# Engineering Standard

SAES-T-624 28 April 2012

Telecommunications Outside Plant - Fiber Optics

Document Responsibility: Communications Standards Committee

## Saudi Aramco DeskTop Standards

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## 1 Scope

This standard covers mandatory requirements governing the engineering, design and installation of the outside plant portion of fiber optic cable systems.

## 2 Conflicts and Deviations

Any deviations, providing less than the mandatory requirements of this standard require written wavier approval as per Saudi Aramco Engineering Procedure SAEP-302.

## 3 References

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

3.1 Saudi Aramco References

Saudi Aramco Engineering Procedure

| | |
|---|---|
| *SAEP-302* | *Instructions for Obtaining a Waiver of a Mandatory Saudi Aramco Engineering Requirement* |

Saudi Aramco Engineering Standards

| | |
|---|---|
| *SAES-P-111* | *Grounding* |
| *SAES-T-018* | *Telecommunications--Symbols, Abbreviations and Definitions* |
| *SAES-T-603* | *Telecommunications--Safeguards and Warning Devices* |
| *SAES-T-628* | *Telecommunications--Underground Cable* |
| *SAES-T-629* | *Telecommunications Buried Cable and Wire* |
| *SAES-T-633* | *Communications Splice Closures* |
| *SAES-T-634* | *Telecommunications--Cable Testing and Acceptance* |
| *SAES-T-887* | *Telecommunications--Protection at Power Plants and Radio Stations* |
| *SAES-T-903* | *Communications Electrical Protection--OSP* |
| *SAES-T-911* | *Telecommunications Conduit System Design* |
| *SAES-T-916* | *Communications Building Cable* |

| | |
|---|---|
| *SAES-T-928* | *Telecommunications--OSP Buried Cable* |

Saudi Aramco Standard Drawings

| | |
|---|---|
| *AA-036748* | *Buried Telephone Cables* |
| *AB-036897* | *Buried/Underground Cable Route Marker Posts and Signs* |

3.2 Industry Codes and Standards

National Electrical Code

| | |
|---|---|
| *ANSI/NFPA 70* | *National Electrical Code (NEC)* |

Electronic Industries Association

| | |
|---|---|
| *EIA/TIA-569* | *Telecommunications Pathways and Spaces* |

Building Industry Consulting Service International

| | |
|---|---|
| *TDMM* | *Telecommunications Distribution Methods Manual* |
| *RCDD* | *A professional registration program administered by the Building Industry Consulting Service International* |

Rural Utility Services (formally REA)

| | |
|---|---|
| *RUS PE-90* | *Specification for Totally Filled Fiber Optic Cable* |

## 4 Design

ANSI/NFPA 70 National Electrical Code (NEC), and the BICSI TDMM are used, as modified below, for designing Saudi Aramco Engineering Standard SAES-T-624. Mandatory items are detailed herein.

4.1 General Requirements

4.1.1 Terms and Definitions

**Attenuation:** A measure of the decrease in energy transmission (loss of light) expressed in decibel (dB). In optical fibers, attenuation is primarily due to absorption and scattering losses.

**Coating:** A layer of composite plastic material covering the fiber to provide mechanical protection.

**Core:** The glass central region in an optical fiber that provides the means for transmitting light.

**Multimode:** A fiber that allows more than one optical mode to propagate.

**Single Mode:** A fiber that supports the propagation of only one mode.

**Operating Wavelength:** The light wavelength at which a system is specified, normally expressed in nanometers (nm). Most single mode fibers can operate at 1,300 nm or 1,550 nm.

**Optical Link Loss Budget:** Total losses allowed for satisfactory operation of an optical fiber system.

**Pigtails:** Small single fiber cords used to terminate optical fiber cables at Central Offices (COs) or regenerators. Each has a:

a) Connector at one end to interface the equipment.

b) Bare fiber at the other end for splicing to a fiber in the main cable.

**Splice Loss:** The amount of loss of light energy caused by angular misalignment, and/or fiber end separation, and/or lateral displacement of fiber axes.

4.1.2 Design Documentation

As a part of each telecommunications work order/project, detail schematic drawings shall be prepared for each fiber optic span/cable route, showing the following information:

1. Fiber cable data:

    a) Cable manufacturer.

    b) Vendor number.

    c) Cable size (number of fibers).

    d) Cable type (filled or air core).

    e) Cable make-up (dielectric or non-dielectric).

    f) Type of fiber (multimode or single-mode).

    g) Dispersion shifted or non-dispersion shifted.

    h) Transmission characteristics (dB loss/km at given wavelength and for multimode bandwidth/km).

i) Dispersion specification in ps/(nm · km).

j) Fiber packaging (single fiber/loose. Buffer; multiple fiber/loose buffer; tight buffer, channel/groove or ribbon type, and color code).

2. Other information:

a) Trunk number/cable number.

b) Span number.

c) Manhole number and duct number.

d) Wall-to-wall measurements (of conduits between manholes).

e) Major intersections and key streets.

f) Fiber cable splice points with station location.

g) Splice-to-splice cable lengths.

h) Record the footage and/or meter markings on the engineering design construction drawings.

i) Change in cable route.

j) All substructures (pipes, utilities, etc.) with station location.

k) Location of marker posts and signs.

4.1.3 Design Drawings Classification

All fiber optic work order/project design drawings shall be composed of three basic groups of drawing classification for consistency in presentation and application of standard symbols and abbreviations and for convenience in execution and recording.

1. Cable Drawing (Cable Schematic)

a. Cable layout shall have all the complete information symbolizing installation, removal or rearrangement of fiber optic cable, terminating equipment and other equipment associated with the fiber cable. It shall also include address or location of the cable route and of the fiber terminal.

b. No part of a cable layout drawing shall be referred to a detail layout in other sheets not associated with the cable layout.

c. Fiber cable shall be properly identified using applicable Saudi Aramco fiber cable designation symbols as specified in SAES-T-018.

d. Fiber terminating equipment (panel) shall be symbolized by proper fiber terminal symbol as specified in SAES-T-018, indicating the terminal number, cable & count and fiber terminating capacity.

e. All fiber cable related functions such as splicing symbol and sequence, fiber cable characteristics and parameters, test information and other directly cable related functions shall be contained in the cable drawing section.

f. Detail presentation or drawing of the fiber cable route, termination, and other cable details shall be shown in section for "Detail Drawings."

2. Trench Drawing (Trench Schematic)

a. The trench layout shall have complete information directly related to all trench and conduit work involved. This will include proposed trench, conduit, manhole substructure symbols and other directly related symbols.

b. Trench section detail, manhole layout and other detail drawings shall be shown in section for "Detail Drawings."

3. Detail Drawings (Detail Schematic)

a. This section shall contain drawings which show detail presentation on any part of the Cable or Trench drawing.

b. Any other drawings presented to enhance readability and layout presentation at the Cable and Trench Schematic shall be shown in this section.

Sectioning or grouping of the three different drawing classifications shall be on a sheet or drawing page basis. Work order drawings involving small size jobs may accommodate more than one section in a drawing sheet provided they are properly segregated by dividing lines and identified accordingly.

4.1.4 Cable Route

The cable route for all new cables shall be approved by the Saudi Aramco Communications Engineering Division of IT. Approved construction installation methods are as follows:

1. Underground (in conduit)
2. Buried (direct burial, i.e., not in conduit)

3. Aerial *

All buried and underground cable routes shall be marked in accordance with Saudi Aramco Standard Drawing AB-036897, Buried/Underground Cable Route Marker Posts and Signs.

*Commentary Note:*

*Use of method number 3 (aerial construction) shall be approved in writing by the Saudi Aramco Communications Standards Committee Chairman and complying with BICSI OSP Manual.*

4.1.5 Attenuation

The maximum attenuation of each fiber within a cable, when normalized to a length of 1 km. At wavelength = 1,300 nm, shall be 0.5 dB/km or less, and at wavelength = 1,550 nm, shall be 0.3 dB/km or less.

4.1.6 Cable Characteristics

All Saudi Aramco fiber optic cables shall comply with *RUS PE-90* specification. Provide optical fiber cables with characteristics, makeup, and handling performance which allow installation:

a) In the proposed Outside Plant (OSP) environment.

b) Using standard equipment and procedures.

4.1.7 Metallic Armor Use

Fiber optic cables may include an integral metallic armor if required for direct buried applications.

4.1.8 Composite Cable Use

Composite cable of power and fiber optic shall not be used unless approved in writing by the Saudi Aramco Communications Standards Committee Chairman.

4.1.9 Use of different cable types

For an individual link, the cable shall be the same type to ensure the same performance characteristics. This is to ensure compatibility in terms of the fiber geometrical parameters, attenuation and dispersion.

4.1.10 Bending Radius

The minimum bending radius for fiber optic cable is:

a) Ten times the cable diameter when the cable is not under tension.

b) Twenty times the cable diameter when the cable is under tension.

4.1.11 Pulling Tension

The pulling tension on fiber optic cables shall not exceed 600 pounds unless greater pulling tensions are specifically approved by the cable manufacturer. When fiber optic cable is pulled, it shall be pulled in a straight line. The cable shall never be bent or wrapped around the hand or any other object as it is pulled. Only vendor approved equipment or methods shall be used.

4.1.12 Cable Environment

All environmental conditions (petroleum, petroleum based products, thermal, chemical, mechanical, electrical conditions, etc.), which could be detrimental to the fiber optic cable when it is installed, shall be identified and all necessary action taken to protect the cable from the potential hazards in its environment.

4.2 Central Office and Remote Site Engineering

4.2.1 Cable Route in Buildings

The fiber optic cable route used from the central office cable vault (or building entrance) to the optical terminal equipment shall be designed in accordance with SAES-T-916, Communications Building Cable and approved in writing by the Saudi Aramco Communications Standards Committee Chairman, and/or signed by a Registered Communications Distribution Designer (RCDD). This cable route shall be shown on the telecommunications OSP design and construction drawings. The following guidelines shall be observed:

1. Do not use power cable runways (AC and/or DC) to support optical cables.
2. Install a new runway or conduit to support the planned optical fiber cable if an office:
   a) Is equipped with a cable grid only, and/or
   b) Does not have available existing cable troughs or race ways.
3. Optical fiber cables may be routed with high frequency (CXR) cable.

4. Avoid a route that would stack future cables in excess of 225 kg/m on top of fiber cables.
5. Do not exceed the fiber cable's minimum bending radius.
6. Coil 30 meters of slack cable in the cable vault and 10 meters if there is no cable vault for restoration.

4.2.2 Fire Protection Requirements in Buildings

Fiber optic cables placed inside all buildings shall comply with the fire protection requirements of ANSI/NFPA 70, NEC Article 770.

4.2.3 Grounding of Metallic Members in Buildings

Metallic members of fiber optic cables, which enter buildings, shall be grounded within 15 meters of the point of entry. If metallic conduit is used, the conduit shall be bonded (at each end) to the fiber optic metallic members and connected to the building ground. Refer to SAES-P-111 for more details.

4.3 Subduct Engineering

4.3.1 Number of Subducts in Four Inch Conduit

A four inch diameter underground conduit that is being set up for fiber optic cable placement shall contain:

1. Three subducts, two 1 ½ in (inside diameter) and one 1 in (inside diameter), or
2. Four 1 in (inside diameter) subducts.
3. Subducts shall have pull rope or pulling tape inside.

4.3.2 Subduct Placement

When placing subduct:

1. Comply with safety and installation requirements of SAES-T-603 and SAES-T-628.
2. Do not allow the pulling length of underground subduct to exceed 455 meters.
3. Station additional personnel at pull-through manholes to:
   a) Help guide subduct into the opposing duct.
   b) Alert the pulling personnel in the event of a mishap.

c) Help with lubricating the subduct as it is pulled in.

4. Use a 380 mm minimum bending radius during installation.

5. At pull through manholes, conduit offset shall be 230 mm or less.

6. Lubricate the subduct throughout the pull by applying generous amounts of lubricant (use lubricant recommended by subduct manufacturer) at the:

   a) Feeding end.

   b) Pull-through locations.

7. In addition to the standard underground placing tools, the following special tools and equipment are required:

   a) Subduct reel(s).

   b) Lashing wire (to be used to secure cable grip on subducts).

   c) One-inch dowels or larger based on subduct size (wood or plastic) or scrap copper cable (to be used for plugging the pulling end of each subduct for a distance of 300-450 mm to prevent subduct from collapsing during the pulling operation).

   d) Portable two-way radios (minimum of two) or other reliable communications ability.

8. Position subduct reels so that the subduct is alternately pulled from the top of one reel and the bottom of the next reel to keep the subducts from twisting during installation.

9. Plug all subduct ends to prevent water, dirt, etc., from entering the subduct.

4.3.3 Subduct Placement in Occupied Ducts

When optional fiber cables/subducts need to be placed in ducts occupied by other types of cables:

- A minimum of two one inch (2x1") subducts shall be placed.
- Copper cables shall not be pulled after the fiber has been installed.

4.3.4 Direct Buried Subduct

If subduct is to be direct buried, it shall be rigid PVC or heavy-walled polyethylene.

4.3.5 Subduct Colors

The subducts, which are placed inside a four inch conduit, shall be different colors per 4.3.1 and according to the following color scheme:

1) Three subducts, two 1-½ in. and one 1 in. Sub-ducts colors are orange, green and white.

   OR

2) Four 1 in. subducts. Sub-ducts colors are orange, green, white and blue.

4.3.6 Subduct Construction Drawings

Construction drawings shall include placement information including but not limited to the following requirements:

1. Duct assignment, to be approved by the Saudi Aramco Communications Engineering Division of IT.
2. Length of the subduct to be left at each cable feed manhole (minimum length of subduct sufficient to reach the opposite wall of the manhole; plus at least 1 meter at manholes where cable reels will be positioned for installation to act as a cable pulling guide).
3. Construction note specifying a 380 mm minimum subduct bending radius during installation.
4. Possible problem areas (e.g., severe bends, dips, conduit transpositions, etc.)
5. A subduct section numbering scheme, if the subduct is ordered to cut lengths.
6. Subduct racking position (e.g., cable rack position, on or under the cable racks, on walls, ceiling, etc.). Allow sufficient lengths of subduct for racking in intermediate manholes. Subduct must be installed so as not to block conduits or obstruct future cable placement.

4.3.7 Subduct Cutting and Splicing

Subduct shall not be cut or spliced for a minimum of 24 hours after placement to allow for subduct shrinkage. Subduct splices shall only be made inside the manhole between the cable vertical racks.

Threaded, self-tapping type subduct couplers shall be used to splice subducts.

4.3.8 Conduit Design

All conduit systems shall be designed to care for the requirements of both fiber and copper (see SAES-T-911).

4.4 Underground Cable Engineering

4.4.1 Subduct Requirements

When a design calls for installing fiber optic cable in an underground conduit system, always place the fiber optic cable inside a subduct. If the conduit system does not have existing subducts in one of its ducts, 3 or 4 subducts shall be placed in one of the existing ducts. It shall be remembered that one spare main duct shall be left vacant for operations and maintenance purposes. Refer to SAES-T-911.

4.4.2 Underground Cable Design and Construction Drawings

Engineering design and construction drawings for underground fiber optic cables shall show the following information:

1. Manholes.
2. Manhole diagrams illustrating cable, rack, and splicing locations of all facilities.
3. Conduit wall-to-wall (inside surface of the first manhole wall to the inside surface of the second manhole wall) measurements.
4. Radius and length of curve for all curves, sweeps and bends.
5. Dips, etc., that would affect cable pulls.
6. Locations for setting up the cable reel.
7. Minimum bending radius of the cables to be installed.
8. Maximum pulling tension of cables.
9. Reel lengths in meters.
10. Warning and cable identification tags or markers required in each manhole.
11. Bonding and Grounding systems.
12. Utility pipes, Hydrocarbon pipes, Railroads and road crossings properly named with station numbers.

4.4.3 Underground Cable Lengths

Fiber optic cable design and construction lengths shall allow sufficient length for:

1. Racking in pull-through manholes.
2. Slack at splice points (minimum of 3 meters plus the requirement of paragraph 4.5.7 below).
3. Central office and other building cabling.
4. Slack for future splice or drop points (minimum of 3 meters plus the requirement of paragraph 4.5.7 below).

4.4.4 Cable Splices

To keep future new cable openings to a minimum, underground fiber optic cable splices shall be located at points where future branch splices will be required, in so far as it is practical to do so. Underground fiber optic cables shall not be cut for splicing convenience.

***CAUTION:*** *All fusion splices shall be made outside manholes and at least 3 meters away from the manhole opening. Mechanical splices may be made either in or out of manholes.*

4.4.5 Field Survey

A field survey shall be made of all proposed fiber optic cable installation routes to determine if there are traffic/parking problems or other unsafe conditions at proposed splice and cable pulling locations. Check each manhole, through which the cable will pass, to confirm that adequate space is available for pulling, racking and splicing the cable. Determine if other conditions exist in the field, which would require change of the tentative design. Cable reel setup locations shall provide adequate space for:

1. Cable trailers.
2. Trucks.
3. "Figure 8's" of cable for split reel pulling, when required.

<u>Figure-eight Configurations</u>

The “figure-eight” configuration should be used to prevent kinking and twisting when the cable must be unreeled or backfed. The "figure-eight" should be approximately 4.5 meters in length.

Each loop should be approximately 1.5 meters to 2.5 meters in diameter.

4.4.6 Cable Ordered by Cut-Length

When cable is to be ordered by reel cut length, the reel cut length should be a total of the following:

1. All wall-to-wall lengths,
2. The amount for racking in all pull-through manholes.
3. The slack loop length at splice points, typically 15 meters on each end.
4. The lap required for splicing the ends of the reel, typically 3 meters for each end of the reel.
5. Central office and other building or termination point cabling.

4.4.7 Cable Placement Tools

The following tools shall be used when placing underground fiber optic cables:

1. A pulling swivel (maximum 7/8-inch diameter).
2. A tension monitoring device, such as:
   a) A dynamometer (1,000 pounds) or equivalent.
   b) A mechanical puller equipped with "built-in" monitoring capability or equivalent.

*Commentary Notes:*

*Note 1. Before starting cable pull, test pulling devices equipped with pre-set load cut-off devices to ensure they are operating properly.*

*Note 2. A running line dynamometer or equivalent shall be used to monitor the pulling tension applied to the cable during the entire cable pulling operation.*

*Note 3. The dynamometer shall be calibrated prior to start of the cable pulling operation and at the intervals specified by the manufacturer.*

*Note 4. An observer shall be stationed to observe the dynamometer during the pulling operation to make sure the set limit is not violated.*

3. A 3/8-inch dacron line for dynamometer calibration [15 to 23 meters].

4. Large cable wheel(s) having a minimum radius of 20 times the cable diameter.

4.4.8 Underground Cables shall be Non-metallic

Underground fiber optic cables shall be all dielectric (non-metallic). When underground fiber optic cables containing metallic members are placed (after receiving proper approval), the metallic members shall be bonded and grounded at all splice points to the manhole ground, which shall be 25 ohms or less.

4.4.9 Cable Placement Coordination

Before starting underground placing work, all personnel shall know the communication signals that will be used. Personnel shall be stationed at:

1. The reel location during pulling activities to maintain proper reel rotation.

2. Pull-through manholes to:

   a) Alert the pulling personnel in the event of a mishap.

   b) Monitor the cable during the pulling process.

   c) Help with cable lubricating, as required.

   d) Help guide the cable into the duct on the opposite side of the manhole if the subduct is non-continuous through the manhole.

4.4.10 Set-up for Cable Pull

At the manhole where the cable reel is set up for pulling-in, bring the end of the subduct out of the manhole (splice on additional subduct if the existing duct is not long enough) and set it in position for feeding the cables. Place a generous amount of lubricant in the subduct before and during the pulling operation. See the manufacturer's recommendations for proper lubricant application. Always use manufacturers recommended lubricants. Do not use petroleum base lubricants.

4.4.11 Cable Racking in Manholes

Fiber optic cables shall be racked in manholes so as to:

1. Lessen the possibility of accidental damage.
2. Separate fiber optic cable/subduct from other cables.
3. Permit subducts to rack on the same brackets or hooks at the same level, when subducts are continuous pieces.
4. Maintain minimum bending radius of ten times the cable diameter.
5. Secure the subduct to the manhole rack with cable support ribbon or tie wraps.

4.4.12 Subduct Percent Fill

To allow sufficient space for pulling grips or pulling eyes, etc., in general, the cross-sectional area of the cable should not exceed 53% of the inside cross-sectional area of the subduct for one cable, 30% for two cables, and 40% for three cables. Refer to ANSI/EIA/TIA-569 for more details on cable capacity for conduits having cross sectional areas ranging from 2 $cm^2$ to 82 $cm^2$.

4.4.13 Safety Requirements

All underground fiber optic cable installations shall comply with the safety requirements of SAES-T-603, "Telecommunications-Safeguards and Warning Devices," SAES-T-628, "Telecommunications - Underground Cable," the "Construction Safety Manual" and all applicable safety practices.

4.5 Direct Buried Cable Engineering

4.5.1 Placement Methods and Safety Requirements

The plowing-in method is the preferred method for burying optical fiber cables. Before plowing in fiber optic cables, it is recommended that the route be pre-ripped so that obstacles can be identified and removed or necessary precautions taken prior to the actual placement of the cable. The placing operation precautions during installation, backfilling, etc., shall be in accordance with SAES-T-928 and SAES-T-629. During the placing operation, buried fiber optic cables shall not be cut for convenience.

4.5.2 Engineering Design

The engineering design shall be well planned such that:

1. The designated number of splice points shall not be increased

during the construction stage.

2. Splice points are spaced to coincide with designated reel lengths.
3. Suitable splice locations are selected.
4. Splice locations are accessible.
5. The number of splice points are kept to a minimum.
6. Buried splices and isolated conduit ends are identified with Electronic Marking System (EMS) markers.
7. Splice locations are safe for personnel.

4.5.3 Splice Placement

Only direct buried type splice closures shall be used in direct buried cable systems. The fiber optic cable "out-of-pit" cable slack shall be coiled and housed inside the splice pit.

4.5.4 Splice Locations

Splice and other access points shall be located so as to avoid areas that:

1. Are vulnerable to damage by vehicular traffic or other means.
2. Are subject to flooding or standing water.
3. Have a number of obstacles (which would tend to increase the need to cut and splice the fiber optic cable), such as:

   - Railroads.
   - Highways.
   - Pipelines.
   - Driveways.
   - Parking lots.

4.5.5 Cable Direct Burial Methods

Direct buried fiber optic cables shall be placed inside a subduct or contain a steel armor, where there is a need to protect the cable against punctures caused by hand tools or gnawing animals. In areas where these dangers are not thought to be a concern, the cable may be of all dielectric material (non-metallic). When required to provide additional protection, split subduct may be placed over the fiber optic cable during installation. All dielectric fiber optic cables shall always be installed inside subducts, when direct burying (open trench or plowing-in methods) them in sharp, rocky, shale-like conditions. In rocky soil,

open trench conditions, place a minimum of 100 mm of sand below and above the fiber optic cable.

4.5.6 Marker Tape

An orange marker tape shall be placed flat in the trench above all open trench direct buried fiber optic cables. The marker tape is to be placed approximately 300 mm below grade. When the fiber optic cable is all dielectric (non-metallic), a detectable marker tape shall be placed in the trench above the cable. The marker tape shall not be placed closer than 300 mm to the cable. When the marker tape is placed by means of plowing, it shall be continuous.

4.5.7 Splices to be made inside Splicer's Vehicle

At all buried 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.

4.5.8 Grounding Metallic Members

All metallic members of a fiber optic cable shall be bonded together and grounded at all splice locations. The ground shall:

1. Be 25 ohms or less resistance.
2. Be attached to the power ground, when available and located within 3 meters.
3. Refer to SAES-T-887 for appropriate protection requirements if the cable is subjected to severe exposure due to fault current or ground potential rise (GPR).

4.5.9 Minimum Cover Requirements

Direct buried fiber optic cables shall be placed with a minimum cover of:

1. 1200 mm, when placed with no additional protection.
2. 760 mm to 1200 mm, when placed inside polyethylene subduct.
3. 250 mm to 760 mm, in rock areas, when placed inside concrete encased conduit (refer to SAES-T-911, SAES-T-928, and Standard Drawing AA-036748).
4. Fiber optic cables shall not be placed with less than 250 mm cover in any situation.

#### 4.5.10 Cable Quantities

When ordering fiber optic cables, include:

1. The measurements between splice points.
2. Splicing overlap -- typically 3 meters at each end.
3. The amount of cable required for "out-of-pit" splicing -- typically 15 meters at each end.

### 4.6 Aerial Cable Engineering

#### 4.6.1 Aerial Cable Limitations

Aerial fiber optic cables shall not be placed, unless approved in writing by the Saudi Aramco Communications Standards Committee Chairman. BICSI TDMM Chapter 2 prior to designing an aerial fiber optic installation.

#### 4.6.2 Support Messenger Strands

Aerial fiber optic cables shall be placed on 6 mm (diameter strand), messengers (support strand) unless unusual loading conditions require larger messengers. The support messenger shall be bonded and grounded in accordance with the requirements of SAES-T-903.

#### 4.6.3 Aerial Subduct

The placing of aerial subduct may be used for:

1. Providing additional mechanical cable protection.
2. Pulling slack for maintenance purposes.
3. Easy cable installation.
4. Preventing pole changeouts by lashing subduct to existing copper cable. Fiber optic cables shall not be lashed directly to copper conductor cables, without using subduct. Fiber optic cables may be lashed together.

*Commentary Note:*

*Aerial subduct shall be ultraviolet (UV) resistant.*

#### 4.6.4 Aerial, Non-Metallic Cables

All dielectric (non-metallic) fiber optic cables shall be used in all aerial installations.

*Exception:*

*Exceptions to this shall be approved in writing by the Saudi Aramco Communications Standards Committee Chairman.*

4.6.5 Grounding Metallic Members in Aerial Cables

When a fiber optic cable containing metallic members, (as an exception to paragraph 4.6.4 above) is placed on a pole line, (and the inductive effects of nearby power lines are not calculated), bond the metallic members to the support strand at all splice points and at intervals not to exceed 2 km. Each bond point shall be grounded to the power ground, where available. In other areas, a ground electrode of 25 ohms resistance or less shall be provided. Joint use with non-grounded power systems greater than 15 kV phase to ground is not permitted. Fiber optic riser cables shall be placed in riser ducts from the base of the pole until the cable exits on the strand. The cable pulling tension shall not exceed 600 pounds. Fiber optic cable bending radii shall not be less than twenty times the cable diameter when the cable is under tension or ten times the cable diameter when the cable is not under tension.

4.6.6 Allowance for Expansion and Contraction

In aerial designs, approximately 150 mm of excess fiber optic cable(s) slack shall be left at every pole for normal expansion and contraction.

4.6.7 Aerial Cable Design

Fiber optic cable system engineering designs and installations shall ensure that:

1. Suitable splice locations are selected:

   a) Clear pole space available.

   b) Areas that provide easy access for:

      - Splicing and maintenance vehicles.
      - Tools and test equipment.

   c) Area available to accommodate splice enclosure.

   d) Avoid locations involving:

      - Personnel safety hazards.
      - Non-Saudi Aramco controlled property.

- Road or highway intersections.
- Congested aerial plant.

2. The designated number of splice points is not increased from those specified on the approved construction drawings. Do not cut aerial fiber optic cables for placing convenience.
3. Splice points are spaced to coincide with designated cable reel lengths.
4. When fiber optic cable is pulled, it shall be pulled in a straight line. The cable shall never be bent or wrapped around the hand or any other object.

4.6.8 Aerial Cable Splice Slack

At splice points in aerial fiber optic cable installations, provide sufficient additional cable slack so that the splice can be made in an environmental van/vehicle free from dust, moisture, and pollutants. After completing the splice, place the fiber optic cable slack and the splice case inside an Optiped (Trade Mark of Coastal Engineered Products) or equivalent type optical storage enclosure or in an above ground pedestal enclosure, in areas where above ground splices are permitted.

4.6.9 Cable Quantities

When ordering fiber optic cables, for aerial installations include:

1. The measurements between splice points.
2. Splicing overlap, typically 3 meters at each end.
3. The amount of cable required for on the ground and in the splicer's vehicle splicing.
4. Expansion loop at each pole.

4.7 Splicing Fiber Optic Cables

4.7.1 Fiber Handling

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.)

4.7.2 Safe Disposal of Scrap Fiber Pieces

Scrap pieces of fiber are dangerous and can penetrate the skin.

Dispose of bare fiber properly by using the sticky side of a piece of tape to pick up and discard any loose ends in a container. Scrap pieces of fiber shall be cleaned up from the work site and properly discarded before leaving a work site.

4.7.3 Cable Minimum Bending Radius

Observe the following minimum bending radius limitations when handling optical fiber cables:

1. Under tension--Twenty times the cable diameter.
2. Not under tension--Ten times the cable diameter.

4.7.4 Additional 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. Isopropyl alcohol.
4. Approved cable cleaner.
5. Approved cleaver tool.
6. Means of communication.
7. Approved mechanical stripping tool to remove fiber coating.

4.7.5 Splices - Methods, Tests & Cautions

Splice fibers with approved fusion splicing equipment or approved mechanical splices. 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-634 for test and acceptance requirements).

***CAUTION:*** *All fusion splices shall be made outside manholes and at least 3 meters away from the manhole opening. Mechanical splices may be made either in or out of manholes.*

4.7.6 Preparations for Splices & 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 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.

4.7.7 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. Recommended types of organizers are Murry, BICC, RayChem, and Fiberlign organizers or equivalent. See SAES-T-633, Communications Splice Closures.

4.7.8 Splice Closures

All splice closures shall be used in accordance with the manufacturer's instructions. Recommended types of closures are RayChem, Murry Stayseal, and BICC splice closures. See SAES-T-633, Communications Splice Closures for more details.

4.7.9 Temporary Bonding and Grounding during Splicing

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.

4.7.10 Safety Glasses Requirement

Safety glasses shall be worn to protect eyes when handling chemicals or cutting fibers.

***WARNING:*** *Never look directly into the end of an optical fiber. If laser light is present, it can seriously damage the eye.*

4.7.11 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.

4.8 Link Loss Budget Requirements

During the design stage a link loss budget shall be prepared and included with the project proposal and design packages. The link loss budget shall include:

- Total fiber attenuation (loss).
- Splice loss (including pigtail splices, if pigtails are used).
- Connector loss.
- Wave Division Multiplex (WDM) losses, if used.
- A margin for light source aging as per manufacturer's specification.
- Link loss margin of 3 dB minimum for restoration splices.

The calculated dB loss cannot exceed the operating range of the terminal equipment that will be installed. Measured end-to-end loss should measure less than the calculated loss. Fibers that measure a higher loss than the link loss budget will not be accepted. All loss measurements shall be documented and distributed in accordance with the requirements of SAES-T-634.

4.9 Spare Fiber Strands in a Fiber Cable

During the design stage of new or upgraded fiber cables systems, spare fiber strands shall be reserved between any two end points of a cable system, including spur links. The following shall be required:

- Design and allocation of the spare strands in any cable system shall be reviewed and approved by the Saudi Aramco Communications Engineering Division of IT. The design shall be included in the cable design package.
- Spare fiber strands shall not be used unless written permission is obtained from the Saudi Aramco Communications Engineering Division of IT.

- Spare fiber strands shall only be used on a temporary basis for emergency service restoration, maintenance, upgrade, and testing activities.
- Spare fiber strands shall be spliced and terminated at the Fiber Distribution Panel (FDP), and marked as spares.
- As a minimum, two fiber strands shall be reserved on fiber cables containing forty eight (24) fibers or less, and four fiber strands on fiber cables containing more than forty eight (48) fibers shall be provided.
- The spare fiber count shall be an even number.

## 5 Testing and Inspection

End-to-end testing shall be carried out on all outside plant fiber optic cable facilities (defined as the span of fiber from the transmitter to the receiver) to document the overall optical loss.

### 5.1 Acceptance Testing Requirements

Acceptance testing requirements for fiber optic cables are covered in SAES-T-634. The three basic tests for fiber optic cables are:

1. End-to-end acceptance tests (typically conducted after completion of installation and splicing and before installing terminal equipment).

   *Commentary Note:*

   *End-to-end attenuation is the amount of optical power lost between cable system connector tips. This will include the fiber and splice loss in the cable system after it has been installed.*

2. Splice acceptance tests (individual splice insertion losses) shall be .05 dB average link splice loss with no single splice loss above 0.1 dB for fusion splices, and 0.1 dB average link splice loss with no single splice loss above .2 dB for mechanical splices; connectors shall have insertion losses of .5 dB or less).
3. On-reel acceptance tests shall be performed on the cable to confirm the manufacturer's tests before the placing operation begins.
4. Each link shall be tested for zero transmission error performance at the highest bit rate expected to be carried over the cable section. This test is to be performed with a transmission analyzer.

### 5.2 As Built Drawings

As-Built drawings shall be updated daily by field installation forces. 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.

5.3 Inspection Department Notification

The Saudi Aramco Inspection Department shall be notified two working days prior to beginning any construction 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.

5.4 Design Variations

Copies of all approved design variations (items for which the Saudi Aramco Communications Standards Committee Chairman and/or Communications Engineering Division of IT is given approval authority in this document) shall be readily available to the representative of the Inspection Department.

**Revision Summary**

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|---|---|
| 18 January 2009 | Revised the "Next Planned Update". Reaffirmed the contents of the document, and reissued with editorial changes. |
| 1 July 2009 | Editorial revision to provide better clarification on the highlighted requirements. |
| 3 November 2009 | Editorial revision to clarify the coloring scheme of the subducts to implement PMT lesson learned. |
| 28 April 2012 | Editorial revision to change the primary contact. |