



## Product Installation Procedure (PIP)

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### Title: **Size Selection & Installation of ES-CAP**



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Note: This document is electronically reviewed and approved - therefore no signature will appear

Consult TE Connectivity for the latest revision of this document

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### 1. SCOPE

This document contains information relating to recommended size selection and installation guidelines for ES-CAP.

### 2. REVISION HISTORY / REASON FOR CHANGE / RELATED DOCUMENTS

Document	Rev No.	Date	Requested By	Incorporated By	Reason
PIP-021	1 (not signed)	August 1996	Product Management	B Jenkins	
PIP-021	2	March 1997	Product Management	B Jenkins	
PIP-021	3	March 2003	Product Management	B Jenkins	
PIP-021	4	September 2003	Product Management	B Jenkins	
114-120003	A	April 2021	Product Management	Clive Benning	Supersedes PIP-021 and addition of ES-CAP-No.0

<b>Related Documents:</b>	<i>ES-CAP Sealing Caps</i>	<i>108-120037</i>
	<i>RBK-ILS MK4 Processor Operation and Maintenance Manual</i>	<i>412-94334-1</i>
	<i>Raychem Seal Test Equipment AD3050</i>	<i>2-1773452-8</i>

### 3. INTRODUCTION

This guide has been produced to aid the stub splice designer and user of ES-CAP to select the most appropriate size and installation conditions to produce optimum results in an environmentally sealed splice for working temperatures up to 125°C.

Note: Fabric tape rated at an operating temperature of 125 °C or higher is advised to secure the cap to the wire bundle for temperature exposure above 105 +/- 3 °C

The document has 3 main sections:

- Section 4                      Splice Design and Preparation Guidelines
- Section 5                      Component Size Selection and Installation Guidelines
- Section 6                      Sealing Verification Guidelines

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**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 component together with the installation conditions for their own application and evaluate the splice against individual requirements.**

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## 4. SPLICE DESIGN AND PREPARATION GUIDELINES

### 4.1 Splice Design

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

For splices having 5 to 7 wires 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 and the following guidelines followed:

Parameter	ES-CAP Size			
	ES-CAP-No.0 <sup>(1)</sup>	ES-CAP-No.1	ES-CAP-No.2	ES-CAP-No.3
No. of wires max	7	7	7	7
CSA min/max range mm <sup>2</sup>	0.5 to 7.5	1.3 to 12	3 to 20	5 to 30
Length	Cap length should be based on application installation trials and sealing verification tests. Available product lengths are outlined in product specification 108-120037			

Note: (1) ES-CAP-No.0 only available in black.

Note: Fabric tape rated at an operating temperature of 125 °C or higher is advised to secure the cap to the wire bundle for temperature exposure above 105 +/- 3 °C

**Due to variations in wire insulation thickness between manufacturers of similar gauge wires, the cross-sectional areas shown above, relate to the cumulative areas of a splice using the outside diameter of each wire in the calculation. Splices outside of these recommendations will require extensive testing to ensure that reliable sealing of the splice can be consistently achieved. (See also Figure 3).**

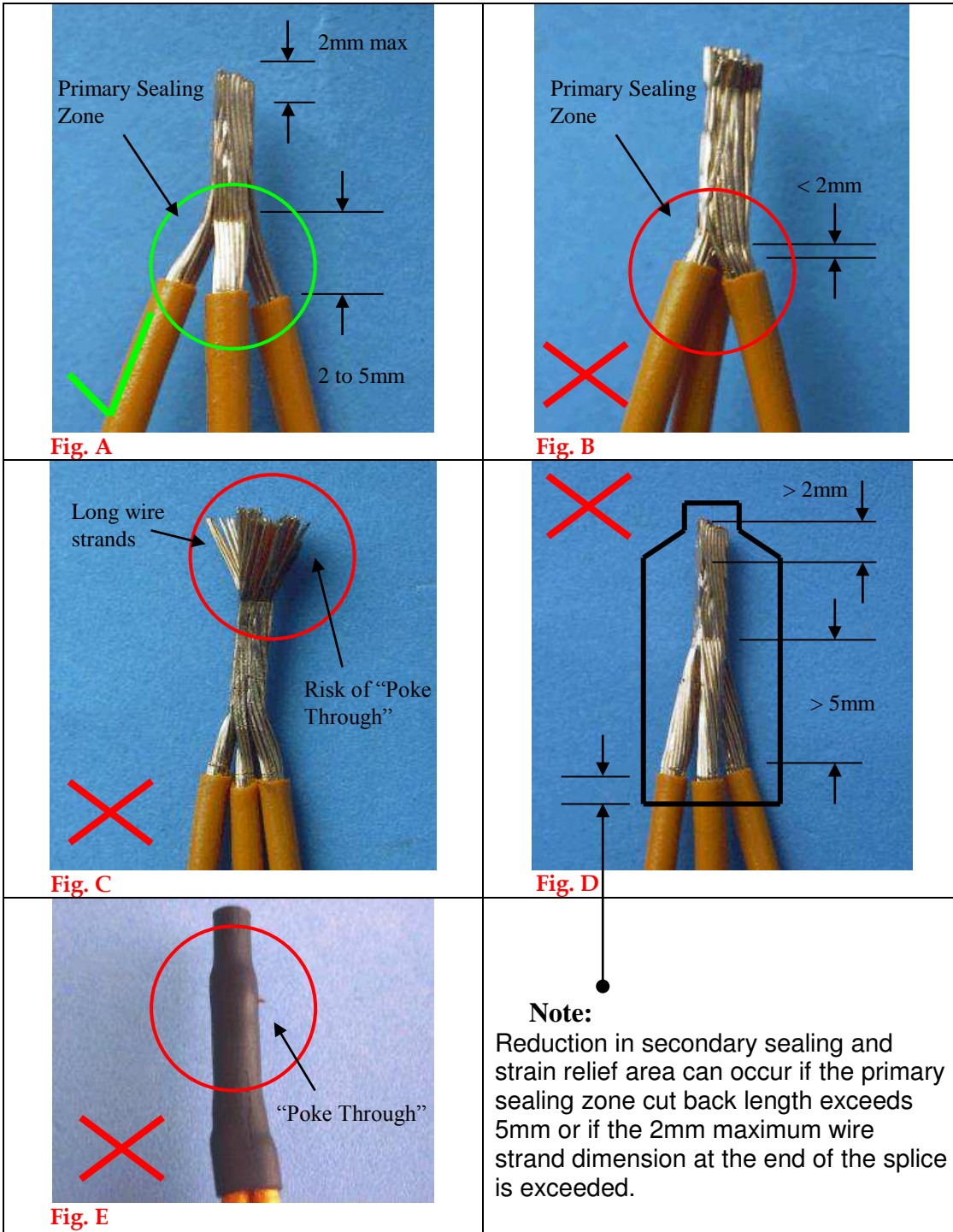
### 4.2 Splice Preparation Guidelines

The splice can be constructed by conventional techniques such as resistance welding, ultrasonic welding, crimping, or 'clip and dip'. There should be no loose strands, especially those pointing upwards which can cause 'poke-through' of the component material during installation.

It is important to ensure that the distance from the nugget/crimp to the wire insulation be  $3.5 \pm 1.5$ mm to allow the adhesive sufficient space to flow and seal between the wires (see Figures 1 and 2).

Figure 1.

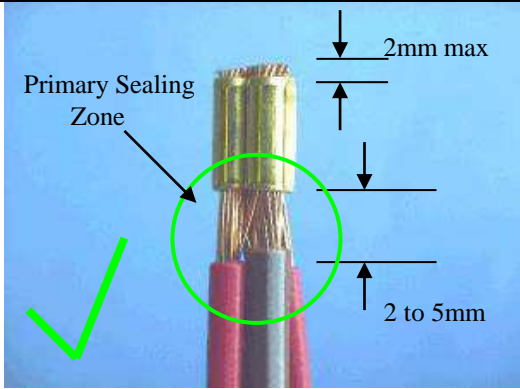
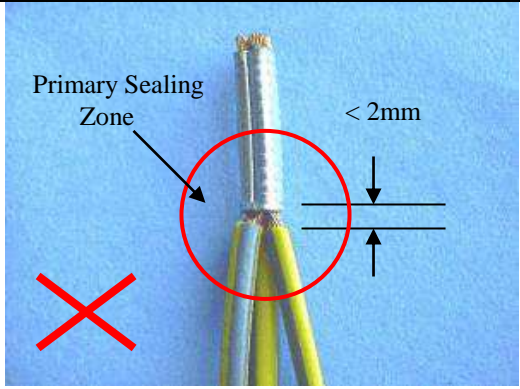
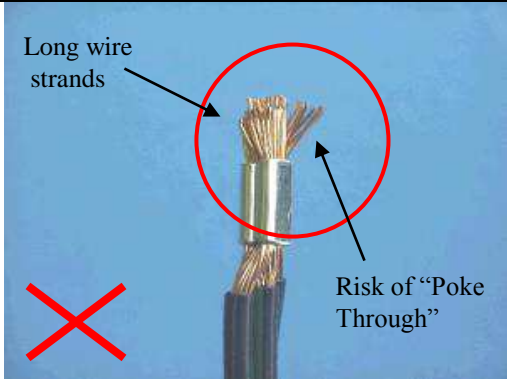
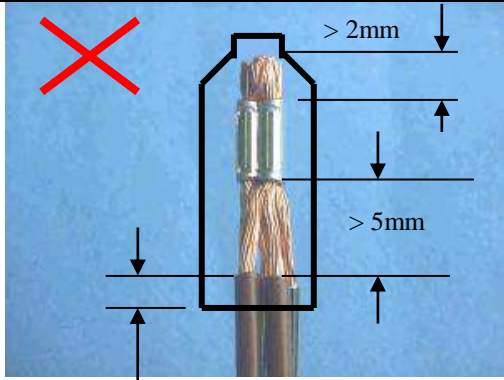
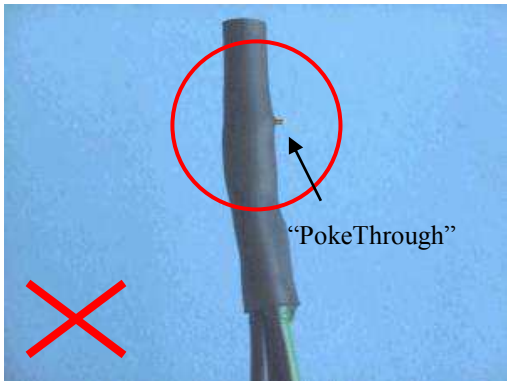
## Splice Preparation Ultra Sonic Welded Splices



PIP-021 Vis.1

Fig 2

## Splice Preparation Crimped Splices

 <p><b>Fig. A</b></p>	 <p><b>Fig. B</b></p>
 <p><b>Fig. C</b></p>	 <p><b>Fig. D</b></p>
 <p><b>Fig. E</b></p>	<p><b>Note:</b> Reduction in secondary sealing and strain relief area can occur if the primary sealing zone cut back length exceeds 5mm or if the 2mm maximum wire strand dimension at the end of the splice is exceeded.</p>

PIP-021 Vis. 2

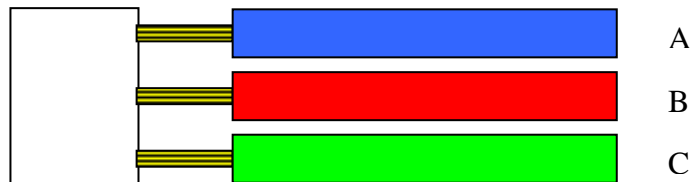
## 5. COMPONENT SIZE SELECTION, INSTALLATION GUIDELINES AND VISUAL STANDARDS

### 5.1 ES-CAP 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. A 'general' chart showing nominal wire insulation OD (mm) and corresponding cross-sectional areas (mm<sup>2</sup>) is given in this guide (*Section 6*). However, it is recommended that the simple calculation shown in 5.1.1 and *Figure 3* be followed to determine the cumulative cross-sectional area of the splice more accurately.

#### 5.1.1 Cumulative Cross-Sectional Area

Figure 3



Where      CSA      = Cumulative cross-sectional area of splice  
               A         = Diameter of Wire A  
               B         = Diameter of Wire B  
               C         = Diameter of Wire C

Note:  $\Pi / 4 \underline{\Omega} 0.8$

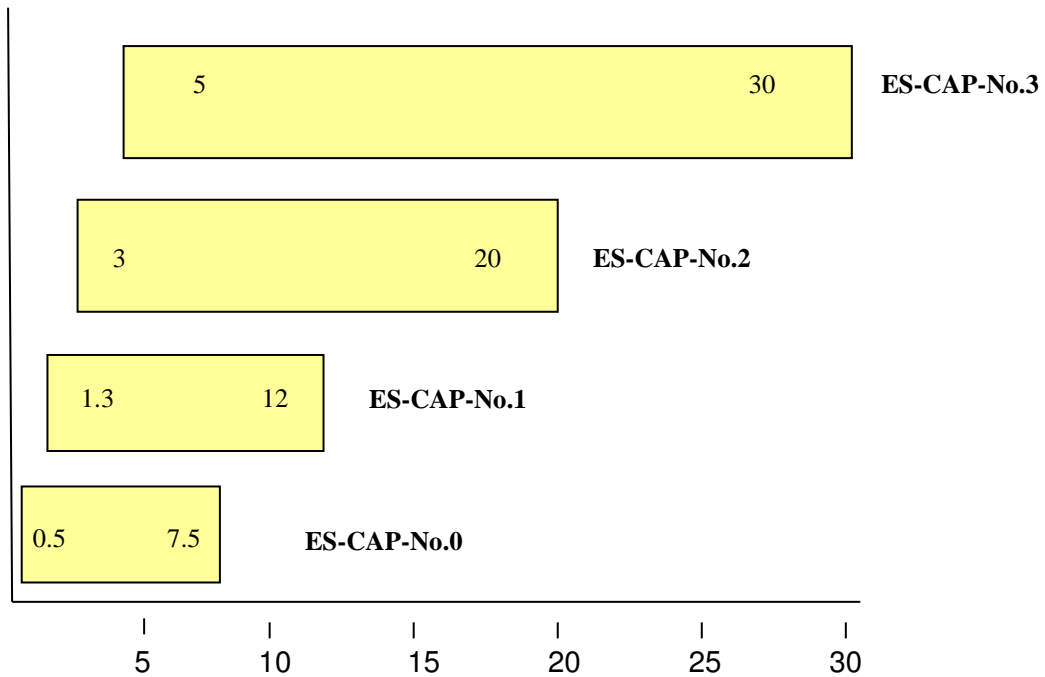
$$CSA = 0.8 (A^2 + B^2 + C^2 \dots)$$

#### 5.1.2 ES-CAP Size Range Table

Failure to comply with these recommendations may result in movement of the ES-CAP on the splice assembly during its working life, unless the installation is 'over-taped' onto the harness wire bundle per normally accepted harness practice. Refer to *Figure 4* for selection of component size. Generally, the smallest ES-CAP which can accommodate the cumulative cross-sectional area of the splice is recommended. In some cases when using mechanical crimping techniques it may be necessary to use the next largest size of ES-CAP.



**Figure 4 ES-CAP Size Range Table**



**Cumulative Cross-Sectional Area mm<sup>2</sup> (based on wire insulation OD)**

## 5.2

### Installation Guidelines

Installations can be carried out using various techniques including discrete Infra Red or Hot Air heating equipment, the selected method being dependent on production area layout and required throughput. It is important that Raychem Infra Red installation equipment be maintained in a state of calibration using a UHI-250A Thermal Probe as described in the RBK-ILS Processor Operation and Maintenance Manual – 412-94334-1.

***NB: It will be necessary to use a location fixture to position the ES-CAP onto the splice during installation.***

The installation 'window' will be dependent on the set point temperature of the equipment, geometry and preparation of splice and the size of component. 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. Typically, it is recommended that discrete heaters such as the TE Connectivity RBK-Processor be set between 450-500°C. It is recommended that 'heat' input as seen by the splice to be installed be measured via a UHI-250A Thermal Probe. (TE Connectivity PCN: 288869-000 CLTEQ-UHI-250A-1-PRB). Refer to *Appendix 2* for explanation of the Thermal Probe.

Verification of sealed joints can be determined as outlined in *Section 6*.

#### 5.2.1 Typical Installation Method using Raychem RBK-Processor

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- 5.2.1.1 Determine the ES-CAP size per section 5.1.
- 5.2.1.2 Ensure installation equipment has been switched on for a minimum of 30 minutes to stabilise.
- 5.2.1.3 Recheck splice for loose wire strands and wire insulation cut back.
- 5.2.1.4 Locate the component onto the splice and position centrally within the heating zone of the application equipment. Use purpose made locating fixtures to support the component during installation.
- 5.2.1.5 Run the splice through the heating equipment at the start times shown in the table below and record the installation conditions, ie, time/set point. Run the UHI probe through at the same conditions to obtain the UHI temperature.
- 5.2.1.6 Increase the heating time in 2 second increments (i.e. increase the UHI temperature by approximately 5-10°C) until the wire insulation or the tubing jacket material shows visual signs of damage. (This is the upper limit of the installation window)
- 5.2.1.7 Check all splices for sealing efficiency per Section 6. If the sample installed at the fastest time (i.e. lowest UHI temperature) passes, then reduce the time further in 1-2 second increments until a sealing failure occurs.
- 5.2.1.8 Prepare 5 sample splices at the fastest time (i.e. lowest UHI temperature) that gave a pass result when tested per *Section 6*. If all 5 pass, this can be regarded as the lower limit of the installation window. If failure occurs, increase the installation time in 1-2 second increments (i.e. increase the UHI temperature), until 5 from 5 pass to give the lower limit.

In order to optimise sealing efficiency in a production environment, it is recommended that the **mid** point between upper and lower limit be used.

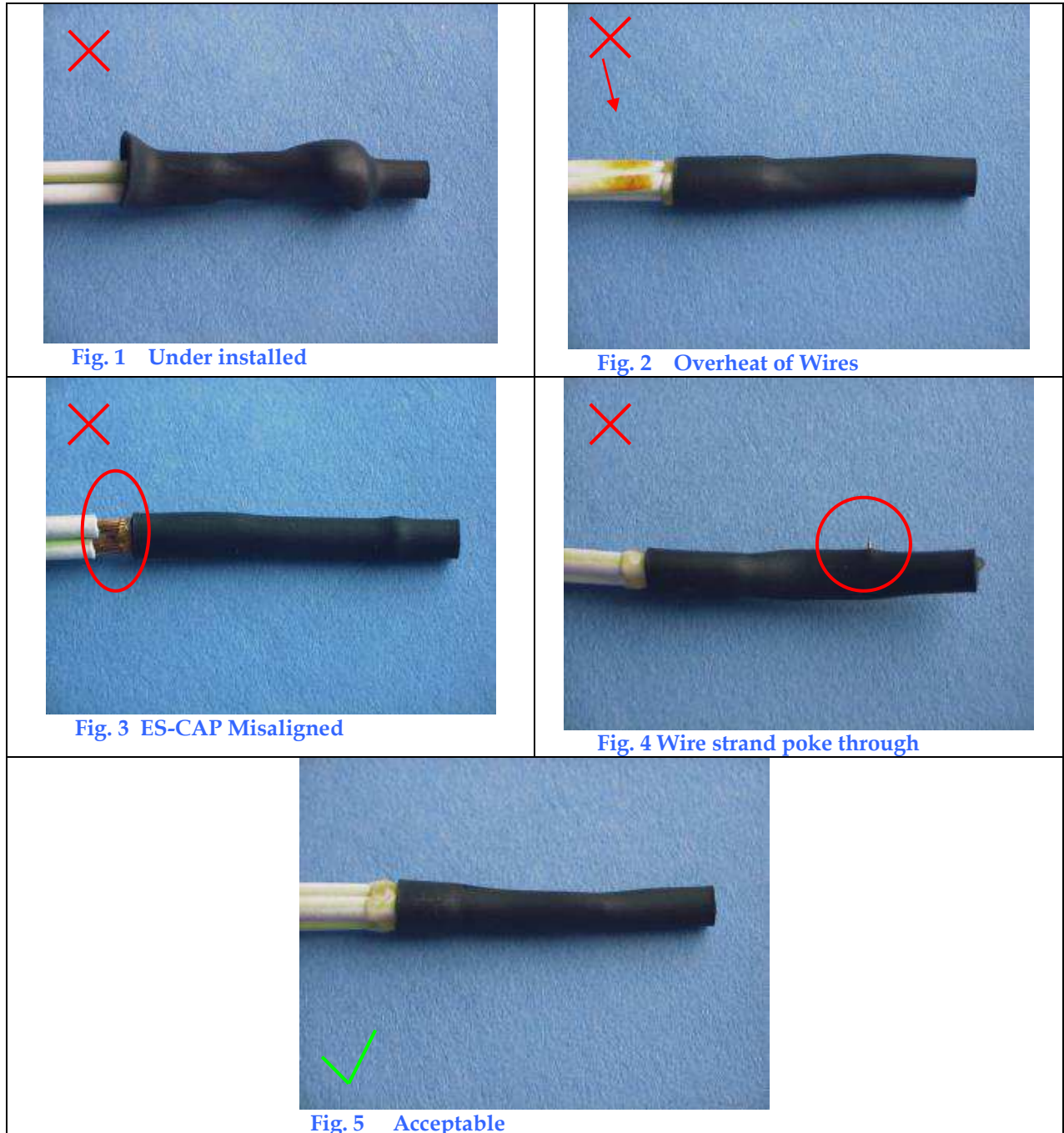
**Note:**

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

In accordance with the above procedure the following times are offered as **approximate start points** for determining the installation window of a particular splice when using a Raychem RBK-Processor at the recommended set point of 450-500°C:

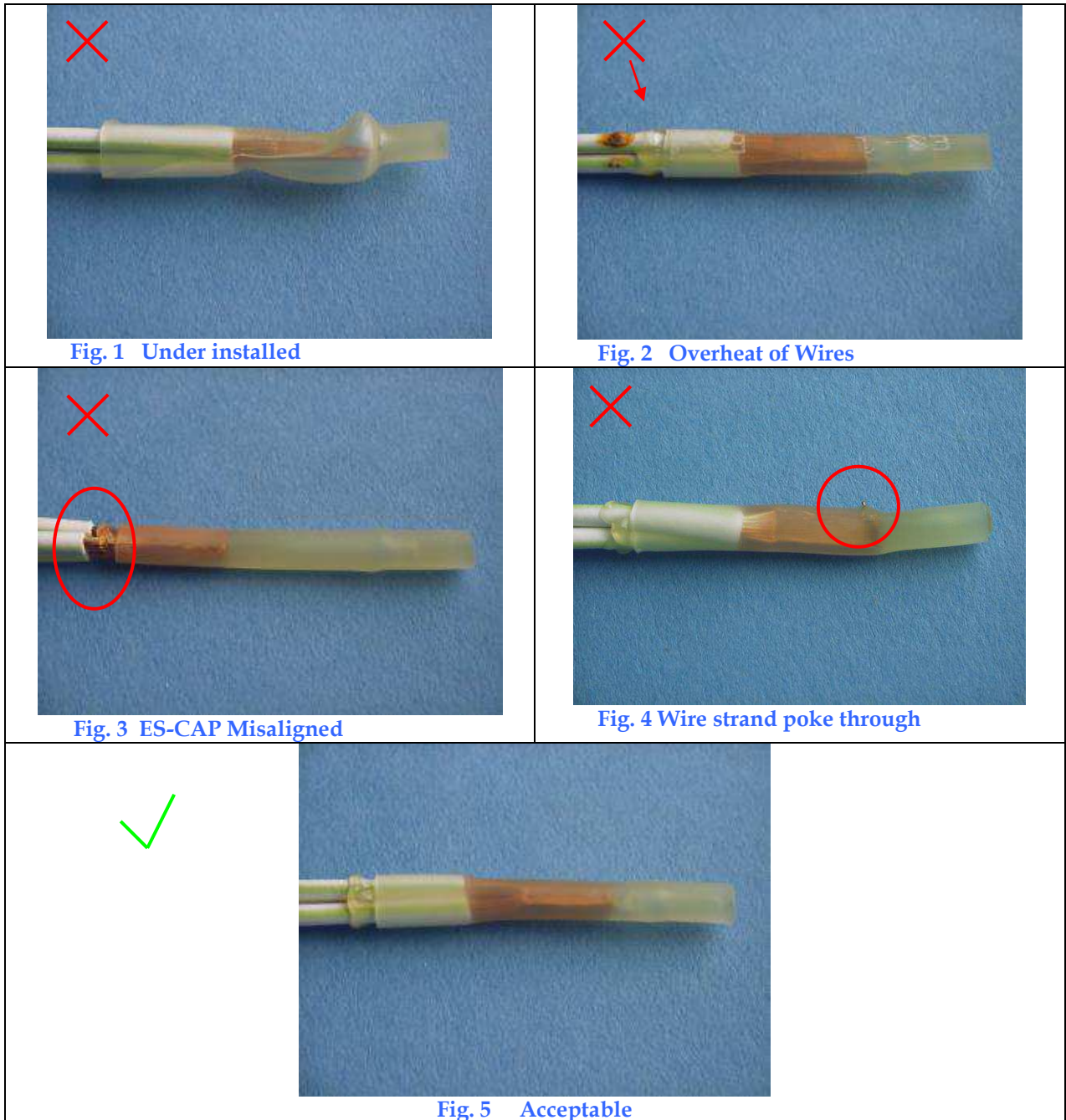
ES-CAP-No.0	6 Seconds
ES-CAP-No.1	8 Seconds
ES-CAP-No.2	12 Seconds
ES-CAP-No.3	16 Seconds

## ES-CAP Visual Standards after Installation



PIP-021-Vis 3

## ES-CAP Visual Standards after Installation



PIP-021-Vis 4

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## 6. SEALING VERIFICATION

### 6.1 Test Methods

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

1. Current Leakage.
2. Insulation Resistance.
3. Air Pressure.<sup>(a)</sup>

- a) 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 leakage techniques for most types of splices.

Raychem Seal Test Equipment AD3050 has been found to be acceptable (for details see Raychem Flyer No. TFAG00017 07/95).

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

**Final verification should be per OEM specification.**

### Appendix 1 – GENERAL WIRE CHART

Nominal Insulation OD (mm)	Cross-Sectional Area of Wire (mm <sup>2</sup> )						
	Number of Wires						
No of Wires →	1	2	3	4	5	6	7
0.5	0.2	0.4	0.6	0.8	1	1.2	1.4
0.6	0.3	0.6	0.9	1.2	1.5	1.8	2.1
0.7	0.4	0.8	1.2	1.6	2	2.4	2.8
0.8	0.5	1	1.5	2	2.5	3	3.5
0.9	0.6	1.2	1.8	2.4	3	3.6	4.2
1.0	0.8	1.6	2.4	3.2	4	4.8	5.6
1.1	0.9	1.8	2.7	3.6	4.5	5.4	6.3
1.2	1	2	3	4	5	6	7
1.3	1	3	4	5	6	8	9
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	
2.7	6	11	17	23	29	34	
2.8	6	12	18	25	31		
2.9	7	13	20	26	34		
3.0	7	14	21	28	35		
3.1	8	15	23	30			
3.2	8	16	24	32			
3.3	9	17	26	34			
3.4	9	18	27				
3.5	10	19	29				
3.6	10	20	31				
3.7	11	22	32				
3.8	11	23	34				
3.9	12	24					
4.1	13	26					
4.2	14	28					

**Appendix 1 – GENERAL WIRE CHART CONTINUED...**

Nominal Insulation OD (mm)	Cross-Sectional Area of Wire (mm <sup>2</sup> )						
	Number of Wires						
No of Wires →	1	2	3	4	5	6	7
4.3	15	29					
4.4	15	30					
4.5	16	32					
4.6	17	33					
4.7	17	35					
4.8	18						
4.9	19						
5.0	20						
5.1	20						
5.2	21						
5.3	22						
5.4	23						
5.5	24						
5.6	25						
5.7	26						
5.8	26						
5.9	27						
6.0	28						
6.1	29						
6.2	30						
6.3	31						
6.4	32						
6.5	33						
6.6	34						
6.7	35						
6.8	36						
6.9	37						
7.0	38						
7.1	40						
7.2	41						
7.3	42						
7.4	43						
7.5	44						
7.6	45						
7.7	46						
7.8	48						

## Appendix 2 – UHI-250A Thermal Probe



**UHI-250A (PCN 288869-000)**

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<sub>1</sub> = ambient temperature
- t<sub>2</sub> = final temperature

When using the probe, M, k, c and t<sub>1</sub> 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: 288869-000).



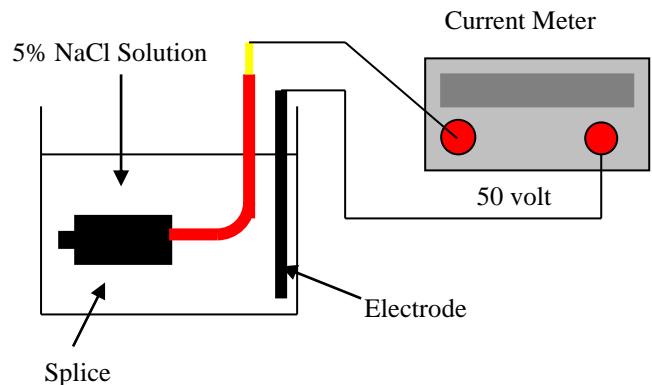
### Appendix 3 – TEST METHODS

#### Current Leakage: Test Method

Immerse the specimens in a water bath containing 5 percent by weight of sodium chloride ( $23 \pm 2^\circ\text{C}$ ).

Check for current leakage after 24 hours immersion.

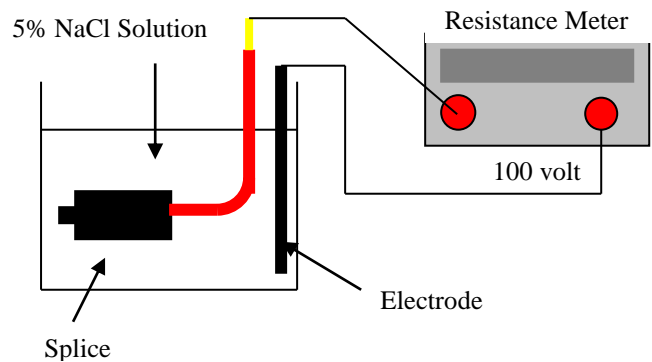
Applied test voltage is 50V dc. Take the reading after 60 seconds. The splice shall be considered sealed if current leakage is less than 0.25 micro amps



#### Insulation Resistance: Test Method

Immerse the specimens in a water bath containing 5 percent by weight of sodium chloride ( $23 \pm 2^\circ\text{C}$ ). Check for Insulation Resistance after 24 hours immersion.

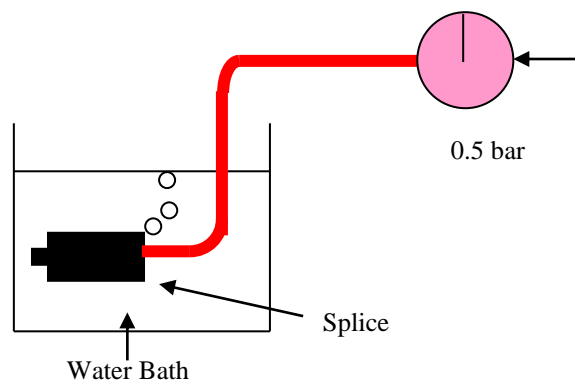
Applied test voltage is 100V dc. Take the reading after 60 seconds. The splice shall be considered sealed if the Insulation Resistance is greater than  $2 \times 10^8$  ohm



#### Air Pressure: Test Method

Immerse the specimens in a water bath. Connect the free end 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.



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## Appendix 4 – TROUBLE SHOOTING

<b>Fault</b>	<b>Possible Cause</b>	<b>Solution</b>
Component not fully shrunk onto splice	Insufficient heat  Insufficient time  Wrong component size	Increase heat. Check UHI-250A reading. Check calibration. Increase time in heater element  Consult component Selection
Component mislocated after installation (milk-off)	Incorrect location prior to installation  Wrong component size	Locate correctly Use alignment fixture  Consult component selection
Component or wire overheated	Excessive heat Excessive time	Reduce heat Reduce time in heater Check calibration
Component scorched on one side	Excessive wire curvature Splice located incorrectly in machine	Use straightened wire Reposition splice. Use alignment fixture.
Component splits	Sharp edge of welded nugget/crimp Wire strand loose Splice overheated Wrong component size selected	Check welder tooling  Reduce heat/time Re-assess. Consult component selection.
Wire strand pokes through component	Wire strand loose from welding or crimp	Check welder/crimp tooling Check splice construction
Cannot seal splice	Inadequate heat  Incorrect size of component Too many wires Contamination on wires Inadequate sealing zone Wire insulation damage before installation	Increase heat Check calibration Refer to sizing guide  Refer to size range table Clean splice Check process Check wire stripping/process
Wire damage at component edge but component visually OK	Overheat Excessive time Splice not centered in machine Mismatch of component/wire Temperature rating	Reduce heat Reduce time Use alignment fixture  Reduce heat/time