



## SPECIFICATION RW-2512

TE 108-121015

### HT-SCE and HT-CT HEAT SHRINK MARKER SLEEVES

#### SCOPE

This quality assurance specification establishes the quality standard for a heat-shrinkable identification sleeving for use in applications where high performance during exposure to organic fluids, especially oils and diesel fuel is required. These special requirements are detailed in Table 5.

The operating temperature for this product is -55°C to +225°C (-67 to +437°F).

This system is an automatic method of identifying items by printing a mark on HT-SCE product range. The mark is permanent upon printing. This system is not recommended where strain relief properties are required.

The marker shall be fabricated from cross linked polymer tubing, flattened and then mounted on a carrier as HT-SCE or supplied as flattened spooled continuous tube as HT-CT. All sizes 2:1 shrink ratio except size 3/32 which is 3:1 shrink ratio (refer to Table 1 for more details).

The marker system comprises specific printers and ribbons; refer to TE document 411-121005 'TE Identification Printer Product Ribbon Matrix'. Products printed with the white or silver ribbons may not fully comply with this specification when exposed to some aggressive fluids, details on page 15. Compliance to this specification can only be guaranteed if TE Connectivity approved printers and ribbons are used.

Unless specified, the tube size for qualification testing is 6.4mm.

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RW-2512



Table of Contents

1 Revision History .....3

2 Scope .....3

3 Requirements.....3

4 Dimensions .....3

5 Figure 1: HT-SCE Sleeve format .....4

6 Dimensions .....5

7 Table 4: General Requirements for Identification Products.....15

8 Specific Requirements for HT-SCE Heat Shrink Sleeving .....18

9 Test Fluids Description .....19

# RW-2512



## 1 REVISION HISTORY

| Revision Number | Description of change                                         | Date      | Incorporated By |
|-----------------|---------------------------------------------------------------|-----------|-----------------|
| 1               | RT-1806 (original)                                            | ---       | ---             |
| 2               | ---                                                           | ---       | ---             |
| 3               | Integrated in to RW doc                                       | July 2004 | Alan Kean       |
| 4               | Addition of printer ribbon matrix, removal of obsolete specs. | Jan 2013  | Lee Smith       |
| 5               | Standardise test fluids, addition of UV resistance test       | Nov 2013  | Alan Kean       |
| 6               |                                                               |           |                 |

## 2 SCOPE

The tests in this specification, as completed on HT-SCE products, define the performance of a high temperature, self-extinguishing, heat shrink marker sleeve for rail, aerospace and construction industries. Test procedures have been selected based on the ability of that test to provide key performance data which can be used by an engineer to provide information which can be used to validate the fit form and function of installed products.

## 3 REQUIREMENTS

### 3.1 Composition, appearance and color

The sleeving shall be fabricated from irradiated, thermally-stabilised polyolefin compound. It shall be homogeneous and essentially free from flaws, defects, pinholes, bubbles, seams, cracks or inclusions. The marker sleeves shall be White unless otherwise specified.

## 4 DIMENSIONS

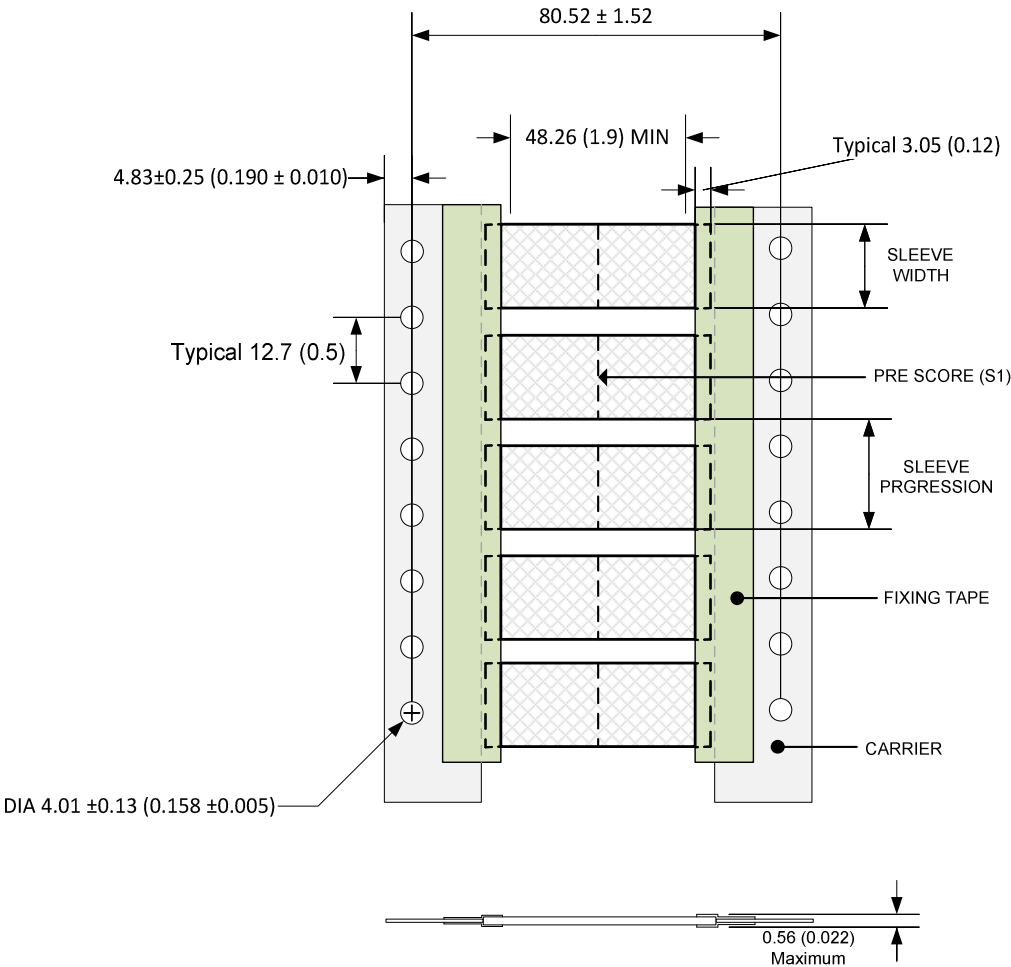
The product shall be supplied in one of the following formats:

- HT-SCE As shown in figure 1 to the dimensions of Table 1.
- HT-CT Continuous tubing to the dimensions of Table 1.

RW-2512



5    FIGURE 1: HT-SCE SLEEVE FORMAT



Dimensions in mm (inch)

# RW-2512



Heat Shrink Product in as Supplied "D" (Expanded) and in the Recovered State "d".

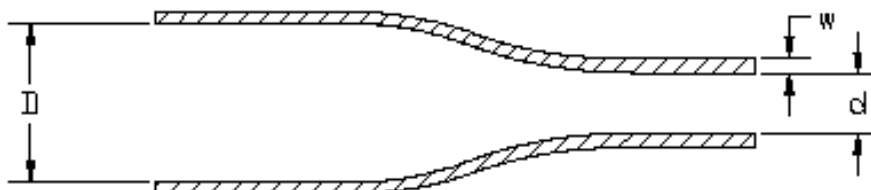


Figure 2. Product Dimensions Change During Recovery

## 6 DIMENSIONS

| HT-SCE and HT-CT |                                              |                                               |                                           |                                            |                                             |                                                    |
|------------------|----------------------------------------------|-----------------------------------------------|-------------------------------------------|--------------------------------------------|---------------------------------------------|----------------------------------------------------|
| Part Description | Minimum Supplied Inside Diameter mm (inches) | Maximum Recovered Inside Diameter mm (inches) | Wall Thickness after Recovery mm (inches) | Minimum Sleeve Flattened Width mm (inches) | Sleeve Progression <sup>1</sup> mm (inches) | Nominal Weight of single sleeve (~50mm long) grams |
| HT-SCE-3/32      | 2.36<br>(0.093)                              | 0.79<br>(0.031)                               | 0.38 ± 0.08<br>(0.015 ± 0.003)            | 4.32<br>(0.17)                             | 12.70 ± 0.64<br>(0.500 ± 0.025)             | 0.14                                               |
| HT-SCE-1/8       | 3.18<br>(0.125)                              | 1.58<br>(0.0625)                              | 0.38 ± 0.08<br>(0.015 ± 0.003)            | 5.84<br>(0.23)                             | 12.70 ± 0.64<br>(0.500 ± 0.025)             | 0.21                                               |
| HT-SCE-3/16      | 4.75<br>(0.187)                              | 2.38<br>(0.0935)                              | 0.38 ± 0.08<br>(0.015 ± 0.003)            | 8.00<br>(0.315)                            | 12.70 ± 0.76<br>(0.500 ± 0.030)             | 0.29                                               |
| HT-SCE-1/4       | 6.35<br>(0.250)                              | 3.18<br>(0.1250)                              | 0.38 ± 0.08<br>(0.015 ± 0.003)            | 10.7<br>(0.42)                             | 16.94 ± 0.89<br>(0.667 ± 0.035)             | 0.38                                               |
| HT-SCE-3/8       | 9.53<br>(0.375)                              | 4.76<br>(0.1875)                              | 0.38 ± 0.08<br>(0.015 ± 0.003)            | 15.49<br>(0.61)                            | 25.40 ± 0.89<br>(1.000 ± 0.035)             | 0.53                                               |
| HT-SCE-1/2       | 12.70<br>(0.500)                             | 6.35<br>(0.250)                               | 0.38 ± 0.08<br>(0.015 ± 0.003)            | 20.3<br>(0.80)                             | 29.64 ± 1.00<br>(1.167 ± 0.040)             | 0.73                                               |
| HT-SCE-3/4       | 19.05<br>(0.750)                             | 9.53<br>(0.3750)                              | 0.38 ± 0.08<br>(0.015 ± 0.003)            | 30.5<br>(1.20)                             | 42.34 ± 1.00<br>(1.667 ± 0.040)             | 1.30                                               |
| HT-SCE-1         | 25.40<br>(1.000)                             | 12.70<br>(0.500)                              | 0.43 ± 0.10<br>(0.017 ± 0.004)            | 40.4<br>(1.59)                             | 50.80 ± 1.00<br>(2.000 ± 0.040)             | 1.61                                               |
| HT-SCE-1-1/2     | 38.10<br>(1.500)                             | 19.05<br>(0.750)                              | 0.43 ± 0.10<br>(0.017 ± 0.004)            | 60.2<br>(2.37)                             | 71.96 ± 1.00<br>(2.833 ± 0.040)             | 2.51                                               |

Table 1. Product dimensions

<sup>1</sup> Sleeve progression column is applicable only for ladder format



## 7. TEST REQUIREMENTS

This specification details the requirements for the HT family of products. Table 4 lists the general requirements and Table 5 lists the specific performance.

## 8. TEST METHODS

### 8.1. Preparation of Test Specimens

When required by the test procedure, product shall be printed using printers and ribbons specified by TE Connectivity. The full list can be found in TE document 411-121005 'TE Identification Printer Product Ribbon Matrix'.

Print random characters onto the sleeving to within approximately 6mm (1/4 inch) of both ends using font type Arial 10 bold. Markers are to be removed from the carrier (non-continuous products) or cut/perforated and separated using TE approved printer systems (HT-CT) before testing. Test in 'fully recovered' form.

The marking shall be examined for legibility in accordance with TE Document 411-121002 Print Contrast Reference Scale. The initial print contrast must be 8 or above.

As required, sleeves or tubing should be recovered by placing them in a forced air oven for 3 minutes at 200±5°C. Specimens will be removed from the oven and allow to cool to 23±3°C for at least 4 hours before continuing. Where required by the test method, testing shall be done on continuous tubing (D-SCE-FLAT). No pre-conditioning period is required prior to testing except where specified.

Unless otherwise specified, all tests shall be made at a temperature of 23±2°C.

### 8.2. Workmanship

Visually examine three samples for workmanship using normal vision and without magnification. Check for flaws, defects, pinholes, bubbles, seams, cracks or inclusions. The visual examination should be made with the specimen placed inside a laboratory light box with D65 illumination.

Measure the colour of as received sleeves before any printing using a spectrophotometer. Measure and record values for  $L^*a^*b^*$  using the 3mm aperture and D65 illuminance. Colour results are recorded for information only.

### 8.3. Print Performance

#### 8.3.1. Mark Adherence

Three fully recovered sleeves shall be prepared as detailed in Clause 8.1 and tested in accordance with TE 109-121012. Samples shall be tested using a Crockmeter fitted with an eraser and 1kg load using the number of rubs specified in the requirement table.

After the Mark Adherence test, the marking shall be examined for legibility using normal reading vision. Print contrast shall be evaluated in accordance with TE 411-121002.

#### 8.3.2. Solvent Resistance

Nine fully recovered sleeves shall be prepared as detailed in Clause 8.1 and tested in accordance with TE 109-121014.

The marking shall be examined for legibility using normal reading vision. Print contrast shall be evaluated in accordance with TE 411-121002



### 8.3.3. Fluid Resistance, Mark Permanence

The test method shall be as specified in TE 109-121039. Prepare three fully recovered markers as detailed in Clause 8.1. Markers shall be completely immersed in each of the fluids for the times and at the temperatures specified in the requirements table. The volume of the fluid shall not be less than 20 times that of the specimen. After immersion, the markers are lightly blotted with tissue paper to remove excess surface fluid and air dried at  $23\pm 2^{\circ}\text{C}$  for  $45\pm 15\text{min}$ . Samples are tested with a Crockmeter fitted with 'Super Twill' cloth and a 1kg load.

Additional testing in IPA is required using three as received and three fully recovered markers as detailed in Clause 8.1. Load the Super Twill' cloth with IPA and test for mark permanence as detailed in TE 108-121-012.

After the print permanence test, marking shall be examined for legibility using normal reading vision. Print contrast shall be evaluated in accordance with TE 411-121002.

## 8.4. Physical Testing

### 8.4.1. Dimensions and Longitudinal Change

The test method shall be as specified in TE 109-121003.

Three 50mm long marker sleeves shall be tested for inside diameter, and a further three 150mm long sleeves taken from a continuous reel shall be tested for Longitudinal Change. For Longitudinal Change, two gauge marks shall be positioned 100mm apart on each sleeve. The markers shall be recovered in a fan assisted air-circulating oven using the details given in 8.1 and the distance between gauge lengths and inside diameter of each shall be measured, after cooling to room temperature. The longitudinal change shall be expressed as a percentage of the original gauge length. The minimum and maximum recovered wall thickness shall be determined.

### 8.4.2. Tensile Strength and Ultimate Elongation

The test method shall be as specified in TE 109-121002. Test five recovered tubular specimens 125mm long. An initial jaw separation of 50mm with a gauge length of 20mm and rate of jaw separation of  $100\pm 5\text{mm}$  per minute shall be used.

### 8.4.3. Specific Gravity

Samples of un-printed product shall be tested to the procedure as specified in TE 109-121015. Three specimens of fully recovered tubing 25mm long should be tested. Test specimens should be prepared to prevent trapping of air.

### 8.4.4. Split Testing

The test method shall be as specified in TE 109-121031. Ten perforated or scored marker sleeves should be tested. Samples should be recovered, onto pre-heated mandrel for at the time and temperature stated in the test method. Samples should be examined for splitting after cooling to  $23\pm 2^{\circ}\text{C}$  as specified in section 8.1.



## **8.5. Thermal Testing**

### **8.5.1. Heat Shock**

The test method shall be as specified in TE 109-121007. Six sleeves shall be prepared as detailed in section 8.1. Specimens shall be conditioned for 4 hours at  $275\pm 2^{\circ}\text{C}$  ( $437\pm 5^{\circ}\text{F}$ ) in an air circulating oven. Remove the markers and leave to cool to room temperature for a minimum of 2 hours at  $23\pm 2^{\circ}\text{C}$  ( $73\pm 5^{\circ}\text{F}$ ).

After conditioning three samples shall be tested for Mark Adherence in accordance with section 8.3.1.

The marking shall be examined for legibility using normal reading vision. Print contrast shall be evaluated in accordance with TE 411-121002.

The three remaining samples shall be tested for resistance to bending. Mandrel diameter for HT-SCE-6.4 size tubing is 19.1mm.

### **8.5.2. Heat Ageing**

The test method shall be as specified in TE 109-121008. Six sleeves shall be prepared as detailed in section 8.1. Specimens shall be conditioned for 168 hours at  $225\pm 2^{\circ}\text{C}$  ( $302\pm 5^{\circ}\text{F}$ ) in an air circulating oven. Markers shall be removed and allowed to cool to room temperature for a minimum of 4 hours at  $23\pm 2^{\circ}\text{C}$  ( $73\pm 5^{\circ}\text{F}$ ).

After conditioning three samples shall be tested for Mark Adherence, in accordance with section 8.3.1.

The marking shall be examined for legibility using normal reading vision. Print contrast shall be evaluated in accordance with TE 411-121002. The remaining three samples shall be tested for resistance to bending. Mandrel diameter for HT-SCE 6.4 size tubing is 19.1mm.

### **8.5.3. Low Temperature Flexibility**

The test method shall be as specified in TE 109-121006. Six fully recovered sleeves shall be prepared as detailed in section 8.1. Specimens shall be conditioned for 4 hours at  $-55\pm 2^{\circ}\text{C}$  in a cold chamber. After conditioning, and whilst still at  $-55\pm 2^{\circ}\text{C}$ , half of the samples shall be immediately tested for resistance to bending. Mandrel diameter for HT-SCE 6.4 size tubing is 19.1mm.

Three of each of the remaining markers shall be removed from the cold chamber and allowed to return to room temperature for a minimum of 2 hours at  $23\pm 2^{\circ}\text{C}$ . Samples shall be tested for Mark Adherence in accordance with section 8.3.1. The marking shall be examined for legibility using normal reading vision. Print contrast shall be evaluated in accordance with TE 411-121002.

### **8.5.4. Thermal Cycling**

The test method shall be as specified in TE 109-121057. Six recovered samples should be prepared for testing as detailed in section 8.1. Specimens shall be conditioned for six cycles of thirty minutes at  $-196\pm 5^{\circ}\text{C}$  and then thirty minutes at  $200\pm 5^{\circ}\text{C}$  in an air circulating oven. After the final cycle remove the markers and leave to cool to room temperature for a minimum of 2 hours at  $23\pm 2^{\circ}\text{C}$ .

Three samples shall be tested for Mark Adherence in accordance with TE 108-121012. The marking shall be examined for legibility using normal reading vision. Print contrast shall be evaluated in accordance with TE 411-121002.

The three remaining samples shall be tested for resistance to bending. Mandrel diameter for HT-SCE 6.4 size tubing is 19.1mm.

## RW-2512



### 8.6. Environmental Testing

#### 8.6.1. Copper Mirror Corrosion

The test method shall be as specified in TE 109-121009. Three glass test tubes should be used. Prepare one control tube with copper mirror only, and two tubes with mirrors and printed product. Prepare samples out of recovered specimens, using at least 150mm<sup>2</sup> surface area of product in each tube. Use a printed sample 10mm long. After the test, mirrors should be assessed for corrosion.

#### 8.6.2. Water Absorption

The test method shall be as specified in TE 109-121016. Three 25mm long helical samples should be cut from recovered printed tubing specimens. Samples should be weighed after drying in the oven and after immersion in water. The mean average of three samples should be stated.

#### 8.6.3. UV Resistance

The test shall be carried out using a UV-O-meter chamber in accordance with ASTM G154. Test for 1000 hours at 1.35 W/m<sup>2</sup>/nm irradiance.

Prepare six printed, recovered samples for testing.

Condition two sets of markers prepared as specified in section 8.1 to the following regimes:

- i) UVA type fluorescent bulbs, consisting of a repeating cycle of 8 hours exposure at 60±2°C (140°F) followed by 4 hours of condensation at 50±2 °C (122°F).
- ii) UVB type fluorescent bulbs, consisting of a repeating cycle of 8 hours exposure at 60±2°C (140°F) followed by 4 hours of condensation at 50±2 °C (122°F).

After conditioning test half of the sleeves for flexibility using a 90° mandrel bend test. Mandrel diameter for HT-SCE 6.4 size tubing is 19.1mm. Samples shall be visually examined for cracking or splitting.

The remainder of the samples shall be measured for Test Mark Adherence in accordance with section 8.3.1. The marking shall be examined for legibility using normal reading vision. Print contrast shall be evaluated in accordance with TE 411-121002.

#### 8.6.4 Vacuum Outgassing

Recover three finished markers for 3 minutes at 200±5°C (392±9°F) and test for percent total weight loss and percent volatile condensable materials. The conditions for testing are: Exposure time, 24 hours; sample temperature, 130±2°C (266 ± 4°F); condensing surface temperature, 18±3°C (64±5°F); and pressure, not greater than 1 x 10<sup>-5</sup> Torr. The vacuum shall be provided by a diffusion pump and a liquid nitrogen trap. The apparatus shall consist of a glass sample chamber, refluxing liquid heat source and a polished stainless steel plate in close contact with a copper cold finger cooled internally by circulating water. The axis of the exit of the sample chamber shall be perpendicular to and approximately 7 mm from the cooled condensing plate. Use a micro balance to weigh the specimens before and after conditioning and calculate total weight loss. Weigh the condensing plate before and after to calculate percent volatile condensable material.



## **8.7. Electrical Testing**

### **8.7.1. Dielectric strength**

The test method shall be as specified in TE 109-121005. Five printed 150mm long specimens to be recovered onto clean steel mandrels (ensuring a tight fit) 24 hours before testing. A 25mm wide aluminium self-adhesive foil electrode to be installed in the centre of each of the recovered and cooled down samples. Average dielectric strength of five samples to be recorded as the result.

### **8.7.2. Volume Resistivity**

The test method shall be as specified in TE 109-121017. Three 200-250mm long printed specimens are to be recovered onto clean 300mm long, steel mandrels (no larger in diameter than 15% of the fully recovered diameter of the tested tubing). Each sample should have a 150mm long silver paint electrode painted a minimum 4 hours before testing. Average volume resistivity value should be recorded as the result.

## **8.8. Fire Safety**

### **8.8.1. Fire Propagation, ASTM D2671 Procedure B**

Five printed samples shall be prepared and tested in accordance with TE method 109-121053. 460mm long samples should be installed onto 530mm long mandrels. Each sample should have a paper flag indicator 250mm above the flame impingement point. The flame should be applied to the sample at a 70° angle. The flame should be applied five times; each application is 15s on and 15s off.

The duration of burning and percentage of the burnt area shall be recorded.

### **8.8.2. EN45545-2 Flammability Hazard Level, Oxygen Index, BS EN ISO 4589-2**

The test method shall be as specified in TE 109-121054. Tests shall be carried out on 3mm thick plaques of the material from which the sleeving is fabricated. The plaque should be irradiation cross-linked to the same degree as the sleeving. Test piece dimensions shall be  $6.5 \pm 0.5\text{mm} \times 80 \pm 1\text{mm} \times 3 \pm 0.5\text{mm}$  cut from the plaques. Samples shall be conditioned for at least 24hrs at  $23 \pm 2^\circ\text{C}$  ( $73 \pm 5^\circ\text{F}$ ) prior to testing. A new test piece shall be used for each determination.

### **8.8.3. Surface Flammability, Flame Spread Index, Is, ASTM E162**

This test is performed in accordance with ASTM E162, with the following modification: Instead of testing a moulded plaque, 25.4mm continuous tubing printed with two lines of text is used.

To arrange the samples to form the specified exposed area, 13mm wide cement board fingers are cut from a single board. Six 75mm lengths are cut from the tube, which is then recovered over the cut cement board fingers. The cement board fingers are butted together to form a single sheet. Five single sheets are placed side by side vertically for each test to create the required test specimens. Samples are conditioned for at least 24 hours at  $23 \pm 2^\circ\text{C}$  ( $73 \pm 5^\circ\text{F}$ ) before fire testing.



**8.8.4. Smoke Optical Density, Ds, ASTM E662**

This test is performed in accordance with ASTM E662, with the following modification: Instead of testing a moulded plaque, 25.4mm continuous tubing printed with two lines of text is used.

To arrange the samples to form the specified exposed area, 13mm wide cement board fingers are cut from a single board. Six 75mm lengths are cut from the tube, which is then recovered over the cut cement board fingers. The cement board fingers are butted together to form a single sheet. Samples are conditioned for at least 24 hours at  $23\pm 2^{\circ}\text{C}$  ( $73\pm 5^{\circ}\text{F}$ ) before fire testing. Testing is carried out using an NBS smoke chamber with a  $25\text{kW/m}^2$  radiant heat. Tests are carried out with and without a pilot flame.

**8.8.5. Heat Release, ASTM E1354**

This test is performed in accordance with ASTM E1354, with the following modification: Instead of testing moulded plaques, 25.4mm continuous tubing which has been printed with two lines of text is used.

To arrange the samples to form the specified exposed area, 13mm wide cement board fingers are cut from a single board. Six 75mm lengths are cut from the tube, which is then recovered over the fingers. The cement board fingers are butted together to form a single sheet. Samples are conditioned for at least 24 hours at  $23\pm 2^{\circ}\text{C}$  ( $73\pm 5^{\circ}\text{F}$ ) before fire testing.

Samples are tested using a  $50\text{kW/m}^2$  heat flux. Average Heat Release Rate, Maximum (peak) heat release rate and Average Specific Extinction Area at 3 minutes is measured.

**8.8.6. Toxic Gas Generation, Bombardier SMP 800-C**

This test is performed in accordance with Bombardier SMP 800-C, with the following modification: Instead of testing a moulded plaque, 25.4mm continuous tubing printed with two lines of text is used to represent end use condition.

To arrange the samples to form the specified exposed area, 13mm wide cement board fingers are cut from a single board. Six 75mm lengths are cut from the tube, which is then recovered over the cut cement board fingers. The cement board fingers are butted together to form a single sheet. Samples are conditioned for at least 24 hours at  $23\pm 2^{\circ}\text{C}$  ( $73\pm 5^{\circ}\text{F}$ ) before fire testing.

SMP 800-C is carried out during the ASTM E662 test. Gases are extracted and analysed using the techniques described in SMP 800-C



## 9. RELATED DOCUMENTS

### 9.1. Related Standards and Issue

|                             |                                                                                                                                                                                               |
|-----------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ASTM D2671: 1999            | Standard Test Methods for Heat-Shrinkable Tubing for Electrical Use                                                                                                                           |
| ASTM G-154-12a              | Standard plastics for operating light and water exposure apparatus (fluorescent UV condensation type) for exposure of non-metallic materials.                                                 |
| AMS-DTL-23053E              | Insulating Sleeving, Electrical, Heat Shrinkable, General Specification for Marking of Electrical Insulation Materials.                                                                       |
| BS 4G 198-3: 1999           | Sleeves and moulded components for aircraft electric cables and equipment wires. Specification for heat shrinkable sleeving for binding, insulation and identification                        |
| BS 6853:1999                | Code of Practice for Fire Precautions In The Design and Construction of Passenger Carrying Trains                                                                                             |
| IEC 60684-2: 1997           | Flexible insulating sleeving - Part 2: Methods of test                                                                                                                                        |
| BS EN ISO 4589-2: 1996      | Plastics – Determination of burning behaviour by oxygen index - Part 2: Ambient temperature test                                                                                              |
| NF X 70 – 100: 1986         | Fire Tests Analysis of Pyrolysis and Combustion Gases Tube Furnace Method                                                                                                                     |
| NF F 16-101: 1988           | Railway Rolling stock fire behaviour choice of materials<br>Rolling Stock Classification A1                                                                                                   |
| DIN 5510-2: 2009-05         | Preventive fire protection in railway Vehicles-Part 2 Fire behaviour and fire side effects of materials and parts; classification, requirements and test methods. Dripping Classification ST2 |
| BS EN 45545-2: 2013+A1:2015 | Railway applications- Fire protection on railway vehicles                                                                                                                                     |
| SAE AS5942: 2014            | Marking of Electrical Insulating Materials                                                                                                                                                    |

**Table 2. Details of related standards**



## 9.2. Table 3: TE Connectivity Documents

| TE Reference | Title                                                    | Complies with           |
|--------------|----------------------------------------------------------|-------------------------|
| 411-121002   | TE Connectivity Print contrast reference scale           | ---                     |
| 411-121005   | TE Identification Printer Product Ribbon Matrix          | ---                     |
| 109-121002   | Tensile Strength and Ultimate Elongation at 23°C         | ASTM D2671              |
| 109-121003   | Dimensions                                               | ---                     |
| 109-121005   | Dielectric strength                                      | ASTM D2671 (ASTM D149)  |
| 109-121006   | Low Temperature Flexibility                              | IEC 60684-2             |
| 109-121007   | Heat Shock                                               | SAE-AS-23053 ASTM D2671 |
| 109-121008   | Heat Ageing                                              | SAE-AS-23053 ASTM D2671 |
| 109-121009   | Copper Mirror Corrosion                                  | AMS DTL 23053           |
| 109-121012   | Print Permanence testing using the Mechanical Crockmeter | SAE AS5942              |
| 109-121014   | Resistance to Solvents                                   | MIL 202 Method 215      |
| 109-121015   | Specific Gravity                                         | ASTM D792               |
| 109-121016   | Water Absorption                                         | ASTM D570               |
| 109-121017   | Volume Resistivity                                       | ASTM D2671 ASTM D257    |
| 109-121031   | Split Testing                                            | ---                     |
| 109-121039   | Fluid Immersion Testing at Room Temperature              | ---                     |
| 109-121053   | Flammability testing                                     | ASTM D2671, procedure B |
| 109-121054   | Limited Oxygen Index                                     | BS EN ISO 4589-2:1999   |
| 109-121057   | Thermal Cycling using liquid Nitrogen                    | ---                     |

The current document issue should be used and reference made in the qualification report

## RW-2512



### 10. SAMPLING

Tests shall be carried out on a sample taken at random from a batch. A batch is defined as that quantity of product extruded at any one time.

Testing frequency shall be Production Routine or Qualification.

Production routine tests consisting of visual examination, dimensions and longitudinal change, print quality and adherence of marking shall be carried out on every batch of sleeving.

Qualification tests shall be carried out to the requirements of the Design Authority.

### 11. STORAGE CONDITIONS

HT-SCE should be stored in its original packaging, with any plastic covers which were included during shipping. Store out of direct sunlight in a clean, dry, dust free, environment. Product should not be stored outside of the designed storage temperature, which is -10°C (14°F) to 40°C (104°F), and 50±30% RH.

### 12. PACKAGING

Packaging shall be in accordance with good commercial practice. Each package shall bear an identification label showing material quantity, description, size, color and batch number. Additional information shall be supplied as specified in the contract or order

### 13. STORAGE LIFE<sup>2</sup>

When stored as prescribed above, the shelf life of HT-SCE is 144 months from date of manufacture.

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<sup>2</sup> Storage life is a guideline based on 30 years of experience. TE Connectivity cannot provide any test data to validate this statement.

## 7 TABLE 4: GENERAL REQUIREMENTS FOR IDENTIFICATION PRODUCTS

| PROPERTY                                                                                                                                                                                                                                                                                                                                                                                                 | TEST METHOD                                                                                                                                                                                                       | UNITS                                          | REQUIREMENTS                                                                                                              | RW-2512 SECTION                                      |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------|
| <b>PRINT PERFORMANCE</b>                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                   |                                                |                                                                                                                           |                                                      |
| <b>Print Quality</b>                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                   |                                                | Legible, minimum print contrast C8                                                                                        | 8.1.                                                 |
| <b>Mark Adherence</b>                                                                                                                                                                                                                                                                                                                                                                                    | TE 109-121012<br>100 rubs, 1kg load, eraser                                                                                                                                                                       | ---                                            | Legible, minimum print contrast C3                                                                                        | 8.3.1.                                               |
| <b>Solvent Resistance</b><br><br>Solution A<br>Solution B<br>Solution C                                                                                                                                                                                                                                                                                                                                  | TE Document 109-121014<br><br>100 strokes, tooth brush                                                                                                                                                            | ---                                            | Legible, minimum print contrast C3                                                                                        | 8.3.2.                                               |
| <b>Fluid Resistance, Mark Permanence</b><br><br>Reference test oil IRM 902<br><br>MIL-PRF-23699 lubricating oil<br><br>Skydrol LD-4 phosphate ester hydraulic fluid<br><br>MIL-H-83282 hydraulic fluid<br><br>JP8 jet fuel<br><br>Diesel fuel<br><br>Propylene glycol de-icing fluid 50/50<br><br>Tap water<br><br>5% Sodium chloride solution<br><br>1% Teepol detergent<br><br>Isopropyl alcohol (IPA) | TE 109-121039<br><br><br><br><br><br><br><br><br><br>24 hours' immersion at 23±2°C, followed by 20 wipes at 1kg load<br><br><br><br><br><br><br><br><br><br>TE108-121012<br>20 cycles, soaked "Super Twill" cloth | ---<br><br><br><br><br><br><br><br><br><br>--- | Legible, minimum print contrast C3 <sup>1</sup><br><br><br><br><br><br><br><br><br><br>Legible, minimum print contrast C3 | 8.3.3.<br><br><br><br><br><br><br><br><br><br>8.3.3. |

<sup>1</sup>For optimum performance black ribbon should be used where possible, see 411-121005. White and silver ribbons do not fully meet these requirements in harsher fluids; for example Skydrol LD-4, Diesel and JP-8.



| PROPERTY                                                                        | TEST METHOD                                                                                                                                                        | UNITS  | REQUIREMENTS                                                                                                    | RW-2512 SECTION |
|---------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|-----------------------------------------------------------------------------------------------------------------|-----------------|
| PHYSICAL TESTING                                                                |                                                                                                                                                                    |        |                                                                                                                 |                 |
| Workmanship                                                                     | Laboratory light box with D65 lighting, using normal or corrected vision at 14 inches.                                                                             | ---    | In accordance with section 8.2                                                                                  | 8.2.            |
| Dimensions                                                                      | TE 109-121003                                                                                                                                                      | mm     | Table 1                                                                                                         | 8.4.1.          |
| Longitudinal Change                                                             | TE 109-121003                                                                                                                                                      | %      | 20 maximum                                                                                                      | 8.4.1.          |
| Tensile Strength                                                                | TE 109-121002                                                                                                                                                      | MPa    | 24.1 minimum                                                                                                    | 8.4.2.          |
| Ultimate Elongation                                                             | TE 109-121002                                                                                                                                                      | %      | 200 Minimum                                                                                                     | 8.4.2.          |
| Specific Gravity                                                                | TE 109-121015                                                                                                                                                      | ---    | 1.80 Maximum                                                                                                    | 8.4.3.          |
| Split Test                                                                      | TE 109-121031                                                                                                                                                      | %      | 100 minimum                                                                                                     | 8.4.4           |
| THERMAL TESTING                                                                 |                                                                                                                                                                    |        |                                                                                                                 |                 |
| Heat Shock<br>4 hours at 275±3°C<br>Mandrel Bend<br>Mark Adherence              | TE 109-121007                                                                                                                                                      | ---    | No damage to the marker and print                                                                               | 8.5.1.          |
|                                                                                 | TE 109-121012<br>50 rubs, 1kg load, eraser                                                                                                                         |        | Legible, minimum print contrast C3                                                                              |                 |
| Heat Ageing<br>168hrs at 225±2°C<br>Mandrel Bend<br>Mark Adherence              | TE 109-121008                                                                                                                                                      | ---    | No damage to the marker and print                                                                               | 8.5.2.          |
|                                                                                 | TE 109-121012<br>50 rubs, 1kg load, eraser                                                                                                                         |        | Legible, minimum print contrast C3                                                                              |                 |
| ENVIRONMENTAL TESTING                                                           |                                                                                                                                                                    |        |                                                                                                                 |                 |
| Copper Mirror Corrosion<br><br>16 Hours at 200°C                                | TE 109-121009                                                                                                                                                      | %      | Damaged area of copper mirror, 8 maximum                                                                        | 8.6.1.          |
| Water Absorption                                                                | TE 109-121016                                                                                                                                                      | %      | 1 Maximum                                                                                                       | 8.6.2.          |
| UV Resistance<br>followed by,<br><br><br>Mandrel Bend<br><br><br>Mark Adherence | ASTM G154<br>UVA and UVB<br>(8 hours dry/4 hours wet cycle)<br><br>360°bend around a mandrel<br>(10 x thickness)<br><br>TE 109-121012<br>20 rubs, 1kg load, eraser |        | 1000 hours at each irradiance<br><br>No damage to the marker and print<br><br>Legible, minimum print contrast 3 | 8.6.3.          |
| ELECTRICAL                                                                      |                                                                                                                                                                    |        |                                                                                                                 |                 |
| Dielectric Strength                                                             | TE 109-121005                                                                                                                                                      | kV/mm  | 23.6 Minimum                                                                                                    | 8.7.1.          |
| Volume Resistivity                                                              | TE 109-121017                                                                                                                                                      | Ohm cm | 1 x 10 <sup>12</sup> Minimum                                                                                    | 8.7.2.          |

# RW-2512

CLASS 1- Public



| PROPERTY                                                                                                                                                         | TEST METHOD                                                                                      | UNITS                                                                | REQUIREMENTS                                                                                                                                             | RW-2512 SECTION |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|----------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| <b>FIRE SAFETY</b>                                                                                                                                               |                                                                                                  |                                                                      |                                                                                                                                                          |                 |
| <b>Fire Propagation,</b><br>ASTM D2671 Procedure B                                                                                                               | TE 109-121053<br>ASTM D2671 procedure B                                                          | ---                                                                  | Burn time shall not exceed 30 seconds, and not more than 25% of indicator flag shall be burned or charred. No dripping or flowing. No burning of cotton. | 8.8.1.          |
| <b>EN45545-2 Flammability Hazard rating:</b><br><br>BS EN ISO 4589-2<br>Oxygen Index (OI),                                                                       | <br><br>BS EN ISO 4589-2<br>TE 109-121054                                                        | %                                                                    | Requirement set R24<br>Hazard Level Classification 3 <sup>3</sup><br><br>32% Minimum                                                                     | 8.8.2.          |
| <b>Surface Flammability,</b><br><br>Flame Spread Index (Is)                                                                                                      | ASTM E 162                                                                                       | ---                                                                  | 35 Maximum                                                                                                                                               | 8.8.3.          |
| <b>Specific Optical Smoke Density, Ds</b><br><br>Flaming Mode<br>1.5 minutes<br>4 minutes<br><br>Flaming Mode<br>1.5 minutes<br>4 minutes                        | ASTM E 662<br>25kW/m <sup>2</sup> radiant heat source.<br><br>Flaming mode and non-flaming mode. |                                                                      | 100 Maximum<br>200 Maximum<br><br>100 Maximum<br>200 Maximum                                                                                             | 8.8.4.          |
| <b>Heat Release<sup>4</sup></b><br><br>Average Heat Release Rate (180 s)<br><br>Maximum (Peak) Heat Release Rate<br><br>Average specific extinction area (180 s) | ASTM E1354<br><br>50kWm <sup>2</sup> applied heat flux with retainer frame                       | kW/m <sup>2</sup><br><br>kW/m <sup>2</sup><br><br>m <sup>2</sup> /kg | ≤ 120<br><br>Over course of test<br>≤ 140<br><br>≤ 500                                                                                                   | 8.8.5.          |

<sup>3</sup> R22 / HL3 supports unlimited internal use, in any operating category and rail car design.

<sup>4</sup> There is currently no requirement for Heat Release testing. TE have incorporated proposed changes to existing FRA 49 CFR Ch. II, Part 238, App. B as recommended by the National Association of State Fire Marshals



| PROPERTY                                            | TEST METHOD                                                                   | UNITS | REQUIREMENTS | RW-2512 SECTION |
|-----------------------------------------------------|-------------------------------------------------------------------------------|-------|--------------|-----------------|
| <b>Toxic Gas Generation</b><br>Bombardier BMS 800-C |                                                                               |       | Maxima:      | 8.8.6.          |
| Carbon Monoxide (CO)                                | Gas extracted during ASTM E662 test. 25kW/m <sup>2</sup> radiant heat source. | ppm   | 3500         |                 |
| Carbon Dioxide (CO <sub>2</sub> )                   |                                                                               |       | 90000        |                 |
| Nitrogen Oxides (NO <sub>2</sub> )                  |                                                                               |       | 100          |                 |
| Sulphur Dioxide (SO <sub>2</sub> )                  | Flaming mode and non-flaming mode assessed, worst case reported.              |       | 100          |                 |
| Hydrogen Chloride (HCl)                             |                                                                               |       | 500          |                 |
| Hydrogen Fluoride (HF)                              |                                                                               |       | 100          |                 |
| Hydrogen Bromide (HBr)                              |                                                                               |       | 100          |                 |
| Hydrogen Cyanide (HCN)                              |                                                                               |       | 100          |                 |

## 8 SPECIFIC REQUIREMENTS FOR HT-SCE HEAT SHRINK SLEEVING

| PROPERTY                                                                                                                                      | TEST METHOD                                                                                                                                                                 | UNITS  | REQUIREMENTS               | RW-2512 SECTION |
|-----------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|----------------------------|-----------------|
| <b>THERMAL</b>                                                                                                                                |                                                                                                                                                                             |        |                            |                 |
| <b>Temperature cycling:</b><br>6 cycles of:<br>0.5hr at -196±5°C (-321±9°F)<br>0.5hr at 200±5°C (392±5°F)<br>Followed by<br>Print performance | IEWI-046<br><br>IEWI-012                                                                                                                                                    | %      | 50 minimum, legible        | 8.5.4           |
| <b>ENVIRONMENTAL</b>                                                                                                                          |                                                                                                                                                                             |        |                            |                 |
| <b>Vacuum Outgassing</b><br>TML (Total Mass Loss)<br>VCM (Volatile Condensable Material)                                                      | ASTM E 595<br>Exposure time, 24hr<br>sample temp. 130±2°C (266±4°F);<br>Condensing surface temp. 18±3°C (64±5°F);<br>and pressure, not greater than 1x10 <sup>-5</sup> Torr | %<br>% | 1.0 Maximum<br>0.1 Maximum | 8.6.4           |

Table 5. Specific Test Requirements for HT-SCE product range



## 9 TEST FLUIDS DESCRIPTION

| Fluid                                             | Description                                                                                                                           |
|---------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------|
| IRM902                                            | Reference Oil (replacement for ASTM oil NO. 2)                                                                                        |
| MIL-PRF-23699                                     | Synthetic lubricating oil STD class (NATO Code 0-156). Has replaced MIL-L-7808 oil at temperatures above 25°C.                        |
| Skydrol LD-4                                      | Widely used aviation phosphate ester based hydraulic fluid.                                                                           |
| MIL-H-83282                                       | The principal hydraulic fluid used in military aircraft. It replaces MIL-H-5606.                                                      |
| JP-8                                              | Kerosene based jet fuel, replacement for JP-4. NATO code is F-34. It's specified by MIL-DTL-83133 and British Defence Standard 91-87. |
| Diesel Fuel<br>(BS EN 590:2009+A1)                | General fuel used in transportation                                                                                                   |
| Propylene Glycol de-icing<br>fluid (SAE-AMS-1424) | Aerospace De-icing fluid, 50/50 % mixture with water                                                                                  |
| Tap Water                                         | Universal solvent                                                                                                                     |
| 5% Sodium chloride solution                       | Sodium chloride is a universal compound used in many chemicals and de-icing fluids                                                    |
| Detergent (1% Teepol)                             | Commonly used industrial detergent                                                                                                    |
| IPA - Isopropyl alcohol                           | Widely used as a solvent and cleaner                                                                                                  |

**Table 6: Description of Test Fluids**

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