



RK 6638 Revision 9

RBK-ILS-125

SCOPE

This Quality Assurance Specification establishes the quality standard for RBK-ILS-125.

The objective of this document is to specify tests that will qualify the performance of Automotive wiring in-line splices, protected and insulated by RBK-ILS-125 tubing using sequential and individual tests that simulate real use conditions.

For Qualification purposes standardized splice components are used to eliminate sample variation. It has been established that the wire insulation material will meet the requirements herein prior to commencement of testing.

Approved Signatories*

	<u>Quality Assurance</u>	<u>Technical</u>	<u>Product Management</u>
Tyco Electronics UK:	Iain Brown	Colin Diss	Mike Kinsella-Dunlop

* This document is electronically reviewed and approved - therefore no signatures will appear.

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1. REVISION HISTORY

Revision Number	Change Request	Date	Incorporated By
5	P1036	September 1995	B. Jenkins
6	CR04-DM-0095	July 2004	B. Jenkins
7	CR-07-DM-135	September 2007	B. Jenkins
8	CR08-DM-067	May 2008	B. Jenkins
9	CR09-DM-049	Aug 2009	C. Benning

2. REQUIREMENTS

2.1 Composition, Appearance and Colour

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. The standard jacket colour shall be black (designated by suffix -0). Inner adhesive wall shall be light amber.

2.2 Dimensions

Specimens shall be prepared and tested as outlined in section 4.1. Dimensions shall meet the requirements shown in Table 9.

2.3 Test Requirements

The requirements of Table 7 (Individual Tests) will be met by either tubing installed onto splices or tubing installed onto mandrels as appropriate when prepared as recommended herein (Section 3). The requirements of Table 8 (Sequential Tests) will be met by tubing installed onto splices.

3. PREPARATION AND INSTALLATION OF TEST SPECIMENS

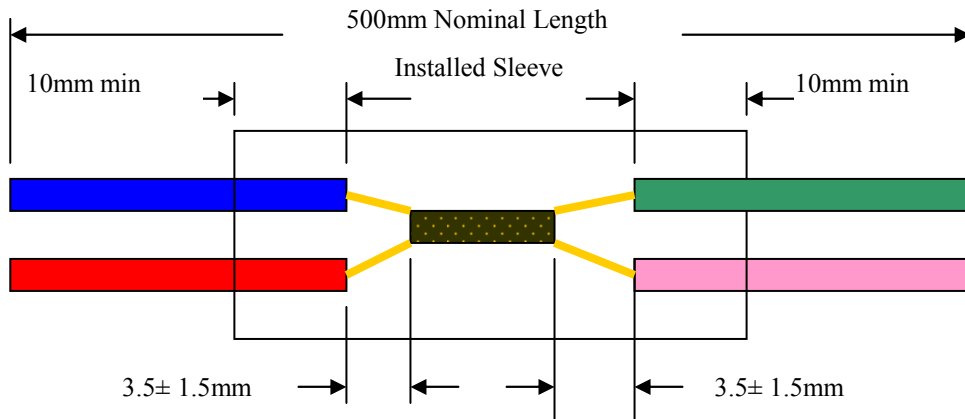
3.1 Sequential, Heat Ageing and Strain Relief Specimens

The overall length of the splice/wire/tube assembly shall be nominally 500 mm and it shall be established prior to testing that the wire insulation material will meet all the tests herein. Wire meeting this requirement is Raychem ACW wire.

The splice assembly is constructed and installed as described in PIP-019 and shown in Fig 1, using Raychem ACW wire as described in Table 1.

3.1 PREPARATION AND INSTALLATION OF TEST SPECIMENS (continued)

Fig 1



3.1.1 Splice Components

Refer to Table 1 for typical component combinations.

Table 1 Splice Components and Construction			
Tube Size	Std. Tube Length (mm)	Splice Configuration	Wire Gauge mm ²
RBK-ILS-125-NR1	50	2:2	0.5
RBK-ILS-125-NR3	65	7:4	1.0
Wire Type	Wire Gauge mm ²	Wire Length mm	Strip Length mm
Raychem ACW0219	0.5	250	15
Raychem ACW0219	0.5	250	15

NB: Splices can be manufactured by ultrasonic, resistance welding or crimping as required by the customer.

3.1.2 Product Application Equipment

Raychem RBK-ILS Processor
 UHI-250 Thermal Probe

3.1.3 Splice Installation

The relevant splice tubing shall be centered onto the splice area and shrunk into position using the RBK-ILS Processor as detailed in Product Installation Procedure PIP-019. The splices shall be allowed to cool naturally to ambient temperature for a minimum of 30 minutes prior to testing for Insulation Resistance as described in Clause 5.1 of this specification.

PREPARATION AND INSTALLATION OF TEST SPECIMENS (Cont'd)

3.2 Physical Property (Individual) Test Specimens

The installation procedures are given in the appropriate test clause. For Scrape Abrasion and Split Resistance, the components shall be selected according to the substrate selection guide Table 2. The mandrels shall be manufactured from a solid steel rod. Unless otherwise specified the tubing shall be installed using a Raychem Thermogun Type CV 1981 at setting 8 with a PR12 reflector. The specimens must be allowed to cool to ambient temperature prior to commencing tests.

Table 2 Substrate Selection Guide

Product	Nominal Substrate Diameter	
	(mm)	(ins)
RBK-ILS-125-0 NR 1	4.8	3/16
RBK-ILS-125-0 NR 2	6.4	1/4
RBK-ILS-125-0 NR 3	9.5	3/8
RBK-ILS-125-0 NR3A	11	7/16
RBK-ILS-125-0-NR4	12.7	1/2

4. INDIVIDUAL PHYSICAL PROPERTY TESTS

4.1 Dimensions and Longitudinal Change

The test method shall be as specified in ASTM D2671. The length and inside diameter of five 150mm long specimens of expanded tubing shall be measured. The specimens shall be recovered at 200°C ± 5°C for 3 minutes in a fan assisted air circulating oven, and immediately quenched in water at room temperature and the dimensions re-measured. The longitudinal change shall be expressed as a percentage of the original length. The recovered jacket wall thickness shall be determined from four measurements equi-spaced around the circumference and the mean value shall be recorded. Blocking of the adhesive liner shall not constitute a failure.

Note: The adhesive used in RBK-ILS-125 is designed to melt and flow around wire splices to create an environmental seal when installed in accordance with PIP-019. Consequently, the inner recovered bore and adhesive wall thickness cannot be reliably or consistently measured after full shrinkage. These dimensions are adequately controlled during the manufacturing process.

PREPARATION AND INSTALLATION OF TEST SPECIMENS (Cont'd)

4.2 Inner Wall Flow Test

This test is carried out on standard length cut pieces of RBK-ILS-125-0 tubing material and is intended as a guide to adhesive flow. Five specimens shall be selected at random and conditioned at $200 \pm 5^\circ\text{C}$ for 3 minutes in a fan assisted air circulating oven after which time approximately 5mm of one end is crimped together using flat faced pliers for approximately 30 seconds. The specimens are then allowed to cool for a minimum of 15 minutes then reconditioned at $200 \pm 5^\circ\text{C}$ for a further 3 minutes. Upon removal from the oven the specimens shall be allowed to cool for 15 minutes minimum and examined for adhesive blocking. The tests shall be considered satisfactory if all specimens are totally blocked in at least one area of the specimen length.

4.3 Split Resistance

Five standard length cut pieces of RBK-ILS-125-0 tubing material shall be selected at random and slid onto the appropriate mandrels as stated in Table 2. The specimens shall then be conditioned in a fan assisted air circulating oven at $200 \pm 5^\circ\text{C}$ for 10 minutes \pm 30 seconds. Upon removal from the oven the specimens shall be examined visually for evidence of splitting. There shall be no splitting.

4.4 Strain Relief

This test is carried out on splice assemblies constructed as described in Clause 3.1. Five specimens of each size shall be tested. Secure one wire from any end in the upper jaw of a suitable tensile testing machine and any other wire from the same end in the lower jaw. The initial jaw separation shall be 100mm and rate of separation shall be 100mm per minute. The test shall be carried out at an ambient temperature of $23 \pm 3^\circ\text{C}$. Each test specimen shall be loaded to 50N and the load immediately released. (Refer to Fig 2) All specimens shall then be checked for Insulation Resistance according to Clause 5.1 of this Specification.

Fig 2 Strain Relief



INDIVIDUAL PHYSICAL PROPERTY TESTS (continued)

4.5 Flammability

The test method shall be essentially in accordance with ISO6722.

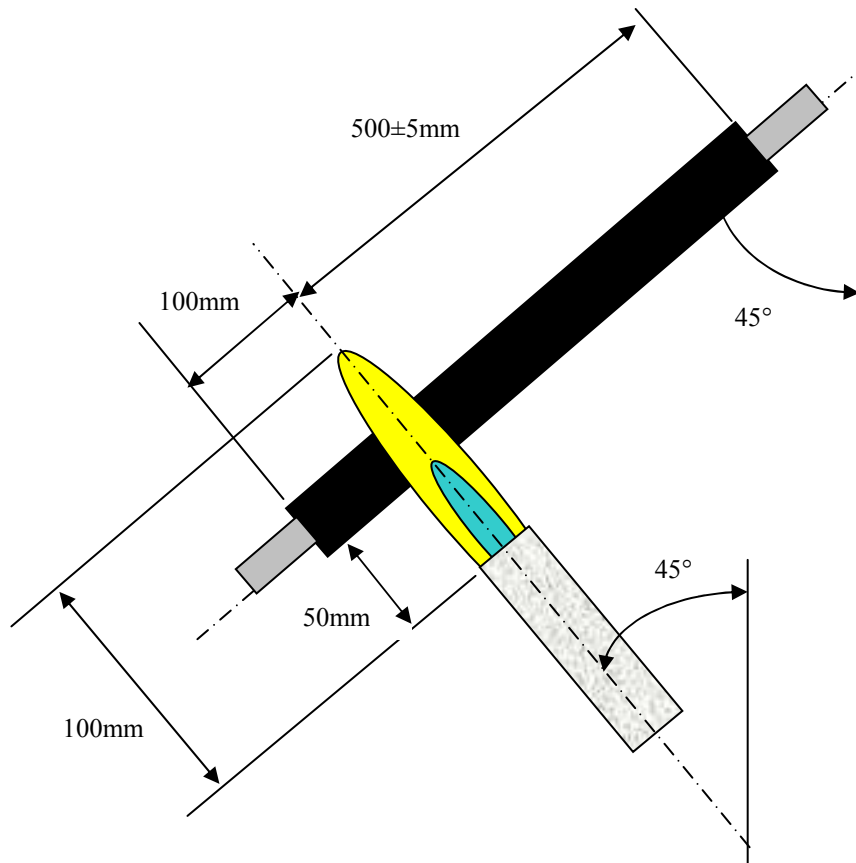
5 lengths of tubing approximately 500mm long shall be shrunk onto metal mandrels having a diameter $75\pm 5\%$ of the specified minimum expanded (as supplied) inside diameter of the tubing.

Use a bunsen burner with a 100mm (4 inch) tube. Adjust the burner to achieve a flame with an inner blue cone of approximately 50mm (2 inches).

Suspend each specimen in a draft free environment in the configuration shown in Fig 3. 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 expressed as the average burning time for the 5 specimens.

Fig 3



INDIVIDUAL PHYSICAL PROPERTY TESTS (continued)

4.6 Scrape Abrasion

The test method is essentially in accordance with that defined in ISO 6722 where a 0.125mm radius needle or profile is drawn back and forth over the splice material. The tests shall be carried out at an ambient temperature of $23 \pm 3^\circ\text{C}$ on five specimens of each size of tubing. The result shall be recorded as the average of the 5 determinations.

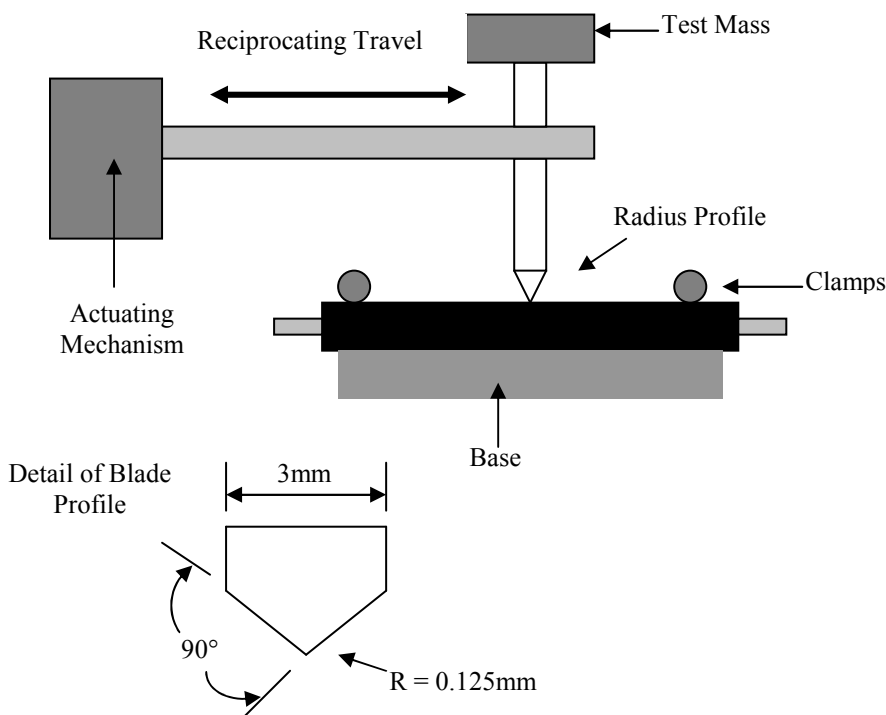
A length of splice tubing approximately 200mm long shall be installed onto the appropriate mandrel as specified in Table 2 by conditioning in a fan assisted air circulating oven at $200^\circ\text{C} \pm 5^\circ\text{C}$ for 3 minutes

Each specimen shall be subjected to the test conditions shown below in Table 3 and shall meet or exceed the cycle requirements given in Table 7. A cycle is defined as one complete forward and backward reciprocation of the test probe. Refer to Figure 4.

Table 3 Scrape Abrasion Test Conditions

Test Temp	$23 \pm 3^\circ\text{C}$
Test Mass	700g
Probe Radius	0.125mm
Cycle Rate	50-60 per minute
Cycle Length	10mm minimum

FIGURE 4 - SCRAPE ABRASION TEST RIG



INDIVIDUAL PHYSICAL PROPERTY TESTS (Cont'd)**4.7 Heat Ageing (Long Term)**

Twenty five specimens shall be prepared as described in Clause 3.1.

The specimens shall be suspended vertically in a fan assisted air circulating oven and conditioned at $125 \pm 3^{\circ}\text{C}$ for 3000 hours. After conditioning, the specimens shall be allowed to cool naturally to room temperature and visually examined for signs of outer jacket cracking. Visual discolouration of the adhesive does not constitute failure.

All specimens shall be subjected to the Insulation Resistance test per Clause 5.1.

4.8 Tensile Strength

5 specimens shall be tested in accordance with ISO37. The Tensile Strength shall be calculated based on the wall thickness of the jacket material only. The result shall be expressed as the average value of the 5 determinations.

4.9 Ultimate Elongation

5 specimens shall be tested in accordance with ISO37. The result shall be expressed as the average value of the 5 determinations.

4.10 2% Secant Modulus

5 specimens shall be tested in accordance with ASTM D882. The test shall be carried out using specimens of expanded tubing. The 2% Secant Modulus shall be calculated based on the wall thickness of the jacket material only. The result shall be expressed as the average value of the 5 determinations.

4.11 Volume Resistivity

5 specimens shall be tested in accordance with ASTM D2671. The result shall be expressed as the average value of the 5 determinations.

5. SEQUENTIAL TEST PROGRAMME

50 Test specimens shall be prepared as described in Clause 3.1. and subjected to the following sequence of tests shown in Clause 5.1 to 5.9.

5.1 Insulation Resistance Test

The apparatus shall be essentially as shown in Figure 5.

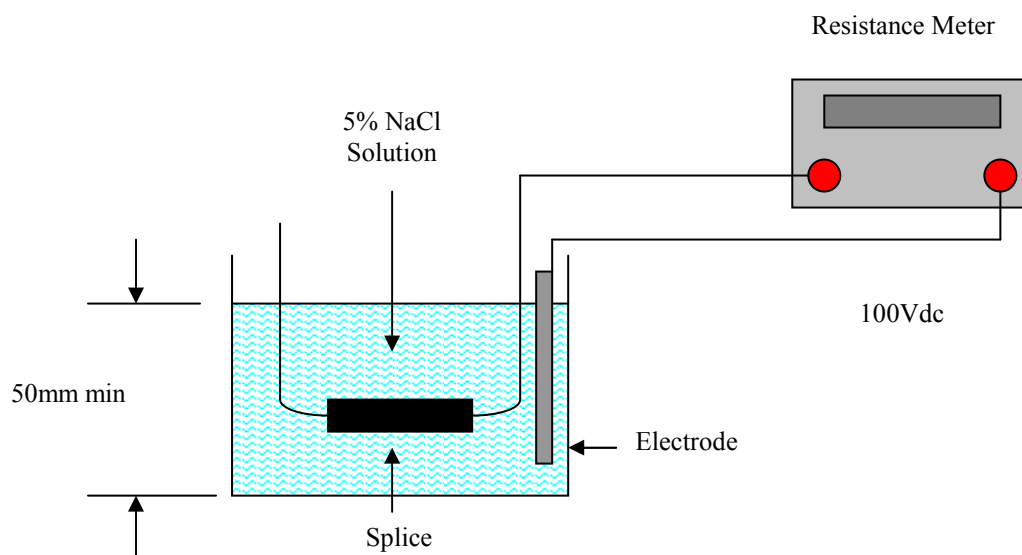
The 50 specimens shall be immersed in salt solution (5% by weight) at $23 \pm 3^{\circ}\text{C}$ for 24 ± 2 hours.

After this conditioning period the resistance between each specimen and an immersed electrode (of surface area 100mm square) shall be measured by means of a suitable Megohmmeter. The reading shall be taken 30 seconds after application of 100V dc. Resistance of less than 2×10^8 Ohms shall constitute a failure.

Subsequent Insulation Resistant tests both in the sequential cycle and individual test sections shall be carried out after 1hour immersion only.

These 50 specimens shall then be subjected to test clause 5.2 Cold Impact.

Fig 5 INSULATION RESISTANCE TEST



SEQUENTIAL TEST PROGRAMME (Cont'd)

5.2 Cold Impact (Sequential)

The test apparatus shall be essentially as shown in Figure 6 and the test method based on ISO 6722.

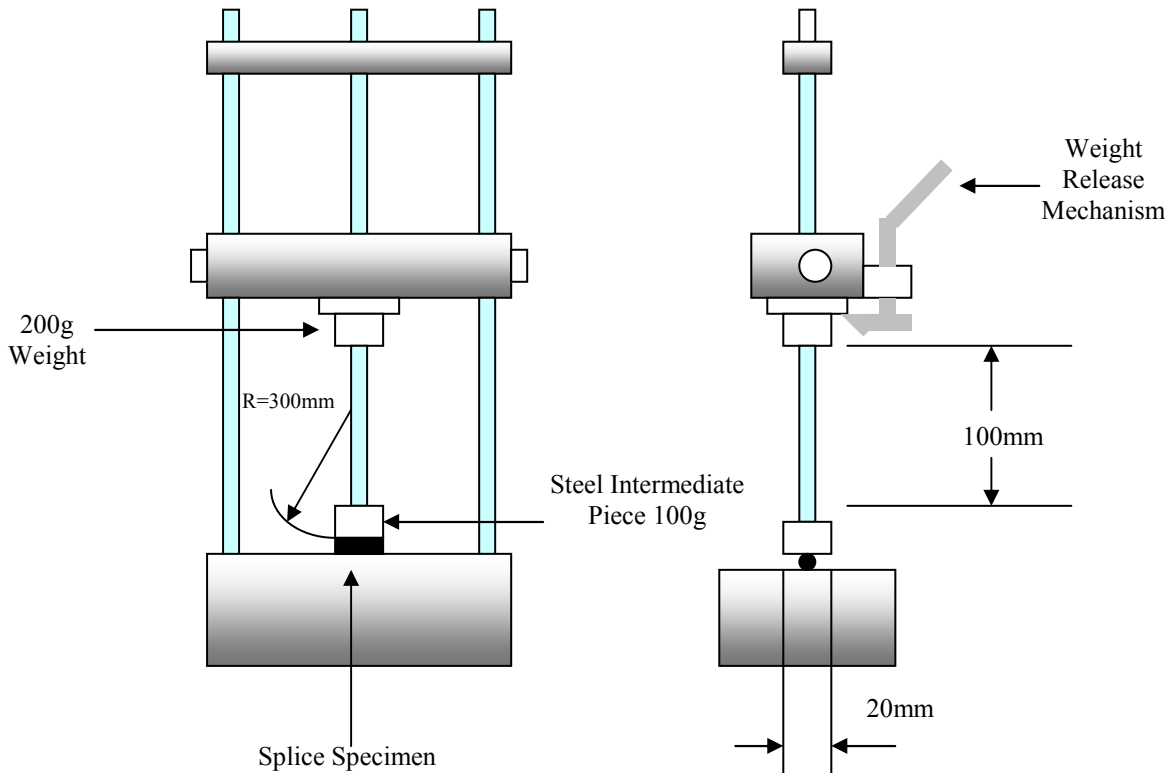
50 splice specimens shall be conditioned together with the test apparatus in a suitable cold chamber for a minimum of 4 hours at $-40 \pm 2^\circ\text{C}$. The apparatus shall be pre-conditioned for a minimum of 4 hours prior to commencement of testing.

Each specimen shall be subjected to a single drop of a 200g weight from a height of 100mm whilst still in the cold chamber ensuring that the weight centrally impacts the splice area.

After test the specimens shall be removed from the cold chamber, allowed to stabilize to room temperature and examined visually for signs of cracking of the outer jacket. Each specimen shall then be subjected to the Insulation Resistance test per Clause 5.1

These 50 specimens shall then be subjected to test clause 5.3. Accelerated Ageing Test.

Fig 6 Cold Impact Test Rig



SEQUENTIAL TEST PROGRAMME (Cont'd)

5.3 Accelerated Ageing Test (Sequential)

50 splice specimens of each size shall be suspended vertically in a fan assisted air circulating oven and conditioned for 168 ± 2 hours at $130 \pm 5^\circ\text{C}$. After the conditioning period the specimens shall be removed from the oven and allowed to cool naturally to room temperature and visually examined for signs of cracking of the outer jacket. Discolouration of the adhesive liner does not constitute a failure. Each specimen shall then be subjected to the Insulation Resistance test per Clause 5.1. These 50 specimens shall then be subjected to test clause 5.4 Thermal Shock.

5.4 Thermal Shock (Sequential)

50 splice specimens of each size shall be suspended vertically in a fan assisted air circulating oven and conditioned for 1 hour \pm 5 minutes at $130 \pm 5^\circ\text{C}$. Immediately after this conditioning period the specimens shall be immersed in a saline solution (5% by weight) at a temperature of 0 to 5°C and conditioned thus for 30 ± 2 minutes. This cycle shall be repeated for a total of five cycles whereby the Insulation Resistance test per Clause 5.1 shall be carried out. These 50 specimens shall then be subjected to test clause 5.5 Temperature/Humidity Cycling.

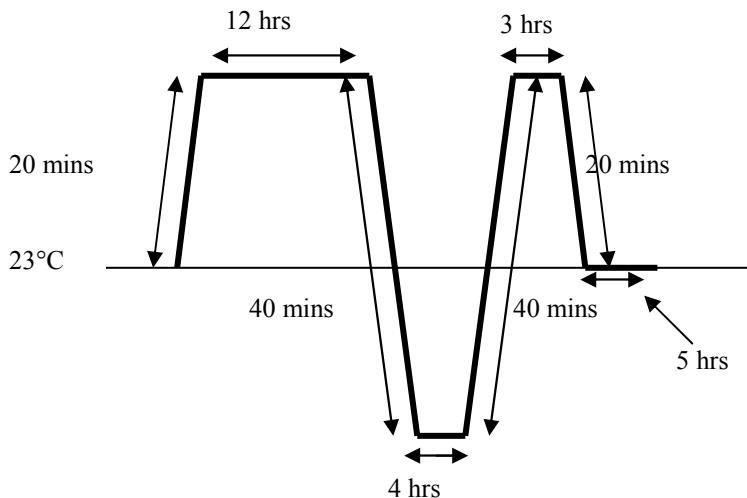
5.5 Temperature/Humidity Cycling (Sequential)

50 splice specimens shall be subjected to the following test regime shown in Table 4 for a total of five cycles. Figure 7 shows typical ramp up and down times together with the dwell periods. After completion of the foregoing test cycle each specimen shall be tested for Insulation Resistance per Clause 5.1. These 50 specimens shall then be subjected to test clause 5.6 Mechanical Vibration.

Table 4 Temperature/Humidity Cycling

12 hours	at	95% RH at 40°C
4 hours	at	-40°C
3 hours	at	95% RH at 40°C
5 hours	at	23°C

FIGURE 7



SEQUENTIAL TEST PROGRAMME (Cont'd)

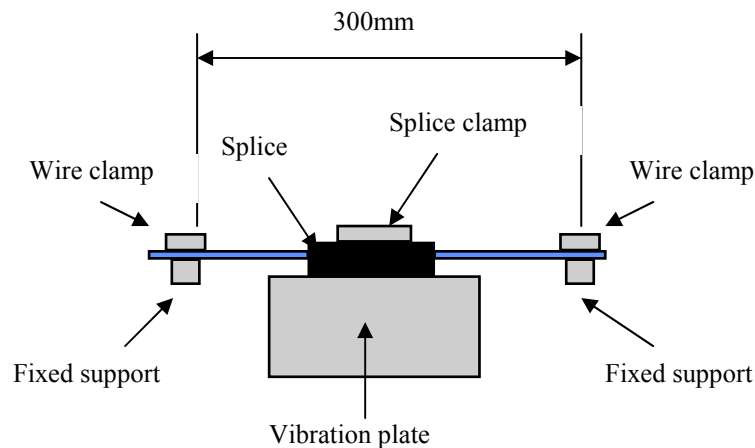
5.6 Mechanical Vibration (Sequential)

The test method shall essentially be in accordance with IEC 6068-2-6. 50 splice specimens shall be subjected to the following vibration regime shown in Table 5. Each specimen shall be clamped horizontally as shown in Fig 8. At the completion of the test, each specimen shall be subjected to the Insulation Resistance Test per Clause 5.1. These 50 specimens shall then be subjected to test clause 5.7 Flex Test.

Table 5 Vibration Regime

10-25Hz	at	1g acceleration
25-500Hz	at	4.5g acceleration
1 Octave per minute		
Test Duration		8 hrs ± 15 minutes

Fig 8



5.7 Flex Test (Sequential)

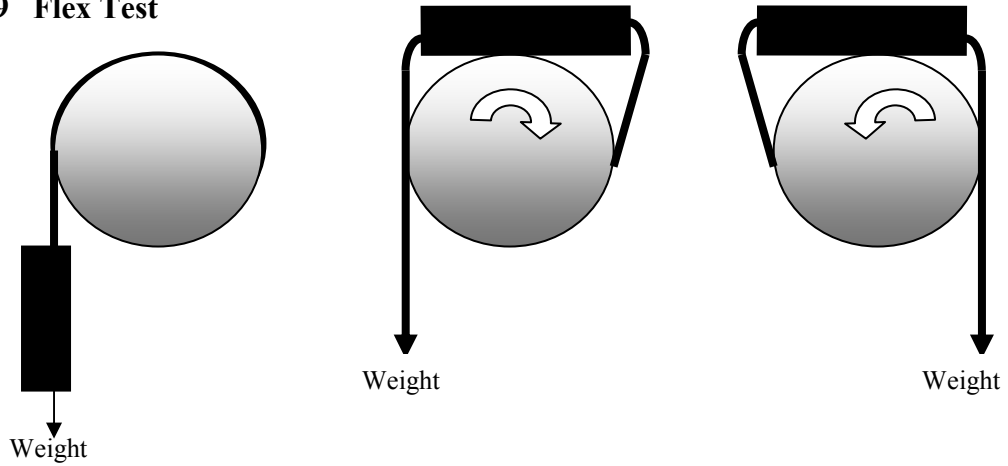
50 splice specimens shall be flexed at Room temperature around a 50.8mm (2") diameter mandrel as follows. Attach one end of the specimen to the mandrel and the other end to a weight (see below). Rotate the mandrel sufficiently to cause the splice area to wrap around the mandrel and the wires on the opposite side of the splice to contact the mandrel. Rotate the mandrel in the opposite direction until the splice is again wrapped around the mandrel. This shall constitute one cycle. Test each sample for 5 cycles. Refer to Fig 9. At the completion of the test, each specimen shall be subjected to the Insulation Resistance Test per Clause 5.1. These 50 specimens shall then be subjected to test clause 5.8 Voltage Withstand.

Weight for RBK-ILS-125-0-NR1 = 2.27kg

Weight for RBK-ILS-125-0-NR3 = 4.54kg

SEQUENTIAL TEST PROGRAMME (Cont'd)

Fig 9 Flex Test



5.8 Voltage Withstand Test (Sequential)

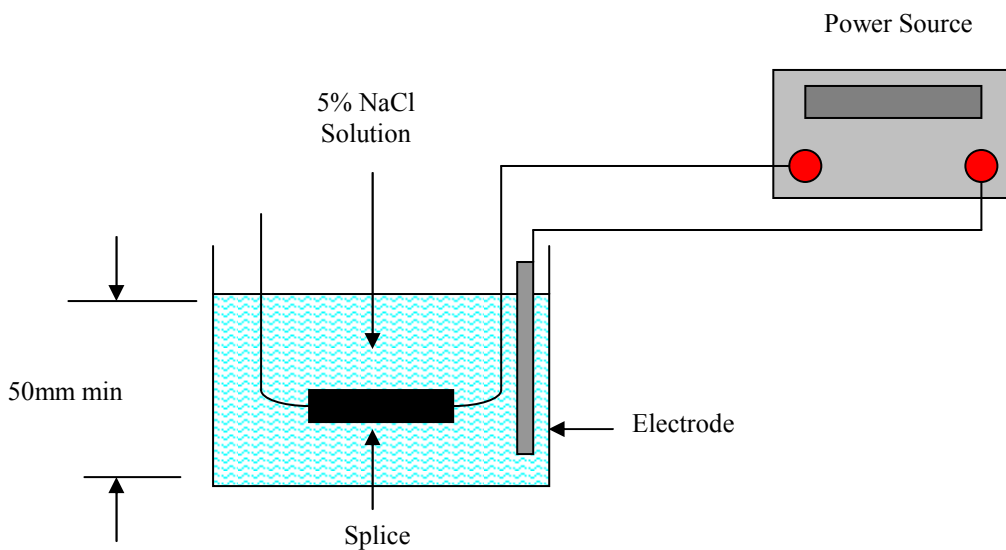
The test method and apparatus shall be essentially as described in IEC 60243 (Refer to Figure 10).

50 splice specimens shall be subjected to the following test.

Each specimen shall be immersed in a 5% (by weight) saline solution at $23 \pm 3^\circ\text{C}$ for $4 \text{ hours} \pm 5 \text{ minutes}$ with the wire ends overhanging the solution bath. The test voltage shall be applied between each conductor and the salt solution at a rate of 500 volts per second until a voltage of 3kV AC is reached. This voltage shall be maintained for 30 minutes. There shall be no flashover of the splice sleeve. These 50 specimens shall then be subjected to test clause 5.9 Fluid Compatibility.

VOLTAGE WITHSTAND TEST RIG

Fig 10



SEQUENTIAL TEST PROGRAMME (Cont'd)

5.9 Fluid Compatibility (Sequential)

50 splice specimens shall be divided into groups of 5 and subjected to the Fluid Test in Clause 5.9.1.

5.9.1 Fluid Soak

5 splice specimens shall be immersed in each of the fluids as specified in Table 6.

A new group of 5 specimens shall be used for each fluid.

After the conditioning period the specimens shall be removed from the fluids, allowed to cool naturally to room temperature, wiped dry and subjected to the Insulation Resistance test per Clause 5.1.

Table 6 Soak Test Fluids

	Test Fluid	Immersion Time	Immersion Temp
a)	Engine Oil ISO 1817 (Oil No 1)	30 ± 2 minutes	100 ± 3°C
b)	Automatic Transmission Fluid Dexron 2™	30 ± 2 minutes	100 ± 3°C
c)	Diesel Fuel to ISO 1817 Liquid F	30 ± 2 minutes	23 ± 2°C
d)	Brake Fluid to DOT 4	30 ± 2 minutes	23 ± 2°C
e)	Gunk™ Degreaser	30 ± 2 minutes	23 ± 2°C
f)	Fluid C* ¹ to ISO 1817	30 ± 2 minutes	23 ± 2°C
g)	Fuel 3* ¹ to ISO 1817	30 ± 2 minutes	23 ± 2°C
h)	Wash Fluid (1% Teepol/Water) by volume	30 ± 2 minutes	23 ± 2°C
i)	Battery Acid to BS3031 (SG 1.25)	30 ± 2 minutes	23 ± 2°C
j)	Engine Coolant/Antifreeze 50/50 by volume	30 ± 2 minutes	23 ± 2°C
* ¹ Use fresh fluid for Fuels 3 and C for each batch test. Seal in airtight containers when not in use to avoid evaporation.			

6. RELATED DOCUMENTS

ASTM D2671-00	Standard Test Methods for Heat-Shrinkable Tubing for Electrical Use
ASTM D882: 2009	Standard Test Methods for Tensile Properties of Thin Plastic Sheeting
BS 3031: 1996	Sulphuric Acid for Use in Lead Acid Batteries
Dot 4	Hydraulic Brake Fluid
IEC 60068-2-6: 2007	Environmental Testing - Test FC And Guidance: Vibration (Sinusoidal)
IEC 60243-1: 1998	Electrical Strength Of Insulating Materials - Test Methods - Tests At Power Frequencies
ISO 37: 2005	Rubber, vulcanized or thermoplastic - Determination of Tensile Stress-Strain Properties
ISO 1817: 2005 - Oil No 1 - Liquid F - Fuel C - Fuel 3	Rubber, vulcanized - Determination of the effect of liquids (Engine Oil) (Diesel Fuel) (Gasoline) (Motor Gasoline containing alcohol)
ISO 6722: 2006	Road Vehicles - 60 V And 600 V Single-Core Cables - Dimensions, Test Methods And Requirements
PIP-019	Size Selection & Installation of RBK-ILS-125-0

7. SAMPLING

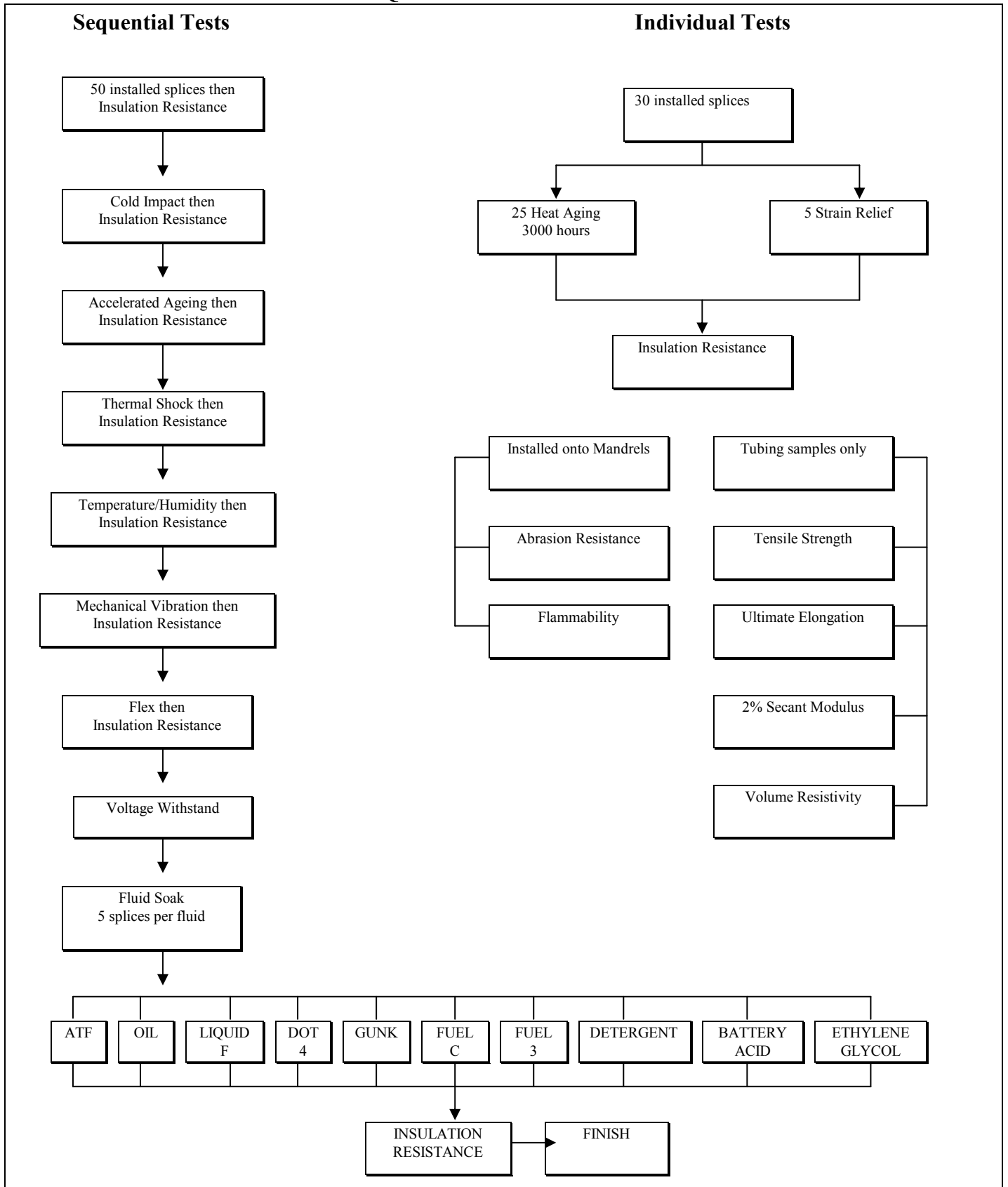
7.1 Qualification

Qualification tests are those performed on tubing submitted for qualification as a satisfactory product and when a change of formulation takes place, and shall consist of all tests listed in this Specification. Tube sizes NR1 and NR3 shall qualify the product range. Qualification test samples shall be cut to the specified lengths and installed onto either splices or the appropriate mandrels. Product is tested on wire configurations or mandrels as specified in Section 3 of this Specification "Preparation and Installation of Test Specimens". The minimum number of specimens to be tested shall be as follows:

- For Sequential Tests: 50 specimens
- For Individual Tests: 5 specimens unless otherwise stated

Refer to the Qualification Flow Chart for more details.

Qualification Flow Chart



SAMPLING (Cont'd)**7.2 Production Routine**

Production Routine tests must be carried out on every batch of finished tubing and shall consist of the following:

Visual Appearance, Dimensions, Longitudinal Change, Inner Wall Flow and Split Resistance.

A minimum of 5 tests shall be carried out on sample lengths taken at random from each batch of finished tubing. A batch of tubing is defined as that quantity of tubing of the same size from the same production run and offered for inspection at the same time.

8. PACKAGING

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

TABLE 7 Test Requirements - INDIVIDUAL TESTS

Test	Test Method	Test Requirements
Dimensions	Clause 4.1 ASTM D2671	As per Clause 2.2
Longitudinal Change	Clause 4.1 ASTM D2671	0 - 10%
Inner Wall Flow	Clause 4.2	Total blocking
Split Resistance	Clause 4.3	No splitting at 200°C
Strain Relief	Clause 4.4	50N
- Insulation Resistance	Clause 5.1	2 x 10 ⁸ Ohms minimum
Flammability	Clause 4.5 ISO 6722	Self extinguishing within 30 seconds
Scrape Abrasion	Clause 4.6 ISO 6722	Nr 1 500 cycles min to cut through Nr 3 5000 cycles min to cut through
Heat Ageing - Visual	Clause 4.7	No cracking of tubing jacket after 3000 hours at 125°C
- Insulation Resistance	Clause 5.1	2 x 10 ⁸ Ohms minimum
Tensile Strength	Clause 4.8 ISO 37	10MPa minimum
Ultimate Elongation	Clause 4.9 ISO 37	250% minimum
2% Secant Modulus	Clause 4.10 ASTM D882	137 MPa minimum
Volume Resistivity	Clause 4.11 ASTM D2671	1.0 x 10 ¹² ohm-cm

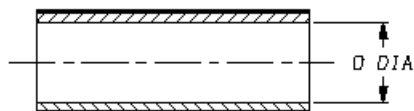
TABLE 8 Test Requirements – SEQUENTIAL TESTS

Insulation Resistance Test	Clause 5.1	2 x 10 ⁸ Ohms minimum after 24 hours immersion
Cold Impact	Clause 5.2	
- Visual	ISO 6722	No cracking of tubing jacket at -40°C.
- Insulation Resistance	Clause 5.1	2 x 10 ⁸ Ohms minimum after 1 hour immersion
Accelerated Heat Ageing	Clause 5.3	
- Visual		No cracking of tubing jacket after 168 hours at 130°C
- Insulation Resistance	Clause 5.1	2 x 10 ⁸ Ohms minimum after 1 hour immersion
Thermal Shock	Clause 5.4	
- Visual		No cracking of tubing jacket after 1 hour at 130°C/30 min immersion at 0 to 5°C (5 cycles)
- Insulation Resistance	Clause 5.1	2 x 10 ⁸ Ohms minimum after 1 hour immersion
Temperature Humidity Cycling	Clause 5.5	
- Insulation Resistance	Clause 5.1	2 x 10 ⁸ Ohms minimum after 1 hour immersion
Mechanical Vibration	Clause 5.6	
- Insulation Resistance	Clause 5.1	2 x 10 ⁸ Ohms minimum after 1 hour immersion
Flex Test (Ambient)	Clause 5.7	
- Insulation Resistance	Clause 5.1	2 x 10 ⁸ Ohms minimum after 1 hour immersion
Voltage Withstand	Clause 5.8	No breakdown at 3kV after 30 minutes
Fluid Soak	Clause 5.9	30 minutes immersion
- Insulation Resistance	Clause 5.1	2 x 10 ⁸ Ohms minimum after 1 hour immersion

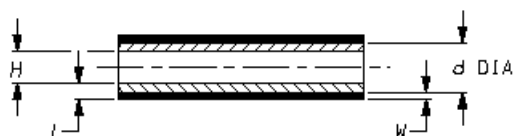
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TABLE 9 Dimensional Requirements

a) Part as supplied.



b) Part fully recovered.



OUTER JACKET;- Irradiated Modified PolyLeFin Type, COLOUR: Black.

INNER LINER;- Thermoplastic Hot-Melt Adhesive, COLOUR: Light amber.

Dimensions (in millimetres).

Part No.	D DIA	Jacket & Liner H DIA	Jacket d DIA	Jacket W(wall)	Jacket & Liner L
	MIN	MAX	MAX	MIN	MIN
	a	b	b	b	b
RBK-ILS-125-NR1	5.75	1.25	2.65	0.6	1.15
RBK-ILS-125-NR2	7.50	1.65	3.45	0.7	1.40
RBK-ILS-125-NR3	11.00	2.40	4.65	0.8	1.80
RBK-ILS-125-3A	14.00	3.00	5.90	0.9	2.15
RBK-ILS-125-NR4	18.30	4.35	7.40	0.9	2.20

Dimension H & L (Jacket & Liner) value is for reference only

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