to the likelihood of electric shock, fire, and injury to persons.

[2] Tapes used as dielectric insulators in damp locations must also comply with the requirements for tapes used as dielectric insulators in dry locations.

6 Results of Tests

6.1 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.

6.2 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.

7 Circulating Air-Oven

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

ALL TAPES

8 General

8.1 The requirements in Sections 9 – 12 apply to all electrical insulating tapes covered in this standard and are supplemented by additional requirements in Sections 13 – 22 in accordance with the functional uses in the end product (see Table 5.1 for guidance). Tapes constructed solely with a metallic backing or similar constructions are not intended to be installed as electrical insulation. The requirements in Sections 9 – 11 apply to all tapes used in applications where elevated temperatures are a concern. The requirements in Thickness, Section 9 and Flame Test, Section 20 apply to all tapes used in applications where flammability is a concern.

8.2 Unless otherwise specified, lengths of 25 mm (1 inch) wide tape for use as specimens in any of the tests specified in this standard is 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 ±5 °C (73.4 ±9 °F) whenever being unrolled. The tape is to be always be unrolled at an even rate of approximately 50 mm/second (2 inch/second). The first three layers of tape is 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 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 8.3 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 15.1.

8.3 Unless otherwise specified, all testing, except for flammability, shall be conducted at 23 ±5 °C (73.4 ±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.

8.4 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 in this standard. Tape constructed with a clear (transparent) overall color shall be considered a unique construction required for testing.

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

8.6 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.

9 Thickness

9.1 All tapes

9.1.1 The average thickness for each tape and each individual layer of a composite tape shall be determined in accordance with 9.2, 9.3, or 9.4 as appropriate.

9.1.2 Each individual layer shall be supplied separately, where practical, with the exception of the adhesive whose thickness shall be obtained by subtracting the average thickness of all non-adhesive layers, resulting in the adhesive thickness.

9.1.3 The average thicknesses shall be determined based on five readings taken at different points on the tape or tape layer and the smallest of these shall be taken as the minimum thickness of the tape.

9.2 Non-rubber tapes

9.2.1 Both the total thickness and individual layer thickness for a non-rubber 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. Foam tapes shall use the thickness gauge from UL 94.

9.3 Rubber tapes

9.3.1 The thickness for a rubber 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.

9.4 Foam tapes

9.4.1 Foam tapes or foam component layers shall use the thickness gauge from UL 94.

10 Rated Temperature

10.1 The rated temperature for the tape shall not be less than the maximum continuous use temperature that the tape may be exposed to under normal operating conditions. The rated temperature is determined by thermal endurance tests indicated in 10.2.

10.2 The tape shall be subjected to each test indicated in 8.1 and shall be conducted in the as-received condition and after 7 days (168 ±2 hours) or optionally after 60 days (1440 ±7 hours) at the exposure temperature, T_E, as shown in Table 10.1.

10.3 The average property value following the 7 or 60 day oven conditioning shall be at least 50 % of the as-received value.

Table 10.1
Rated Temperature Exposures

Rated Temperature T_R (°C)	Exposure Temperature T_{E7} (°C) for 7 day (168 ±2 hours) conditioning	Optional Exposure Temperature T_{E60} (°C) for 60 day (1440 h ±7 hours) conditioning
80	111	87
90	121	97
105	136	113
130	162	138
150	182	158
155	187	164
180	213	189
200	233	209
220	253	230
240	274	250
250	284	260

For those tapes with a rated temperature (T_R) lower or higher than indicated in this Table, the following formulas shall be used:

7 Day Exposure Equation = T_{E7} (°C) = 1.02[T_R(°C) + 296] − 273

Exception: At the manufacturers option, the following 60 day exposure may be used:

Optional 60 Day Exposure Equation = T_{E60} (°C) = 1.02[T_R(°C) + 273] − 273

11 Physical Properties – Tensile Strength

11.1 Non-rubber tapes

11.1.1 The tensile strength for non-rubber tape constructions shall be evaluated in accordance with the Breaking Strength and Elongation method in ASTM D1000.

11.1.2 Sample sets of five specimens shall be tested after each of the following conditions:

a) As-received; and

b) 7 or 60 day conditioning as specified in Table 10.1.

11.1.3 The maximum load is to be noted from the dial or scale and recorded together with the original measured width and thickness of the specimen for use in calculating the tensile strength. The average tensile strength value following 7 or 60 day oven conditioning shall be at least 50 % of the as-received value.

11.1.4 For composite tapes, the average tensile strength value referenced in 11.1.3 shall correspond to the first composite layer to rupture.

11.2 Rubber tapes

11.2.1 The tensile strength for rubber tape constructions shall be evaluated using the method described in 11.2.4 – 11.2.8.

11.2.2 Sample sets of five specimens shall be tested after each of the following conditions:

a) As-received; and

b) 7 or 60 day conditioning as specified in Table 10.1.

11.2.3 Two strips of the tape, each 203 mm (8 inches) long, are to be placed together with their adhesive sides in contact and are to be rolled to eliminate any entrapped air. A dumbbell-shaped specimen is to be cut from the plied strips, using a die (die A) in ASTM D412, having a constricted portion 12.00 mm, +0.05 mm, minus 0.00 mm (0.500 inch, +0.002 inch, minus 0.00 inch) wide and 59 ±2 mm (2.32 ±0.08 inches) long.

11.2.4 The test shall be conducted on a power-driven machine provided with a device that indicates the actual maximum load applied to the specimen. If a machine of the spring-balance type is used, provision is to be made so that the spring does not recoil. The machine is to be adjusted to make the speed of the power-actuated grip 500 ±25 mm/min (20 ±1 inches/min). The applied tension as indicated by a dial or scale is to be accurate to 2 % or less of the value read.

11.2.5 The specimen is to be clamped in position with the constricted portion of the specimen is outside of and between the grips. The movable grip is to be adjusted to make the specimen taut, but not under tension.

11.2.6 The grips are to be separated at the rate indicated in 11.2.5 until the specimen ruptures.

11.2.7 The load at rupture 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.

11.2.8 The maximum load is to be noted from the dial or scale and recorded together with the original measured width and thickness of the specimen for use in calculating the tensile strength. The average tensile strength value following 7 or 60 day oven conditioning shall be at least 50 % of the as-received value.

12 Dielectric Breakdown Test (Non-Rubber and Rubber)

12.1 The dielectric breakdown for non-rubber and rubber tape constructions shall be evaluated in accordance with the Dielectric Breakdown Voltage short time method described in ASTM D1000.

12.2 Sample sets of five specimens shall be prepared based on its construction:

a) Non-rubber tapes – a single layer specimens of finished tape (backing plus adhesive) shall be used.

b) Rubber tapes – three, 150 mm (6 inches) lengths of the finished tape are to be used in constructing each specimen. With its adhesive side up, one piece of the tape is to be laid flat on a smooth, horizontal surface. A second piece is to be laid onto one long edge of the first with its adhesive side down, with its length parallel to the length of the first piece, and with an overlap of 3.2 mm (0.125 inch). The third piece is to be laid similarly onto the remaining long edge of the first. Both joints are to be rolled to provide intimate contact. For tapes having a non-rectangular cross-section, testing of specimens having a rectangular cross-section and a thickness equivalent to the minimum thickness of the non-rectangular construction are considered representative. The average thickness of the center strip of each rubber tape specimen shall be determined as indicated in 9.3.1.

12.3 Sample shall be tested after each of the following conditions:

a) As-received; and

b) 7 or 60 day conditioning as specified in Table 10.1; and

c) 96 ±2 hours at 23 ±2 °C (73.4 ±3.6 °F) and 96 ±2 % relative humidity conditioning.

12.4 Specimens conditioned in the air oven are allowed to stabilize for 16 to 96 hours at 23 ±5 °C (73.4 ±9 °F) and 50 ±10 % relative humidity before testing.

12.5 Specimens conditioned in the humidity chamber are to be removed one at a time before testing. 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 is to be repeated for each of the five specimens per set, one at a time, to minimize misleading results caused by further drying of the specimens.

12.6 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 meet the following requirements:

a) 7 or 60 day oven conditioning shall be at least 50 % of the as-received value.

b) 96 h humidity conditioning shall be at least 90 % of the as-received value.

13 Insulation Resistance – Test for Indirect Measurement of Conductor Corrosion (Non-Rubber and Rubber)

13.1 The insulation resistance in high humidity for tapes shall be evaluated in accordance with the Insulation Resistance at High Humidity method described in 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).

13.2 Sample sets of five specimens shall be tested. In addition to testing of those colors indicated in 8.4, this test shall also be performed on any color which involves metallic pigments.

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

14 Comparative Tracking Index (CTI) (Non-Rubber and Rubber)

14.1 The CTI test shall be performed in accordance with the ASTM D3638 or IEC 60112 methods described in UL 746A. The test shall be performed on both the adhesive and backing surfaces.

14.2 A minimum of 40 specimens should be prepared, each 125 mm by 50 mm (5 by 2 inches) consisting of sufficient layers to build the specimen to a minimum thickness of 3 mm (0.12 inch). Specimens shall be adhered to a metal plate, 20 specimens with adhesive side up and 20 specimens with the adhesive side down. Samples shall be adequately secured to the metal plates so that they are flat and free of wrinkles, air bubbles and contamination which may appear in the layered specimen. Double sided tape may be used to adhere the backing-side to the metal plate. These samples are to be supplied with a release liner to prevent contamination.

14.3 The CTI rating is defined as the maximum voltage at which tracking does not occur after 50 drops of the conductive test solution has fallen onto the sample between the test electrodes for five specimens. For the IEC 60112 test method, once the 50 drop CTI voltage for each side is determined, the tape will additionally need to meet the following:

a) Erosion depth measurement – The five specimens used to determine the 50 drop CTI is to be cleaned of any debris or loosely attached degradation products and placed on the platform of a depth gauge. The maximum depth of erosion of each specimen shall be measured to an accuracy of 0.1 mm (0.004 inch), using a 1-mm (0.04-inch) nominal diameter probe having a hemispherical end. The maximum erosion depth result is the largest measured value of the five specimens.

Erosion depths of less than 1 mm (0.04 inch) shall be reported as < 1 mm (0.04 inch). Erosion depth of 0 shall not be reported; and

b) Confirmation test – An additional set of five specimens shall successfully complete a 100-drop confirmation test at a voltage that is 25 V lower than the 50 drop CTI voltage. If tracking occurs prior to 100 drops, the test shall be repeated at 25 V lower increments until five successful results are obtained. This lower voltage shall then be reported in parentheses after the 50 drop CTI voltage.

14.4 The results from the worst performing side (adhesive side or backing side) shall be used to categorize the tape's CTI performance in accordance with Table 14.1.

Table 14.1
Comparative Tracking Index Categories

50 Drop Comparative Tracking Index, CTI, V	Material Group per UL 840, UL 60950-1 & UL 61010-1, using IEC Results only	UL 746A Performance Level Category, PLC, using ASTM Results Only
CTI ≥ 600	I	0
400 ≤ CTI < 600	II	1
250 ≤ CTI < 400	IIIa	2
175 ≤ CTI < 250	IIIa	3
100 ≤ CTI < 175	IIIb	4

15 Test for Adhesion Strength (Non-Rubber and Adhesive Coated Rubber)

15.1 The adhesion strength for an adhesive coated tape shall be evaluated in accordance with the Adhesion Strength to Steel and Backing method described in ASTM D1000.

15.2 Sample sets of three specimens shall be tested in the as-received condition.

15.3 The average adhesion strength shall be at least 0.175 N/mm (16 oz-f/inch or 1 lb/inch) when applied to the following surfaces, except for double sided adhesive tape:

a) Tape applied to steel; and

b) Tape applied to tape backing.

16 Storage Test

16.1 Non-rubber tapes

16.1.1 A non-rubber adhesive coated tape shall retain its adhesion strength after an unused roll of tape is conditioned.

16.1.2 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 ±2.0 °C (104.0 ±3.6 °F) for 60 days; or

b) 65.0 ±2.0 °C (149.0 ±3.6 °F) for 10 days (Alternate condition, at the manufacturer’s option).

16.1.3 Samples shall be evaluated in accordance with 15.1 and 15.2.

16.1.4 The tape shall comply with the adhesion strength requirements in 15.3.

16.2 Rubber tapes

16.2.1 A rubber tape shall retain its adhesion strength after an unused roll of tape is conditioned.

16.2.2 An unused roll of tape is to be laid flat in a full-draft circulating-air oven at a temperature of 40 ±2 °C (104 ±3.6 °F) for 60 days.

16.2.3 The tape shall meet the following requirements:

a) Not become unduly attached to the separator; and

b) Meet the fusion test in ASTM D4325 (see Sections Significance and Use, Apparatus and Procedure)

17 Exposure to Heat (Non-Rubber and Rubber)

17.1 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).

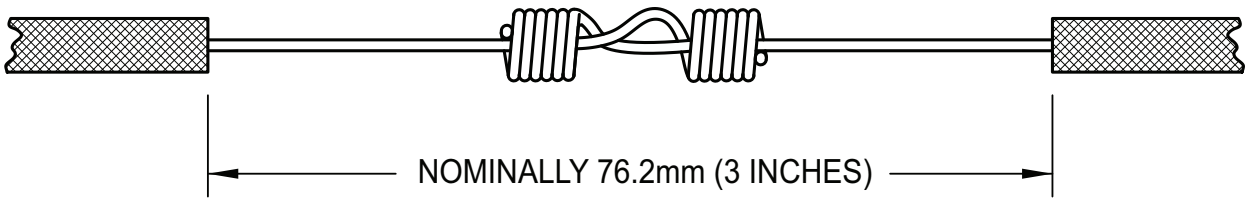
17.2 Sample sets of four specimens shall be conditioned for 7 days, or optionally after 60 days, at the exposure temperature, T_E (see Table 10.1) in a full-draft circulating-air oven.

17.3 To determine whether a tape complies with 17.1, four tape-insulated splices made with Type T, TW, THW, THWN, THHN, RH, RHW, RHH, or XHHW wire as described in 17.4 are to be wrapped with the tape as indicated in 17.5 and conditioned, flexed, and examined as indicated in 17.6 – 17.7. The solid uncoated copper conductor shall have a diameter of 2.05 mm (12 AWG).

17.4 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 17.1). The spliced ends of the conductor are to be crimped with pliers to remove sharp projections.

Figure 17.1

Western union splice



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17.5 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 to then 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.

17.6 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 °C (73.4 ±9 °F) for 16 to 96 hours, and subjected to flexing as described in 17.7. If the tape observes any of the items indicated in 17.1, the test shall be terminated and the 7 or 60 day specimens shall be removed from the oven and discarded. If the tape does not observe any of the items under 17.1, the two remaining specimens shall stay in the oven for a total of 7 or 60 days, and then 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 17.7.

17.7 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 to then 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 to then 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 is 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.

18 Physical Properties – Elongation

18.1 Non-rubber tapes

18.1.1 The elongation for non-rubber tape constructions excluding fiber, paper, glass, polymer films with reinforcement or fabric tapes 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.

18.1.2 Sample sets of five specimens shall be tested after each of the following conditions:

a) As-received; and

b) 7 or 60 day conditioning as specified in Table 10.1.

18.1.3 The average elongation value shall meet the following requirements:

a) As-received value shall be at least 50 % or greater.

b) 7 or 60 day oven conditioning shall be at least 50 % of the as-received value.

18.2 Rubber tapes

18.2.1 The elongation for rubber tape constructions shall be evaluated using the method described in 18.2.3 – 18.2.7.

18.2.2 Sample sets of five specimens shall be tested after each of the following conditions:

a) As-received; and

b) 7 or 60 day conditioning as specified in Table 10.1.

18.2.3 Specimens shall be prepared as described in 11.2.3.

18.2.4 The specimens are to be marked by means of a marker consisting of a stamp with parallel blades capable of making fine lines with ink on a specimen without damage to the tape. The lines (bench marks) are to be 50 mm (2 inches) apart and applied on the constricted portion of the specimen and at right angles to the longitudinal axis of the specimen. Measurement of elongation is to be made with reference to the center of each mark, halfway between the edges.

18.2.5 The elongation and tensile strength tests shall be conducted simultaneously as described in 11.2.4.

18.2.6 The specimen is to be clamped in position with both 50 mm (2 inches) bench marks outside of and between the grips. The movable grip is to be adjusted to make the specimen taut, but not under tension.

18.2.7 The grips are to be separated at the rate indicated in 11.2.4 until the specimen ruptures. During separation, the distance between the bench marks is to be observed continuously so that the distance is observed and recorded at the instant of rupture with accuracy of at least 2 mm (0.1 inch). The elongation is to be taken as the increase in distance between the bench marks, which originally were 50 mm (2 inches) apart.

18.2.8 The average elongation value shall meet the following requirements:

a) As-received value shall be 50 % or greater.

b) 7 or 60 day oven conditioning shall be 50 % of the as-received value.

19 Deformation Test (Non-Rubber)

19.1 The thickness of the insulation (tape) over a splice covered with tape shall not decrease more than 50 % after conditioning, under pressure, as described in 19.2 – 19.4.

19.2 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.

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

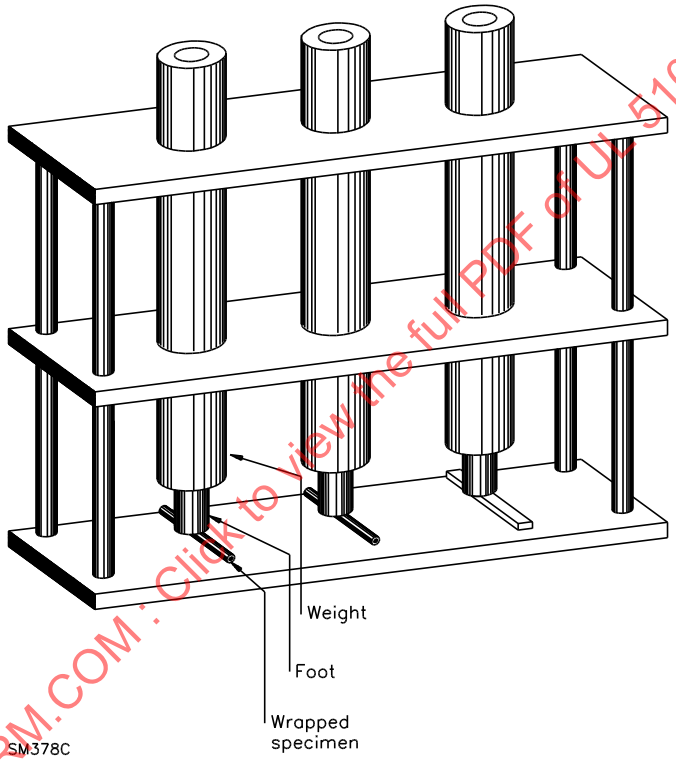
a) A full draft air-circulating oven capable of maintaining the required air temperature as specified in 7.1; and

b) The necessary weights needed to exert a total force of 4.90 N (500 gf) mounted in a metal frame so as to have free vertical movement, as illustrated in Figure 19.1. 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 9.2.1.

Figure 19.1

Weights and specimens in supporting frame for deformation test



19.4 The specimen is to be then be placed in the oven for one hour of preliminary heating at the temperature 20 ±2 °C (68 ±3.6 °F) above the rated temperature, along with the weight(s) 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 to be carefully removed from under the weight and the thickness re-measured at the marked location within 15 seconds of removal from the oven, in the same manner as specified in 19.2. 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 conditioning;

T_2 is the overall sample diameter after oven conditioning; and

C is the conductor diameter.

20 Flame Test

20.1 Tape marked "Flame Retardant" in accordance with 24.2 shall not flame longer than 60 seconds following any of five, 15 second 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.

20.2 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 20.3 – 20.16.

20.3 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.

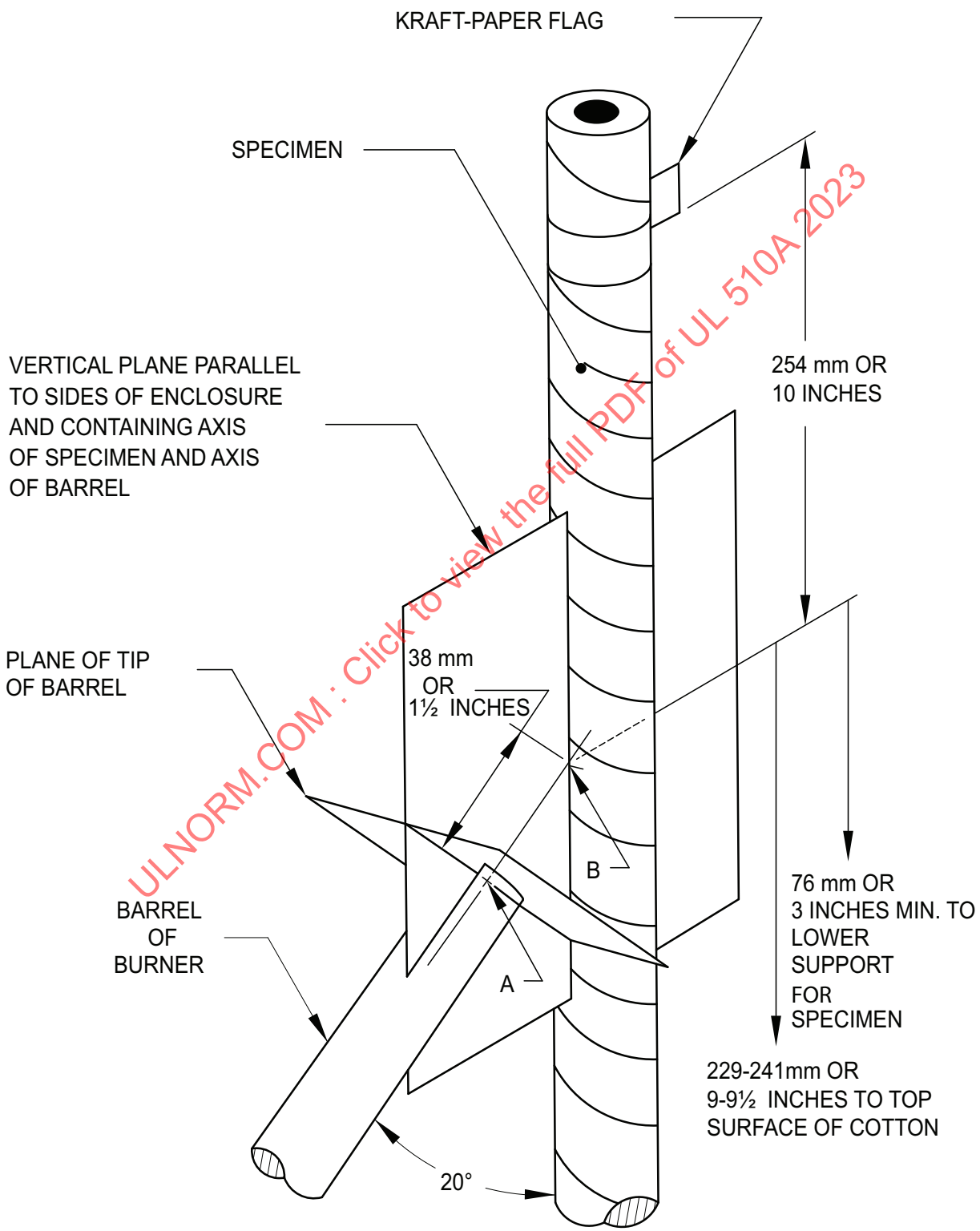
20.4 The test specimen is to be prepared as follows. A straight clean steel rod 460 mm (18 inches) long and 3.2 mm (0.125 inch) in diameter is to be supported in a winding jig. The winding jig is to support the rod at each end and have a crank for rotating the rod so that the tape can be wound thereon. 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 to then 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.

20.5 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 touches 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 20.1). 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 20.1

Essential dimensions for flame test

Proportions exaggerated for clarity of detail



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