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IPC-TM-650
TEST METHODS MANUAL

1 SCOPE

This test method is used for determining the change of one or more functionally relevant parameters in e-textiles as a result of cyclic stretching or dynamic tensile forces.

1.1 Principles of Test E-textile specimens are exposed to cyclic stretching within the range of elastic deformation up to a given number of cycles while observing a change of one or more relevant functional parameters throughout the cycles or at regular intervals. A specimen of custom size is cut from the e-textile and is cycled at a constant rate of extension.

1.2 Terms and Definitions

1.2.1 Critical Area The areas of e-textiles that have a higher tendency of failure compared to other areas (e.g., joints, connection points, textile electrodes) or that if affected will negatively impact product functionality or the product capability to operate as intended.

1.2.2 Cycle When a sample returns to its original state after single reciprocation.

1.2.3 Cycle Rate The number of cycles per time unit.

1.2.4 Data Recorder A measuring device used to record electrical resistance or electrical continuity.

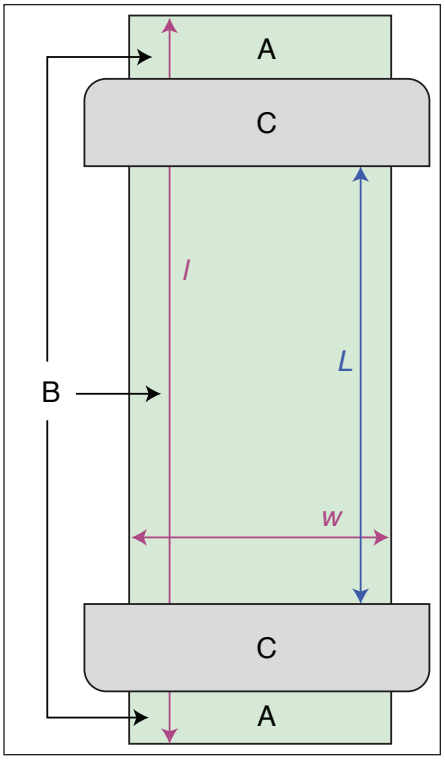

Figure 1 Specimen Parameters

Figure key
A – Data recorder
B – Specimen
C – Clamp

2 APPLICABLE DOCUMENTS

2.1 IPC[1]

IPC-TM-650 Test Methods Manual

2.4.56 Tensile Behavior of E-Textiles

2.1 International Organization for Standardization (ISO)[2]

ISO 139 Textile Standard atmosphere for conditioning and testing

3 TEST SPECIMENS

3.1 Specimen Preconditioning All test specimens **shall** be conditioned for ≥ 24 hours according to ISO 139. If other conditions are specified, they should be reported with the test results.

1 www.ipc.org
2 www.iso.org

3.2 Specimen Description

Specimens **shall** be cut from the e-textile according to the following specifications:

- Specimens **shall** be cut so that critical areas are located in the middle of the specimen.
- The specimen **shall** be cut in rectangular shape. The width of the specimen **shall** be defined as w and the testing length is defined as L. The total length of the specimen **shall** be defined as l (see Figure 1).
- The testing length (L) and width (W) need to be large enough to fit a critical area of the e-textile that **shall** be tested.
- The specimen size also needs to fit to machine and clamp dimensions and be able to be stretched to target elongation εmax. Clamp width should be larger or equal to specimen width.
- The total length (l) **shall** be large enough to enable clamping and, as needed, attachment of data recording connectors at the ends of the specimen.

If applicable, remove insulation from conductive structures at both ends of the specimen for data recorder attachment.

3.3 Number of Specimens

The number of test specimens **shall** be defined to respect the statistical treatment (at least five per affected critical area).

4 APPARATUS AND MATERIAL

4.1 Tensile Testing Machine or Stretch Testing Machine This machine is capable of non-destructive tensile or stretch testing including cycling. The machine applies tensile (pulling) force to a material and measures the specimen's response to the stress.

The clamping device of the machine **shall** be positioned with the center of the two jaws in the line of applied force, the front edges **shall** be at right angles to the line of applied force, and their clamping faces **shall** be in the same plane.

The jaws **shall** be capable of holding the test specimen without allowing it to slip and designed so that they do not cut or otherwise weaken the test specimen.

See Figure 2.

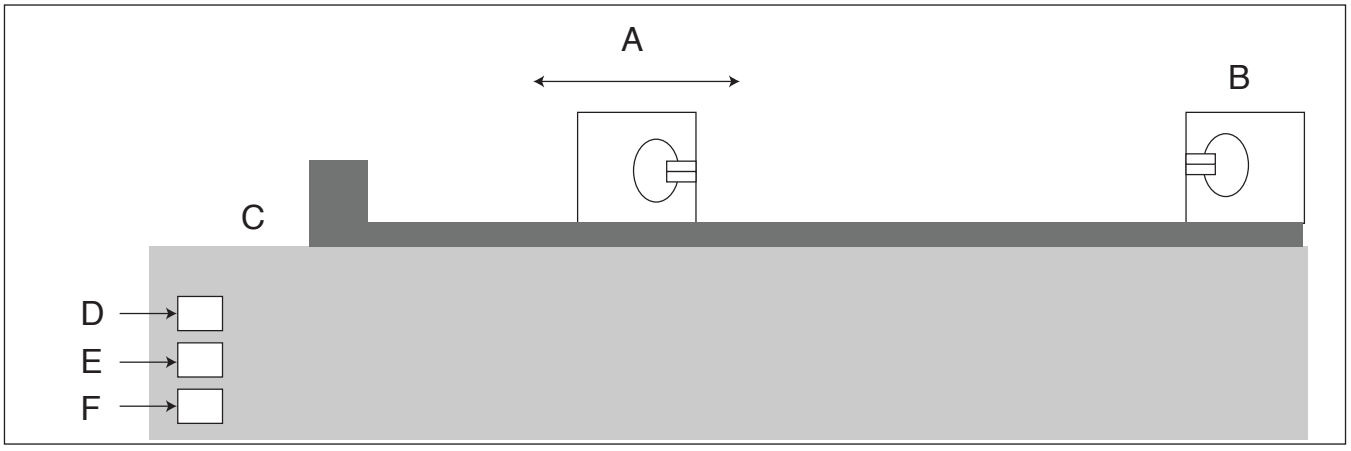

Figure 2 Exemplary Testing Machine Schematic (Horizontal or Vertical)

Figure key

A – Dynamic clamp
B – Stationary clamp
C – Linear actuator
D – Power in
E – Power out
F – Data logger out

4.2 Data recorder for functionality testing

5 TEST PROCEDURE

5.1 Using the data recorder, measure the initial value of the relevant functional parameter(s). Conduct a visual inspection of the specimen prior to testing.

5.2 Determine the maximum elongation (ε_{max}) of the specimen for the test. The maximum elongation **shall** be within the elastic deformation region obtainable from the tensile testing results (yellow in Figure 3). Chose ε_{max} from the elastic range to reflect use-case conditions or other target values. A tensile strength test according to IPC-TM-650, Method 2.4.56 **shall** be performed prior to stretch testing to determine the elastic and plastic deformation regions for the specimen. See Figure 3, which provides an example of a stress-strain curve with elastic and plastic regions with range from which ε_{max} **shall** be chosen.

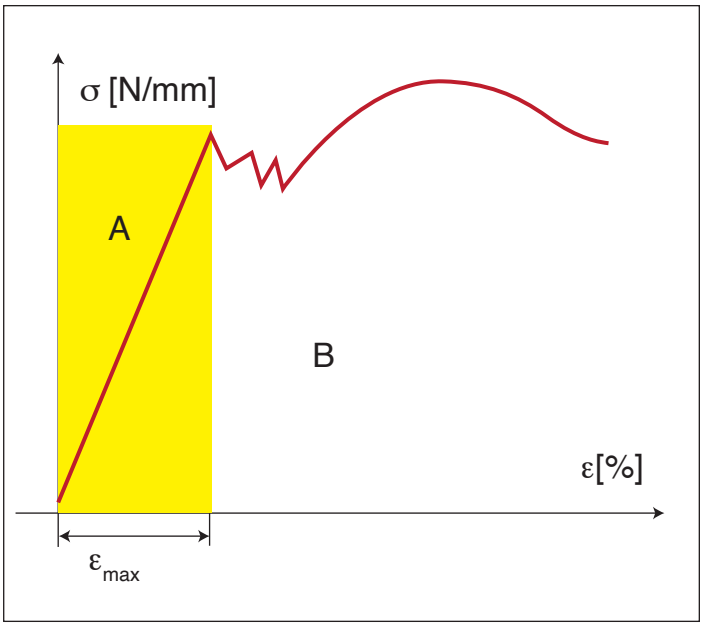

Figure 3 Stress-Strain Curve Example

Figure key
A – Elastic region
B – Plastic region

5.3 Set clamping distance to L. Specimen should be clamped in a way that pretension is minimized.

5.4 Set the machine movement as follows (see Figure 4):

- Set a rate of extension for the test cycles. The speed with which the specimen is stretched **shall** be AABUS and **shall** reflect the use case. The duration of one test cycle is t_{test}, the testing frequency is $1/ t_{test}$. Test cycles don't have a specified hold time.
- The interval of measurement **shall** be AABUS. Measurements **shall** be conducted at least during the first and last cycle. If measurements are taken every cycle, every test cycle will be a measurement cycle.
- Each measurement cycle **shall** include two hold periods at ε_{max} and ε_0 to allow for data recorder measurement. The length of the hold time t_{hold} **shall** be adapted to the measuring time of the data recorder. The duration of measuring cycles $t_{measure}$ consists of two stretch periods and two hold periods.

5.5 Connect all required functional components to the data recorder. Set the data recorder to take measurements at the hold points of each measurement cycle. The recorder **shall** take two measurements per measurement cycle (at ε_{max} and ε_0).

6 TEST REPORT

The report **shall** contain the following information:

- Date and time of test
- Testing location and name of tester
- Environmental test conditions (if differing from ISO 139)
- Number of test specimens
- Description of test specimens (size, cutting direction (warp/weft (wovens), course/wale (knits)), type of critical area, location of critical area within specimen, etc.)
- Description/Specifications of testing equipment
- Testing parameters/specifications (number of test cycles, testing elongation ε_{max}, other info)
- Cycle count/time intervals for intermediate testing (if applicable)
- Test results (parameter values before, during (if applicable) and after testing); if applicable: plotting of parameter values over time / cycle count), other types of measurements
- Results of visual inspection before, during (if applicable) and after testing
- Any deviations from the presented methods
- Comments

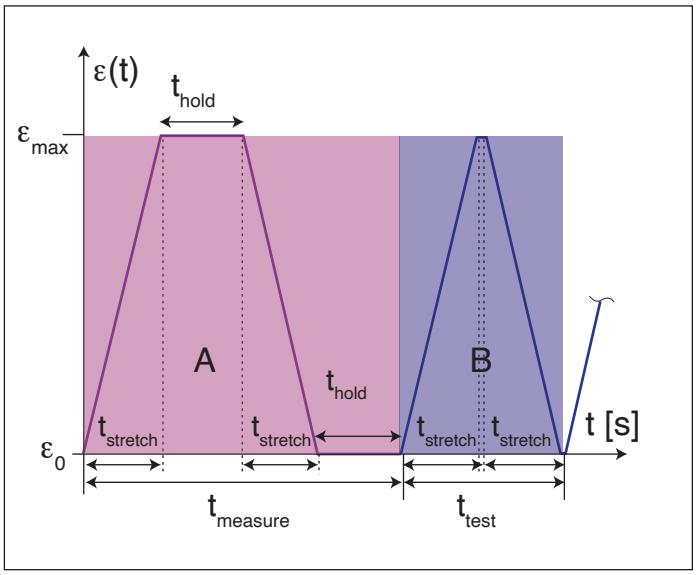

Figure 4 Measurement Cycle and Test Cycle

Figure key
A – Measuring cycle
B – Test cycle

Figure note: Short hold periods during test cycles are machine dependent due to movement reversal.

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