

## Tech Brief

# CTI: The Comparative Tracking Index Test

The Comparative Tracking Index (CTI) is the maximum voltage, measured in volts, at which a material withstands 50 drops of contaminated water without tracking. Tracking is defined as the formation of conductive paths due to electrical stress, humidity, and contamination.

The CTI test provides an accelerated simulation of conditions of surface discharges and possible resulting tracking and failure (typically a “short”) in equipment using insulating materials. This test also provides a means to compare insulating materials performances under wet and contaminated conditions.

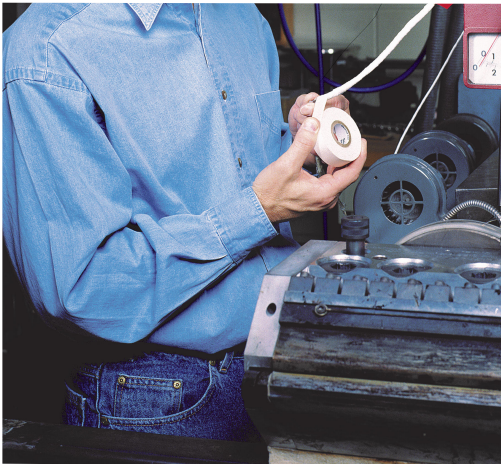
CTI requirements became important to manufacturers after the publication of the Underwriters Laboratories document UL 1950 in March 1992. UL 1950 is the UL Standard for Safety titled “Information Technology Equipment including Electrical Business Equipment.” Section 2.9 of this document outlines requirements for Creepage Distance, which is the shortest path between two conductive parts measured along the surface of the insulation.



Depending on the CTI of the insulating material used, the minimum creepage distance required will vary. The higher the CTI value, the lower the minimum creepage distance required. In practice, the higher the CTI of the insulating material used, the closer two conductive parts can be. The result is often a smaller part, increasingly desirable in technology and industry today. These values would be of particular interest to design engineers who must comply with UL requirements.

The original test method referred to in UL 1950 was IEC Publication 112. This method requires a 3-mm thick sample\*, subjected to a voltage, while one drop of test electrolyte solution (0.1% ammonium chloride) falls every 30 seconds onto the sample surface. The test continues until either 50 drops fall or tracking occurs. Failure results if tracking occurs before 50 drops fall, generating enough amps to trip the tester’s built-in over-current relay. If the

\*In order to meet the 3-mm thickness requirement, the electrical tapes must be carefully stacked one layer upon another until the thickness is achieved.



sample burns the test is inconclusive and should be repeated using a thicker sample. The maximum test voltage is 600 volts; if failure occurs voltage is typically decreased by 25 volts and the test repeated until a voltage is reached that the sample can pass.

The passing voltage must be repeated for a total of five test sites on the sample. The sample must, in addition, also pass 100 drops at 25 volts less than the original passing voltage.

When all conditions are met, a Material Group is determined for the insulating material based upon the passing voltage for the 50-drop test. Both the backing and adhesive sides of tapes are tested. Prior to 2008, the lower of the two voltage levels determined the Material Group assigned.

Material Groups are identified in UL 1950, Section 2.9:

|                         |                      |
|-------------------------|----------------------|
| (a) Material Group I    | 600 $\leq$ CTI       |
| (b) Material Group II   | 400 $\leq$ CTI < 600 |
| (c) Material Group IIIa | 175 $\leq$ CTI < 400 |
| (d) Material Group IIIb | 100 $\leq$ CTI < 175 |

UL revised the requirements and references for Material Group Classifications after 2008, eliminating the Material Group IIIb rating. The current notes regarding CTI Material Groups state the following in the Online Certifications Directory:

|                         |   |
|-------------------------|---|
| (a) Material Group I    | May be marked "Comparative Tracking Index (CTI) equal to or greater than 600V, PLC=0, UL840 Material Group I, when tested to IEC60112 on both sides of tape.  |
| (b) Material Group II   | May be marked "Comparative Tracking Index (CTI) ) equal to or greater than 400V but less than 600V, PLC=1, UL840 Material Group II, when tested to IEC60112 on both sides of tape.                                |
| (c) Material Group IIIa | May be marked "Comparative Tracking Index (CTI) equal to or greater than 175V but less than 400V, PLC=2 or 3, UL840 Material Group IIIa, when tested to IEC60112 on both sides of tape.                           |
| (d) Material Group IIIa | May be marked "Comparative Tracking Index (CTI) 325(275) on Adhesive side, UL840, Material Group IIIa and/or CTI 225 on Film Side, Material Group IIIa or equivalent when tested to IEC60112, 4th Edition (2003). |
| UL Standard 840         | Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment. UL 746A is referenced in UL840.  |
| UL Standard 746A        | Standard for Polymeric Materials - Short Term Property Evaluations.   |

The 3M Electrical Markets Division (EMD) Laboratory tested and determined a CTI value for more than 50 Electrical Insulating Tapes from 3M. Underwriters Laboratory has tested 37 insulating and conductive tapes from 3M to verify results. CTI testing at UL is optional.

UL added Material Groups assigned to the tapes tested at UL to the UL Online Certifications Directory. To see these references, go to [www.ul.com](http://www.ul.com), then click on Online Certifications Directory, and enter E17385 into the search cell for UL File Number. Click on the link provided there to find a list of all EMD UL-Recognized tapes; CTI values are indicated by subscripts (a, b, c, or d). Of the tapes tested, 3M qualified 34 for Material Group I rating, and UL qualified 24 of those, verifying 3M procedure and method.



The following table shows results for current 3M OEM Electrical Insulating Tapes:

| 3M™ Tape | CTI Value | Material Group (3M) | Material Group (UL) |
|----------|-----------|---------------------|---------------------|
| 1        | 600       |                     | I                   |
| 5        | 600       | I                   |                     |
| Super 10 | 600       |                     | I                   |
| 11       | 600       | I                   |                     |
| 12       | 600       | I                   |                     |
| 16       | 600       | I                   |                     |
| Super 20 | 600       |                     | I                   |
| 27       | 600       |                     | I                   |
| 28       | 600       |                     | I                   |
| 44       | 600       |                     | I                   |
| 44D      | 600       |                     | I                   |
| 44T-A    | 600       |                     | I                   |
| 46       | 475       | II                  |                     |
| 54       | 600       |                     | I                   |
| 55       | 600       | I                   |                     |
| 56       | 600       |                     | I                   |
| 57       | 600       |                     | I                   |
| 58       | 600       |                     | I                   |
| 60       | 600       | I                   |                     |
| 61       | 600       | I                   |                     |
| 62       | 600       | I                   |                     |
| 63       | 600       | I                   |                     |
| 69       | 600       |                     | I                   |
| 74       | 600       |                     | I                   |
| 75       | 600       | I                   |                     |
| 79       | 600       | I                   |                     |
| 90       | 600       | I                   |                     |
| 92       | 150       | IIIb                |                     |
| MR94     | 600       | I                   |                     |
| MR94B    |           |                     | IIIa                |
| 1205     | 125       | IIIb                |                     |
| 1276     | 600       | I                   |                     |

| 3M™ Tape   | CTI Value | Material Group (3M) | Material Group (UL) |
|------------|-----------|---------------------|---------------------|
| 1291       | 600       | I                   |                     |
| 1298       |           |                     | II                  |
| 1312       | 600       |                     | I                   |
| 1318B-1    | 200       | IIIa                |                     |
| 1318B-2    | 200       | IIIa                |                     |
| 1318W-1    | 450       | II                  |                     |
| 1318W-2    | 450       | II                  |                     |
| 1318Y-1    |           |                     | I                   |
| 1318Y-2    | 600       |                     | I                   |
| 44HT       | 600       | I                   | I                   |
| 1318 Clear | 600       |                     | I                   |
| 1318-MW    | 600       |                     | I                   |
| 1339       | 600       | I                   |                     |
| 1350B-1    |           |                     | IIIa                |
| 1350B-2    |           |                     | IIIa                |
| 1350W-1    |           |                     | IIIa                |
| 1350W-2    |           |                     | IIIa                |
| 1350Y-1    |           |                     | II                  |
| 1350Y-2    |           |                     | IIIa                |
| 1350F-B-1  |           |                     | IIIa                |
| 1350F-B-2  |           |                     | IIIa                |
| 1350F-W-1  |           |                     | IIIa                |
| 1350F-W-2  |           |                     | IIIa                |
| 1350F-Y-1  |           |                     | II                  |
| 1350F-Y-2  |           |                     | IIIa                |
| 1350T-1    |           |                     | II                  |
| 1351T-1    | 600       |                     | I                   |
| 1351-1     | 600       |                     | I                   |
| 1351-2     | 600       |                     | I                   |
| 1554       | 600       | I                   |                     |
| 1098-1     | 550       |                     | II                  |
| 1098 Black | 600       |                     | I                   |

3M is a trademark of 3M Company.

### Important Notice

All statements, technical information, and recommendations related to 3M's products are based on information believed to be reliable, but the accuracy or completeness is not guaranteed. Before using this product, you must evaluate it and determine if it is suitable for your intended application. You assume all risks and liability associated with such use. Any statements related to the product which are not contained in 3M's current publications, or any contrary statements contained on your purchase order shall have no force or effect unless expressly agreed upon, in writing, by an authorized officer of 3M.

### Warranty; Limited Remedy; Limited Liability.

3M's product warranty is stated in its Product Literature available upon request. **3M MAKES NO OTHER WARRANTIES INCLUDING, BUT NOT LIMITED TO, ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.** If this product is defective within the warranty period stated above, your exclusive remedy shall be, at 3M's option, to replace or repair the 3M product or refund the purchase price of the 3M product. **Except where prohibited by law, 3M will not be liable for any direct, indirect, special, incidental or consequential loss or damage arising from this 3M product, regardless of the legal theory asserted.**



**Electrical Markets Division**  
6801 River Place Blvd.  
Austin, TX 78726-9000 USA

Phone 800-676-8381  
Fax 800-828-9329  
Web [www.3M.com/oem](http://www.3M.com/oem)

© 3M 2016. All rights reserved.