



TC-CAPS SPECIFICATION

TEC-108-120013

Raychem TC-CAPS Semi-rigid, Flame- Retardant Polyolefin Caps

TC-CAPS is a single wall 2.5:1 shrink ratio heat shrinkable cap fabricated from crosslinked flame-retardant polyolefin. Widely used for wire terminations because of their light weight, small size and durability. Vibration-proof caps are used to insulate and terminate dead-end electrical cables, fixtures, connectors, and other electrical equipment. Also, used to protect the ends of wire during storage.

RoHS and REACH compliant.

Operating temperature range: -55°C to 135°C (-67°F to 275°F).

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1. SCOPE

This specification covers the requirements for one type of flame-retardant, electrical insulating cap, whose diameter will reduce to a predetermined size upon the application of heat in excess of 135°C (275°F). This cap is widely used for wire terminations because of their light weight, small size and durability. Vibration-proof caps are used to insulate and terminate dead-end electrical cables, fixtures, connectors, and other electrical equipment. Also, used to protect the ends of wire during storage. These requirements are detailed in Table 3.

2. APPLICABLE 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.

2.1. American Society for Testing and Materials (ASTM)

D2671 Standard Methods of Testing Heat-Shrinkable Tubing for Electrical Use

(Copies of ASTM publications may be obtained from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103 or via the ASTM website at <http://www.astm.org>).

2.2. International Organization for Standardization (ISO)

ISO 846 Plastics -- Evaluation of the action of microorganisms

(Copies of ISO publications may be obtained from the International Organization for Standardization, 1, rue de Varembé, CH-1211 Geneva 20, Switzerland or via the ISO website at <http://www.iso.ch/iso/en/ISOOnline.frontpage>)

3. REQUIREMENTS

3.1. DIMENSIONS

The dimensions shall be in accordance with Table 1.

3.2. MATERIALS

The caps shall be fabricated from thermally stabilized, flame resistant, modified polyolefin tubing and shall be cross-linked by irradiation. They shall be homogeneous and essentially free from flaws, defects, pinholes, bubbles, cracks and inclusions.

3.3. COLOR

The standard colors are: White, Red and Gray each for a specific size per Table 1.

3.4. PROPERTIES

The caps and tubing shall meet the requirements of Table 2.



4. QUALITY ASSURANCE PROVISIONS

4.1. CLASSIFICATION OF TESTS

4.1.1. Qualification Tests

Qualification tests are those performed on tubing submitted for qualification as a satisfactory product and shall consist of all tests listed in Table 2 of this specification.

4.1.2. Acceptance Tests

Acceptance tests are those performed on tubing submitted for acceptance under contract. Acceptance tests shall consist of only final cap dimensions.

4.2. SAMPLING INSTRUCTIONS

4.2.1. Qualification Test Samples

Qualification test samples shall be made both finished caps for the dimensions and electrical requirements and from expanded tubing made from the same extrusion and irradiated to the same dose as the caps. For all the tubing tests, at least 300 meters (1000 ft.) of tubing should be extruded without forming the caps. This tubing should be expanded 2.5:1. Qualification of the TC 4005 size qualifies all sizes

4.2.2. Acceptance Test Samples

Acceptance test samples shall consist of not less than 10 caps selected at random from each lot. A lot shall consist of all tubing of the same size from the same production run and offered for inspection at the same time.

4.2.3. Lot Formation

A lot shall consist of all tubing of the same size, from the same production run, and offered for inspection at the same time.

4.3. TEST PROCEDURES

Unless otherwise specified, perform tests on specimens which have been recovered by heating for 3 minutes in a $200 \pm 5^{\circ}\text{C}$ ($392 \pm 9^{\circ}\text{F}$) oven. Condition the test specimens (and measurement gauges when applicable) for 3 hours at $23 \pm 3^{\circ}\text{C}$ ($73 \pm 5^{\circ}\text{F}$). For referee purposes, condition the test specimens at 50 ± 5 percent relative humidity for 3 hours prior to testing. Use mechanical convection type ovens in which air passes the specimens at a velocity of 30 to 60 m (*100 to 200 feet*) per minute.

4.3.1. Dimensions and Longitudinal Change

Measure three 150 mm (*6 inch*) specimens of tubing, as supplied, for length ± 1 mm ($\pm 1/32$ inch) and inside diameter in accordance with ASTM D 2671. Condition the specimens for 3 minutes in a $200 \pm 5^{\circ}\text{C}$ ($392 \pm 9^{\circ}\text{F}$) oven, cool to $23 \pm 3^{\circ}\text{C}$ ($73 \pm 5^{\circ}\text{F}$), then re-measure. Prior to and after conditioning, the dimensions of the tubing shall be in accordance with Table 1 and the longitudinal change shall be in accordance with Table 3. Calculate the longitudinal change as follows:

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$$C = ((L_1 - L_0) / L_0) \times 100$$

Where: C = Longitudinal Change [percent]

L_0 = Length Before Conditioning [inches (mm)]

L_1 = Length After Conditioning [inches (mm)]

4.3.2. Dielectric Withstand

Insulate a 12" long metal mandrel with a diameter equal to 75% of the expanded end-cap ID (C), so that all of the mandrel is completely insulated except for the two ends. A 1" section shall be left uninsulated at one for the contact of an electrical lead. The other end shall have an uninsulated length equal to the minimum depth of the end-cap opening (B). The end on which the end-cap will be applied shall be "squared-off" but with rounded edges, so that there are no sharp corners or edges.

Slide the cap onto the uninsulated end of the mandrel and shrink the end-cap on to the mandrel using a heat gun, taking care to have the mandrel fully inserted into the end-cap.

Immerse the end-cap in a water bath containing 0.5% of an ionic wetting agent. Position the end-cap so that 0.125" of the end-cap and a minimum of 6.0" of the insulated end of the mandrel extend above the water bath.

Immediately apply voltage between the mandrel and the water bath, increasing the voltage from 0 to 2500 V at a rate not faster than 500 V/sec but within a 10-sec maximum.

Hold the applied 2500 V for 1.0 minute.

There shall be no evidence of a dielectric failure.

4.3.3. Tensile Strength and Ultimate Elongation

Perform the tests in accordance with ASTM D 2671 using 25 mm (1 inch) bench marks, 25 mm (1 inch) initial jaw separation and jaw separation speed of 50 ± 5 mm (2.0 ± 0.2 inches) per minute. Calculate the tensile strength based on the recovered wall thickness.

4.3.4. Heat Shock

The test method shall be as specified in ASTM D2671. Five tubing specimens shall be prepared in accordance with Section 4.3.1. The specimens shall be suspended vertically in a fan assisted air-circulating oven and conditioned at 250°C (482°F) for 4 hours. After conditioning the specimens shall be allowed to cool naturally to room temperature and visually examined for signs of cracking.

4.3.5. Heat Aging

Ten tubing specimens shall be prepared in accordance with Section 4.3.1. The specimens shall be suspended vertically in two fan assisted air circulating ovens, conditioned at $175 \pm 3^\circ\text{C}$ ($347 \pm 5^\circ\text{F}$) for 168 hours. After conditioning, the specimens shall be allowed to cool naturally to room temperature and visually examined for signs of cracking. The samples shall then be tested for Ultimate elongation in accordance with Section 4.3.1.2.

4.4. REJECTION AND RETEST

Failure of any sample of tubing to conform to any one of the requirements of this specification shall be cause for rejection of the lot represented. Tubing which has been rejected may be replaced or reworked to correct the defects and resubmitted for



acceptance. Before resubmitting, full particulars concerning previous rejection and action taken to correct the defects shall be furnished to the inspector.

5. PREPARATION FOR DELIVERY

5.1. FORM

5.1.1. The caps shall be supplied as cut pieces.

5.2. PACKAGING

5.2.1. Packaging shall be in accordance with good commercial practice.

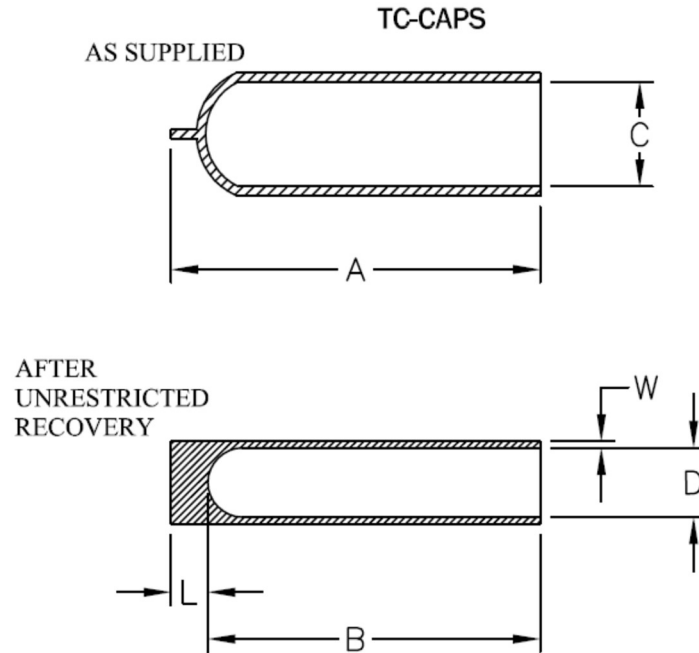
5.3. MARKING

5.3.1. Each container of caps shall be permanently and legibly marked with the size, quantity, manufacturer's identification, part number and lot number.



APPENDIX

**Table 1
Dimensions**



Millimeters (*Inches*)

Size	A	B	L	C	D	W
		Minimum	Nominal	Minimum	Maximum	
TC 4001	19.1(0.750) ± 1.6(0.062)	10.2 (0.400)	3.8 (0.15)	1.6 (0.63)	0.8 (0.030)	0.51(0.020) ± 0.1(0.005)
TC 4003	25.1(1.000) ± 1.6(0.062)	14 (0.550)	3.8 (0.15)	3.2 (0.125)	1.3 (0.050)	0.64(0.025) ± 0.1(0.005)
TC 4005	28.6(1.125) ± 1.6(0.062)	14 (0.550)	3.8 (0.15)	6.4 (0.250)	2.5 (0.100)	0.69(0.027) ± 0.1(0.005)

Color:
TC 4001 White
TC 4003 Red
TC 4005 Gray

**Table 2
Low Temp Flex and Heat Shock Mandrel Sizes**

Recovered Tubing Diameter		Mandrel Size	
mm	in	mm	in
0.58 – 3.18	0.023 - 0.125	7.87 – 7.98	0.310 - 0.314



Table 3
Requirements

CAP PROPERTIES	Unit	Requirement	Test Method
PHYSICAL Dimensions	mm (<i>in</i>)	Table 1	Section 4.3.1 ASTM D 2671
ELECTRICAL Dielectric Withstand		Pass 2500 V/60s	Section 4.3.2
TUBING PROPERTIES			
PHYSICAL Tensile Strength	MPa (<i>psi</i>)	13.8 (<i>2000</i>) minimum	ASTM D 2671
Elongation	Percent	200 minimum	Sec 4.3.3
Longitudinal Change	Percent	± 10	ASTM D 2671
Secant Modulus	MPa (<i>psi</i>)	172 (<i>25,000</i>) minimum	ASTM D 2671
Specific Gravity	--	1.35 maximum	ASTM D 2671
Low Temperature Flexibility 4 hr. at -55 ± 1°C (-67 ± 2°F) Mandrel Dimensions in Table 2	--	No Cracking	ASTM D 2671 Procedure C
Heat Shock 4 hr. at 250 ± 3°C (482 ± 5°F) Mandrel Dimensions in Table 2		No Dripping, Flowing or Cracking	ASTM D 2671
Heat Age, %E 168 hr./175°C	Percent	100 minimum	ASTM D 2671
ELECTRICAL Dielectric Strength	Volts/mm (<i>Volts/mil</i>)	31,500 (<i>800</i>) minimum	ASTM D 2671 Note 1
Volume Resistivity	Ohm-cm	1.0 x 10 ¹⁴ Minimum	
CHEMICAL Corrosion, Copper Contact 168 hours at 150 ± 2°C (302 ± 4°F)	--	No Pitting or Blackening of Copper	ASTM D 2671 Procedure B
Corrosion, Copper Mirror 16 hours at 150 ± 2°C (302 ± 4°F)	--	No removal of copper	ASTM D 2671 Procedure A
Flammability	--	Self-extinguishing within 1 minute, 25% maximum flag burn, no falling burning particles	ASTM D 2671 Procedure B
Fungus Resistance followed by: Tensile Strength Ultimate Elongation Dielectric Strength	MPa (<i>psi</i>) Percent Volts per mm (<i>Volts per mil</i>)	13.8 minimum (<i>2000</i>) 200 minimum 19,650 minimum (<i>500</i>)	ISO 846 Method B Section 4.3.3 ASTM D 2671 ASTM D 2671
Water Absorption 24 hours at 23 ± 3°C (73 ± 5°F)	Percent	0.5 maximum	ASTM D 2671

NOTE 1: Recover the specimens on the metal mandrels for 10 minutes, minimum, at 175 ± 2°C (347 ± 4°F) or until the tubing is completely shrunk on the mandrels.