

Guidance Note : LV Cable Splice **Testing/Qualification**

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Contents

1.0	Introduction.....	3
2.0	Background.....	3
3.0	Scope of this Guidance Note.....	3
4.0	Verification / Qualification Testing.....	3
4.1	<i>Conductor Joint Tests</i>	3
4.1.1	<i>Samples Required</i>	3
4.1.2	<i>Conductor Diameter</i>	3
4.1.3	<i>Testing</i>	4
4.1.4	<i>DC Conductor Resistance</i>	4
4.1.5	<i>Results</i>	4
4.2	<i>Insulated Conductor Tests</i>	4
4.2.1	<i>Samples Required</i>	4
4.2.2	<i>Testing and Inspection</i>	4
4.3	<i>Complete Cable Tests</i>	5
4.3.1	<i>Samples Required</i>	5
4.3.2	<i>Testing</i>	5
4.3.3	<i>Inspection</i>	5
5.0	Acceptance Testing.....	5
5.1	<i>Conductor</i>	5
5.2	<i>Insulated Conductor</i>	5
5.3	<i>Completed Spliced Cable</i>	6
6.0	References.....	6

1.0 Introduction

API 17E specifies the requirements to qualify LV cable designs. In addition, API17E specifies the requirements to qualify LV cable splices. These requirements are based on electrical testing and electrical characteristics but do not detail any methods, mechanical testing and associated acceptance criteria for splicing.

This guidance note sets out to address this gap in the API standard with the following objectives:

- To provide guidance on the typical practices used in the Umbilical Industry
- To provide a basis for inclusion into future editions of API 17E

2.0 Background

Control umbilicals manufactured in accordance with API 17E regularly contain low voltage (LV) cables. These umbilicals are supplied in very long lengths and are often required to be joined with splices at both the cable and umbilical level due to limitations in manufacturer's capacity.

Splices shall be subject to the same verification/qualification process and acceptance criteria as the un-spliced insulated conductors and cables. This process shall be documented in the manufacturer's written specifications. This does not imply that the mechanical properties of un-spliced cables will be the same as spliced cables, but that the acceptance criteria for a spliced section of cable should be the same as for a virgin/un-spliced cable section.

3.0 Scope of this Guidance Note

This guidance note recommends the complete qualification testing program (electrical and mechanical) to fully qualify a LV cable splice, along with detailed acceptance criteria.

In addition, the recommendations for routine verification acceptance testing of splices performed is also included, along with acceptance criteria.

Cable splices, covered by this guidance note are for:

- Cables to be incorporated into an umbilical.
- Static applications only and not for use in dynamic applications.
- Planned cable splices during umbilical manufacture onshore.
- Unplanned cable splices onshore, in the event of cables being damaged during umbilical manufacture or termination.
- AC and DC cable designs.
- Onshore work only, NOT including offshore splicing or repairs to cables.
- Planned splicing of same size cables only, NOT including splicing of different size cables within umbilical termination / UTA's.

4.0 Verification / Qualification Testing

Verification tests are performed on samples of a particular cable splice, method and conductor size, and are intended to qualify the design as being fit for purpose.

A range of recommended tests and inspections on various samples of conductor, insulated core and complete cable, are as follows.

4.1 Conductor Joint Tests

4.1.1 Samples Required

A number of conductor samples are required, with and without conductor joints. Conductor joints can be brazed, welded or crimped, depending on manufacturer's specifications and procedures. Each sample should be 1m minimum length, or longer to suit suppliers bend and tensile test machines.

4.1.2 Conductor Diameter

Prior to any testing, the conductor samples containing joints, should have the diameter over the jointed areas measured, to ensure the measured values are within the supplier's specified tolerances.

4.1.3 Testing

Tensile tests should be carried out on samples of conductor, typically in accordance with ASTM E8 / E8M, as follows:

- Virgin conductor (no joins)
- Jointed conductor samples

All testing should be carried out to failure.

The Ultimate Tensile Strength (UTS) and the yield strength of the jointed conductor must comply with manufacturers specification. The conductor needs to be shown as ductile in accordance with the manufacturer's specification.

4.1.4 DC Conductor Resistance

DC conductor resistance should be carried out, as per API 17E.

4.1.5 Results

All results should be retained to include in the final qualification / verification report.

4.2 Insulated Conductor Tests

4.2.1 Samples Required

A number of insulated conductor samples, with and without conductor joints. Each 1m minimum length, or longer to suit suppliers bend and tensile test machines.

4.2.2 Testing and Inspection

4.2.2.1 Conductor Diameter

Prior to any preconditioning or testing, the conductor samples containing joints, should have the diameter over the jointed areas measured prior to insulation reinstatement.

4.2.2.2 Insulation Diameter

The outside diameter of the insulated conductors (cores) should be measured post insulation reinstatement but before any preconditioning or testing.

4.2.2.3 Bend Preconditioning

Samples of insulated conductor with conductor joints and reinstated insulation should undergo bend preconditioning. The bending is to ensure that no delamination or loss of integrity of the reapplied insulation occurs.

A minimum of three reverse bends should be performed on the sample.

One reverse bending cycle is equivalent to two bends around a mandrel with a radius equal to or smaller than the MBR of the insulated conductor, where the second bend is in the opposite direction to the first, in accordance with the manufacturer's specification.

4.2.2.4 Post Bending Electrical Tests

Following the bend preconditioning the insulated conductor samples should be tested in a hyperbaric chamber, at a nominal test pressure of 35 bar or maximum hydrostatic pressure at service water depth, whichever is greater, or unless otherwise agreed. Duration at hydrostatic pressure should be 22 hours as per API 17E. The number of jointed insulated conductor samples should be in accordance with the qualification requirements of API 17E for a non-jointed cable qualification. DC Insulation resistance, HVDC, HVAC and complete breakdown electrical testing of the insulated conductors (cores) should be carried out, in accordance with API 17E and manufacturer's specifications.

4.2.2.5 Dissection (insulated conductor samples)

Should the testing above pass, and if desired, and for information, following hydrostatic testing, the insulated conductor samples containing conductor joints and reinstated insulation can be dissected to remove the reinstated insulation over the conductor joint.

4.3 Complete Cable Tests

4.3.1 Samples Required

A number of complete cable samples (pair, triad, quad etc) with a full splice (jointed conductors, re-instated insulation, and any other reinstated layers – belt, screen, jacket etc). Each 1m minimum length, or longer to suit the supplier’s procedures and testing requirements.

4.3.2 Testing

4.3.2.1 Bend Preconditioning

Samples of complete cable with a full splice should undergo bend preconditioning. The bending is to ensure that no delamination or loss of integrity of the reapplied layers occurs.

A minimum of three reverse bends should be performed on the sample.

One reverse bending cycle is equivalent to two bends around a mandrel with a radius equal to or smaller than the MBR of the completed cable, where the second bend is in the opposite direction to the first, in accordance with the manufacturer’s specification.

4.3.2.2 Post Bending Testing

Insulation resistance, conductor resistance and High Voltage DC electrical tests are to be conducted on the samples in accordance with API 17E, with no requirement for submersion in water and with the acceptance criteria as specified by the manufacturer.

4.3.3 Inspection

4.3.3.1 The following is to be conducted during splice implementation or through dissection post testing to ensure a dimensional record of the splice qualified.

Carry out conductor diameter measurements on conductor joints.

Carry out measurement of the diameter over insulation on conductor joints.

Carry out measurement of the diameter over the external jacket reinstatement of the completed cable, to ensure that the jointed area is within the manufacturer’s specified tolerances.

5.0 Acceptance Testing

Acceptance testing should be performed on the joined production lengths and 100% of manufactured cable splices, prior to their inclusion in an umbilical, as follows:

5.1 Conductor

The conductor joints should have the diameter over the jointed areas measured prior to reinstatement of the insulation.

All measurements should within manufacturer’s specification.

5.2 Insulated Conductor

The outside diameter of the insulated conductors (cores) should be measured post insulation reinstatement.

All measurements should be within manufacturer’s specification.

DC conductor resistance tests are to be conducted in accordance with API 17E, with the acceptance criteria as specified by the manufacturer.

An insulation resistance test and High Voltage DC test is to be conducted, whilst, at a minimum the spliced insulated conductor section(s) are submerged in town main or potable water for a period defined by, and under hydrostatic pressure as specified by the manufacturer. The insulation resistance and High Voltage DC tests are to be conducted in accordance with API 17E.

5.3 Completed Spliced Cable

Diameters of the spliced sections are to be measured at each stage of reinstatement, notably the final over-sheath, and should comply with the manufacturer's specification.

The full range of acceptance tests should be performed on the completed spliced cables in accordance with API 17E. The acceptance criteria should be in accordance with the manufacturer's specification.

6.0 References

ISO 13628-5, Petroleum and natural gas industries – Design and operation of subsea production systems, Part 5: Subsea umbilicals

API 17E, Specification for Subsea Umbilicals

ASTM E8/ E8M: 2015: Standard test methods for tension testing of metallic materials