



RW 2063 Revision 4

ATUM TUBING (Black)

SCOPE

This Quality Assurance Specification establishes the quality standard for a semi-flexible, electrically insulating, adhesive-lined heat shrinkable tubing

Approved Signatories*

This document is electronically reviewed and approved and so no signatures will appear.

1. REVISION HISTORY

| Revision Number | Change Request | Date | Incorporated By |
|-----------------|-----------------------------|-------------------|-----------------|
| 0 | Formerly RK 6025 Revision 6 | | |
| 1 | CR00-DM-0059 | 10 April 2000 | Linda. Abrams |
| 2 | CR02-DM-0280 | 14 November 2002 | Linda. Abrams |
| 3 | CR07-DM-127 | 11 September 2007 | Linda. Abrams |
| 4 | Via DMTEC | 28 February 2014 | C. Diss |

2. REQUIREMENTS

2.1 Composition, Appearance and Colour

The tubing shall be homogeneous and essentially free from pinholes, flaws, bubbles, cracks, seams, defects and inclusions. The colour shall be black.

2.2 Dimensions

| | Size | Minimum Inside Diameter as supplied mm (in) | Maximum Inside Diameter after recovery mm (in) | Total Wall Thickness after recovery mm (in) | Inner Meltable Wall Thickness after recovery mm (in) |
|-----|-------|---|--|---|--|
| 3:1 | 3/1 | 3.0 (0.118) | 1.0 (0.039) | 1.00 ± 0.30 (.039 ± .012) | 0.50 (0.020) |
| | 6/2 | 6.0 (0.236) | 2.0 (0.079) | 1.00 ± 0.30 (.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) |
| 4:1 | 4/1 | 4.0 (0.157) | 1.0 (0.039) | 1.00 ± 0.30 (.039 ± .012) | 0.50 (0.020) |
| | 8/2 | 8.0 (0.315) | 2.0 (0.079) | 1.00 ± 0.30 (.039 ± .012) | 0.50 (0.020) |
| | 12/3 | 12.0 (0.472) | 3.0 (0.118) | 1.40 ± 0.30 (.055 ± .012) | 0.60 (0.024) |
| | 16/4 | 16.0 (0.630) | 4.0 (0.157) | 1.78 ± 0.38 (.070 ± .015) | 0.75 (0.030) |
| | 24/6 | 24.0 (0.945) | 6.0 (0.236) | 2.25 ± 0.55 (.089 ± .022) | 0.80 (0.031) |
| | 32/8 | 32.0 (1.260) | 8.0 (0.315) | 2.54 ± 0.55 (.100 ± .022) | 1.00 (0.039) |
| | 52/13 | 52.0 (2.047) | 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.

2.3 Test Requirements

The test requirements shall be as specified in Table 1.

3. TEST METHODS

3.1 Preparation of Test Specimen

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 ± 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 212. 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.

3.2 Dimensions 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 specimens 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.

3.3 Tensile Strength and Ultimate Elongation

The test method shall be as specified in ISO 37. For tubing of recovered bore greater than 4mm, five Type 2 dumb-bell specimens shall be tested. For tubing of recovered bore less than or equal to 4mm, five tubular specimens 125mm long shall be tested. Initial jaw separation shall be 50 mm and rate of jaw separation shall be 50 ± 5 mm per minute. The test shall be carried out at a temperature of $23 \pm 2^\circ\text{C}$.

3.4 Secant Modulus at 2% Strain

The test method shall be as specified in Method A of ASTM D882. 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 ± 1 mm per minute. The test shall be carried out at a temperature of $23 \pm 2^\circ\text{C}$.

3.5 Specific Gravity

The test method shall be as specified in Method A of ISO 1183.

TEST METHODS (Cont'd)**3.6 Inner Wall Adhesion**

The test shall be carried out on Size 40/13 ATUM. Five cylindrical rolling drum adhesion test mandrels 25mm long by 25mm diameter and of surface material as specified shall be cleaned and degreased. Specimens of Size 40/13 ATUM approximately 50mm long shall be recovered on to the mandrels by conditioning in a fan assisted air circulating oven 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 ATUM shall be trimmed level with the ends of the mandrels. The specimens shall be slit axially and peeled from the mandrels in a suitable tensile testing machine such that the tubing peels off at a rate of $50 \pm 5\text{mm}$ length 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.

3.7 Heat Shock

The test method shall be as specified in ASTM D2671.
The specimens shall be conditioned in a fan assisted air circulating oven as specified in Table 1.

3.8 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 1.

3.9 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 $20 \times$ specimen thickness $\pm 10\%$.
The specimens and mandrels shall be conditioned as specified in Table 1.

3.10 Flammability

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

3.11 Electric Strength

The test method shall be as specified in IEC 60243 (short-time test).

TEST METHODS (Cont'd)**3.12 Copper Mirror Corrosion**

The test method shall be as specified in ASTM D2671.
The specimens shall be conditioned as specified in Table 1.

3.13 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 ± 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.

3.14 Fluid Resistance

The test method shall be as specified in ISO 1817.
Five tensile test specimens prepared as in Clause 3.3. shall be completely immersed in each of the fluids for the times and temperatures specified in Table 1. 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 $1\text{h} \pm 15\text{m}$. The Tensile Strength and Ultimate Elongation of each specimen shall be tested according to Clause 3.3. The test shall be repeated on the remaining specified fluids.
Five rolling drum adhesion strength test specimens prepared as in Clause 3.6 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 $1\text{h} \pm 15\text{m}$.
The adhesion of each specimen shall be tested according to Clause 3.6.
The test shall be repeated on the remaining specified fluids.

3.15 Fungus Resistance

The test method shall be as specified in ISO 846.
The specimens shall be conditioned for 56 days, and tested for Tensile Strength and Ultimate Elongation according to Clause 3.3.

4. RELATED STANDARDS & issue

| | |
|-------------------|---|
| ASTM D882-02 | Standard Test Methods for Tensile Properties of Thin Plastic Sheeting |
| ASTM D2671-00 | Standard Test Methods for Heat-Shrinkable Tubing for Electrical Use |
| IEC 60212: 1971 | Standard Conditions for Use Prior to and During Testing of Solid Electrical Insulating Materials |
| IEC 60243-1: 1998 | Methods of Test for Electric Strength of Solid Insulating Materials Part 1 Tests at Power Frequencies |
| ISO 37: 2005 | Rubber, vulcanized or thermoplastic - Determination of Tensile Stress-Strain Properties |
| ISO 62: 1999 | Determination of Water Absorption |
| ISO 188: 2007 | Rubber, vulcanized - Accelerated Ageing or Heat Resistance Tests. |
| ISO 846: 1997 | Plastics - Evaluation of the action of microorganisms. |
| ISO 1183: 2004 | Methods for determining the density and relative density of non-cellular plastics |
| ISO 1817: 2005 | Rubber, vulcanized - Determination of the effect of liquids |

5. SAMPLING

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 Production Routine, 10th Batch or Qualification. Production Routine tests consisting of Visual Examination, Dimensions, and Longitudinal Change shall be carried out on every batch of tubing. 10th batch tests shall consist of Tensile Strength, Ultimate Elongation, Secant Modulus at 2% Strain and Specific Gravity.

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

6. 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.

FIGURE 1 - Peel Specimen in Tensile Tester

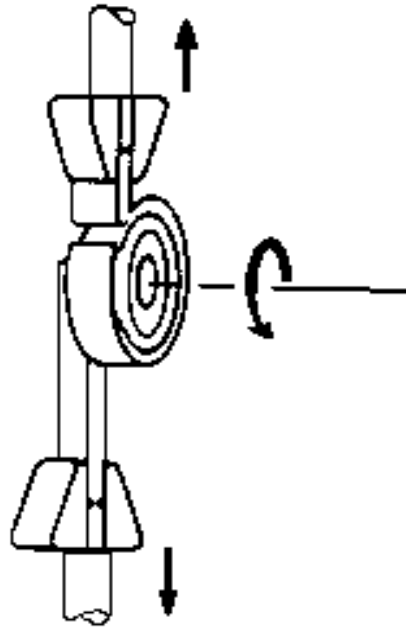


TABLE 1 Test Requirements

| Test | Test Method | Test Requirements |
|---|-------------|---|
| Visual Examination | - | As per Clause 2.1 |
| Dimensions | ASTM D2671 | As per Clause 2.2 |
| Longitudinal Change | ASTM D2671 | 0 to -15% |
| Tensile Strength | ISO 37 | 9.0 MPa minimum |
| Ultimate Elongation | ISO 37 | 300% minimum |
| Specific Gravity | ISO 1183 | 1.25 maximum |
| Secant Modulus at 2% Strain | ASTM D882 | 125 MPa maximum |
| Inner Wall Adhesion - ATUM to RNF-100 - ATUM to Aluminium | Clause 3.6 | 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. No burning or charring of indicator |
| Copper Mirror Corrosion (16h ± 30m at 150 ± 3°C) | ASTM D2671 | No corrosion of mirrors |
| Water Absorption (24 ± 2h immersion at 23 ± 2°C) | ISO 62 | 0.5% maximum |

TABLE 1 Test Requirements (Cont'd)

| Test | Test Method | Test Requirements |
|---|--------------------------|--|
| Fluid Resistance 24 ± 2h immersion at 23 ± 2°C <ul style="list-style-type: none"> • Diesel Fuel to BS 2869 Class A1 • Hydraulic Fluid to H-515 (Mil-H-5606) • Lubricating Oil to O-149 | ISO 1817 | |
| <ul style="list-style-type: none"> - Tensile Strength - Ultimate Elongation - ATUM to RNF-100 - ATUM to Aluminium | ISO 37 Clause 3.4 | 7 MPa minimum 300% minimum 150 N/25 mm minimum 60 N/25 mm minimum |
| Fungus Resistance <ul style="list-style-type: none"> - Tensile Strength - Ultimate Elongation | ISO 846 ISO 37 | 9.0 MPa minimum 300% minimum |

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