DM.TEC Reference: 108-121015
Issue No.: 07
Issue Date: May 2019

CLASS 1: PUBLIC
(See TE Policy TEC-02-04)

SPECIFICATION RW-2512

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

SCOPE

This specification establishes the quality standard for heat-shrinkable identification marker sleeves for use in applications where high temperature performance or where extreme resistance to cleaning solvents is required. They are also used in space applications where low outgassing is critical. These special requirements are detailed in Table 5.

The operating temperature for this product is -55℃ to +225℃ (-67 to +437℉).

This system is a computerised method of identifying items by printing a mark on HT-SCE and HT-CT product ranges which is permanent upon printing. This system is not recommended where strain relief properties are required.

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

The marker system comprises specific printers and ribbons; refer to TE Connectivity (TE) document 411-121005 ‘TE Identification Printer Product Ribbon Matrix’. Compliance to this specification can only be guaranteed if TE Connectivity approved printers and ribbons are used. All ribbons used must have an expiry date which exceeds the testing period. Products printed with white or silver ribbons may not fully comply with this specification when exposed to some aggressive fluids as detailed in **Table 4** (Page 13).

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

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2. COMPOSITION, APPEARANCE AND COLOR

The marker sleeves shall be fabricated from irradiated, thermally-stabilised polyvinylidene compound. It shall be homogeneous and essentially free from flaws, defects, pinholes, bubbles, seams, cracks or inclusions. The marker sleeves shall be white or yellow, other colours available on request.

3. DIMENSIONS

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

I. HT-SCE As shown in figure 1 to the dimensions of Table 1.
II. HT-CT As shown in figure 2 to the dimensions of Table 1.

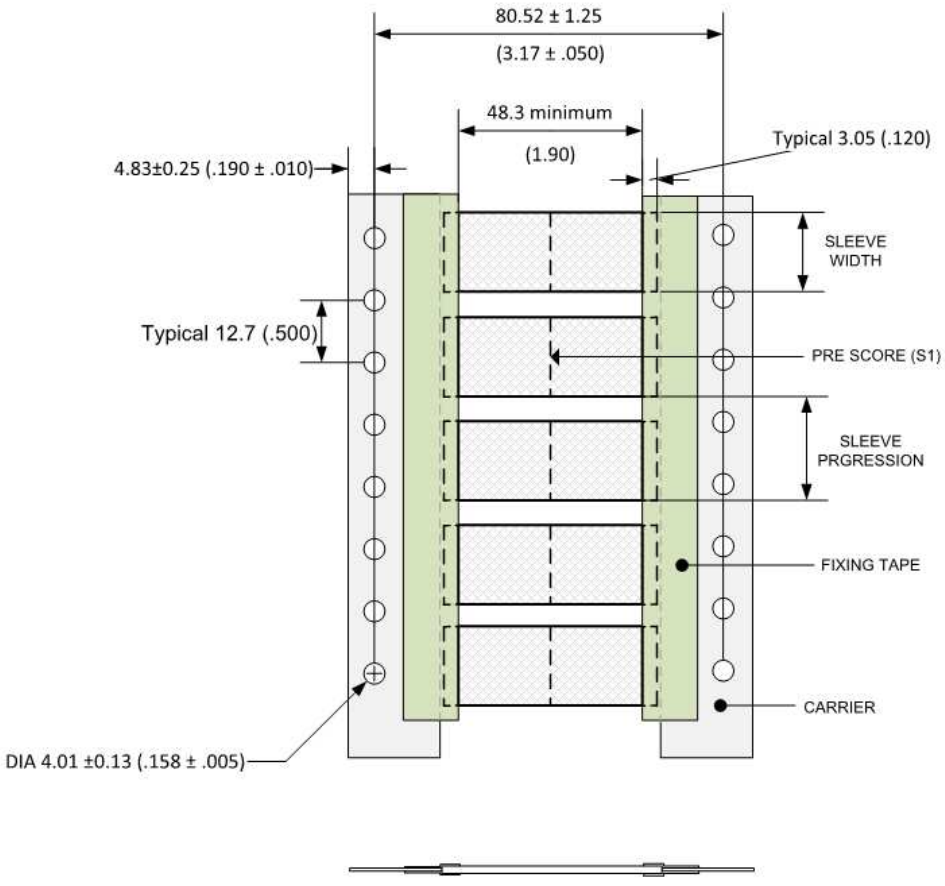


Figure 1: Marker Sleeve Format – Dimensions in mm (inch).

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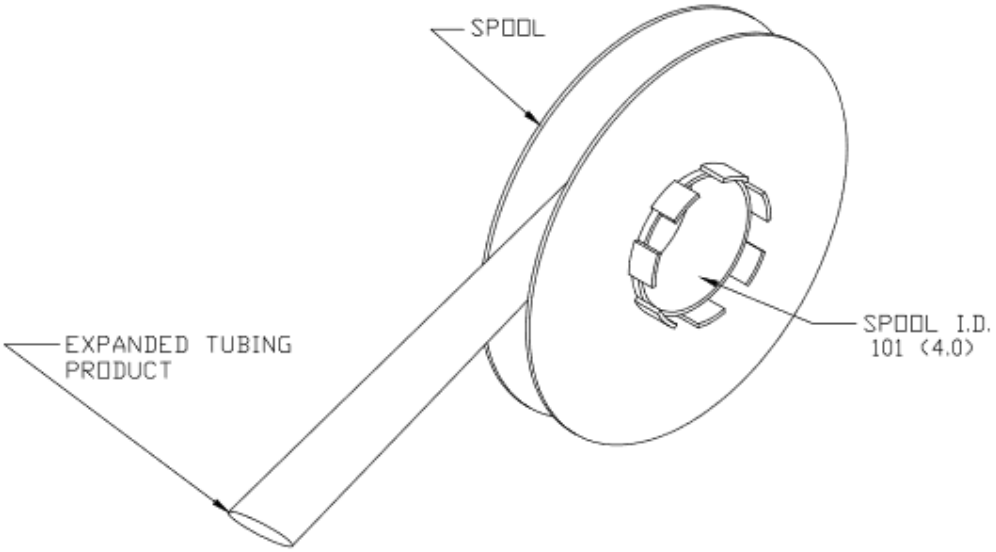


Figure 2: HT-CT format – Dimensions in mm (inch).

Heat Shrink Product (Fig. 3) in 'as Supplied' (Expanded) "D", and in the Recovered State "d".

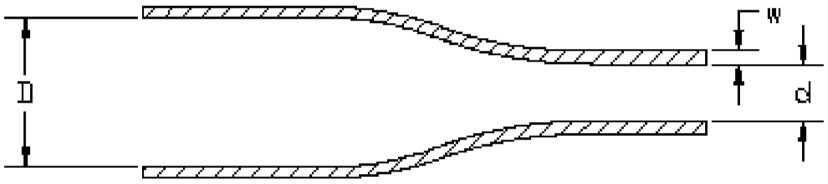


Figure 3: Product Dimensional Change During Recovery

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Table 1. Product Dimensions

HT-SCE and HT-CT						
Part Description	**"D" Minimum Supplied Inside Diameter mm (inches)**	**"d" Maximum Recovered Inside Diameter mm (inches)**	**"w" Wall Thickness after Recovery mm (inches)**	**Minimum Sleeve Flattened Width mm (inches)**	**Sleeve Progression[1] mm (inches)**	**Nominal Weight of single sleeve (~50mm long) grams**
HT-SCE-3/32	2.36 (.093)	0.79 (.031)	0.38 ± 0.08 (.015 ± .003)	4.32 (.170)	12.7 ± 0.64 (.500 ± .025)	0.14
HT-SCE-1/8	3.18 (.125)	1.58 (.063)	0.38 ± 0.08 (.015 ± .003)	5.84 (.230)	12.7 ± 0.64 (.500 ± .025)	0.21
HT-SCE-3/16	4.75 (.187)	2.38 (.094)	0.38 ± 0.08 (.015± .003)	8.00 (.315)	12.7 ± 0.76 (.500 ± .030)	0.29
HT-SCE-1/4	6.35 (.250)	3.18 (.125)	0.38 ± 0.08 (.015 ± .003)	10.7 (.421)	16.9 ± 0.89 (.665 ± .035)	0.38
HT-SCE-3/8	9.53 (.375)	4.76 (.188)	0.38 ± 0.08 (.015 ± .003)	15.5 (.610)	25.4 ± 0.89 (1.00 ± .035)	0.53
HT-SCE-1/2	12.7 (.500)	6.35 (.250)	0.38 ± 0.08 (.015 ± .003)	20.3 (.800)	29.6 ± 1.00 (1.17 ± .040)	0.73
HT-SCE-3/4	19.0 (.750)	9.53 (.375)	0.38 ± 0.08 (.015 ± .003)	30.5 (1.20)	42.3 ± 1.00 (1.67 ± .040)	1.30
HT-SCE-1	25.4 (1.00)	12.7 (.500)	0.43 ± 0.10 (.017 ± .004)	40.4 (1.59)	50.8 ± 1.00 (2.00 ± .040)	1.61
HT-SCE-1-1/2	38.1 (1.50)	19.0 (.750)	0.43 ± 0.10 (.017 ± .004)	60.2 (2.37)	72.0 ± 1.00 (2.83 ± .040)	2.51

[1] Sleeve progression column is applicable only for ladder format (HT-SCE)

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4. TEST METHODS

All tests should be carried out in 'fully recovered' form except where specified.

4.1. PREPARATION OF TEST SAMPLES

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.

When required by the test procedure, marker sleeves 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 marker sleeves to fill the printable area, using font type Arial 10 bold, capital letters to be used. HT-SCE product shall be removed from the carrier and HT-CT products shall be cut/perforated and separated using TE approved printer systems before testing.

The printing shall be examined for legibility in accordance with TE document 411-121002 Print Contrast Reference Scale. The initial print contrast must be C8 or above.

Marker sleeves or tubing should be recovered in a forced air oven for 3 minutes at 200±5℃ (392±10℉). Samples shall be removed from the oven and allowed to cool to 23±2℃ (73±4℉) for at least 4 hours bef ore continuing. Where required by the test method, testing shall be done on continuous tubing.
No pre-conditioning period is required prior to testing except where specified.

All tests shall be made at a temperature of 23±2℃ (73±4℉) unless otherwise specified.

4.2. WORKMANSHIP

Visually examine three 'as received' marker sleeves 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 sample placed inside a laboratory light box with D65 illumination.

Using the method described in TE document 109-121035, measure the colour of 'as received' marker sleeves before any printing. Record values for L*a*b* using the 8mm (0.32") aperture and D65 illuminance. Colour results are recorded for information only.

4.3. PRINT PERFORMANCE

4.3.1. MARK ADHERANCE

The test method shall be as specified in TE document 109-121012.
Three marker sleeves shall be prepared as detailed in Section 4.1. Samples shall be tested using a modified Crockmeter fitted with an eraser and 1kg load using the number of rubs specified in Table 4.

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

4.3.2. SOLVENT RESISTANCE

The test method shall be as specified in TE document 109-121014.
Nine marker sleeves shall be prepared as detailed in Section 4.1. The printing shall be examined for legibility using normal reading vision. Print contrast shall be evaluated in accordance with TE document 411-121002.

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4.3.3. FLUID RESISTANCE AND PRINT PERMANENCE

The test method shall be as specified in TE document 109-121039.
Three marker sleeves per fluid shall be prepared as detailed in Section 4.1. Marker sleeves shall be completely immersed in each fluid for the times and at the temperatures specified in Table 4. The volume of the fluid shall not be less than 20 times that of the sample. After immersion, the marker sleeves are lightly blotted with tissue paper to remove excess surface fluid and air dried at 23±2℃ (73±4℉) for 45±15min. Samples shall be tested with a modified Crockmeter fitted with 'Super Twill' cloth and a 1kg load.

Additional testing in IPA is required using three as supplied, and three fully recovered marker sleeves prepared as detailed in Section 4.1. Soak the 'Super Twill' cloth with IPA and test for mark permanence as detailed in TE document 109-121012.

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

4.4. PHYSICAL TESTING

4.4.1. DIMENSIONS AND LONGITUDINAL CHANGE

The test method shall be as specified in TE document 109-121003.
Three 50mm (1.97") long unrecovered marker sleeves shall be tested for inside diameter. The marker sleeves shall be measured before recovery, then recovered as detailed in Section 4.1 and the measurements taken again. The wall thickness of the marker sleeves shall also be measured following recovery and the minimum and maximum recovered wall thickness shall be reported.

Three 150mm (5.91") long unrecovered marker sleeves taken from a continuous reel shall be tested for Longitudinal Change. Make two gauge marks, 100mm (3.94") apart on each marker sleeve. The marker sleeves shall then be recovered as detailed in Section 4.1. and the distance between gauge marks measured and change expressed as a percentage of the original gauge length.

4.4.2.TENSILE STRENGTH AND ULTIMATE ELONGATION

The test method shall be as specified in TE document 109-121002.
Five 125mm (4.92") marker sleeves shall be prepared as detailed in Section 4.1.

4.4.3. SPECIFIC GRAVITY

The test method shall be as specified in TE document 109-121015.
Three unprinted marker sleeves 25mm (.98") in length shall be prepared as per TE document 109-121015.
Test samples should be prepared to prevent trapping of air.

4.4.4. SPLIT TESTING

The test method shall be as specified in TE document 109-121031.
Ten unprinted, perforated or scored marker sleeves shall be tested. Samples should be recovered onto a mandrel which has been pre-heated for the time and at the temperature stated in the test method. Samples should be examined for splitting after cooling to 23±2℃ (73±4℉).

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4.5. THERMAL TESTING

4.5.1. HEAT SHOCK

The test method shall be as specified in TE document 109-121007.
Six unrecovered marker sleeves shall be prepared as detailed in Section 4.1. Samples shall be conditioned for 4 hours at 275±2℃ (437±4℉) in an air circulat ing oven, then removed and allowed to cool for a minimum of 2 hours at 23±2℃ (73±4℉).

After conditioning three samples shall be tested for Mark Adherence in accordance with section 4.3.1. The printing shall be examined for legibility using normal reading vision. Print contrast shall be evaluated in accordance with TE document 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 (3/4”).

4.5.2.HEAT AGEING

The test method shall be as specified in TE document 109-121008.
Six unrecovered marker sleeves shall be prepared as detailed in Section 4.1. Samples shall be conditioned for 168 hours at 225±2℃ (302±4℉) in an air circulatin g oven, then removed and allowed to cool for a minimum of 4 hours at 23±2℃ (73±4℉).

After conditioning three samples shall be tested for Mark Adherence, in accordance with section 4.3.1. The printing shall be examined for legibility using normal reading vision. Print contrast shall be evaluated in accordance with TE document 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 (3/4”).

4.5.3. LOW TEMPERATURE FLEXIBILITY

The test method shall be as specified in TE document 109-121006.
Six marker sleeves shall be prepared as detailed in Section 4.1. Samples shall be conditioned for 4 hours at -55±2℃ (-67±4℉) in a cold chamber. After condition ing, and whilst still at -55±2℃ (-67±4℉), three s amples shall be immediately tested for resistance to bending. Mandrel diameter for HT-SCE 6.4 size tubing is 19.1mm (3/4”).

The remaining three samples shall be removed from the cold chamber and allowed to return to 23±2℃ (73±4℉) for a minimum of 2 hours. The samples shal l then be tested for Mark Adherence in accordance with section 4.3.1.

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

4.5.4. THERMAL CYCLING

The test method shall be as specified in TE document 109-121057.

Six marker sleeves shall be prepared as detailed in Section 4.1. Samples shall be conditioned for six cycles. Each cycle shall consist of thirty minutes at -196±5℃ (-321±10℉) in liquid nitrogen, followed by thi rty minutes at 200℃±5℃ (392±10℉) in an air circulating oven. After the final cycle the marker sleeves shall be allowed to cool for a minimum of 2 hours at 23±2℃ (73±4℉).

Three samples shall be tested for Mark Adherence in accordance with TE document 109-121012. The printing shall be examined for legibility using normal reading vision. Print contrast shall be evaluated in accordance with TE document 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 (3/4”).

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4.6. ENVIRONMENTAL TESTING

4.6.1. COPPER MIRROR CORROSION

The test method shall be as specified in TE document 109-121009.
Three unrecovered marker sleeves shall be tested. After the test, mirrors should be assessed for corrosion.

4.6.2. WATER ABSORPTION

The test method shall be as specified in TE document 109-121016.
Three marker sleeves shall be prepared as detailed in Section 4.1. The mean average should be reported.

4.6.3. UV RESTISTANCE

The test method shall be as specified in ASTM G154. Test for 1000 hours at 1.35 W/m²/nm irradiance.
Twelve marker sleeves shall be prepared as detailed in Section 4.1. Condition 6 marker sleeves as described in section (i) and six marker sleeves as described in section (ii) below:

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

After conditioning, three of each conditioned marker sleeves shall be tested for resistance to bending. Mandrel diameter for HT-SCE 6.4 size tubing is 19.1mm (3/4”). Samples shall be visually examined for cracking or splitting.

The remainder of the samples shall be tested for Mark Adherence in accordance with section 4.3.1.

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

4.6.4. VACUUM OUTGASSING

The test method shall be as specified in ASTM E 595.
Three marker sleeves shall be prepared as detailed in Section 4.1.

The conditions for testing are:

i. Exposure time = 24 hours.
ii. Sample temperature = 130±2℃ (266±4℉).
iii. Condensing surface temperature = 18±3℃ (64±5° F).
iv. Pressure not greater than 1 x 10-5 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 7mm (.276”) from the cooled condensing plate. Use a micro balance to weigh the samples before and after conditioning and calculate total weight loss. Weigh the condensing plate before and after to calculate percent volatile condensable material.

Report the percentage of Total Mass Loss (TML) and percent of Collected Volatile Condensable Materials (CVCM).

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4.7. ELECTRICAL TESTING

4.7.1. DIELECTRIC STRENGTH

The test method shall be as specified in TE document 109-121005.
Five marker sleeves 150mm (5.91") long shall be printed as detailed in Section 4.1. The marker sleeves shall then be recovered onto preheated mandrels in a forced air oven for 3 minutes at 200±5℃ (392±10℉).
The average dielectric strength of five samples to be recorded.

4.7.2. VOLUME RESISTIVITY

The test method shall be as specified in TE document 109-121017.
Three marker sleeves approx. 200mm (7.87") long shall be printed as detailed in Section 4.1. The average volume resistivity value should be recorded.

4.8. FIRE SAFETY

4.8.1. FIRE PROPAGATION - ASTM D2671 Procedure B

The test method shall be as specified in TE document 109-121053.
Five marker sleeves 460mm (18.1") long shall be prepared as detailed in Section 4.1. The duration of burning and percentage of the burnt area shall be recorded.

4.8.2. EN45545-2 FLAMMABILITY HAZARD LEVEL - Oxygen Index, BS EN ISO 4589-2

The test method shall be as specified in TE document 109-121054.
Tests shall be carried out on 3mm (0.12") thick plaques of the material from which the marker sleeves are fabricated. Each plaque should be irradiation cross-linked to the same degree as the marker sleeves. Test piece dimensions shall be 6.5±0.5mm x 80±1mm x 3±0.5mm (0.26±0.02" x 3.15±0.04" x 0.12±0.02") cut from the irradiated plaques. Samples shall be conditioned for at least 24hrs at 23±2℃ (73±4℉) prior to t esting.

4.8.3. SURFACE FLAMMABILITY - Flame Spread Index, Is, ASTM E162

The test method shall be as specified in ASTM E162 with the following modification: Instead of testing a moulded plaque, a 25.4mm (1.00") piece of continuous tubing printed with two lines of text shall be used.

To form the specified exposed area, cut six of 13mm (0.51") wide cement board fingers. Cut six of 75mm (2.95") lengths of continuous tube and recover one over each of the 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 samples. Samples are conditioned for at least 24 hours at 23±2℃ (73 ±4℉) before testing.

4.8.4. SMOKE OPTICAL DENSITY - Ds, ASTM E662

The test method shall be as specified in ASTM E662 with the following modification: Instead of testing a moulded plaque a 25.4mm (1.00") piece of continuous tubing, printed with two lines of text shall be used.

To form the specified exposed area, cut six of 13mm (0.51") wide cement board fingers. Cut six of 75mm (2.95") lengths of continuous tube and recovered one over each of the 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 samples. Samples are conditioned for at least 24 hours at 23±2℃ (73 ±4℉) before testing.

Testing is carried out using an NBS smoke chamber with a 25kW/m2 radiant heat. Tests are carried out with and without a pilot flame.

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4.8.5. TOXIC GAS GENERATION - Bombardier SMP 800-C

The test method shall be as specified in Bombardier SMP 800-C and is carried out during the ASTM E662 test.

4.8.6. HEAT RELEASE - ASTM E1354

The test method shall be as specified in ASTM E1354 with the following modification: Instead of testing a moulded plaque, a 25.4mm (1.00”) piece of continuous tubing, printed with two lines of text shall be used.

To form the specified exposed area, cut six of 13mm (0.51”) wide cement board fingers. Cut six of 75mm (2.95”) lengths of continuous tube and recovered one over each of the 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 samples. Samples are conditioned for at least 24 hours at 23±2℃ (73 ±4℉) before testing.

Samples are tested using a 50kW/m² heat flux. Average Heat Release Rate, Maximum (peak) heat release rate and Average Specific Extinction Area at 3 minutes is measured.

5. RELATED DOCUMENTS

5.1. TABLE 2 – DETAILS OF RELATED STANDARDS AND ISSUE

ASTM D2671-13	Standard Test Methods for Heat-Shrinkable Tubing for Electrical Use
ASTM G-154-16	Standard Practice for Operating Fluorescent Ultraviolet (UV) Lamp Apparatus for Exposure of Non-metallic Material
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 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
ASMT G21-15	Standard practice for resistance of synthetic polymeric materials to fungi
UL 224	Extruded Insulated Tubing

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5.2. TABLE 3 – TE CONNECTIVITY DOCUMENTS

TE Document	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 test	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	Mark Adherence	SAE AS5942
109-121014	MIL STD 202 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 in accordance with ASTM D2671 Procedure B & C	ASTM D2671, procedure B
109-121054	Limiting Oxygen Index (LOI) test	BS EN ISO 4589-2:1999
109-121057	Thermal Cycling using liquid Nitrogen	---

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6. FREQUENCY

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 marker sleeves.

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

7. 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 range of -10℃ (14℉) to 35℃ (104℉), and 50±30% Relative Humidity.

8. PACKAGING

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

9. SHELF LIFE

The shelf life of HT-SCE AND HT-CT is 144 months from date of manufacture when stored as prescribed above.

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10. TABLE 4 – GENERAL REQUIREMENTS FOR IDENTIFICATION PRODUCTS

PROPERTY	TEST METHOD	UNITS	REQUIREMENTS	SECTION
PRINT PERFORMANCE				
Print Quality			Legible, minimum print contrast C8	4.1
Mark Adherence	TE document 109-121012,100 rubs, 1kg load, eraser	---	Legible, minimum print contrast C3	4.3.1
Solvent Resistance Solution A Solution B Solution C	TE document 109-121014 100 strokes, tooth brush	---	Legible, minimum print contrast C3	4.3.2
Fluid Resistance, Mark Permanence Reference test oil IRM 902 MIL-PRF-23699 lubricating oil Skydrol LD-4 phosphate ester hydraulic fluid MIL-H-83282 hydraulic fluid JP8 jet fuel Diesel fuel Propylene glycol de-icing fluid 50/50 Tap water 5% Sodium chloride solution 1% Teepol detergent	TE document 109-121039 24 hours immersion at 23±2℃ (73.4±4℉), followed by 20 wipes at 1kg load	---	Legible, minimum print contrast C3 [2]	4.3.3
Isopropyl alcohol (IPA)	TE108-121012 20 cycles, soaked “SuperTwill” cloth	---	Legible, minimum print contrast C3 [3]	4.3.3
Workmanship	Laboratory light box with D65 lighting, using normal or corrected vision at 14 inches (355.6mm).	---	In accordance with section 8.2	4.2

[2] 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.
[3] 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.

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PROPERTY	TEST METHOD	UNITS	REQUIREMENTS	SECTION
Dimensions	TE document 109-121003	mm	Table 1	4.4.1
Longitudinal Change	TE document 109-121003	%	20 Maximum	4.4.1
Tensile Strength	TE document 109-121002	MPa	24.1 minimum	4.4.2
Ultimate Elongation	TE document 109-121002	%	200 Minimum	4.4.2
Specific Gravity	TE document 109-121015	---	1.80 Maximum	4.4.3
Split Test	TE document 109-121031	%	100 Minimum	4.4.4
THERMAL TESTING				
Heat Shock 4 hours at 275±3℃ (527±6℉) Mandrel Bend Mark Adherence	TE document 109-121007 TE document 109-121012 50 rubs, 1kg load, eraser	---	No damage to the marker and print Legible, Minimum print contrast C3	4.5.1
Heat Ageing 168hrs at 225±2℃ (437±4℉) Mandrel Bend Mark Adherence	TE document 109-121008 TE document 109-121012 50 rubs, 1kg load, eraser	---	No damage to the marker and print Legible, Minimum print contrast C3	4.5.2
ENVIRONMENTAL TESTING				
Copper Mirror Corrosion 16 Hours at 200℃ (392℉)	TE document 109-121009	%	Damaged area of copper mirror, 8 Maximum	4.6.1
Water Absorption	TE document 109-121016	%	1 Maximum	4.6.2
Fungus Resistance	Followed by Mark Adherence		Rating of 1 or less 20 Rubs, 1kg load, Eraser	ASTM G21
PHYSICAL TESTING				
UV Resistance followed by, Mandrel Bend	ASTM G154 UVA and UVB (8 hours dry/4 hours wet cycle) 360° bend around a mandrel (10 x thickness)		1000 hours at each wavelength No damage to the marker and print	4.6.3

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PROPERTY	TEST METHOD	UNITS	REQUIREMENTS	SECTION
Mark Adherence	TE document 109-121012 20 rubs, 1kg load, eraser		Legible, minimum print contrast C3	
ELECTRICAL TESTING				
Dielectric Strength	TE document 109-121005	kV/mm	23.6 Minimum	4.7.1
Volume Resistivity	TE document 109-121017	Ohm/ Cm	1 x 10^{12} Minimum	4.7.2
FIRE SAFETY				
Fire Propagation ASTM D2671 Procedure B	TE document 109-121053 ASTM D267 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.	4.8.1
Flammability Hazard rating EN45545-2 BS EN ISO 4589-2 Oxygen Index (OI), UL224	BS EN ISO 4589-2 TE document 109-121054	%	Requirement set R24 Hazard Level Classification 3 32% Minimum Pass VW-1 Rating	4.8.2 UL224
Specific Optical Smoke Density, Ds Flaming Mode 1.5 minutes 4 minutes Non-Flaming Mode 1.5 minutes 4 minutes	ASTM E 662 25kW/m2 radiant heat source. Flaming mode Non-flaming mode.		 100 Maximum 200 Maximum 100 Maximum 200 Maximum	4.8.4
Heat Release [4] Average Heat Release Rate (180 s) Maximum (Peak) Heat Release Rate Average specific extinction area (180 s)	ASTM E1354 50kWm2 applied heat flux with retainer frame	kW/m^2 kW/m^2 m^2/kg	 ≤ 120 Over course of test ≤ 140 ≤ 500	4.8.6

[4] 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.

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PROPERTY	TEST METHOD	UNITS	REQUIREMENTS	SECTION
Toxic Gas Generation **Bombardier BMS 800-C** Carbon Monoxide (CO) Carbon Dioxide (CO2) Nitrogen Oxides (NO2) Sulphur Dioxide (SO2) Hydrogen Chloride (HCl) Hydrogen Fluoride (HF) Hydrogen Bromide (HBr) Hydrogen Cyanide (HCN)	Gas extracted during ASTM E662 test. 25kW/m2 radiant heat source. Flaming mode and non-flaming mode assessed, worst case reported.	ppm	Maxima: 3500 90000 100 100 500 100 100 100	4.8.5

11. TABLE 5: SPECIFIC REQUIREMENTS FOR HT-SCE HEAT SHRINK SLEEVING

PROPERTY	TEST METHOD	UNITS	REQUIREMENTS	RW-2512 SECTION
THERMAL				
Thermal Cycling: 6 cycles of: 0.5hr at -196±5℃ (-321±9℉) 0.5hr at 200±5℃ (392±5℉) Followed by Print performance	 TE document 109-121046 TE document 109-121012	%	50 Minimum, legible	4.5.4
Low Temperature flexibility 4 hours at -55℃, followed by: Mandrel Bend Mark Adherence	TE 109-121006 360°bend around a mandrel (10 x thickness) TE 109-121012 20 rubs, 1kg load, eraser	 --- ---	 No damage to the marker and print Legible, minimum print contrast 3	4.5.3
ENVIRONMENTAL				
Vacuum Outgassing TML (Total Mass Loss) VCM (Volatile Condensable Material)	ASTM E 595 Exposure time, 24hr sample temp. 130±2℃ (266±4℉); Condensing surface temp. 18±3℃ (64±5℉); and pressure, not greater than $1x10^{-5}$ Torr	 % %	 1.0 Maximum 0.1 Maximum	 4.6.4

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12. TABLE 6: 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-L7808 oil at temperatures above 25℃ (77℉).
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 (BS EN 590:2009+A1)	General fuel used in transportation
Propylene Glycol de-icing 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

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