Engineering Standard

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Telecommunications: Fiber Optic Cables for Outside Plant (OSP) and Inter/Intra Building Applications

Document Responsibility: Communications Standards Committee

Contents

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1 Scope

This standard covers mandatory requirements governing the engineering, design, and installation of fiber optic cable systems for the following applications;

1.1 Outside Plant (OSP)

Single Mode Fiber Optic Cable shall be use for Outside Plant (OSP).

1.2 Inter and Intra Building

Multimode Fiber Optic Cable and Single Mode Fiber Optic Cable shall be utilize in inter and intra building installations for all data communications and Local Area Network applications. Other applications like PBXs, video, and various multiplexing uses for short-length links may also be supported by this standard.

Commentary Notes:

1. *The multimode fiber optic cable parameters as specified in this standard are applicable for transmission speed up to 155 megabits per second (Mbps) for distances up to 2 km (OM1), transmission speed up to 1 Gigabit per second (Gbps) for distances up to 550 m (OM2) or transmission speed up to 10 Gigabit per second (Gbps) for distances up to 300 m (OM3) only. Multimode fiber cable usage shall be in accord with IT Engineering Department.*
2. *For higher speeds and longer distances, single mode fiber optic cables shall be used.*

2 Conflicts and Deviations

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

Any deviation from the requirements herein shall follow internal company 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.

3.1 Saudi Aramco References

Saudi Aramco Engineering Procedures

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

SAES-P-111	*Grounding*
SAES-T-629	*Telecommunications Outside Plant - Copper Cable*
SAES-T-632	*Telecommunications: Splicing Copper Cables, Fiber Optic Cables, and Types of Splice Closure*
SAES-T-911	*Telecommunications Conduit System Design*
SAES-T-916	*Communications Building Cable*
SAES-T-919	*Submarine Fiber Optic Cable*
SAES-T-928	*Telecommunications-OSP Buried Cable*

Saudi Aramco Materials System Specification

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

Saudi Aramco Standard Drawings

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

Saudi Aramco Manuals

CSM	*Saudi Aramco Construction Safety Manual*

3.2 Industry Codes and Standards

International Telecommunications Union – Telecommunications Standardization Sector (ITU-T)

G.651	*Characteristics of a 50/125 Micrometer Multimode Graded Index Optical Fiber Cable*
G.652	*Characteristics of a Single-Mode Optical Fiber Cable*
G.653	*Characteristics of a Dispersion-Shifted Single-Mode Optical Fiber Cable*
G.655	*Characteristics of a Non-zero Dispersion Shifted Single-Mode Optical Fiber Cable*

American National Standard Institute

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

Electronic Industries Association

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

Building Industry Consulting Service International

BICSI TDMM	*Telecommunications Distribution Methods Manual*
BICSI OSPDRM	*Outside Plant Design Reference Manual*

4 Definitions and Acronyms

4.1 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.

Long Haul: Cabling and telecommunications circuits that span a considerable distance (long distance), well beyond the range of a campus.

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 connector at one end to interface the equipment and a 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.

4.2 Acronyms

GPR	ground potential rise
OSP	outside plant
OTDR	optical time domain reflectometer

5 Design

5.1 General Requirements

5.1.1 For OSP Design Reference

The BICSI Outside Plant Design Reference Manual (OSPDRM latest edition) is hereby recognized as the referenced detailed design information.

5.1.2 For Inter and Intra Building Design Reference

The BICSI TDMM (latest edition) is hereby recognized as the referenced detailed design information.

5.1.3 Design drawings shall use conventional symbols as specified in SAES-T-018 Telecommunications - Symbols, Abbreviations, and Definitions.

5.1.4 Designer Certification Requirements

All telecommunications system designs by non-Aramco design offices (such as GES Contractor, LSTK, etc.) must be done under the design authority of a valid/current BICSI Registered Communications Distribution Design (BICSI RCDD and/or OSP Specialty). This is to ensure that a minimum level of competency has been provided in the telecommunications infrastructure and OSP cable system design.

For external design contractors, the RCDD and/or OSP shall be a direct employee of that company.

All related design drawings must be stamped by the RCDD and/or OSP specialist before the package can be Issued for Construction (IFC).

5.2 Outside Plant (OSP) Consideration

This section will follow ANSI/NFPA 70 National Electrical Code (NEC), and the BICSI TDMM, as modified below.

5.2.1 General Requirements

5.2.1.1 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) Maintenance hole number and duct number

   d) Wall-to-wall measurements (of conduits between maintenance holes)

   e) Major intersections and key streets

   f) Fiber cable splice points with station location

   g) Splice-to-splice cable lengths

   h) 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

5.2.1.2 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 refer 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. In addition, naming of cables shall be properly identify using Network Engineer through coordination with IT Engineering Department.

   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 the 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, maintenance hole substructure symbols and other directly related symbols.

b) Trench section detail, maintenance hole layout and other detail drawings shall be shown in the 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.

5.2.1.3 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:

Aerial construction shall only be approved through a waiver and complying with BICSI OSPDRM.

5.2.1.4 Cable Characteristics

All Saudi Aramco fiber optic cables shall comply with *18-SAMSS-625* specification. Provide optical fiber cables with characteristics, makeup, and handling performance which allow installation:

1. In the proposed Outside Plant (OSP) environment
2. Using standard equipment and procedures

5.2.1.5 Metallic Armor Use

Fiber optic cables may include an integral metallic armor if required for direct buried applications. Refer to Section 5.1.5.5 for additional requirements.

5.2.1.6 Composite Cable Use

Outside plant composite cable of power and fiber optic shall not be used.

Commentary Note:

The intent of this standard is to address outside plant design. The stand-alone and composite submarine FO cables are addressed in SAES-T-919.

5.2.1.7 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.

5.2.1.8 Bending Radius

The minimum bending radius for fiber optic cable is:

1. Ten (10) times the cable diameter when the cable is not under tension
2. Twenty (20) times the cable diameter when the cable is under tension

5.2.1.9 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.

5.2.1.10 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.

5.2.2 Central Office and Remote Site Engineering

5.2.2.1 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, 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 (Coaxial cable) 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. Provides adequate storage of cable slack, it shall have a coil/loop of 15 meters of slack cable in the cable vault or cellar and 10 meters if there is no cable vault for restoration.

5.2.2.2 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.

5.2.2.3 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.

5.2.3 Subduct Engineering

5.2.3.1 Number of Subducts in Four Inch Conduit

A four (4)-inch diameter underground conduit that is being set up for fiber optic cable placement shall contain:

1. Three (3) pieces subducts composed of two (2) pieces of 1½ inches – inside diameter subducts and one (1) piece of one (1) inch - inside diameter subduct, or
2. Four (4) pieces of one (1) inch - inside diameter subducts.
3. Subducts shall have pull rope or pulling tape inside.

5.2.3.2 Subduct Placement

When placing subduct:

1. Comply with safety and installation requirements of SAES-T-629.
2. Do not allow the pulling length of underground subduct to exceed 455 meters.
3. Station additional personnel at pull-through maintenance holes 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. Refer to SAES-T-911 requirements pertaining to “Minimum Spacing between Cables and MH Ceiling” and “Minimum Space between Cables and MH Floor”.
5. At pull through maintenance holes, 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.

5.2.3.3 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 (2 x1") subducts shall be placed.
- Copper cables shall not be pulled after the fiber has been installed.

5.2.3.4 Direct Buried Subduct

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

5.2.3.5 Subduct Colors

The subducts, which are placed inside a four inch conduit, shall be different colors per Section 5.1.3 and according to the following color scheme:

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

OR

2. Four 1 in. subducts. Subducts colors are orange, green, white, and blue.

5.2.3.6 Sub duct Construction Drawings

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

1. Duct assignment, to be approved by IT Engineering Department.
2. Length of the subduct to be left at each cable feed maintenance hole (minimum length of subduct sufficient to reach the opposite wall of the maintenance hole; plus at least 1 meter at maintenance holes 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 maintenance holes. Subduct must be installed so as not to block conduits or obstruct future cable placement.

5.2.3.7 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 maintenance hole between the

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

5.2.3.8 Conduit Design

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

5.2.4 Underground Cable Engineering

5.2.4.1 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, 4 pcs. of 1 in. subducts shall be placed in one of the existing ducts and one subduct shall be left vacant for operations and maintenance purposes. Refer to SAES-T-911.

5.2.4.2 Underground Cable Design and Construction Drawings

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

1. Maintenance holes
2. Maintenance hole diagrams illustrating cable, rack, and splicing locations of all facilities
3. Conduit wall-to-wall (inside surface of the first maintenance hole wall to the inside surface of the second maintenance hole 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 maintenance hole
11. Bonding and grounding systems

12. Utility pipes, hydrocarbon pipes, railroads, and road crossings properly named with station numbers.

5.2.4.3 Underground Cable Lengths

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

1. Racking in pull-through maintenance holes.
2. Slack at splice points (minimum of 3 meters plus the requirement of Section 5.2.5.7 below).
3. Central office and other building cabling.
4. Slack for future splice or drop points (minimum of 3 meters plus the requirement of Section 5.2.5.7 below).

5.2.4.4 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 maintenance holes and at least 3 meters away from the maintenance hole opening. Mechanical splices of fiber optic cable is not permitted by Saudi Aramco.

5.2.4.5 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 maintenance hole, 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:

- Cable trailers
- Trucks
- "Figure 8's" of cable for split reel pulling, when required

The "figure-eight" configuration should be used to prevent kinking and twisting when the cable must be unreeled or back fed. 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.

5.2.4.6 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 maintenance holes
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.

5.2.4.7 Cable Placement Tools

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

1. A pulling swivel (maximum ⅞-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:

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

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

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

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

3. A ⅜-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

5.2.4.8 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 maintenance hole ground, which shall be 25 ohms or less.

5.2.4.9 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 maintenance holes 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 maintenance hole if the subduct is non-continuous through the maintenance hole.

5.2.4.10 Set-up for Cable Pull

At the maintenance hole where the cable reel is set up for pulling-in, bring the end of the subduct out of the maintenance hole (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-based lubricants.

5.2.4.11 Cable Racking in Maintenance Holes

Fiber optic cables shall be racked in maintenance holes so as to:

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

5.2.4.12 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 D for more details on cable capacity for conduits having cross sectional areas ranging from 2 cm^2 to 82 cm^2.

5.2.4.13 Safety Requirements

Applicable standard for all underground fiber optic cable installations shall comply with the safety requirements stated in SAES-T-629, Telecommunications Outside Plant - Copper Cable," the Saudi Aramco Construction Safety Manual (CSM) and all applicable safety practices.

5.2.5 Direct Buried Cable Engineering

5.2.5.1 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.

5.2.5.2 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

5.2.5.3 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.

5.2.5.4 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

5.2.5.5 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.

5.2.5.6 Marker Tape or Warning Tape

To reduce the chance of an accidental dig-up, marker/warning tape a minimum of 300 mm below grade but high enough above cables to allow detection before cables are damaged.

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.

5.2.5.7 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.

5.2.5.8 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.

Note: Refer to SAES-T-795 for appropriate protection requirements if the cable is subjected to severe exposure due to fault current or ground potential rise (GPR).

5.2.5.9 Minimum Cover Requirements

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

1. 1,200 mm, when placed with no additional protection.
2. 760 mm to 1,200 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.

5.2.5.10 Cable Quantities

When ordering fiber optic cables, include:

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

5.2.6 Aerial Cable Engineering

5.2.6.1 Aerial Cable Limitations

Aerial fiber optic cables shall not be placed, unless approved through a waiver. Refer to BICSI OSPDRM and BICSI TDMM before designing an aerial fiber optic installation.

5.2.6.2 Support Strand or Messenger

Refer to BICSI OSPDRM for support strand sizing.

5.2.6.3 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 through a waiver.

5.2.6.4 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) 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.

5.2.6.5 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

5.2.6.6 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.

5.2.6.7 Grounding Metallic Members in Aerial Cables

When a fiber optic cable containing metallic members, (as an exception stated in Section 5.1.6.3 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.

5.2.7 Splicing Fiber Optic Cables

Refer to SAES-T-632, for Splicing fiber optics cable requirements.

5.2.8 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 standard.

5.2.9 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 by IT Engineering Department. The design shall be included in the cable design package.
- Spare fiber strands shall not be used unless written permission is obtained from IT Engineering Department.
- 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 (2) fiber strands shall be reserved on fiber cables containing twenty four (24) fibers or less, and four (4) fiber strands on fiber cables containing more than forty eight (48) fibers and shall be provided.
- The spare fiber count shall be an even number.

5.3 Inter and Intra Building Consideration

This section describes the fiber optic cables for inter-building (campus) and intra-building (building distribution system - riser and plenum applications).

5.3.1 The following fiber cable (FOC) shall be either of the followings;

SINGLE-MODE OPTICAL FIBER (Dispersion-Shifted or Non-Zero Dispersion-Shifted) - (In accordance with applicable ITU-T-G.652 /ITU-T-G.653/ ITU-T-G.655)

Or

62.5 μm (core)/125 μm (cladding) MULTIMODE, GRADED-INDEX OPTICAL WAVEGUIDE FIBER (In accordance with applicable EIA/TIA-455 series)

Or

50 µm (core)/125 µm (cladding), MULTIMODE, GRADED-INDEX OPTICAL WAVEGUIDE FIBER (In accordance with the latest version of ITU-T G.651)

Commentary Note:

Per Saudi Aramco IT best practice, it is highly recommended to use:

- *Single Mode OS1 Fiber (ITU-T G.652.D) for Inter-building (campus) connectivity.*
- *OM3 (50µm) laser optimized fiber and/or Single Mode OS1 Fiber (ITU-T G.652.D for intra-building backbone.*

The optical fibers shall consist of a solid glass cylindrical core and cladding covered by Ultra Violet (UV) acrylate or equivalent coating.

All fiber optic cables installed as wiring within buildings shall be air core, Optical Fiber Non-conductive Plenum (OFNP) or Optical Fiber Non-conductive Riser (OFNR) type with or without non-metallic moisture barrier and shall be listed as being suitable for the purpose, listed as being resistant to spread of fire in accordance with the NEC Article 770 Section 770-26, installed in accordance with Section 770-110, and marked in accordance with Table 770-179.

Inter-building or entrance fiber optic cables shall be either air core or Polyethylene sheath filled cables with or without metallic moisture barrier. All filled cables and cables with metallic strength member or moisture barrier, shall be terminated and grounded in accordance with the NEC codes.

5.3.2 The following requirements shall be comply in accordance with the 18-SAMSS-625 as follows:

1. The multimode fiber cores shall have graded (parabolic) refractive index profiles with CORE DIAMETERS of 62.5 ± 3.0 micrometers.
2. The core non-circularity of fibers shall not exceed 6%.
3. The CLADDING DIAMETER of the glass fiber shall be 125.0 ± 2.0 micrometers.
4. The cladding diameter of the fiber shall be nominally concentric with the fiber core. The cladding concentricity error shall not exceed 6%.
5. The cladding non-circularity shall not exceed 2%.
6. The Numerical Aperture of the fiber shall be 0.275 ± 0.015 when measured.

7. The Attenuation of the fibers within the cable shall not exceed 4 dB/km at 850 nanometers and 1.5 dB/kilometer at 1,300 nanometers.
8. Attenuation discontinuities in the fiber's length shall not exceed 0.2 dB at 1,300 ± 20 nanometers when measured.
9. Measurement of the attenuation shall be conducted at the wavelength specified for application and must be expressed in dB/km.
10. The minimum Bandwidth of the fiber cable shall be 160 MHz-km @ 850 nanometers and 500 MHz-km @ 1,300 nanometers.
11. The optical fibers shall be coated with one or more plastic materials or compositions to preserve the intrinsic strength of the glass. The COATING DIAMETER shall be at least 250.0 ± 15.0 micrometers.
12. The coating concentricity error shall not exceed 16%.

5.3.3 Other Design Considerations

1. The following requirements shall comply in accordance with 18-SAMSS-625, as follows;
   a) The Micro bending attenuation of the fiber shall not exceed 0.30 dB when measured at 1,300 ± 20 nanometers.
   b) The individual fiber shall withstand tensile stress of minimum 0.35 gigapascal (50 kpsi) for approximately one second.
   c) The maximum force required to remove 25 mm of protective fiber coating shall not exceed 13 newton.
   d) The color designations for Fiber and Buffer Tube identification.
2. The outer cable jacket shall be marked at regular intervals (not to exceed 2 m) with the following information:
   a) As required by NEC Article-770 (Table-770-179).
   b) Name of Manufacturer
   c) Year of Manufacture
   d) Number of Fibers in the cable
   e) Sequentially numbered length markers in meters
3. Fiber optic cable connectors shall follow the requirements in SAES-T-916.

6 Installation

The installation of all Fiber Optic Cables for OSP (Outside Plant) and Inter/Intra-building applications covered by this standard shall comply with this standard, SAES-O-201 (Application of Security Directives), SAES-T-916 (Communications Building Cable), the Telecommunications Distribution Methods Manual (BICSI TDMM) of the Building Industry Consulting Service International (BICSI), the National Electrical Code (NEC).

7 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.

7.1 Acceptance Testing Requirements

Acceptance testing requirements for fiber optic cables shall comply the requirements stated in the table below, and five (5) basic tests for fiber optic cables as follows, see Table 1.

Table 1- Acceptance Testing Requirements

Test	Requirement
1) End-to-End Loss *(typically conducted after completion of installation and splicing, also before installation of terminal equipment's using OTDR).*	100% of fibers in both directions, and 100% of fiber splices and connections; (individual splice loss shall not exceed the following limits; The maximum attenuation of each fiber within a cable, when normalized to a length of 1 km: a) At wavelength = 1,300 nm, shall be 0.5 dB/km or less, and b) At wavelength = 1,550 nm, shall be 0.3 dB/km or less. c) Individual splice insertion loss 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 0.2 dB for mechanical splices; d) Connectors shall have insertion losses of 0.5 dB or less).
2) On-reel	Acceptance tests shall be performed on the cable to ensure materials quality prior to installation using OTDR.

Test	Requirement
3) Measuring Power (Power Meter Test)	This measurement is the basis for loss measurements as well as the power from a source or presented at a receiver.
4) Link Test *Commentary Note:* *This type of testing is applicable for long haul networks to ensure proper link performance and typically for back bone fiber.*	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) Chromatic Dispersion Coefficient *Commentary Note:* *This type of testing is applicable for long haul networks to ensure proper link performance and typically for back bone fiber.*	**Fiber Type** / **Wavelength Range (nm)** / **Maximum Chromatic Dispersion Coefficient [ps/(nm.km]** **Zero-Dispersion** 1288-1339 3.5 1271-1360 5.3 **Dispersion Shifted** 1525-1575 3.5 **Non-Zero Dispersion Shifted** 1530-1565 6.0
6) Polarization Mode Dispersion Coefficient *Commentary Note:* *This type of testing is applicable for long haul networks to ensure proper link performance. This typically apply to very high bite rates of 40 Gbit/s and above.*	PMD coefficient shall be below 0.5 ps/√km

7.2 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).

7.3 On-reel acceptance tests shall be performed on the cable to confirm the manufacturer's tests before the placing operation begins.

7.4 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.

7.5 After each fiber is tested in one direction (Office A to Office B or host-remote link), loss measurements shall be documented on the Optical Fiber Cable Acceptance Test Record (Exhibit 1). Upon test completion, transmitter and receiver shall be reversed, and test shall be repeated in the other direction (Office B to Office A or host-remote link).

Commentary Note:

The transmitter is located in Office B, the receiver is located in Office A.

7.6 Optical fiber cable acceptance test shall be recorded on the Optical Fiber Cable Acceptance Test Record (Exhibit 1) according to Table 2 instructions.

Table 2 – Optical Fiber Cable Acceptance Test Record Instructions

In Term	Specify
A	End-to-end test or Splice Loss Data
B	The assigned span number designation
C	The assigned cable/trunk number
D	The assigned cable count
E	The type of fiber, i.e., multimode or single mode
F	The designed wavelength, e.g., 1310 or 1550 nm
G	The calculated allowable loss
H	Central Office A
I	Central Office B
J	Fiber color, Buffer tube color

7.7 As-built Drawings

As-Built drawings shall be updated daily by field installation forces, also drawings and acceptance tests results shall be provided and/or submitted to Saudi Aramco IT Engineering Department and/or Area IT before Mechanical Completion Certificate (MCC).

7.8 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.

7.9 Design Variations

Copies of all approved design variations document shall ready be available to the any representative, i.e., Inspection Department, IT Engineering Dept.

Revision Summary

25 May 2014	Revised the Next Planned Update, reaffirmed the content of the document, and reissued as major revision.
3 August 2015	Editorial revision to paragraph 4.9, fifth (5^{th}) bullet.
18 October 2016	Major revision as part of Communications Standards Committee optimization initiative to be in alignment with international standards and its functionality. It also provides better clarification and understanding to the standard's users.
22 January 2018	Consolidation of SAES-T-634 to this standards, adding requirements address to testing of fiber optic cables.

Exhibit 1 – Optical Fiber Cable Acceptance Test Record

OPTICAL FIBER CABLE ACCEPTANCE TEST RECORDS Page _____ of _____

Area Location: _____ BI/ER #:_____ Date: _____

Check One Box: *(A)* ☐ A. End-to-End Fiber Test ☐ B. Splice Loss Data

SPAN NUMBER	CABLE NUMBER	CABLE COUNT
_____ *(B)*	_____ *(C)*	_____ *(D)*

FIBER TYPE:	WAVELENGTH (nm)	MAX. ALLOWABLE LOSS: (dB)
(E) ☐ A. Single Mode ☐ B. Multimode _____	_____ *(F)*	_____ *(G)*

A	OFFICE A	OPERATOR'S NAME	OFFICE B	OPERATOR'S NAME
	_____ *(H)*	_____	_____ *(I)*	_____

B	SPLICE LOCATION	TYPE TEST SET USED	DISTANCE TO SPLICE
	_____ TYPE OF TEST EQPT. USED _____	_____ TEST SET LOCATION _____	_____ TEST SET OPERATOR'S NAME: _____

FIBER NO.	COLOR (J)	FINAL MEASURED LOSS (dB)		CHROMATIC DISPERSION COEFFICIENT (CD) ps/(nm·km)		POLARIZATION MODE DISPERSION COEFFICIENT (PMD) ps/√km	FIBER NO.	COLOR (J)	FINAL MEASURED LOSS (dB)		CHROMATIC DISPERSION COEFFICIENT (CD) ps/(nm·km)		POLARIZATION MODE DISPERSION COEFFICIENT (PMD) ps/√km
	BUFFER	FIBER	A - B	B - A				BUFFER	FIBER	A - B	B - A		
1							19						
2							20						
3							21						
4							22						
5							23						
6							24						
7							25						
8							26						
9							27						
10							28						
11							29						
12							30						
13							31						
14							32						
15							33						
16							34						
17							35						
18							36						

Remarks:
_____
_____

This form to be completed by Fiber Test Operator at receiving location