General Installation Procedure for Splice Sealing Products

NB: The recommendations presented here are based on general industry information.

Since TE Connectivity does not have knowledge of the specific application and the end use conditions of all users, each user should determine the correct size of tubing together with the installation conditions for their own application and evaluate against their individual requirements.

Note: The size and colour of the product may be different from the images in this document. The images mentioned in this document are for representation purpose only.

Contents Page

1. SCOPE

This document details the important aspects of splice design together with general installation guidelines when using TE Raychem splice sealing products.

2. REVISION HISTORY / REASON FOR CHANGE / RELATED DOCUMENTS

Rev	Date	Prepared By	Doc Approved By	Remarks
A	Mar 2024	Kamalasaravanan	Richard Kewell	New Document

2.1. Applicable Product Family

BATTU, ES1000, FL2500, QS1500, RPPM and SCT

2.2. Customer Assistance

Reference Product Base Part Number and Product Code are representative of. Use of these numbers will identify the product line and help you to obtain product and tooling information when visiting www.te.com or calling the number at the bottom of page 1.

2.3. Drawings

Customer drawings for product part numbers are available from www.te.com. Information contained in the customer drawing takes priority.

2.4. Specifications

Product Specification for product part numbers available from www.te.com provides product performance and test results.

2.5. Shelf Life

Refer document Global Dimensional Life for Heat Shrink Tubing Standard Size Products 408-32191 for details regarding the shelf life.

2.6. Safety

Appropriate Personal Protective Equipment (PPE) should be worn, and installation should take place with fume extraction or in a well-ventilated area.

3. INTRODUCTION

This guide has been produced to aid the splice designer and user of TE Raychem Splice Sealing tubing to select the most appropriate size and installation conditions to produce optimum results in an environmentally sealed splice.

The document has three main sections:

Section 4. Splice Design and Preparation Guidelines
Section 5. Tube size selection and installation guidelines
Section 6. Sealing verification guidelines

NB: The recommendations presented here are based on general industry information. Since TE Connectivity does not have knowledge of the specific application and the end use conditions of all users, each user should determine the correct size of tubing together with the installation conditions for their own application and evaluate the splice against individual requirements.
(Refer to TE Connectivity to ensure latest issue of this document)

4. SPLICE DESIGN AND PREPARATION GUIDELINES

4.1. Splice Design

There are many factors, which can influence the successful installation of a heat shrink sleeve for splice sealing. These include:

I. Total number of wires.
II. Number difference of wires between each side.
III. Cumulative insulation cross-sectional area.
IV. Cumulative insulation cross-sectional area difference between each side
V. Distance from the nugget to the wire insulation

Generally, for splices having no more than 4 wires per side the installation and sealing characteristics are excellent.

For splices having 5 to 7 wires per side the configuration is more complex and corresponding installation times are likely to be longer and the installation window smaller. Consequently, these splices may require additional work in establishing production installation conditions. For optimum performance and compatibility, it is recommended that T3 (125°C) rated wire be used.

4.2. Splice Preparation Guidelines

The splice can be constructed by conventional techniques such as resistance welding, ultrasonic welding, crimping or “clip and dip”. The strands of the conductor must be completely captured in the nugget or crimped area. There should be no loose strands; especially those pointing upwards which can cause “poke-through” of the tubing material during installation.

It is important to ensure that the distance from the nugget to the wire insulation be 3.5 ± 1.5mm to allow the adhesive sufficient space to flow and seal between the wires (see Figures 1 & 2). The copper wire strands from opposing sides of the splice must not compromise this dimension. Additionally, the wire around the splice should be essentially free of dirt, oil, solder, flux, and moisture for optimum performance.

Figure 1

Splice Preparation Guidelines (Ultrasonic welded Splices)

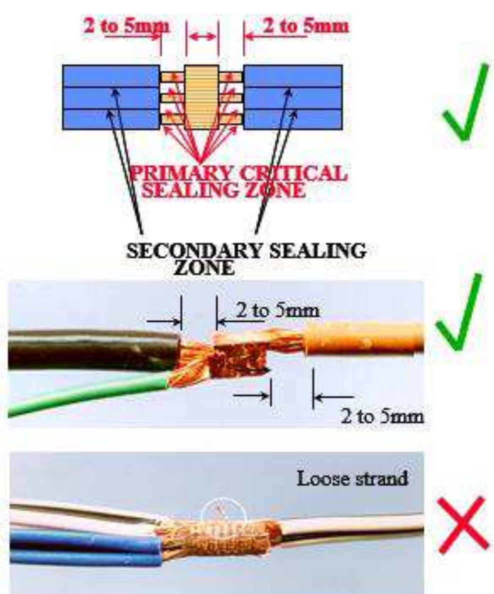
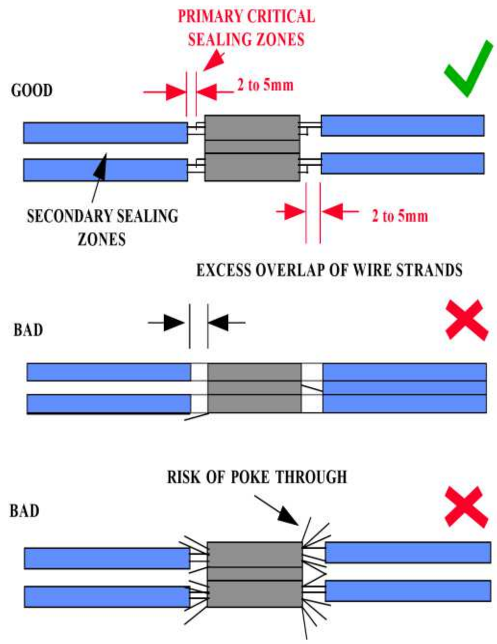


Figure 2

Splice Preparation Guidelines
(Crimped Splices)

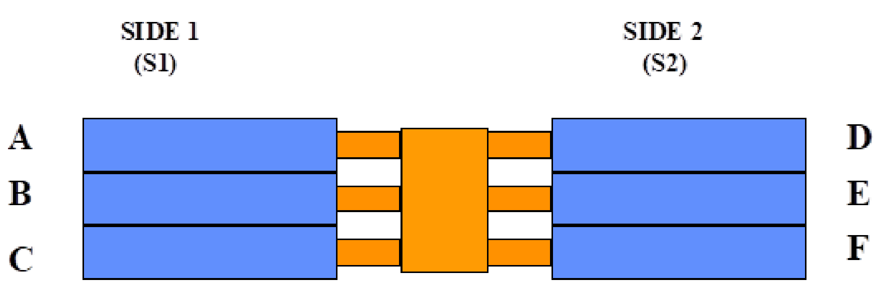


5. TUBING SIZE SELECTION AND INSTALLATION GUIDELINES

5.1. Tube Size Selection

Wire insulation diameters for a given gauge of wire can vary depending on the manufacturer. This will influence the cumulative cross-sectional area of the wire bundle in the splice. However, it is recommended that each user should determine the correct size of tubing together with the installation conditions for their own application and evaluate the splice against individual requirements. However, it is recommended that the simple calculation shown below, and Figure 3 be followed to determine the cumulative cross-sectional area more accurately for each side of the splice.

Figure 3



Cumulative Cross-Sectional Area

S1 = 0.8 ($A^2 + B^2 + C^2$ ....) **S2 = 0.8 ($D^2 + E^2 + F^2$..................)**

Where S1 = Cumulative area of side 1

S2 = Cumulative area of side 2

A Diameter of wire A

B Diameter of wire B

C Diameter of wire C

D Diameter of wire D

E Diameter of wire E

F Diameter of wire F

Note: $\Pi/4 \triangleq 0.8$

5.2. Installation Guidelines

Installations can be carried out using various techniques including discrete or belt type heaters, the selected method being dependent on production area layout and required throughput. It is important that installation equipment be maintained in a state of calibration using an UHI-250A thermal probe as described in the RBK-ILS Processor Operation and Maintenance Manual THFIT/MR/109.

The installation “window” will be dependent on the set point temperature of the equipment, geometry and preparation of splice and the size of tubing. Generally, the installation window will be small if the splice geometry is complex, and the equipment set point high. For lower set points the window will be larger, but the corresponding installation time will be longer. Generally, it is recommended that discrete heaters such as the Raychem RBK-Processor be set at 450 - 500°C, the Raychem IR1839 belt heater at 490°C and the Model 19 Belt heater at 550°C.

It is recommended that “heat” input as seen by the splice to be installed be measured via a UHI-250A Thermal Probe. (Tyco Electronics PCN-288869, CLT-EQUIP-UHI-250A-PROBE. Refer to Appendix 2 for explanation of the Thermal Probe.)
Verification of sealed joints can be determined as outlined in Section 6.

Installation Method:

a. Determine tube size per section 5.1.
b. Ensure installation equipment has been switched on for a minimum of 30 minutes to stabilize.
c. Recheck for loose wire stands and wire insulation cut back. Centrally locate the tubing onto the splice and position centrally within the heating zone of the application equipment. (See Figures 4 & 5).
d. Run the splice through the heating equipment, record the installation conditions, i.e. processor time/set point, belt heater speed/set point. Run the UHI probe through at the same conditions to obtain the UHI temperature.
e. Increase the UHI probe temperature by 5-10°C increments by changing the processor time in 1-2 second steps, or belt heater speed (not the set temperature) until the wire insulation or tubing jacket material shows visual signs of damage. (This is the upper limit of the installation window.)
f. Check all splices for sealing efficiency (0.5 bar air pressure per section 6). If the sample installed at the lowest UHI sealing temperature passes, then lower the UHI probe temperature by 5° - 10°C increments until a sealing failure occurs.
g. Prepare 5 sample splices at the minimum conditions, which gave a pass result when tested per section 6. If all 5 passes, this can be regarded as the lower limit of the installation window. If failures occur raise the UHI probe temperatures as previously until 5 from 5 pass to give the lower limit. If damage is seen before sealing is achieved, then the splice configuration may need re-design.

To optimize sealing efficiency in a production environment it is recommended that the midpoint between upper and lower limit be used.

Note: Sealing time for a given splice will depend on its complexity, number of wires and the wire type.

Figure 4

Visual standards before installing tubing.
(Ultrasonic Welded Splices)

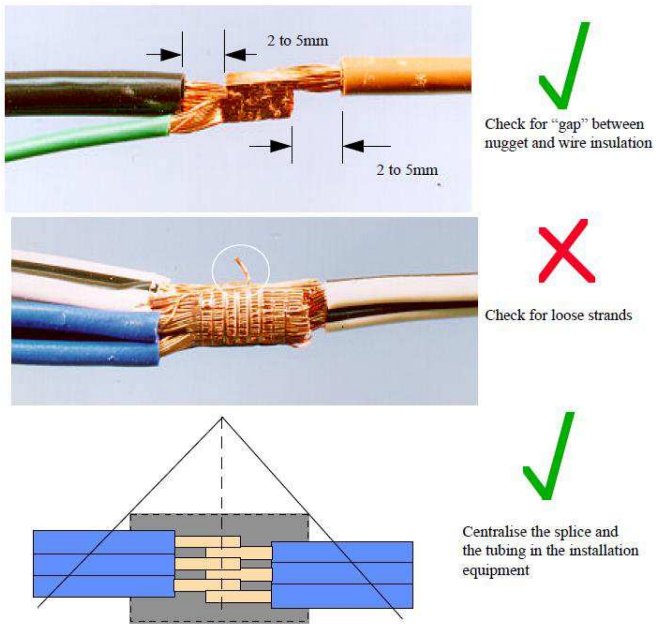
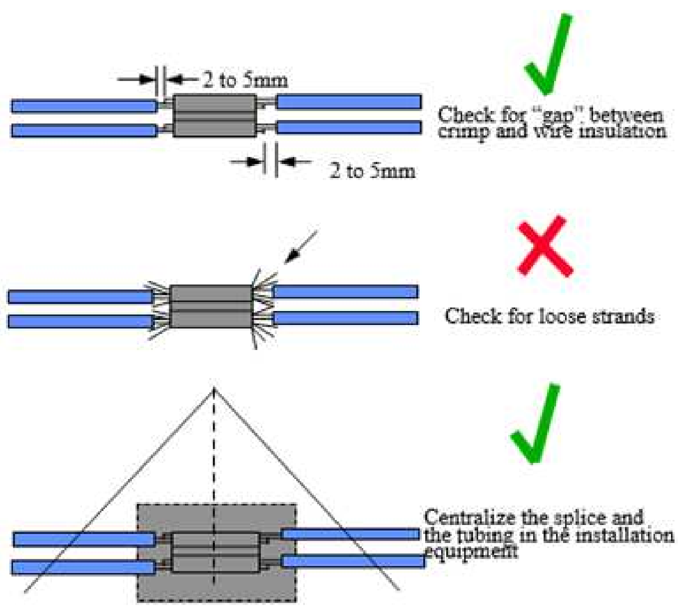


Figure 5

Visual standards before installing tubing.
(Crimped Splices)



6. SEALING VERIFICATION / VISUAL STANDARDS

6.1. Test Methods

A variety of test methods exist which are incorporated by many major Automotive OEMs to determine the environmental integrity of an installed splice including:

1. Current Leakage
2. Insulation Resistance
3. Air Pressure
   a) Not suitable for splices manufactured by "clip and dip".
   b) Will not detect poke-through.

Refer to Appendix 3 for Test Methods.

For speedy determination of splice installation windows, it is recommended that an air pressure test be used. Experience has shown excellent correlation between this method and Insulation Resistance / Current techniques for most types of splices.

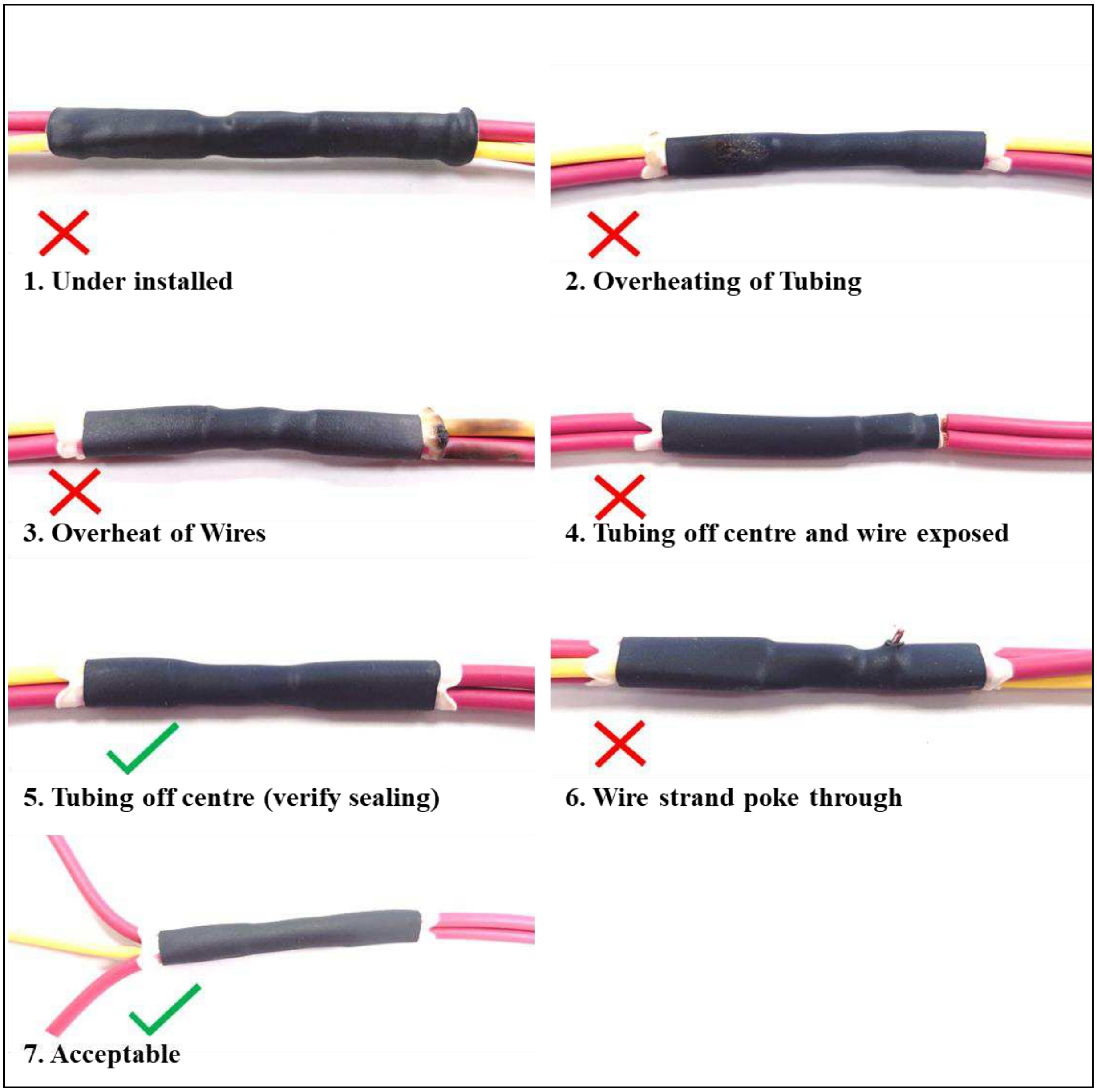
TE Connectivity Seal Test equipment AD 3050 has been found to be acceptable (for details see TE Connectivity Flier No TFAE00017 07/95).

It can also be used to monitor sealing efficiency periodically throughout a production run.

Final verification should be per OEM specification.

6.2. Visual Standards

Visual Standards after Installation



Appendix 1: General Wire Chart

Nominal OD (mm)	Approximate Cross-Sectional Area mm² based on wire insulation diameter						
	Number of Wires						
	1	2	3	4	5	6	7
1.4	2	3	5	6	8	9	11
1.5	2	4	5	7	9	11	12
1.6	2	4	6	8	10	12	14
1.7	2	5	7	9	11	14	16
1.8	3	5	8	10	13	15	18
1.9	3	6	9	11	14	17	20
2.0	3	6	9	13	16	19	22
2.1	3	7	10	14	17	21	24
2.2	4	8	11	15	19	23	27
2.3	4	8	12	17	21	25	29
2.4	5	9	14	18	23	27	32
2.5	5	10	15	20	25	29	34
2.6	5	11	16	21	27	32	37
2.7	6	11	17	23	29	34	40
2.8	6	12	18	25	31	37	43
2.9	7	13	20	26	34	40	46
3.0	7	14	21	28	35	42	49
3.1	8	15	23	30	38	45	53
3.2	8	16	24	32	40	48	56
3.3	9	17	26	34	43	51	60
3.4	9	18	27	36	45	54	64
3.5	10	19	29	38	46	56	67
3.6	10	20	31	41	51	61	71
3.7	11	22	32	43	54	65	75
3.8	11	23	34	45	57	68	79
3.9	12	24	36	48	60	72	84

Appendix 1: General Wire Chart (continued.)

Nominal OD (mm)	Approximate Cross-Sectional Area mm² based on wire insulation diameter						
	Number of Wires						
	1	2	3	4	5	6	7
4.0	13	25	38	50	63	75	88
4.1	13	26	40	53	66	79	
4.2	14	28	42	55	69	83	
4.3	15	29	44	58	73	87	
4.4	15	30	46	61	76		
4.5	16	32	48	64	80		
4.6	17	33	50	66	83		
4.7	17	35	52	69	87		
4.8	18	36	54	72			
4.9	19	38	58	75			
5.0	20	39	59	79			
5.1	20	41	61	82			
5.2	21	42	64	85			
5.3	22	44	66	88			
5.4	23	46	69				
5.5	24	48	71				
5.6	25	49	74				
5.7	26	51	77				
5.8	26	53	79				
5.9	27	55	82				
6.0	28	57	85				
6.1	29	58	87				
6.2	30	60					
6.3	31	62					
6.4	32	64					
6.5	33	66					
6.6	34	68					
6.7	35	70					
6.8	36	73					
6.9	37	74					
7.0	38	77					
7.1	40	80					
7.2	41	81					
7.3	42	84					
7.4	43	86					
7.5	44	88					
7.6	45						
7.7	46						
7.8	48						

Appendix 2: UHI-250A THERMAL PROBE

UHI-250A (PCN 288869)

The heat applied to a splice is conveniently measured by a TE Connectivity UHI-250A Thermal Probe. This Thermal Probe has a known mass of aluminium with fixed dimensions and a thermocouple embedded in the aluminium. The theory of use of the Probe is derived from the equation for calculating the quantity of heat required to raise a mass from one temperature to another.

$$Q = Mkc\,(t_2 - t_1)$$

Where
- Q = Quantity of Heat
- M = Mass
- k = units constant
- c = specific heat
- t_1 = ambient temperature
- t_2 = final temperature

When using the probe, M, k, c and t_1 are constant so that the final temperature (ignoring heat loss) is proportional to the quantity of heat.

$$t_2 = \propto Q$$

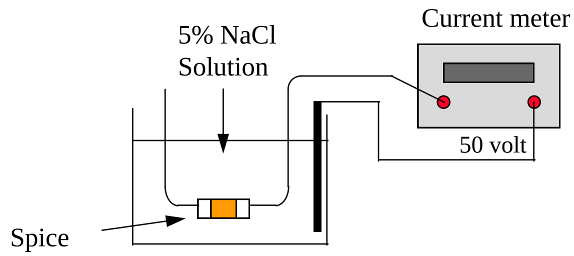
The temperature rise of the aluminium is proportional to the heat received during the time the Probe is in the heat zone of the heater. By relating this temperature to the sealing performance of a given splice the window for this splice can be defined. The lower point is the lowest temperature at which the splice seals and the upper point the highest temperature at which no thermal damage is observed. The best probe temperature (quantity of heat) for a given splice is normally set at the midpoint of the window. This midpoint temperature is best determined in the manufacturing environment where the splice is to be sealed.

The UHI-250A Thermal Probe is available through your local TE Connectivity Office
(PCN: 288869).

Appendix 3: Test Methods

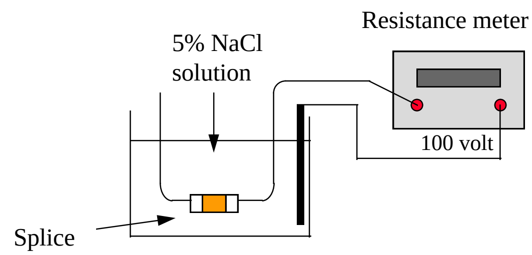
Current Leakage: Test Method

Immerse the centre section of the specimens in a water bath containing 5 percent by weight of sodium chloride (23 ± 2°C).
Check for current leakage after 24 hours immersion.
Applied test voltage is 50V dc. Take the reading after 60 seconds. The splice shall be considered sealed if current leakage is less than 0.25 micro amps



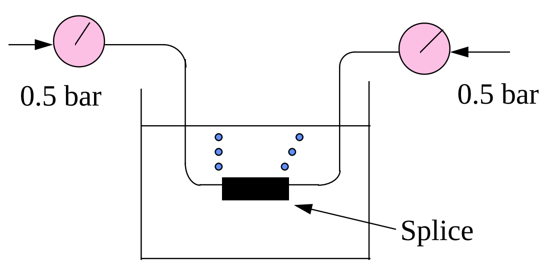
Insulation Resistance: Test Method

Immerse the centre section of the specimens in a water bath containing 5 percent by weight of sodium chloride (23± 2°C). Check for Insulation Resistance after 24 hours immersion. Applied test voltage is 100V dc. Take the reading after 60 seconds. The splice shall be considered sealed if the Insulation Resistance is greater than 2×10^8 ohm



Air Pressure: Test Method

Immerse the centre section of the specimens in a water bath. Connect both ends to a regulated air supply and apply 0.5 bar for 1 minute. If no bubbles arise from the splice area sealing is considered acceptable.
Final verification should be per OEM specification.



Appendix 4: Trouble Shooting

Fault	Possible Cause	Solution
Sleeve not fully shrunk onto splice	Insufficient heat Insufficient time Wrong tube size	Increase heat. Check UHI-250A reading Increase time in heater element Consult Tube Selection
Sleeve mislocated after installation (milk-off)	Incorrect location prior to installation Splice unbalanced	Locate correctly (offset) Use alignment guide on heater Redesign splice if possible Consult local TE Connectivity rep
Sleeve partially recovered at one end	Splice did not align centrally in application equipment	Use guidelines on machine for centralisation Check calibration
Sleeve or wire overheated	Excessive heat Excessive time	Reduce heat Reduce time in element Check calibration
Sleeve scorched on one side	Excessive wire curvature Splice located incorrectly in machine	Use straightened wire Reposition splice
Sleeve splits	Sharp edge of nugget/crimp Wire strand loose Splice overheated Wrong tube size selected	Check welder tooling Reduce heat/time Reassess
Wire strand pokes through tube	Wire strand loose from welding	Check welder tooling Check splice construction
Cannot seal splice	Inadequate heat Incorrect size of tube Too many wires Contamination on wires Inadequate sealing zone	Increase heat Refer to sizing guide Reconstruct splice Clean splice Check process Check calibration
Wire damage at sleeve edge but sleeve visually OK	Overheat Excessive time Splice not centred in machine Mismatch of tube/wire Temperature rating	Reduce heat Reduce time Use guides on machine Reduce heat/time