BATTU HEAT-SHRINK TUBING SPECIFICATION

TEC-108-120006

Raychem BATTU Tubing
Environmental Sealing,
Polyolefin, Semi-rigid, Adhesive-Lined

BATTU is a dual wall tubing designed to insulate terminals for battery cable applications. Being semi-rigid it will also offer a degree of strain relief.
The adhesive in BATTU provides bonds to a wide variety of plastics, rubbers and metals including polyethylene, aluminum, steel and copper.
RoHS and REACH compliant.
Continuous operating temperature -55 to 125°C *(-67 to 257 ºF)*.

Table of Contents

| Indicates Change

BATTU Heat-shrink Tubing

1. SCOPE

This Quality Assurance Specification establishes the quality standard for BATTU. The objective of this document is to specify tests that will qualify the performance of BATTU for protecting, insulating Ring Terminals. Due to the variation in size and design of ring terminals no claim is made with respect to sealing in this specification. This specification covers the requirements for a dual wall, electrically insulating, extruded tubing, whose diameter will reduce to a predetermined size upon application of heat in excess of 135ºC *(275ºF)*.

2. APPLICABLE DOCUMENTS

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

2.1. AMERICAN SOCIETY FOR TESTING AND MATERIAL (ASTM)

ASTM D 471	Standard Test Method for Rubber Property—Effect of Liquids
ASTM D 975	Standard Specification for Diesel Fuel
ASTM D 2671	Standard Methods of Testing Heat-Shrinkable Tubing for Electrical Use
ASTM D 3306	Standard Specification for Glycol Base Engine Coolant for Automobile and Light-Duty Service

(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. SOCIETY OF AUTOMOTIVE ENGINEERS (SAE)

SAE J 1127	Low Voltage Battery Cable, Standard
SAE J 1703	Motor Vehicle Brake Fluid

(Copies of SAE publications may be obtained from the Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, Pennsylvania 15096).

2.3. INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 6722-1	Road vehicles – 60 V and 600 V single core cables -- Part 1: Dimensions, test methods and requirements for copper conductor cables.

(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)

2.4. MILITARY STANDARDS

MIL-STD-104	Limits for Electrical Insulation Color

| Indicates Change

3. REQUIREMENTS

3.1. DIMENSIONS

The dimensions shall be in accordance with Table 1.

3.2. MATERIALS

The tubing components shall be essentially free from pinholes, bubbles, cracks, defects and inclusions and shall be constructed as a dual walled heat shrinkable tubing having a hot melt adhesive inner wall with an outer wall of an irradiated, modified polyolefin material.

3.3. COLOR

The standard jacket color shall be Black, Red, Orange and Yellow. Other colors may be available on request. Inner adhesive wall shall be light amber.

3.4. PROPERTIES

The 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 this specification.

4.1.2. Acceptance Tests

Acceptance tests are those performed on tubing submitted for acceptance under contract. Acceptance tests shall consist of:

Dimensions
Tensile Strength
Ultimate Elongation
Heat Shock
Longitudinal Change

4.2. SAMPLING INSTRUCTIONS

4.2.1. Qualification Test Samples

Qualification test samples shall consist of 45 m *(150 feet)* of any size tubing both black and, for all other colors, white. For the Peel and Sleeve Creep tests only BATTU-25.4/12.7-0 is needed for all colors since the adhesive is the same in all cases.

4.2.2. Acceptance Test Samples

Acceptance test samples shall consist of not less than 5 m *(16 feet)* of tubing 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 had the adhesive removed and have been recovered by heating for 3 minutes in a 200 ± 5ºC *(392 ± 9ºF)* oven. Condition the test specimens (and measurement gauges when applicable) for 3 hours at 23 ± 3ºC *(73 ± 5ºF)*. 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 *(± 1/32 inch)* and inside diameter in accordance with ASTM D 2671. Condition the specimens with adhesive for 3 minutes in a 200 ± 5°C *(392 ± 9°F)* oven, cool to 23 ± 3°C *(73 ± 5°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:

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

Where: C = Longitudinal Change [percent]
L_0 = Length Before Conditioning [inches (mm)]
L_1 = Length After Conditioning [inches (mm)]

4.3.2. Tensile Strength and Ultimate Elongation

Perform the tests in accordance with ASTM D 2671 using a jaw separation speed of 50 ± 5 mm *(2.0 ± 0.2 inches)* per minute. Calculate the tensile strength based on the wall thickness of the jacket only.

4.3.3. Flammability

The test method shall be essentially in accordance with ISO6722.
Recover five 500 mm *(20 inch)* lengths of tubing with adhesive over mandrels with a diameter 75 ± 5 percent of the specified minimum expanded (as supplied) inside diameter of the tubing.

| Indicates Change

Using a Bunsen burner with a 100 mm *(4 inch)* tube, adjust the burner to achieve a flame with an inner blue cone of approximately 50 mm *(2 inches)*. Suspend each specimen in a draft free environment in the configuration shown in Figure 1. The time of exposure of the test flame to each specimen is one 30 second application.
Record the time for each specimen to self-extinguish after removal of the flame. The result is the average burning time for all five specimens.

4.3.4. Split Resistance

Five standard length cut pieces of BATTU tubing material shall be selected at random and slid onto the appropriate mandrels as calculated using the following formula:

(Mandrel Diameter +/- 5%) = d + 0.8 x (D – d)

The dimensions are from the Tubing Dimensions in Table 1. The specimens shall then be conditioned in a fan assisted air circulating oven at 200 ± 5°C *(392 ± 9°F)* for 10 ± 0.5 minutes. Upon removal from the oven the specimens shall be examined visually for evidence of splitting. There shall be no splitting.

4.3.5. 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.

4.3.6. Heat Aging (Short and Long Term)

Ten tubing specimens shall be prepared in accordance with Section 4.3.1., however remove the adhesive prior to recovery. The specimens shall be suspended vertically in two fan assisted air circulating ovens, conditioned at 125 ± 3°C *(257 ± 5°F)* for 3000 hours, and 158 ± 3°C *(316 ± 5°F)* for 168 hours. After conditioning, the specimens shall be allowed to cool naturally to room temperature and visually examined for signs of outer jacket cracking.
The samples shall then be tested for Tensile strength and Ultimate elongation in accordance with Section 4.3.2.

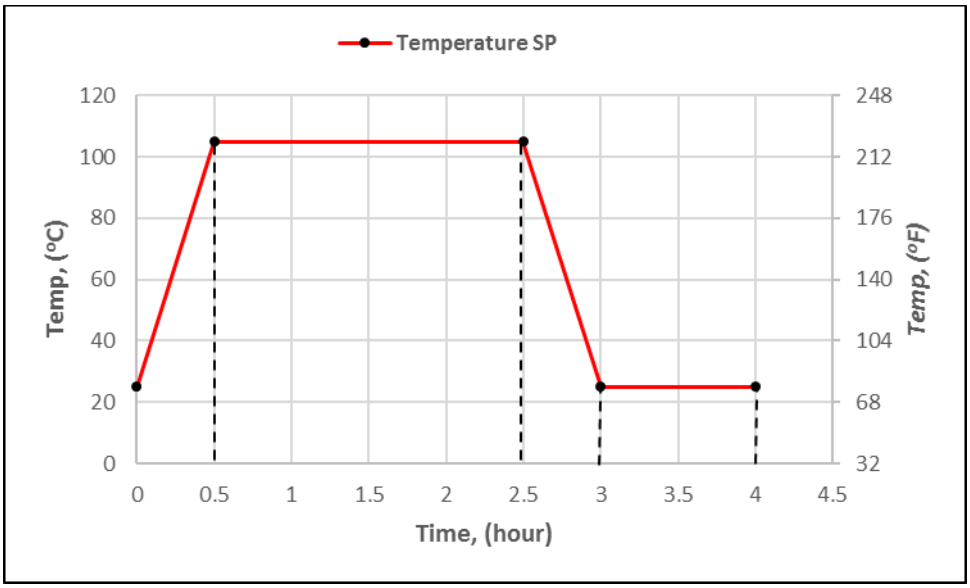
4.3.7. Sleeve Creep

Prepare three test samples by installing a 50.8 mm *(2 inch)* length of BATTU-25.4/12.7-0 over a 0000, OD~20 mm *(0.8 inch)*, crimped lug assembly of so that the tubing is positioned so that the entire flat spade part of the lug is not covered by the heat shrink and the tube is at the point where the crimped lug becomes flat. Place in an air circulating oven at 150 ± 3ºC *(302 ± 5ºF)* for 5 minutes, then cool to room temperature for 4 hours.
Measure the overall splice length after installation and measure the distance from the top of the lug to the bottom of the splice, note these dimensions before and after the 25 temperature cycles.
After which they are loaded suspended vertically from the lug in a cycling oven where each cycle is composed of the following steps:

- Temperature ramping up from 25ºC *(77ºF)* to 105ºC *(221ºF)*, 0.5 hour,

| Indicates Change

• Temperature at 105°C *(221°F)*, 2.0 hour,
• Temperature ramping down from 105°C *(221°F)* to 25°C *(77°F)*, 0.5 hour,
• Temperature at 25°C *(77°F)*, 1.0 hour.



After 25 cycles in which the degree of movement of the tubing is measured and recorded. It is considered a failure if any portion of the crimp is exposed or the tube splits. Minor shifting of the tube is allowed as long as no portion of the crimp is exposed.

4.3.8. Fluid Resistance

All specimens are prepared as in Section 4.3. Using the C die cut tensile and elongation specimens from the recovered tubing. Cut one corner off of these specimens, then measure the thickness at this end of the test specimen before and after fluid emersion to calculate swell. Prepare five 152 mm *(6 inch)* Tubing samples for each fluid used for dielectric testing post fluid exposure.

4.3.8.1. Immerse 3 specimens for 1 hour at 100 ± 3°C *(212 ± 5°F)* in each of the following fluids:

Oil, IRM 903 (ASTM D 471)
Automatic Transmission Fluid (Dexron III/Mercon)
Engine Coolant, Type III (ASTM D 3306)

4.3.8.2. Immerse 3 specimens for 24 hours at 23 ± 3°C *(73 ± 5°F)* in each of the following fluids:

Diesel Fuel, Grade No. 2 (ASTM D 975)
Windshield Washer Fluid
Fuel C, ASTM D 471
Engine Cleaner, GUNK*

| Indicates Change

Brake Fluid, SAE J 1703

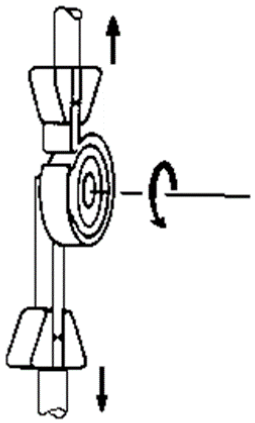
*Trademark of the Radiator Specialty Co., Charlotte, NC

4.3.8.3. Visually inspect all fluid immersion specimens for integrity. After immersion, lightly wipe the specimens and allow to air dry at 23 ± 2°C *(73 ± 5ºF)* for 45 ± 15 minutes. Calculate the percent swell of the T and E specimens at the indicated end. Then test Tensile Strength and Dielectric Strength.

4.3.9. Peel Strength

The test shall be carried out on BATTU-25.4/12.7. Five cylindrical rolling drum adhesion test mandrels 25mm *(1 in)* long by 19mm *(0.75 in)* diameter and of surface material as specified shall be cleaned and degreased. Specimens of BATTU-25.4/12.7 approximately 50mm long shall be recovered on to the mandrels by conditioning in a fan assisted air circulating oven at 150 ± 5°C *(302 ± 9°F)* for 20 minutes. After conditioning the specimens shall be removed from the oven and allowed to cool naturally to room temperature. Surplus lengths of BATTU tubing 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 ± *5mm (2 ± 0.2in)* length per minute as the mandrel rotates. See Figure 1. The test shall be carried out at a temperature of 23 ± 3°C *(73 ± 5°F)*. 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.

Peel Specimen in Tensile Tester Setup



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

| Indicates Change

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 tubing shall be supplied in cut pieces, unless otherwise specified.

5.2. PACKAGING

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

5.3. MARKING

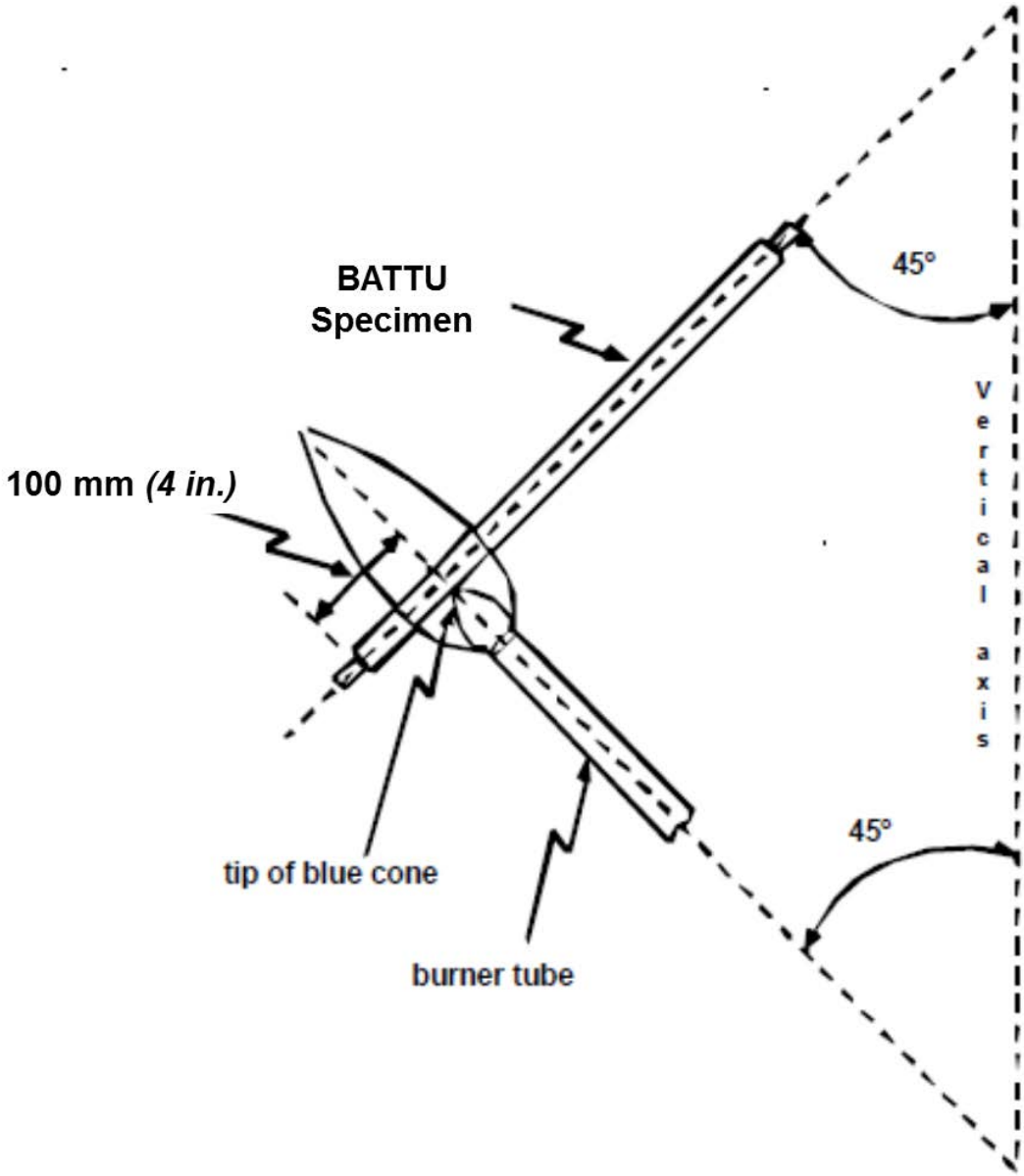
5.3.1. Each container of tubing shall be permanently and legibly marked with the size, quantity, manufacturer's identification, part number and lot number.

| Indicates Change

APPENDIX

FIGURE 1

FLAME TEST SETUP



| Indicates Change

TABLE 1
Mandrel Dimensions
For Heat Shock Bend Testing

Inside diameter of tubing (maximum recovered) mm *(in)*	Mandrel Diameter	
	in.	mm.
3.3 – 6.4 *(0.126 – 0.250)*	0.375 ± 0.003	9.50 ± 0.08
6.5 – 25.4 *(0.251 – 1.000)*	0.438 ± 0.004	11.10 ± 0.10

TABLE 2
Requirements

PROPERTY	UNIT	REQUIREMENT	TEST METHOD
PHYSICAL Dimensions	mm *(inches)*	BATTU Tubing Customer Drawing	ASTM D 2671
Longitudinal Change	Percent	+0, -10	Note 1
Tensile Strength	MPa *(psi)*	10.3 *(1500)* minimum	ASTM D 2671
Ultimate Elongation	Percent	250 minimum	Note 2
Secant Modulus (Expanded)	MPa *(psi)*	137 *(2.0 x 10^4)* minimum	ASTM D 2671 Note 4
Split Resistance	---	Pass	Section 4.3.4
Heat Shock 4 hours at 225 ± 3°C *(437 ± 5°F)*	---	No dripping, flowing or cracking	Table 1 ASTM D 2671
Short Term Heat Resistance 168 hours at 158 ± 1°C *(316.4 ± 1.8°F)* Followed by test for:			ASTM D 2671
Ultimate Elongation	Percent	200 minimum	
Tensile Strength	MPa *(psi)*	6.9 *(1000)* minimum	
Long Term Heat Resistance 3000 hours at 125 ± 3°C *(257 ± 5°F)* Followed by test for:			ASTM D 2671
Ultimate Elongation	Percent	200 minimum	
Tensile Strength	MPa *(psi)*	6.9 *(1000)* minimum	
Color	---	Pass	MIL-STD-104
Peel Strength To Copper To Crosslinked Poly (TAT-125)	N/25mm *(Lbf/in)*	60 *(13.76)* minimum 60 *(13.76)* minimum	Section 4.3.9
Sleeve Creep	---	Pass	Section 4.3.7
Flammability	---	Self-extinguishing within 30 sec	Section 4.3.3 ISO 6722-1

| Indicates Change

TABLE 2
Requirements (continued)

PROPERTY	UNIT	REQUIREMENT	TEST METHOD
ELECTRICAL Dielectric Strength Sizes 1/8" through 1"	Volts/mm *(Volts/mil)*	19,700 *(500)* minimum	ASTM D 2671 Note 3
Volume Resistivity	ohm-cm	1.0 x 10^{12} Minimum	
Fluid Resistance			ASTM D 2671 Section 4.3.8
Ultimate Elongation	Percent	200 minimum	
Tensile Strength	MPa *(psi)*	6.9 *(1000)* minimum	
Dielectric Strength	Volts/mm *(Volts/mil)*	19,700 *(500)* minimum	
Swell	Percent	50 maximum	

NOTE 1: Condition the specimens for 3 minutes at 200 ± 3°C *(392 ± 5°F)* and cool to room temperature before final measurements.

NOTE 2: Use a 50 ± 5-mm/min *(2 ± .2-inch/min)* jaw separation speed.

NOTE 3: Recover the specimens without adhesive 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.

NOTE 4: Calculated based on wall thickness of jacket only.

| Indicates Change