Engineering Standard

SAES-T-632 31 December 2019

Telecommunications: Splicing Copper Cables, Fiber Optic Cables, and Types of Splice Closure

Document Responsibility: Communications Standards Committee

Contents

Summary of Changes (rev. 31 December 2019)

No.	Paragraph No.	Change Type (New, Modification,..)	Technical Change(s)
1	1 (Scope)	Modify	Splicing of fiber optic cable and copper cable requirements for onshore facilities and offshore platform.
2	3.2	Deleted	Standards which are (1) No longer an active standard, and (2) No reference/s to the body of the document.
3	3.2	Add	New standards to aligned with international standards, (1) TIA-606-C, and (2) NECA/FOA 301 -2016.
4	5.1.1.3	Modify	In alignment with international standards – BICSI latest revision with regards to "Inside building requirements which shall be non-filled type splices for use except in cable vault locations".
5	5.1.1.4	Modify	It is mandatory desirable that installed cable sections be tested before and after splicing.
6	5.1.2.6	Add	Add new section in alignment with international standard – BICSI latest revision.
7	5.1.3.2	Modify	In alignment international standard - NECA/FOA 3-10-2016.
8	5.2.1.3	Add	Add requirements to aligned with SAES-T-624 standard.
9	5.2.1.6	Modify	In alignment SAES-T-624 standard and NECA/FOA 301 standard.
10	5.2.1.13	Add	New requirements in alignment with internationals standards (BICSI & NECA/FOA), as well as SAES-T-624.
11	5..2.1.14	Add	New requirements in alignment with internationals standards (BICSI & NECA/FOA), as well as SAES-T-624.
12	5.2.1.15	Add	Sub-section in alignment with internationals standards (BICSI & NECA/FOA).
13	5.2.2.2	Modify	(Remove/Change) standard requirements which referencing to single source (vendor names, brand name, and manufacturer name).
14	5.2.2.14, Table 2	Modify	Replaced correct sizing of pedestal to UPC-1278
15	5.3.2	Modify	Modify section that leads to single-sourcing (brand name), also Table 2, was deleted in the revision.
16	5.3.8	Deleted	This lead to single-sourcing (manufacturer and brand name), utilizing BICSI OSPDRM standard latest version.
17	5.3.9	Deleted	
18	5.4	Add	Add new section for offshore platform procedure
19	5.5	Add	Add new section for labeling procedure (pedestal, splice closure and cables)

1 Scope

This standard describes the minimum requirements and the acceptable methods of splicing communications cables and types of splice cases/closures for used copper (plastic insulated) and fiber optic cables.

Typical applications of these methods include inside plant (ISP) and outside plant (OSP) which include buried and underground splices. In addition, this include splicing of fiber optic cable and copper cable for offshore platform. Aerial application for OSP is not recommended, and it is use only for temporary applications.

2 Conflicts and Deviations

Any conflicts between this document and other applicable Mandatory Saudi Aramco Engineering Requirements (MSAERs) shall be addressed in writing to the EK&RD Coordinator.

Any deviation from the requirements herein shall follow internal company procedure SAEP-302, Waiver of a Mandatory Saudi Aramco Engineering Requirement.

3 References

The selection of material and equipment, and the design, construction, maintenance, and repair of equipment and facilities covered by this standard shall comply with the latest edition of the references listed below, unless otherwise noted.

3.1 Saudi Aramco Documents

Saudi Aramco Engineering Procedure

SAEP-302	*Waiver of a Mandatory Saudi Aramco Engineering Requirement*

Saudi Aramco Engineering Standards

SAES-T-018	*Telecommunications - Symbols, Abbreviations, and Definitions*
SAES-T-624	*Fiber Optic Cables for Outside Plant (OSP) and Inter_Intra Building Applications*
SAES-T-629	*Telecommunications Outside Plant - Copper Cable*
SAES-T-795	*Grounding, Bonding, and Electrical Protection for Telecommunications Facilities*
SAES-T-920	*Telecommunications Cable Information*

Saudi Aramco Materials System Specification

18-SAMSS-625 *Outside Plant - Fiber Optic Cable Specifications (Single Mode and Multiple Mode)*

Saudi Aramco General Instruction

GI-0002.100 *Work Permit System*

GI-1021.000 *Street and Road Closure: Excavations, Reinstatement, and Traffic Controls*

3.2 Industry Codes and Standards

Building Industry Consulting Services International (BICSI)

BICSI (TDMM) *Telecommunications Distribution Methods Manual (Latest Version)*

BICSI (OSPDRM) *Outside Plant Design Reference Manual (Latest Version)*

National Electrical Contractors Association (NECA)

NECA/FOA 310-2016 *Standard for Installing and testing of Fiber Optics*

National Fire Protection Association

NFPA 70 *National Electrical Code (NEC)*

Rural Utilities Service (RUS)

BULLETIN 1753F-401 *RUS Standard for Splicing Copper and Fiber Optic Cables*

Telecommunications Industry Association

TIA-606-C *Administrative Standard for Commercial Telecommunications Infrastructure*

4 Definition

Acceptance Test: A test or set of tests performed to demonstrate satisfactory completion of a predetermined task or group of tasks on which project acceptance is dependent.

Bridged Tap: A connection that enables multiple appearances of the same cable pair at several distribution points.

Buried Cable: A cable that is installed under the surface of the ground in such a manner that it cannot be removed without disturbance to the soil. Also referred to as direct-buried cable.

Butt Splice: A splice case or closure where cables to be spliced enter from one end only.

Cable Vault: A telecommunications space, typically subterranean, located within or between buildings and used for the distribution, splicing, and termination of cabling.

Encapsulant: A permanent or removable filling compound for a splice enclosure to prevent water intrusion.

Even Count: Copper cable with each 25 pair count starting with 1, 26, 51, 76, 101, etc. All PIC cable is of even-count construction.

Odd Count: Copper cable with additional spare pairs in the pair count. 25 pair groups count may not start pair # 26, 51, etc.

Splicing: The act of joining copper conductors or fiber strands together.

Splice Case or Splice Closure: A metal or plastic housing with a semi-cylindrical cavity used in identical pairs to clamp around a cable splice to provide a closure.

Straight Splice: A splice case or closure where one cable enters from one end and the other cable enters from the other end.

Underground Cable: A telecommunications cable installed under the surface of the earth in a trough or duct that isolates the cable from direct contact with the soil.

5 Design

5.1 General

The protection of splice points for OSP system must be of primary concern in the system design. Choosing the right closure can mean the difference between a properly running system and unacceptable levels of downtime.

5.1.1 Splicing

5.1.1.1 Splicing Connector Hardware

Connecting hardware used to connect or join the individual conductors or fibers shall meet the requirement of this standard. Splicing operations that involve pairs containing working services shall utilize splice connectors that permit splicing without the interruption of service. Provide correct connector size to accommodate the cable gauge of the supplied cable. The splice connector manufacturer's recommendations shall be followed concerning connector selection and use.

Refer to BICSI OSPDRM latest revision.

5.1.1.2 Splicing Locations

Splicing can be found in underground and direct-buried construction such as:

- Pedestal
- Maintenance hole (MH)
- Buildings
- Vaults
- Splice pits (buried splice)
- Poles

Commentary Notes:

(1) Aerial splicing (as per Saudi Aramco standard it is for temporary use).

(2) Splicing closure located inside a Handholes (HH) shall not be permitted.

5.1.1.3 Closure Configurations

Splices closures are both used in copper and fiber optic applications and they can be pressurize, non-pressurize, filled, and non-filled. They are typically to secure and protect cables and splices. Provide strain relief and allow for re-entry.
The splice closure are classified according to the configuration of cables that enter the closure such as;

- Straight: only one cable can enter each end of the closure.
- Butt: two or more cables can enter only one end of the closure.
- Branch: two or more cables can enter either end of the closure.

The design engineer shall clearly identify and specify the proper size and type splice closure on the IFC drawings.
All splice closures materials used in Saudi Aramco on Outside Plant (OSP) shall be of filled type, and inside building shall be non-filled type splices for use except in cable vault locations.

Commentary Note:

Refer to BICSI OSPDM - Outside Plant Design Reference Manual (latest version) for additional requirements to comply.

5.1.1.4 Both cables copper and fiber optic strands shall be free from defects. It is mandatory that installed cable sections be tested before and after splicing.

- Each reel of cable for copper cables are recommended to be tested for grounds, opens, shorts, crosses, and shield continuity before and after installation.
- Also, it is recommended for FOC to be tested by OTDR (Optical Time – Domain Reflectometer) for continuity and dB loss before and after installation.

Commentary Note:

Before splicing, the cables shall be tested, recorded before and after installation.

5.1.1.5 Cables and splicing materials used on outside plant projects shall be of filled type. Copper cables shall comply with SAES-T-920, fiber optic cables shall comply with 18-SAMSS-625.

5.1.1.6 The design engineer should carefully consider the amount and location of the splice closures in underground cable plant, whether the transmission medium is copper or optical fiber cable. The goal is to maximize cable run and minimize splices, since they may be a source of unpredictable amount of subsequent troubles.

5.1.1.6 Fusion Splices

Electric arc-fusion is the most widely used method to make reliable single or mass optical splices in the field. The fusion process is realized by using specially-developed splicing machines.

Commentary Notes:

(1) Mechanical Splices will only be permitted on an exception basis for the immediate service restoration of damaged facilities.

(2) Fusion Splice equipment shall be calibrated regularly and calibration certificate shall be provided at least a minimum of six (6) months validity.

5.1.1.7 All cable splicing operation for fiber optic and copper cable shall be performed by a certified cable splicer with valid ID or certification. The cable splicer/technician shall be Saudi Aramco certified or certified by a recognized international standard organization.

5.1.1.8 Close contact and coordination shall be maintained at all times with plant area, oil production and processing proponents, when doing fiber optic and copper cables splicing activities in their areas. All Saudi Aramco Safety and Security Requirements and Policies shall be observed (GI-0002.100 and GI-1021.000).

5.1.1.9 Precautions shall be taken to prevent the ingress of moisture and other contaminants during all phases of the splicing installation. When an uncompleted splice must be left unattended, it shall be sealed with CR tape to prevent the ingress of moisture and other contaminants.

5.1.1.10 It is important that no wire shall come in contact with uninsulated portions of the bonding ribbons, bond clamps, or any metallic part within the closure.

5.1.2 Splice Cases/Closures

5.1.2.1 Lead sheath splice closures shall not be used, since lead sheath cable is no longer used by Saudi Aramco for new Construction.

5.1.2.2 Thermo fit (heat shrinkable) wrap around sleeves are available for cable sheath repairs and as splice closures on new cable Construction.

5.1.2.3 When placing or handling encapsulating compounds, follow manufacturer's recommendation, safety (warnings) precautions, and all other applicable Saudi Aramco safety standards and instructions.

5.1.2.4 All direct buried or underground cable splice closures shall be filled with a re-enterable encapsulating compound.

5.1.2.5 Due to the requirement for heat for the installation of the heat-shrinkable (thermo fit) sleeves (closures), discernment must be used in selecting locations in which it will be used and all applicable safety precautions and Loss Prevention standards adhered to. Installations are to be made in accordance with manufacturer's instructions.

5.1.2.6 Building Cable Entrance

(1) Only non-filled fire retardant rated splices cases shall be used in buildings entrances when splicing an outside plant cables with an indoor cables. Outside plant cable sheath

and cable filling compound are susceptible to fire and will support combustion.

(2) Splices inside the building entrance shall be made as close as practicable to the point where the outside plant cables enter the building with maximum of 15 meters.

(3) Cable splices shall not be mounted or placed in overhead cable trays or below raised floors. It shall be accessible to cable technicians at floor level.

5.1.2.7 Splice closure (offshore platform) for submarine cable system shall meet the followings requirements.

(1) It is made of highly corrosion resistant material and applicable on most cable designs.

(2) Easy to re-enter.

(3) The subsea closure shall be designed in accordance with the manufacturer recommendations.

5.1.3 Others (Safety and etc.)

Close contact and coordination shall be maintained at all times with plant area, oil production and processing proponents, when doing fiber optic and copper cables splicing activities in their areas. All Saudi Aramco Safety and Security Requirements and Policies shall be observed.

5.1.3.1 For personnel safety, the shields and metallic strength members of the cables to be spliced shall be bonded together and grounded before splicing activities are started.

5.1.3.2 Only non-filled fire retardant rated splices shall be used only in buildings to splice an outside plant cables with an indoor cables. OSP cables entering a building shall not be more than 15 meters. Install an indoor cables type and shall be listed as Communication Riser Cable (Type CMR) in accordance with NFPA 70 "National Electrical Code", Article 770 or NECA/FOA 3-10-2016.

Commentary Note:

Splices shall be made as close as practical to the point where the outside plant cables enter the building within 15 meters.

5.1.3.3 Special care shall be exercised to avoid damaging the conductor insulation when cutting through the cable shield and

removing the shield. Sharp edges and burrs shall be removed from the cut end of the shield.

5.1.3.4 Fiber Optic Splicing Safety

(1) Eye protection: Safety glasses shall be worn when handling glass fibers. After handling fiber, wash hands thoroughly is mandatory.

(2) Never look directly into the end of optical fiber with the naked eye or a magnifying device. The light used for signal transmission in the fiber optics is generally invisible to the human eye but may operate at power level that can harmful to the eye.

(3) Dispose of bare scrap fibers by using the sticky side of a piece of tape to pick up and discard loose fiber ends. Fiber scraps easily penetrate the skin and are difficult to remove.

(4) During the splicing operations, handle fibers carefully to avoid introducing flaws, breaking or scratching the fiber surface, or in any way damaging the fibers (sharp bends, crushing forces, etc.)

Commentary Note:

For additional safety procedure refer to NECA/FOA 310-2016 standard.

5.1.3.5 Bonding and Grounding

(1) Bonding and grounding of cables and splice cases shall be in accordance with SAES-T-795. It shall be bonded to the TMGB (P-Producer) with a minimum of # 6 AWG (see SAES-T-795 for more details).

(2) Bonding clips shall be provided on all metallic cable to permit reliable electrical connections to the aluminum shield for noise-shielding purposes and for maintenance of electrical continuity.

(3) Prior to starting splice work, as a safety precaution, place a temporary bonding jumper across the splice opening to join all metallic members of any cables that are not all dielectric, and bond them to the local ground electrode.

5.2 Splicing Consideration

5.2.1 Fiber Optics Cable (FOC) Consideration

This section specifies the minimum splicing requirements for fiber optic cables (FOC).

5.2.1.1 Splicing of fiber optic cables shall comply with the requirements of this standard, and in addition to the following standards:

- BULLETIN 1753F-401, RUS Standard for Splicing Copper and Fiber Optic Cable

  The following requirement shall be added:

  - Buried Splices

    It shall be installed in MHs and splice vaults (known as Optiped) to accommodate the splice case and the required splicing slack. An alternative to the Optiped is a cabinet or pedestal specifically designated for fiber optic splice cases.

    Commentary Notes:

    Typical locations that may utilize fiber splice pedestals are classified areas inside plants where maintenance holes and hand holes are not permitted.

    The use of direct buried splice closure installation method shall be permitted to be use.

- BICSI OSPDRM: Outside Plant Design Reference Manual (Latest Version)
- BICSI (TDMM): Telecommunications Distribution Methods Manual (Latest Version)

Below are added minimum requirements that shall be meet adhere to splicing fiber optics cables;

5.2.1.2 Outside Plant (OSP) fiber optic cables shall comply with 18-SAMSS-625.

5.2.1.3 Connection Characteristics

Splicing efficiency between optical fibers is a function of light loss across the fiber junctions measured in decibels (dB). Only same type fibers shall be spliced together.

For an individual link, the cable shall be the same type to ensure the same performance characteristics. In addition, to ensure compatibility in terms of the fiber optic types, refer to SAES-T-624.

5.2.1.4 Fiber Core Alignment

Fiber splicing techniques shall be conducted in such a manner that the cores of the fibers will be aligned as perfectly as possible to allow maximum light transmission from one fiber to the next. Core misalignment is illustrated in Figure 1:

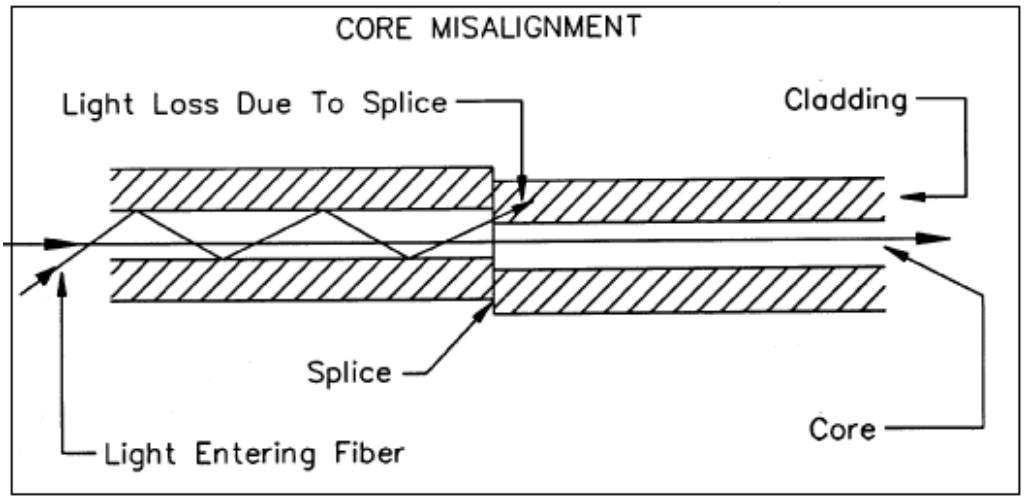

Figure 1 - Core Misalignment

5.2.1.5 Splice Loss

In practice, the field measurement of each splice loss during construction of a fiber route is usually indicated by the fusion splicing machine. When fusion is completed, the splicing machine will inspect the splice and estimate the optical loss of the splice. Individual splice insertion loss shall be 0.05 dB average link splice loss with no single splice loss above 0.1 dB for fusion splices.

Splice loss can also be caused by fiber defects such as non-identical core diameters, cores not in center of the fiber, and non-circular cores. Such defects are depicted in Figure 2:

Commentary Notes:

(1) Undesirable splice losses are caused by poor splicing techniques including splicing irregularities such as improper

cleaves and dirty splices.

(2) After splicing is complete, the actual splice loss in the field shall be determined by bidirectional OTDR test.

(3) Dust caps on fiber patch panel ports shall always be kept closed when not in use to prevent foreign matters from entering the optical ports that may affect optical power signal.

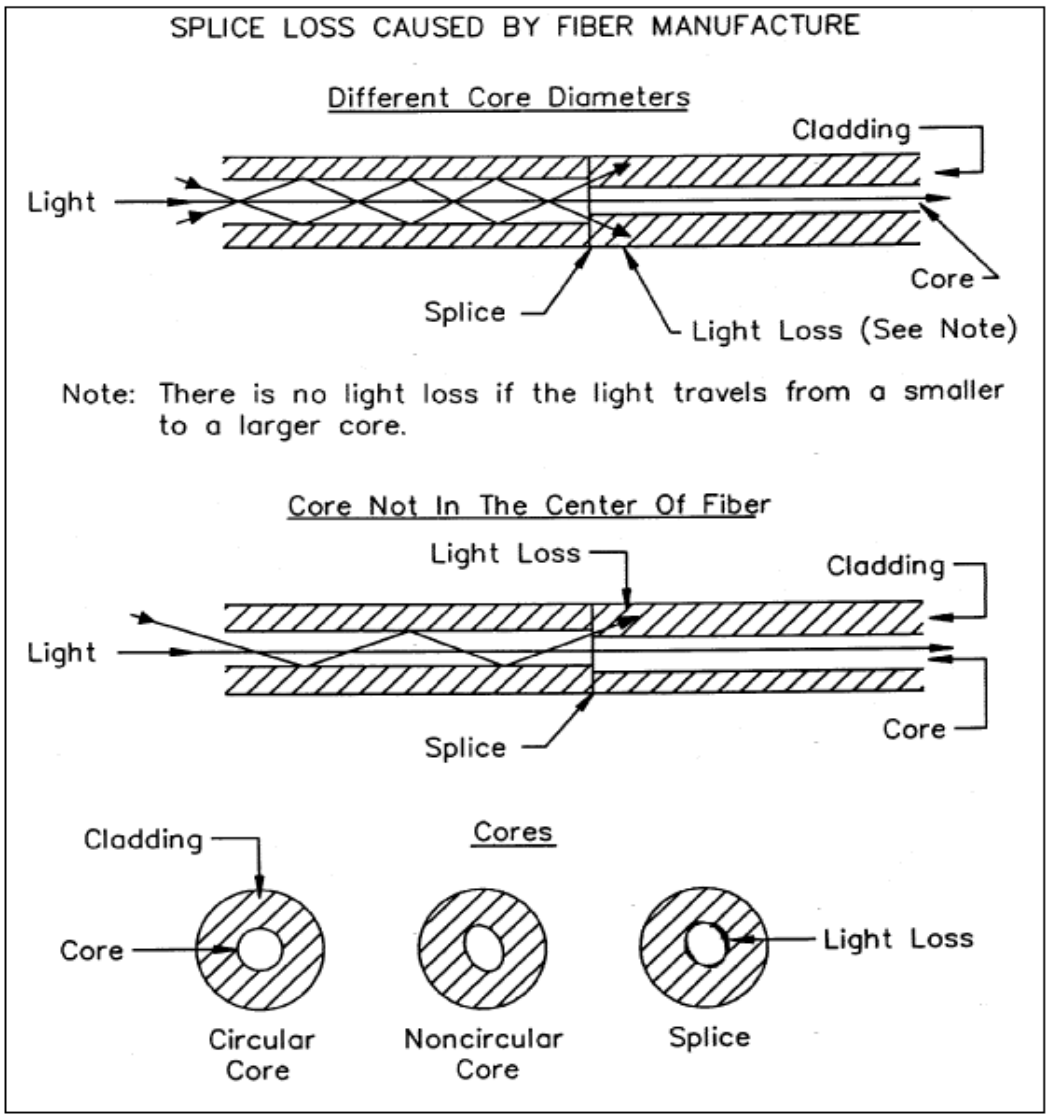

Figure 2 - Splice Loss

5.2.1.6 The cable manufacturer's recommendations concerning bending radius shall be observed. Unless the cable manufacturer's recommendation is more stringent, the minimum bending radius for fiber optic cable shall as follows;

Never exceed the recommended cable bend radius:

(1) 10 x Cable outside diameter - No Tension (installed) or after completion of the pull.

(2) 20 x Cable outside diameter -Under Tension (being installed) or if there is no recommendation available from the cable manufacturer during the installation, then the cable shall not be pulled over the specified bend radius.

5.2.1.7 The cable manufacturer's recommendations concerning buffer tube bending radius shall be observed. Unless the cable manufacturer's recommendation is more stringent, the minimum bending radius for buffer tubes is usually between 38 mm (1.5 in.) and 76 mm (3.0 in.). The bending limitations on buffer tubes are intended to prevent kinking. Buffer tube kinking may cause excessive optical loss or fiber breakage.

5.2.1.8 Fiber Optic Color Code: The standard fiber optic color code for buffer tubes and individual fibers shall be identical for the cables to be spliced and in accordance with 18-SAMSS-625 as shown in Table 1. Splicing shall follow this scheme.

Table 1 - Fiber and Buffer Tube Identification

Buffer Tube and Fiber No.	Color	Buffer Tube and Fiber No.	Color
1	Blue	13	Blue/Black Tracer
2	Orange	14	Orange/Black Tracer
3	Green	15	Green/Black Tracer
4	Brown	16	Brown/Black Tracer
5	Slate (Gray)	17	Slate (Gray)/Black Tracer
6	White	18	White/Black Tracer
7	Red	19	Red/Black Tracer
8	Black	20	Black/Yellow Tracer, or Natural/Black Tracer
9	Yellow	21	Yellow/Black Tracer
10	Violet	22	Violet/Black Tracer
11	Rose	23	Rose/Black Tracer
12	Aqua	24	Aqua/Black Tracer

5.2.1.9 OSP fiber optics (FOC) splicing and closure requirements stated on SAES-T-624 shall be complied.

5.2.1.10 Tools for Splices

In addition to the normal splicing tools, the following materials shall be required:

(1) Optical fiber splicing kit
(2) Lint-free tissue
(3) Approved cleaver tool
(4) Means of communication

5.2.1.11 Splices - Methods, Tests and Cautions

(1) Splice fibers with approved fusion splicing equipment shall be use. Fiber optic splices shall be tested for splice loss as splices are being made, using an approved optical time domain reflectometer (OTDR) or local injection detection (see SAES-T-624 for test and acceptance requirements).

(2) Fiber optic cable splicing inside building must be performed in dust free or controlled environment. OSP fiber optic cable splicing in the field must be performed in approved splicing van, or splicing trailer.

(3) At all buried or underground splice locations, sufficient additional cable length (slack) shall be left to reach from the splice enclosure (or splice pit) to the inside of a cable splicer's vehicle or other facility that maintains a suitable environment for splicing fiber optic cable.

CAUTION:

All fusion splices shall be made outside maintenance holes (MH) and at least 3 meters away from the maintenance hole opening.

5.2.1.12 Preparations for Splices and Other Requirements

Before beginning the splicing operation:

(1) Secure the cable in an optical fiber splice organizer.
(2) Bond and ground all metallic members of the cable. The measured ground resistance shall be 25 ohms or less.
(3) To prevent fiber damage, handle buffer tubes and fibers carefully, when bending and placing in the organizer.

Comply with the following when splicing fiber optic cables:

(1) When splicing the fibers, follow the manufacturer's instruction for the splicing equipment being used.

(2) Use an approved buffer stripper.

(3) The fiber coating stripper used shall be approved for the specific size fiber being stripped.

(4) To minimize damage to the bare fiber, avoid excessive wiping (more than five times). Before cleaving, wipe the fiber twice with a new tissue dampened with 90% grade alcohol or any % grade alcohol available in the market to remove any coating debris from the stripped fiber.

(5) Cleave the fiber with an approved cleaving tool. Do not use hand scribes for cleaving.

(6) If required, wipe the fiber after cleaving to remove dirt or grease. Avoid excessive wiping.

5.2.1.13 Splice Arrangement for Fiber Optic Cables

(1) Buried splices shall be installed in Splice-pit enclosure to accommodate the splice case and the required splicing slack shown in Figure 3. An alternative Splice-pit enclosure is an enclosure specifically designed for fiber optic splice cases.

(2) Each buried splice shall be identified for future locating by these methods.

(a) One method of marking the splice point is the use of a marker post with a warning sign.

(b) Another method is the burying of an electronic locating device such as Electronic Marking System (EMS) markers.

(3) Underground splices shall be stored in maintenance hole (MH) provided with sufficient support including the cable slack.

(4) Splice case at the building entrance or at the telecommunications spaces (TER/EF/TR) shall be a non-filled type and properly supported independently from the cable support.

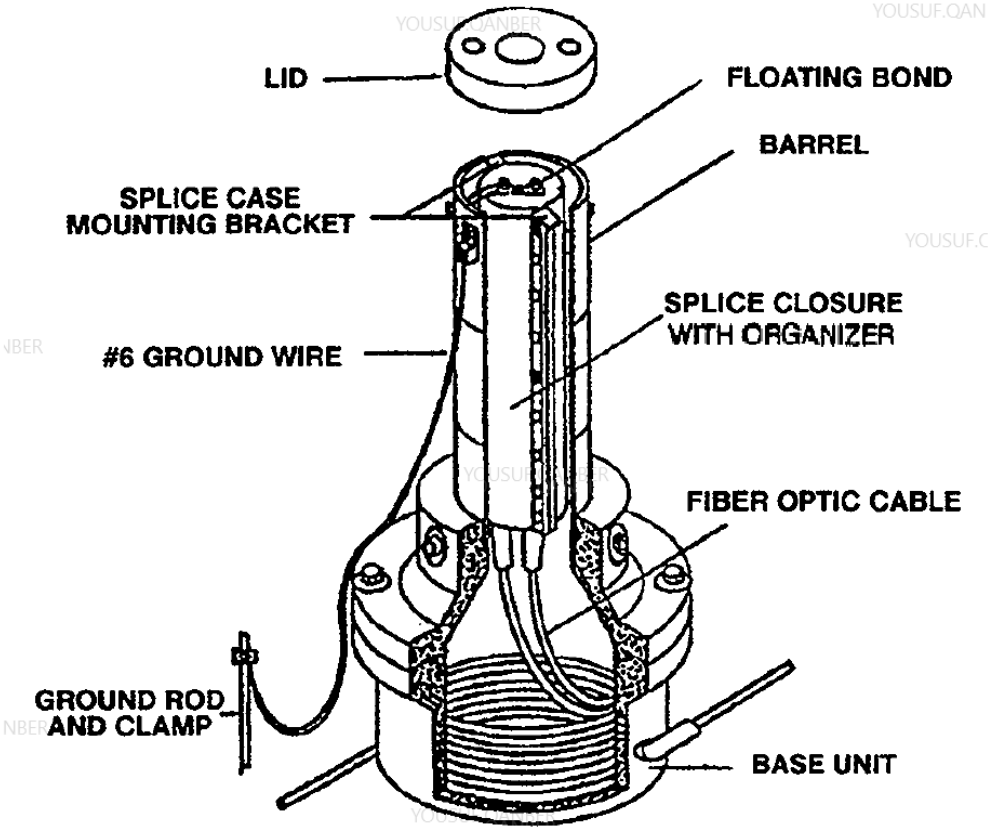

Figure 3 – Splice-Pit Enclosure

5.2.1.14 Management of Fiber Optic Cable Slack/Loop Cable

(1) Splicing and racking slack shall be considered when making cable length calculations. Fiber optic splice closure shall have 1.0 meter of stripped cable inside the splice closure.

(2) Splice slack or loop at splice points shall requires 3.0 meters (both end).

Commentary Note:

For onshore applications it shall comply with additional requirements stated in SAES-T-624.

(3) Provides cable slack or loop of 15 meters of slack cable in the cable vault or cellar, and 10 meters if there is no cable vault for restoration. This can be useful in the event of cable repair or relocation needed.

5.2.1.15 Fiber Distribution Patch Panel

(1) Fiber distribution patch panels are used to terminate and distribute optical fiber cables and shall be a type that the fiber optic cable enters from the rear of the patch panel.

(2) Fiber distribution patch panels are dedicated for IT network systems applications. For non-IT fiber optic cables shall be terminated separately from IT patch panel.

(3) It shall be equipped with a mechanism to relieve strain on the cable. Use cable management hardware on the racks to route and separate cables to minimize potentials for damage and facilitate moves, additions and changes.

Commentary Note:

Cable ties use shall be hand tightened to be snug but loose enough to be moved along the cable by hand. Then excess length of the ties shall be cut off to prevent future tightening. Also, hook-and loop fastener ties are mandatory for fiber optic cables, as they cannot apply crush loads sufficient to harm the cable.

5.2.2 Copper Cables Consideration

This section specifies the minimum requirements of splicing communications copper cables.

5.2.2.1 The following standards shall be apply in addition to this standard:

(1) BULLETIN 1753F-401, RUS Standard for Splicing Copper

(2) BICSI (TDMM): Telecommunications Distribution Methods Manual (Latest Version)

(3) BICSI (OSPDM): Outside Plant Design Reference Manual (Latest Version)

Below are the minimum requirements that shall be meet and adhere to when splicing a copper cables.

5.2.2.2 Splice Connectors

(1) Provide splice connectors with a polycarbonate body and cap and a tin-plated brass contact element. Connector shall accommodate 22 to 26 AWG solid wire with a maximum insulation diameter of 1.65 mm 0.065 inch. Fill connector

with sealant grease to make a moisture resistant connection, in accordance with RUS Bull 1753F-401.

The following list of splicing materials / connectors is the most widely used for splicing polyethylene conductors:

- UR type connectors
- UG type connectors
- PICABond type connectors

(2) The UR connector can be used to insulate, butt splice, and seal any two or three 19, 22, 24, or 26 gauge cable conductors. The UG connector can be used for tap splices.

5.2.2.3 Splice Connectors Crimp the connector with a standard E9 crimping tool (E9-E or E9-Y) until the cap of the connector is flush with the connector base as shown in Figure 4.

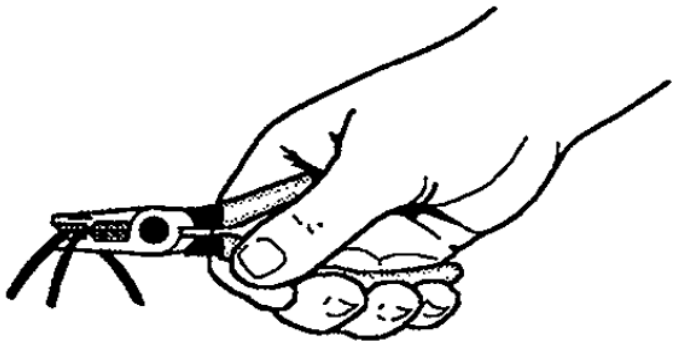

Figure 4 - E9 Crimping Tool

5.2.2.4 Twist each spliced pair loosely four times to prevent them from separating. Use the following illustration shown in Figure 5 as a reference to apply twists to conductors.

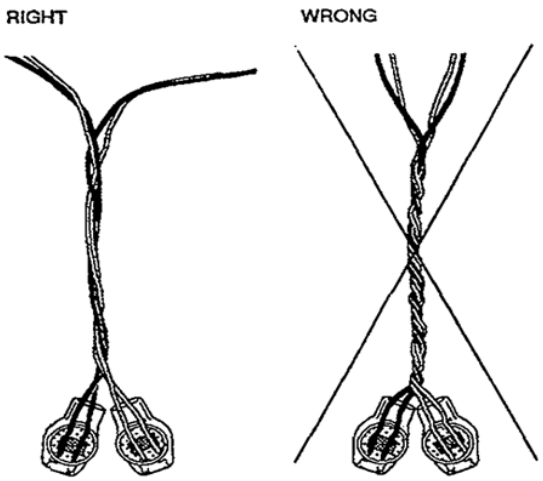

Figure 5 - Twists to Conductors

5.2.2.5 The PICABond connector is smaller than the UR/UG type connectors. The use of a PICABond connector results in a much smaller splice bundle. This smaller splice bundle is very desirable in high pair count cables. The Picabond connector is available with sealant for through and bridge connections in a butt splice configuration. See Figure 6 for various combinations of conductors using Picabond connector.

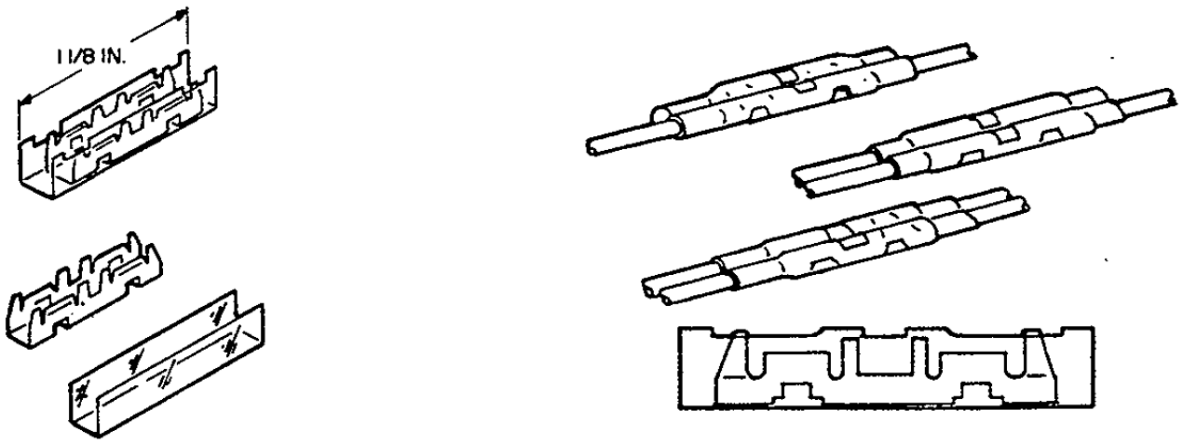

Figure 6 – Typical Connector Type Shown Joining Various Combinations of Conductors

5.2.2.6 The crimping tool is designed to hold, cut the conductors, and crimp the connector in one operation. The crimping tool may be used separately as a hand held tool (Figure 7) or placed in the holder. The holder, however, should be used whenever making splices of 100 pairs or more.

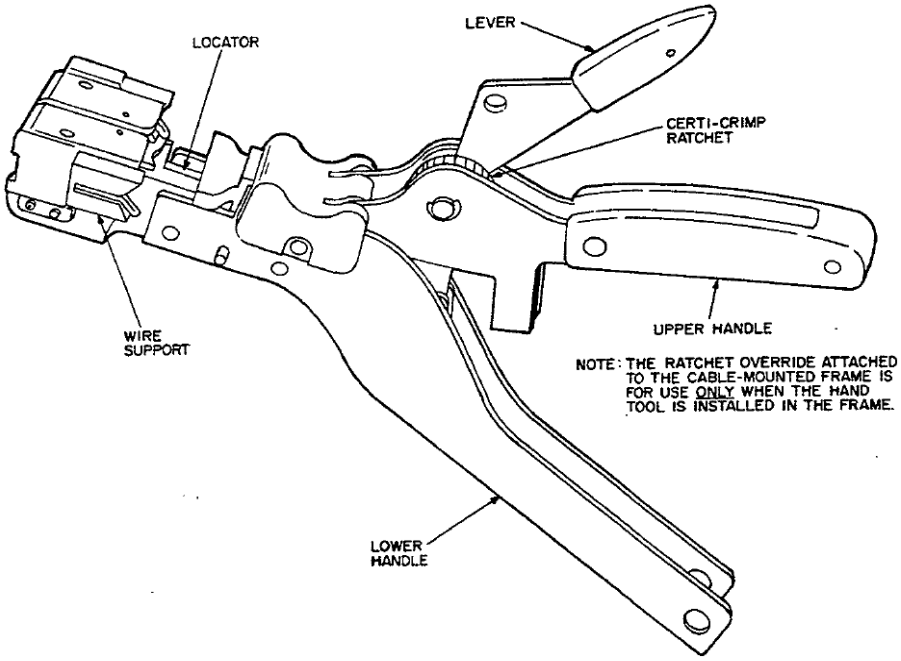

Figure 7 - Crimping Tool

5.2.2.7 Each Picabond connector consists of a preassembled two-piece housing (contact retainer housing and wire entry housing) and an insulation displacement contact. This contact will accept solid copper conductors in any combination of 19 through 26 AWG in the conductor holes. This conductor is crimped with a standard crimping tool.

5.2.2.8 It is necessary that at least one connector be checked for mechanical quality of crimp, with the crimp gauge as shown in Figure 8, at the beginning and end of each shift and after every 25 pairs are connected.

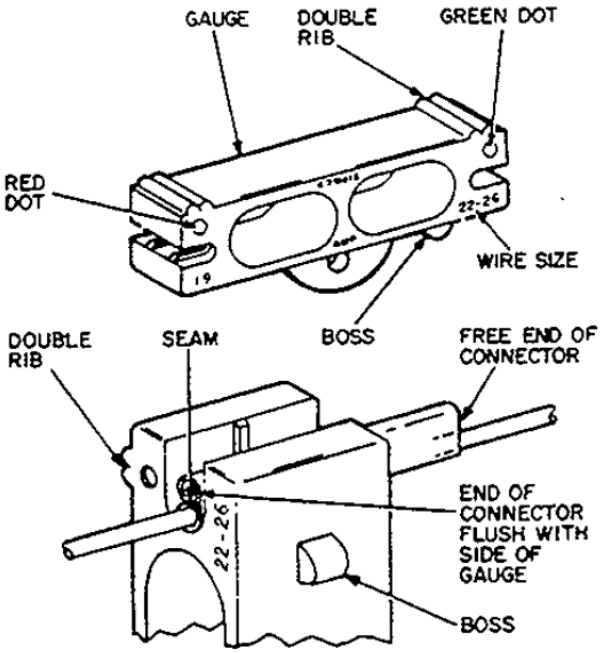

Figure 8 - Connector Crimp Gauge

Gauging Crimped Connectors Procedure:

(1) First, select the proper gauge end: each end is stamped with the wire size it accepts; each end has a color dot to match the connector's color.

(2) Notice the seam in the connector and the double rib on the gauge. Push the connector into the gauge so that its seam faces the double rib. Place the connector so that its end is flush with the side of the gauge

(3) Hold the free end of the connector and release the gauge. It might fall off the connector. If it does, repeat the test on the other end of the connector.

(4) If either ends of the connector sticks in the gauge, the connection may be defective or insufficient pressure applied during crimping. Re-crimp the connector just gauged and gauge it again. If the connector passes the gauging, go back and re-crimp all the connections made since the last good gauging.

(5) Any connectors that fail the preceding inspection procedures must be replaced. Use the A-MP hand tool to re-crimp or replace all defective connectors.

Commentary Notes:

1. *Defective crimping and gauging tools must be removed from site and replaced with good quality ones and not used on any cable splicing until they are repaired.*

2. *When two cables are being spliced together, it is necessary to maintain the correct polarity for all individual cable pairs being spliced throughout the entire cable span. The tip conductors of one cable must be spliced to the tip conductors of the other cable and the ring conductors of one cable must be spliced to the ring conductor of the other conductor.*

5.2.2.9 Cable numbering and count identification minimize the chance of error during a cable transfer. Cable pairs that are energized are identified by numerical designations, and dead pairs are identified by alphabetical designations. Cable designations, as presented in Figure 9, shall be shown on the construction drawings as per SAES-T-018 and include the following parts:

- Cable Type Designation
- Cable Number Designation
- Dead Pair Designation

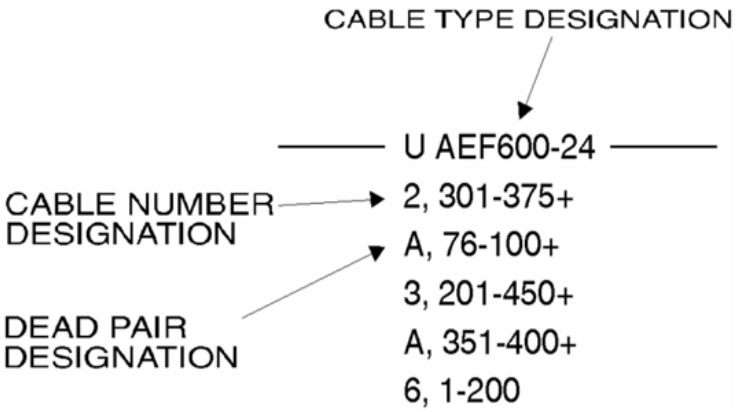

Figure 9 - Cable Designation

5.2.2.10 All Saudi Aramco cables shall be even count color coded plastic insulation cables (PIC). Standard binder group to binder group, color to color splicing is the only type of splicing that is used by Saudi Aramco. This section covers the following methods for copper cable splicing:

(1) Straight Splices

Telecommunication cable of the same size can be joined through the use of a straight splice. A straight splice joins

like color binder groups only, and the cable pairs are joined color to color. All binder groups are marked at both ends of the straight splice. The straight splice as shown in Figure 10 joins, by means of a connector, the matching cable pair conductors (ring to ring and tip to tip) from one cable to another cable to form a complete circuit.
The cable pair conductor must be seated firmly against the stop to ensure a satisfactory electrical connection.

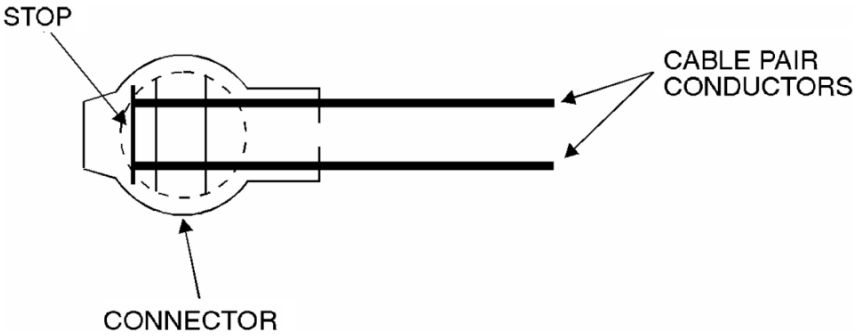

Figure 10 - Straight Splice

(2) Butt Splices

Bridge and tap connections can be accomplished through the use of butt splices. The bridge connection joins three or more cable pair conductors (ring-to-ring or tip-to-tip) to form a parallel circuit. The bridge connection, or half tap connection, as shown in Figure 11, joins three cable pair conductors through the use of a connector. The cable pair conductors must be set firmly against the stop to ensure a satisfactory electrical connection.

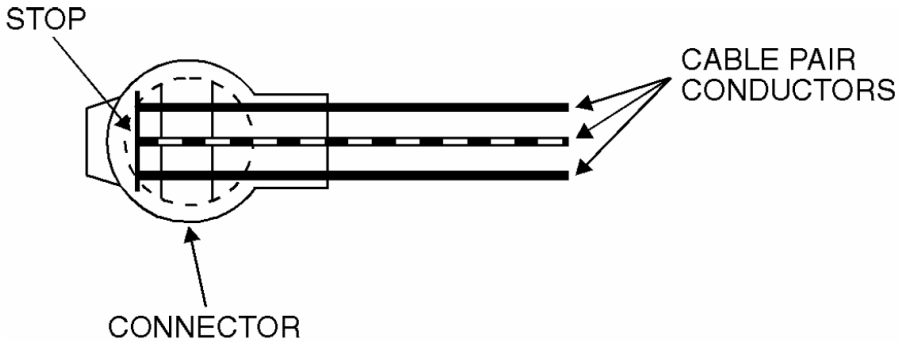

Figure 11 - Bridge Connection

5.2.2.11 Cable Tag

(1) All outside plant cables, copper or Fiber Optic, shall be identified with the proper designation using cable tag. Each tag must be stenciled (font size see Section 5.5) with an arrangement of letters and/or numbers as indicated on the design drawings.

(2) Figure 12 shows the types of tags made from sheet metal (Lead/ Stainless steel) that are used for cable identification at MH, pedestals and telecommunications rooms. Any equivalent tag may be used if approved by Area IT.

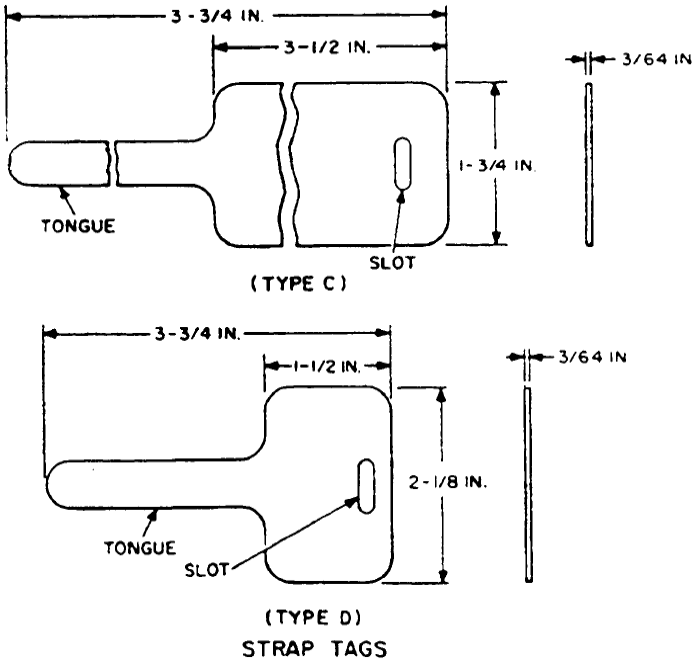

Figure 12 - Cable Tag

5.2.2.12 Tags must be placed on the cables for both ends (source and destination) between the point where they emerge from a duct and the first cable rack. A tag must be placed on lateral cables as well as on the main cable and after stub-up including pedestal, MH and HH.

5.2.2.13 The strap-type tag is placed around the sheath and the tongue pulled through the slot and bent back on itself (Figure 10). Also, the tongue length shall be as per cable diameter requirements plus the bend-locked.

The C-type strap tag (Figure 13) is used on cables having a diameter of 1 inch or more. The D-type tag (Figure 10) is used on cables with a diameter of less than 1 inch.

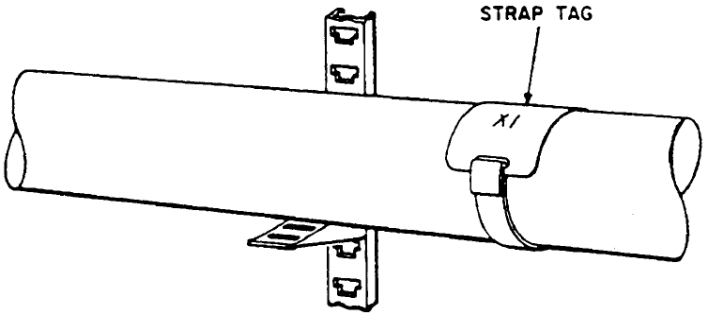

Figure 13 - Strap Tag

5.2.2.14 Splice Arrangements for Copper Cables

(1) Buried Splices

Direct buried splice cases accommodate straight splices, branch splices, and load coils. Direct buried splices shall be nonmetallic filled type and shall be used only when above ground splicing inside cabinets or pedestals or inside maintenance holes is not practicable. Refer to splice cases/closures on this standard for material details on direct buried splice/closure.

(2) Concreate tiles or blocks shall be placed 15 cm (6 in.) above the buried splice case to prevent damage to the splice case from future digging. If the soil below the splice does not form a firm base, a concreate slab or block shall be placed beneath the splice case. The concrete tiles or blocks shall be painted with orange color for identification as telecommunication system.

(3) Each buried splice shall be identified for future locating. One method of marking the splice point is the use of a marker post with a warning sign. Another method is the burying of an electronic locating device such as Electronic Marking System (EMS) markers.

(4) Cable Cabinets and Pedestals

Cabinets and pedestals are housings primarily intended to house, organize, and protect cable terminations incorporating splice connectors, ground lugs, and load

coils. Activities typically performed in pedestals are cable splicing, shield bonding and grounding, loading, and connection of subscriber service drops.

Typical splice capacities for cabinets and pedestals in Saudi Aramco are shown in Table 2. However, larger size pedestals are permissible if service requirements dictate their usefulness.

Table 2 - Saudi Aramco Typical Pedestals and Cabinets Splice Capacities

Pedestal Type	Maximum Splice Pair Capacity	9COM	Description
TYPE 1	400 Pair	6000001102	Pedestal Components/Hardware – CAD 6
TYPE 2	900 Pair	6000001140	Pedestal Components/Hardware - CAD 8
TYPE 3	1800 Pair	6000012175	Pedestal Components/Hardware - UPC 1000
TYPE 4	2700 Pair	6000001215	Pedestal Components/Hardware - UPC 1278

(5) Underground Splices (Maintenance Holes)

a. Underground splice cases accommodate straight splices, branch splices, and load coils. Underground splices shall be filled.

b. Precautions shall be taken to prevent the ingress of moisture and other contaminants during all phases of the splicing installation. When an uncompleted splice must be left unattended, it shall be sealed to prevent the ingress of moisture and other contaminants.
All underground splice openings that require temporary protection, regardless of cable size, shall be covered with CR (Cohesive Rubber) tape.
All underground CR tape coverings shall be flash-tested for leaks along the seams and at the cables.

5.2.2.15 The length of cable sheath to be removed shall be governed by the type of splicing hardware used. Follow the splice case manufacturer's recommendations.

(1) For pedestals or large pair count splice housings. Consider removing enough cable sheath to allow the conductors to extend to the top of the pedestal and then to hang downward to approximately 15 centimeters (cm) [6 inches (in.)] above the baseplate.

(2) Caution shall be exercised to avoid damaging the conductor insulation when cutting through the cable shield and removing the shield. Sharp edges and burrs shall be removed from the cut end of the shield.

5.2.2.16 Binder Group Identification

Color coded plastic tie wraps shall be placed loosely around each binder group of cables before splicing operations are attempted. The tie wraps shall be installed as near the cable sheath as practicable and shall conform to the same color designations as the binder ribbons. Twisted wire pigtails shall not be used to identify binder groups due to potential transmission degradation.

5.2.2.17 Splice Organization

Spliced pair bundles shall be arranged in firm layups with minimum conductor tension in accordance with the hardware manufacturer's instructions.

5.2.2.18 Binder Tape

Perforated non-hygroscopic and non-wicking binder tape should be applied to splices housed in filled splice cases. The binder tape allows the flow of filling compound while holding the splice bundles near the center of the splice case to allow adequate coverage of filling compound.

5.3 Splices Cases/Closures Consideration

5.3.1 Splice Cases that are equipped to receive encapsulating compound, shall only be used on OSP cables such at cable vault, maintenance holes, and direct buried or inside pedestal.

5.3.2 Direct buried and underground closure provide housing for splice and bonding and grounding. This shall be designed to restore the sheath mechanical integrity and electrical properties. Communications cables may enter this closure from one or both ends.

5.3.3 Whether used on filled or air core type cables, or whether splices are buried or underground, the closure must be filled with a re-enterable encapsulating compound. Installation shall be in accordance with the manufacturer's instruction, *see BICSI OSPDRM latest version for reference.*

5.3.4 Heat Shrinkable Splice Closures

Heat shrinkable splice sleeves and closures are generally available locally. Listed below are brief descriptions and uses of some locally available Heat-Shrinkable (Thermo fit) Sleeves (Closures). The list below is not comprehensive, but is typical of what is available in this type closure.

- 102L:

  Heat-shrinkable caps for sealing cable ends in non-pressurized or low performance pressurized applications. It is a medium-wall molded cap internally coated with an adhesive or mastic sealant. The end cap is available in sizes to fit cables that range from 4 mm to 115 mm diameter. For installation, the cap is centered over the ends of the cable and heat shrunk to form a seal of the cable ends.

- XAGA 200:

  Consists of a heat-shrinkable wrap around sleeve with a stainless steel channel closure and a pre-formed non-hydroscopic laminate to insulate, compact, and shape the splice. To insure proper installation the wrap around sleeve is coated externally with a heat-sensitive paint that changes color when enough heat has been applied for proper installation. XAGA 200 has a splice capacity up to 200 pairs (.6 mm/22 AWG) in configurations up to three cables in and three cables out and is used for sealing and protection of unpressurized cable splices.

- XAGA 200R:

  Is used for the sealing and protection of cable splices in the unpressurized telephone distribution network. A variable liner provides a laminated aluminum barrier against moisture vapor transmission as well as mechanical protection for the splice bundle. The shrinkable wrap around sleeve forms a watertight seal to the cable jacket. Up to three cables can enter each end of the sleeve. Each kit comes complete with filling compound for protection from water ingress. This sleeve comes in four sizes and can be used on a splice with a maximum of 120 mm diameter.

- XAGA 250:

  Is used to seal telephone cable splices for filled or unpressurized air core cable. This wrap around, heat-shrinkable splice closure will accommodate in-line as well as branch splices on polyethylene or lead

sheath cable. It may be used for direct buried, aerial, and underground installations. It provides a watertight seal that is also re-enterable for cable repair and rearrangements. It is constructed of a material formulated to resist UV radiation and atmospheric contamination. A splice encapsulation kit does not come with the XAGA 250, but is available in a separate kit. The XAGA 250 comes in different sizes and can be used on splices with maximum diameters of 200 mm.

- WRST:

  Wrap-around repair sleeves are split sleeves closed by a slide-on metal channel. WRST sleeves are suitable for all types of cables in direct buried, underground, or aerial applications. It is designed for use over transitions in a cable where a large shrink ratio is required. This sleeve is suited for repairing all types of sheath openings and sheath damage (trouble openings, fire and steam damage, cable bend repair, and etc.). It comes in several sizes and can be used on cables from 10 mm to 190 mm diameter.

5.3.5 The Preformed Stainless Steel Splice Closure (a non-filled type splice closure) or equivalent may be used on underground cables when the splice will be located inside a manhole. This type installation may require an annual preventive maintenance program (pressure test of splice closures, etc.) for verification of splice integrity. Installation materials and procedures shall comply with the manufacturers' recommendations.

5.3.5.1 Assemble the closure casing such that the hardware and fasteners are easily accessible without twisting or turning the cables.

5.3.5.2 Unfilled splice closures shall be sealed to provide air and water tight integrity, and left unpressurized at the completion of the splices. Nitrogen gas shall be injected into the assembled closures and pressure tested to 5 – 10 psi for leakage or as per the manufacturer recommendations.

5.3.6 All direct buried or underground cable splice closures shall be filled with a re-enterable encapsulating compound on air core as well as filled cables. The splice closure used shall be a type that is manufactured to hold encapsulating compound. The Pressure Wrap Kit, or a similar product utilizing a perforated web liner, shall be used in all encapsulated re-enterable splice closures.

5.3.7 Additional Requirements to be Consider

5.3.7.1 Fiber Optics Cables

(1) Typical fiber optic (FO) splice closure are define in BICSI OSPDRM - Outside Plant Design Reference Manual (latest version)

Commentary Note:

Manufacturer specifications should be consulted for splice closure capacity.

(2) Cables Splice Organizers

Non-metallic splice organizers shall be used for organizing fibers at splice points. Installation shall be in accordance with the manufacturer's instructions.

(3) Cleaving Tools

An approved Universal Fiber Optic Cleaving Tool shall be used in cleaving fibers. All cleaving tools shall be used according to the manufacturers' instructions.

5.3.7.2 Copper Cables

Typical balance twisted-pair splice closure are define in BICSI OSPDM - Outside Plant Design Reference Manual (Latest edition).

5.4 Offshore Platform Fiber Optic Cable Splicing

Refer to Section 5.2 on this standard for the requirements to comply.

5.5 Labeling Procedure

5.5.1 Labelling of copper and fiber optic cables shall conform with TIA-606C: Administrative Standard for Commercial Telecommunications Infrastructure.

5.5.2 Text on labels should be a font without serifs, upper case and large enough to be easily read. This is also to ensure that the identifiers are easily read. In addition, labels should be resistant to the environmental conditions at the point of installation (such as moisture, heat, or ultraviolet light), and should have a design life equal to or greater than that of the labeled component.

5.5.3 For OSP requirements, all labels shall be resistant to the environmental conditions at the point of installation (such as moisture, temperature, or ultraviolet light).

5.5.4 Labelling of Pedestal and Splice Housing, *see Figure 14*.

5.5.4.1 Place a "Warning Underground Cable" label centered one inch below the top cover of the housing.

5.5.4.2 Use reflective to show the pedestal identification number.

5.5.4.3 Place the cable lead number vertically one inch below the lower right corner of the "Warning labels" (if applicable).

Commentary Note:

The lead number and terminal shall be coordinated with the Information Technology Engineering Department.

5.5.4.4 Place the load point designator number vertically one inch below the pedestal identification number (if applicable).

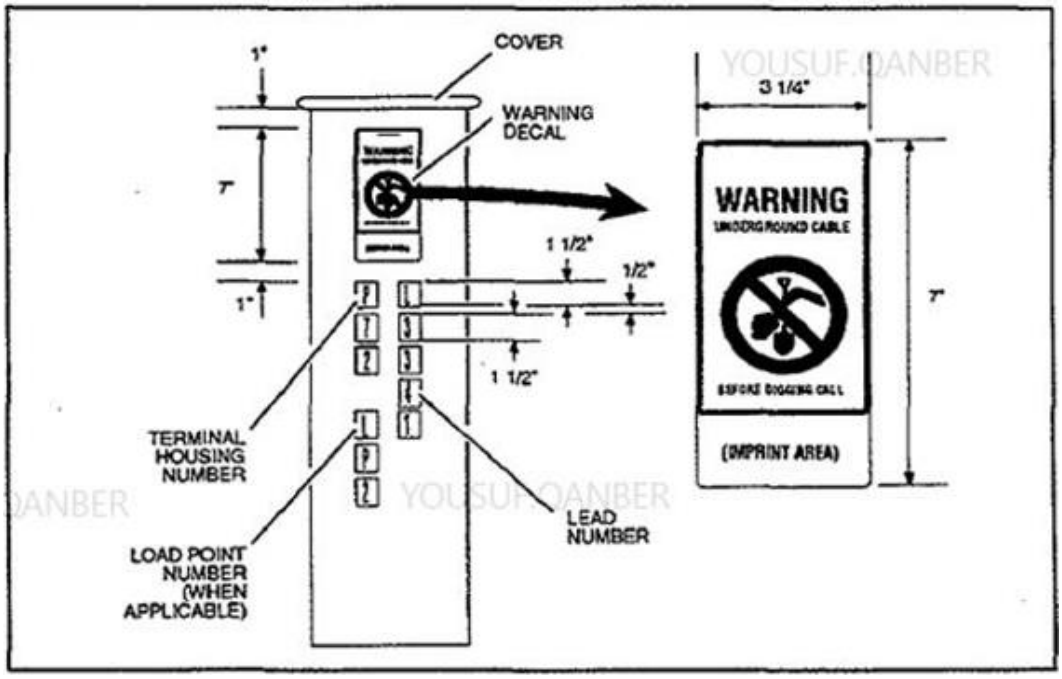

Figure 14 – Typical Pedestal Labeling

6 Installation

6.1 Cable Splicing

6.1.1 Cable splice locations and other splicing details should be specified in Issued for Construction (IFC) drawings in accordance with SAES-T-018.

6.1.2 The installation instructions provided by the manufacturer of splicing materials shall be followed except where those instructions conflict with the procedures specified in this standard.

6.1.3 All applicable safety precautions and Loss Prevention standards must be adhered to in the use and installation of the Cable Repair Auto wrap. Choose with care the locations in which this repair method will be used, due to the presence of heat and 120 volt electrical source. Comply with NFPA 70 safety precautions.

6.1.4 Personnel/technician assigned to perform cable splicing or any of its components shall have training in the proper techniques and have a minimum of 3 years' of recent experience in splicing and terminating the specified cables. Modular splices (to be use for indoor application only) shall be performed by manufacturer certified personnel or under direct supervision of manufacturer trained personnel for products used.

Copper and fiber optic cable splicing shall be performed by qualified Saudi Aramco certified splicer with valid certification or valid fiber optic or copper cable splicer/technician certification by a recognized international organizations.

6.2 Splice Closure

6.2.1 Cable splice closures shall be installed in accordance with the manufacturer's instruction unless directed otherwise in this Standard.

6.2.2 All splice cases installed on feeder copper cables shall be filled, whether buried, or underground.

7 Inspection and Testing

7.1 Cable Splicing

7.1.1 Copper and fiber optic cable splicing, testing and acceptance shall be performed in accordance with the company standards, SAES-T-624 for Fiber optic cables and SAES-T-629 for Copper cables. The tests and inspections shall be witnessed by the proponent representative, Inspection Department and other involved stakeholders.

7.1.2 The OTDR and optical power meter tests shall be conducted for end-to-end cable acceptance tests for fiber optic cables (FOC). Also, CD and PMD test results for specified cables under test shall submitted.

7.1.2.1 Fusion splicing machines shall be kept in proper working condition. Regular maintenance in accordance with the machine manufacturer's recommendations shall be observed.

7.1.2.2 An optical time domain reflectometer (OTDR) shall be used for testing splices. The OTDR shall be stationed at the main telecommunications room (TER) or buildings as launch point for testing individual splices as they are made and for end-to-end signature tests for the fiber optic link.

Commentary Note:

Acceptance resting requirements of Fiber Optics cable shall comply with SAES-T-624 standard.

7.1.3 Inspection Department Notification

The Saudi Aramco Inspection Department shall be notified two working days prior to beginning any cable splicing or testing so that all necessary inspections can be scheduled. The Inspection Department shall be notified two working days prior to backfilling any trenches or starting any acceptance testing.

7.2 Splice Closure

All quality assurance (QA) Inspections shall be done by a qualified communications inspector. All non-filled splice closures if used shall be flash tested and inspected for proper seals. Buried and underground splices shall be inspected to assure proper fill (of encapsulating compound) in the closure and use of the recommended (by closure manufacturer) encapsulating compound.

7.3 As-built Drawings

Shall be updated daily by field installation crew. As-built drawings and acceptance tests results shall be provided to and approved by the Saudi Aramco Communications Engineering Division of IT before the Mechanical Completion Certificate (MCC) is approved.

7.4 Quality Assurance (QA)

Quality assurance inspections shall be performed during all phases of construction by Saudi Aramco Inspection Department Inspector. Inspections shall be done by a qualified communications inspector.

Revision Summary

31 December 2019	Major revision, see table in page 2 for the summary of changes.
7 May 2019	Editorial revision as part of content confirmation assessment
18 October 2016	Major revision consolidating two standards (SAES-T-632 and SAES-T-633) into one document as part of communications standards committee's optimization initiative. Such as it will in alignment with international standards, functionality, and technology evolution. It also provide better clarification and understanding to the standards users.
17 February 2015	Major revision. The standard has been re-written to: (1) Include fiber cable splicing, and (2) Remove reference to GTE.