



# SPECIFICATION 108-120066

## DWHF TUBING

**DWHF is an adhesive-lined, electrically insulating and flame-retarded heat-shrinkable tubing with no intentionally added halogens, compliant to R22 requirements of EN45545-2 at HL3 and available in 3:1 expansion ratio.**

THIS IS A CLASS 1 DOCUMENT WHICH IS NON-CONFIDENTIAL.

*The information contained within this document is the property of TE Connectivity. It is supplied in confidence and the commercial security of the contents must be maintained. It must not be used for any purpose other than that for which it is supplied nor may any information contained in it be disclosed to unauthorized persons. It must not be reproduced in whole or in part without obtaining written permission from TE Connectivity (TE).*

While TE has made every reasonable effort to ensure the accuracy of the information in this specification, TE does not guarantee that it is error-free, nor does TE make any other representation, warranty or guarantee that the information is accurate, correct, reliable or current. TE reserves the right to make any adjustments to the information contained herein at any time without notice. TE expressly disclaims all implied warranties regarding the information contained herein, including, but not limited to, any implied warranties of merchantability or fitness for a particular purpose. The dimensions in this specification are for reference purposes only and are subject to change without notice. Specifications are subject to change without notice. Consult TE for the latest dimensions and design specifications.

\*Trademark. Raychem, TE Connectivity, TE connectivity (logo), and TE (logo) are trademarks. Other logos, product and/or company names may be trademarks of their respective owners.



## Table of Contents

<b>1.</b>	<b>SCOPE .....</b>	<b>3</b>
<b>2.</b>	<b>REVISION HISTORY .....</b>	<b>3</b>
<b>3.</b>	<b>RELATED DOCUMENTS.....</b>	<b>3</b>
<b>4.</b>	<b>REQUIREMENTS</b>	
	<b>4.1 Composition, Appearance and Colour.....</b>	<b>4</b>
	<b>4.2 Properties.....</b>	<b>4</b>
<b>5.</b>	<b>QUALITY ASSURANCE PROVISIONS .....</b>	<b>4</b>
	<b>5.1 CLASSIFICATION OF TESTS .....</b>	<b>4</b>
	<b>5.1.1 Qualification Tests .....</b>	<b>4</b>
	<b>5.1.2 Production routine tests .....</b>	<b>4</b>
	<b>5.1.3 10<sup>th</sup> Batch test</b>	
<b>6.</b>	<b>TEST METHODS.....</b>	<b>5- 8</b>
<b>7.</b>	<b>PACKAGING.....</b>	<b>8</b>
	<b>TABLE 1 TUBING DIMENSIONS .....</b>	<b>9</b>
	<b>TABLE 2 REQUIREMENTS .....</b>	<b>10</b>
	<b>FIGURE 1 PEEL TEST.....</b>	<b>11</b>



## 1. SCOPE

This specification establishes the quality standard for DWHF tubing. DWHF is an adhesive-lined, electrically insulating and flame-retarded heat-shrinkable tubing with no intentionally added halogens, is compliant to R22 requirements of EN45545-2 at HL3 and available in 3:1 expansion ratio.

Continuous operating temperature -55 °C to + 110°C

## 2. CHANGE HISTORY

Revision	Change request	Date	Incorporated By
A	via PDMLink	February 2022	M. Bakare
B			
C			
D			
E			

## 3. RELATED DOCUMENTS

This specification takes precedence over documents referenced herein. Unless otherwise specified, the latest issue of referenced documents applies. The following documents form a part of this specification to the extent specified herein.

ASTM D882	Standard Test Methods for Tensile Properties of Thin Plastic Sheeting
ASTM D2671	Standard Test Methods for Heat Shrinkable Tubing for Electrical Use
IEC 60212	Standard Conditions for Use Prior to and During Testing of Solid Electrical Insulating Materials
IEC 60243-1	Methods of Test for Electric Strength of Solid Insulating Materials part1 Tests at Power Frequencies
ISO 37	Rubber, vulcanized or thermoplastic – Determination of Tensile Stress-Strain Properties
ISO 62	Determination of Water Absorption
ISO 188	Rubber, vulcanized -Accelerated Ageing or Heat Resistance Tests
ISO 846	Plastics-Evaluation of the action of micro-organisms
ISO 1183	Methods for determining the density and relative density of non-cellular plastics
ISO 1817	Rubber, vulcanized – Determination of the effect of liquids



#### 4. **REQUIREMENTS**

##### 4.1 **COMPOSITION, APPEARANCE AND COLOUR**

The tubing shall be fabricated from thermally stabilised, modified polyolefin jacket and polyolefin-based, hot melt adhesive and shall be crosslinked by irradiation. It shall be homogeneous and essentially free from flaws, defects, pinholes, bubbles, seams, cracks, and contaminants. The jacket shall be black.

##### 4.2 **PROPERTIES**

The tubing shall meet the requirements of Table 2.

#### 5. **QUALITY ASSURANCE PROVISIONS**

##### 5.1 **CLASSIFICATION OF TESTS**

Tests shall be carried out on a sample taken at random from each batch of finished tubing. A batch of tubing is defined as that quantity of tubing extruded at any one time. Testing frequency shall be Qualification, 10<sup>th</sup> batch or Production Routine as detailed below:

##### 5.1.1 **Qualification Tests (frequency in accordance with the Design Authority)**

Qualification tests are those performed on tubing submitted for qualification as a satisfactory product and shall consist of all tests (including Limiting Oxygen Index, Smoke Generation and Toxicity) which shall be reviewed every 3 years.

##### 5.1.2 **Production Routine Tests (Every Batch)**

Visual examination  
Dimensions  
Longitudinal change

##### 5.1.3 **10<sup>th</sup> Batch Testing (Every 10<sup>th</sup> batch)**

Tensile Strength  
Ultimate elongation  
Secant modulus at 2% strain  
Specific gravity



## 6.0 TEST METHODS

### 6.1 Preparation of Test Specimens

Unless otherwise specified, tests shall be carried out on specimens of tubing recovered by conditioning in a fan assisted air circulating oven at  $200 \pm 5^{\circ}\text{C}$  for  $6 \pm 1$  minutes and allowed to cool in air to ambient temperature. No pre-conditioning period is required prior to testing. Unless otherwise specified, all tests shall be made under standard ambient conditions according to IEC Publication 60212. In cases of dispute the tests shall be carried out at a temperature of  $23 \pm 2^{\circ}\text{C}$  and at  $50 \pm 5\%$  relative humidity.

---

### 6.2 Dimensional and Longitudinal Change

The test method shall be as specified in ASTM D2671. The length and inside diameter of three 150mm long specimens of expanded tubing shall be measured. The specimen shall be recovered in a fan-assisted, air-circulating oven and the length and inside diameter of each shall be measured. The longitudinal change shall be expressed as a percentage of the original length. The minimum and maximum recovered wall thickness shall be determined.

---

### 6.3 Tensile Strength and Ultimate Elongation

The test method shall be as specified in ISO 37. For tubing of recovered bore greater than 4mm, five tubular type 2 dumb-bell specimens shall be tested. For tubing of recovered bore less than or equal to 4mm, five tubular specimen 125mm long shall be tested. Initial jaw separation shall be 50mm and rate of jaw separation shall be  $50 \pm 5$ mm per minute. The test shall be carried out at a temperature of  $23 \pm 2^{\circ}\text{C}$ . Calculation of tensile strength shall be based on the cross-sectional area of the jacket only.

---

### 6.4 Secant Modulus at 2% Strain

The test method shall be as specified in Method A of ASTM D882. The test is to be carried out on recovered tubing. For tubing of recovered bore greater than 6mm, five strip specimens 150mm long shall be tested. For tubing of recovered bore less than or equal to 6mm, five tubular specimens 150mm long shall be tested. Initial jaw separation shall be 100mm and rate of jaw separation  $10 \pm 1$ mm per minute. The test shall be carried out at a temperature of  $23 \pm 2^{\circ}\text{C}$ .



## 6.5 Specific Gravity

The test shall be carried out in accordance with Method A of ISO 1183

---

## 6.6 Inner Wall Adhesion

The test shall be carried out on size 40/13 DWHF. Five cylindrical rolling drum adhesion test mandrels 25mm long x 25mm diameter and of surface material specified shall be cleaned and degreased. Specimens of size 40/13 DWHF approximately 50mm long shall be recovered onto the mandrels by conditioning in a fan assisted air circulating oven set at  $150 \pm 3^{\circ}\text{C}$  for 20 minutes. After conditioning, the specimens shall be removed from the oven and allowed to cool naturally to room temperature. Surplus lengths of the DWHF tubing shall be trimmed level with the ends of the mandrels. The specimens shall be slit axially and peeled from mandrels in a suitable tensile testing machine such that the tubing peels off at a rate of  $50 \pm 5\text{mm}$  per minute as the mandrel rotates. See figure 1.

The test shall be carried out at a temperature of  $23 \pm 2^{\circ}\text{C}$ . The mean peel off force for each specimen shall be recorded, and the mean of the five recorded measurements reported as the Inner Wall Adhesion.

---

## 6.7 Heat Shock

The test shall be as specified in ASTM D2671.

The specimens shall be conditioned in a fan assisted air circulating oven as specified in Table 2.

---

## 6.8 Heat Ageing

The test method shall be as specified in ISO 188.

For tubing of recovered bore greater than 6mm, five strip specimens 75mm x 6mm shall be tested. For tubing of recovered bore less than or equal to 6mm, five tubular specimens 75mm long shall be tested. The specimens shall be conditioned in a fan assisted air circulating oven as specified in Table 2.

---

## 6.9 Low Temperature Flexibility

The test method shall be as specified in Procedure C of ASTM D2671.

The tubing shall be tested in the “as supplied” state.

Mandrel diameter shall be  $20 \times \text{specimen thickness} + 10\%$ .

The specimens and mandrels shall be conditioned as specified in Table 2.



#### 6.10 **Flammability**

The test method shall be as specified in Procedure C of ASTM D2671.  
The test shall be carried out on size DWHF 19/6.

---

#### 6.11 **Limiting Oxygen Content**

The test method shall essentially be according to ISO 4589-2 and performed on sizes 6/2 and 24/8.

The specimens shall be recovered onto stainless steel mandrels having a diameter approximately equal to 2mm and 8mm.  
It shall be performed at a facility acknowledged by CERTIFER<sup>1</sup> for EN45545-2 testing.

---

#### 6.11 **Smoke Generation**

The test method shall essentially be according to ISO 5659-2 and performed on unexpanded sizes 6/2 and 24/8.

The specimens shall be cut open longitudinally and flattened with only the jacket exposed to the heat flux.

It shall be performed at a facility acknowledged by CERTIFER<sup>1</sup> for EN45545-2 testing.

---

#### 6.11 **Toxicity**

The test method shall be as specified in NF X 70-100.

It shall be performed at a facility acknowledged by CERTIFER<sup>1</sup> for EN45545-2 testing.

---

#### 6.12 **Copper Mirror Corrosion**

The test method shall be as specified in ASTM D2671.

The specimens shall be conditioned as specified in Table 2.

---

#### 6.13 **Water Absorption**

The test method shall be as specified in Method 1 of ISO 62.

For tubing of recovered bore greater than 8mm, three disc specimens of diameter  $25 \pm 1$ mm shall be cut from the tubing. For tubing of recovered bore less than or equal to 8mm, three tubular specimens 50mm long shall be cut from the tubing.

---

<sup>1</sup> CERTIFER is a notified body recognised by European Commission for Directives 2008/57/EC and 2016/797 regarding interoperability of rail systems



#### 6.14 **Fluid Resistance**

The test method shall be as specified in ISO 1817.

Five tensile test specimens prepared as in Clause 6.3 shall be completely immersed in each of the fluids for the times and temperatures specified in Table 2. The volume of the fluid shall not be less than 20 times that of the specimen. After immersion, lightly wipe the specimens and allow to air dry at  $23 \pm 2^{\circ}\text{C}$  for  $1\text{h} \pm 15$  mins. The Tensile Strength and Ultimate Elongation of each specimen shall be tested in accordance with clause 6.3. The test shall be repeated on the remaining specified fluids.

Five rolling drum adhesion strength specimens prepared in accordance with Clause 6.6 shall be immersed in each of the fluids for the times and temperatures specified in Table 1. After immersion, lightly wipe the specimens and allow to air dry at  $23 \pm 2^{\circ}\text{C}$  for  $1\text{h} \pm 15$  mins.

The adhesion of each specimen shall be tested according to Clause 6.6.

The test shall be repeated on the remaining specified fluids.

---

#### 6.15 **Fungus Resistance**

The test method shall be as specified in Method B of ISO 846.

The specimens shall be conditioned for 56 days and tested for Tensile Strength and Ultimate Elongation in accordance with clause 6.3.

---

### 7.0 **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.

---





**TABLE 1**  
**Tubing Dimensions**

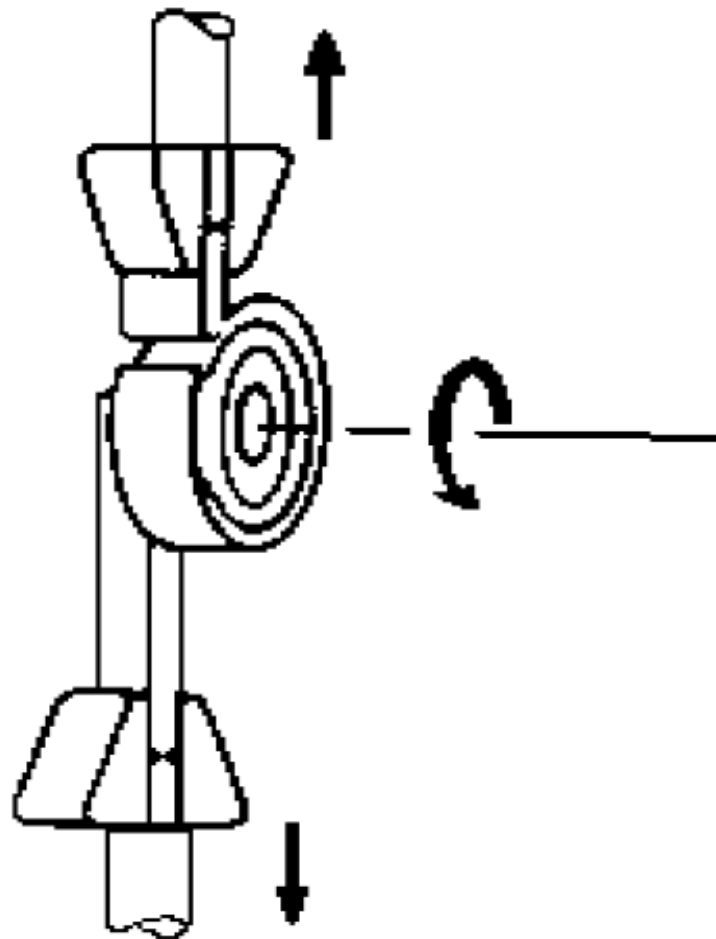
Size	Minimum Inside Diameter mm (in)	Maximum Inside Diameter after recovery mm (in)	Total wall thickness after recovery mm (in)	Inner Meltable Wall thickness after recovery (Nominal) Mm (in)
<b>3:1</b>				
3/1	3.0 (0.118)	1.0 (0.039)	1.00 ± 0.30 (0.039 ± .012)	0.50 (0.020)
4.5/1.5	4.5(0.177)	1.5 (0.059)	1.00 ± 0.30 (0.039 ± .012)	0.50 (0.020)
6/2	6.0 (0.236)	2.0 (0.079)	1.00 ± 0.30 (0.039 ± .012)	0.50 (0.020)
9/3	9.0 (0.354)	3.0 (0.118)	1.40 ± 0.30 (.055 ± .012)	0.60 (0.024)
12/4	12.0 (0.472)	4.0 (0.157)	1.78 ± 0.38 (.070 ± .015)	0.75 (0.030)
19/6	19.0 (0.748)	6.0 (0.236)	2.25 ± 0.55 (.089 ± .022)	0.80 (0.031)
24/8	24.0 (0.945)	8.0 (0.315)	2.54 ± 0.55 (.100 ± .022)	1.00 (0.039)
40/13	40.0 (1.575)	13.0 (0.512)	2.54 ± 0.55 (.100 ± .022)	1.00 (0.039)

**Tubing of special expanded or recovered dimensions may be supplied as specified in the contract or order.**



**TABLE 2**  
**Requirements**

PROPERTY	TEST METHOD	REQUIREMENT
Visual examination		As per Clause 4.1
Dimensions	ASTM D2671	As per Clause 6.2
Longitudinal Change	ASTM D2671	0 to -15%
Tensile Strength	ISO 37	9.0 MPa minimum
Ultimate Elongation	ISO 37	300% minimum
Secant Modulus @ 2% strain (recovered)	ASTM D882	125 MPa maximum
Specific Gravity	ISO 1183	1.25 maximum
Inner Wall Adhesion - DWHF to RNF-100-X (EMEA)  - DWHF to Aluminium	Clause 6.6	150 N/25mm minimum  60 N/25mm minimum
Heat Shock 4h ± 15m at 225 ± 5°C	ASTM D2671	No dripping, cracking or flowing of outer wall
Heat Ageing (168 ± 2h at 150 ± 3°C)	ISO 188	No dripping, cracking or flowing of outer wall
Low Temperature Flexibility (4h ± 15m at -55 ± 2°C)	ASTM D2671	No cracking
Electric strength	IEC 60243-1	12 MV/m minimum
Flammability	ASTM D2671	Duration of burning 60s maximum with no burning or charring of indicator
Limiting Oxygen Content	ISO 4589-2	32% minimum
Smoke Generation (D <sub>s</sub> ; 25 kWm <sup>-2</sup> )	ISO 5659-2	150 maximum
Toxicity (C.I.T. <sub>NLP</sub> ; 600°C)	NF X 70-100-1 and -2	0.75 maximum
Copper Mirror Corrosion (16h ± 2h at 150 ± 3°C)	ASTM D2671	No corrosion of mirrors
Water Absorption (24 ± 2h at 23 ± 2°C)	ISO 62	0.5% maximum
Fluid Resistance 24 ± 2h immersion at 23 ± 2°C - Diesel Fuel (Pump to EN 590)  - Hydraulic Fluid to H-515 (Mil-H-5606)  - Lubricating oil to O-149	ISO 1817	
<ul style="list-style-type: none"> <li>• Tensile strength</li> <li>• Ultimate Elongation</li> <li>• DWHF to RNF-100-X (EMEA) adhesion</li> <li>• DWHF to Aluminium adhesion</li> </ul>	ISO 37  Clause 6.6	7 MPa minimum 300% minimum 150 N/25mm minimum 60 N/25mm minimum
Fungus Resistance - Tensile Strength - Ultimate Elongation	ISO 846  ISO 37	9.0 MPa minimum 250% minimum



**FIGURE 1** Peel test specimen in tensile tester