Engineering Standard

SAES-T-629 14 May 2019

Telecommunications Outside Plant - Copper Cable

Document Responsibility: Communications Standards Committee

Contents

1 Scope

This standard covers the mandatory requirements governing the engineering, design, and installation of telecommunications outside plant (OSP) copper cables.

2 Conflicts and Deviations

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

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

3 References

The selection and design 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 References

Saudi Aramco Engineering Procedure

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

Saudi Aramco Engineering Standards

SAES-T-018	*Telecommunications - Symbols, Abbreviations, and Definitions*
SAES-T-632	*Telecommunications: Splicing Copper Cables, Fiber Optic Cables and Types of Splice Closure*
SAES-T-795	*Grounding Systems for Communications Facilities*
SAES-T-911	*Communication Conduit System Design*
SAES-T-916	*Telecommunications Building Cable Systems*
SAES-T-920	*Telecommunications - Cable Information*
SAES-T-928	*Telecommunications - OSP Buried Cable*

Saudi Aramco Standard Drawings

AA-036748	*Buried Telephone Cables/Distribution Wires - Installation Details*

AB-036897	*Buried/Underground Cable Route Marker Post and Signs*

Saudi Aramco General Instructions

GI-0002.100	*Work Permits*
GI-0002.709	*Gas Testing Procedure - Using Gas Monitor*
GI-1021.000	*Street and Road Closure: Excavations, Reinstatements, and Traffic Controls*

Safety Management System (SMS)

Saudi Aramco Construction Safety Manual

3.2 Industry Codes and Standards

Building Industry Consulting Services International

BICSI	*Building Industry Consulting Services International, TDMM (Telecommunications Distribution Methods Manual)*
BICSI	*Outside Plant (OSP) Design Reference Manual (OSP DRM)*

National Fire Protection Agency

NFPA 70	*National Electrical Code (NEC)*

International Electrotechnical Commission

IEC-60708	*Low-Frequency Cables with Polyolefin Insulation and Moisture Barrier Polyolefin Sheath*

Underwriters Laboratories, Inc.

UL 1479	*Standard for Safety Fire Tests of Through-Penetration Firestops*
UL 94	*UL Standard for Safety Test for Flammability of Plastic Materials for Parts in Devices and Appliances Fifth Edition*

4 Definitions and Terms

AML: Actual Measured Loss at 1,004 Hz. The measured value of transmission loss, expressed in decibels that include any impairment caused from attenuation, noise and bandwidth restrictions. The actual value is then compared to an objective or calculated value.

Balance: The amount of cancellation of current flowing along tip and ring conductors. Currents that are not cancelled are heard by the subscriber as noise metallic. Balance is in dB and can be calculated by:

Balance = (Noise-to-Ground + 40) - Noise Metallic

or

Balance = Power influence - Circuit Noise

BOC: Build Out Capacitance. This passive device is a capacitor that is bridged between the two conductors of a cable pair and is used to simulate the capacitance of a missing length of cable.

Cable Shield: A metallic layer located under the outer covering of a cable that protects the cable pair. It can be composed of woven, braided, foil wrap, or metal tube that, when bonded and grounded, prevents electromagnetic/electrostatic interference from being induced into the inner wire conductor.

Continuity: The continuity test determines if the tip and ring conductors are continuous.

Polarization Mode Dispersion (PMD): Polarization mode dispersion is a form of modal dispersion where two different polarizations of light in a waveguide, which normally travel at the same speed, travel at different speeds due to random imperfections and asymmetries, causing random spreading of optical pulses. Unless it is compensated, which is difficult, this ultimately limits the rate at which data can be transmitted over a fiber.

dBm: dB reference to the milliwatt. dBm is the amount of power relative to that represented by a 1,004 Hz signal which will feed one milliwatt of power into a 600 ohm resistive load.

dBrn: A value of decibels above reference noise that begins at a “O” level dBrn - 90 dB. The measured value describes that power level of a noise as seen through a line weighting network of the test set.

dBrnC: dBrn with C message weighting. dBrnC is measure of the interfering effect of noise expressed as the dB above reference noise of -90 dBm at 1,004 Hz.

EML: Expected Measured Loss - The EML is the 1,004 Hz loss that is expected to be measured between specified test points.

Ground: A conducting connection, whether intentional or accidental, between an electrical circuit or equipment and the earth, or to some conducting body that serves in place of the earth.

Hz: Hertz, unit of frequency: on cycle per second.

Insertion Loss: The transmission loss caused by inserting a component or network in a circuit. The ratio of power received at a load before insertion to that received at a load after insertion, expressed in decibels.

Insulation Resistance: The insulation resistance test is taken to ensure that the value of resistance each conductor has to all other conductors in a cable and to the cable shield is a minimum of 1,000 megohm-miles.

Loaded Loop: A loop into which lumped inductance (loading coil) is introduced at fixed intervals to compensate for the distributed cable capacitance. The addition of loading coils properly placed, reduces mid-voice band loss, and flattens the frequency response over most of the voice band, but creates a sharp cut-off at the high-frequency band edge.

Loop Resistance: The actual DC resistance of the circuit.

Noise Metallic (Differential Noise): The noise measured across the tip and ring of a circuit; the noise the subscriber hears.

Noise-to-Ground (Common Mode Noise): A measure of the power influence on the cable conductors whose magnitude is a function of the power line current and voltage present at particular harmonic frequencies. Although the subscriber cannot hear noise-to-ground, its magnitude determines the level of noise metallic that is heard.

Noise to Ground = Power Influence - 40 dB.

PCM: Pulse Code Modulation

POTS: Plain Old Telephone Service

Power Influence: The characteristics of power circuits and associated apparatus that determine the character and intensity of the fields they produce.

Resistance Unbalance: A measurement of the equality of the dc resistance of the tip-to-ground versus the ring-to-ground with the pair grounded at the far end.

Shield Continuity: Verifies the cable shield continuity for the entire length of cables being tested.

5 General Requirements

5.1 OSP Design Reference

The BICSI Outside Plant (OSP) Design Reference Manual (current version) is hereby recognized as the referenced detailed design information. Design drawings shall use conventional symbols as specified in *SAES-T-018* Telecommunications – Symbols, Abbreviations, and Definitions.

5.2 OSP Designer Certification Requirements

All OSP telecommunications system designs by non-Aramco design offices (such as GES Contractor, LSTK, etc.) must be done under the design authority of a valid BICSI Registered Communications Distribution Design (BICSI RCDD and/or OSP Specialty) 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).

5.3 Design Documentation

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

1. Copper cable data:
   a) Cable manufacturer
   b) Vendor number
   c) Cable size (number of pairs)
   d) Cable type (filled or air core)
   e) Cable design (single jacket, inner/ outer jackets, aluminum shield, solid insulation, foam skin insulation, steel armor, etc.)
   f) Pairs wire gauge
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) Cable splice points with station location
   g) Splice-to-splice cable lengths
   h) The meter markings on the engineering design construction drawings
   i) Changes in cable route

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

k) Location of marker posts and signs.

5.4 Design Drawings Classification

All copper cable 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 copper cable, terminating equipment and other equipment associated with the fiber cable. It shall also include address or location of the cable route and 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) Cable shall be properly identified using applicable Saudi Aramco copper cable designation symbols as specified in SAES-T-018.

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

   e) All cable related functions such as splicing symbol and sequence, 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 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.

5.5 Cable Route

The cable route for all new cables shall be as follows;

1. Underground (in conduit)
2. Buried (direct burial, i.e., not in conduit)
3. Aerial construction shall only be approved through a waiver and complying with BICSI OSPDRM.

All buried and underground cable routes shall be marked in accordance with Saudi Aramco Standard Drawing AB-036897, Buried/Underground Cable Route Marker Posts & Signs, and Standard Drawing AA-036748.

5.6 Cable Characteristics

All Saudi Aramco copper cables for underground or direct buried installation shall be of filled core type. Cable material shall comply with SAES-T-920 and IEC-60708 specification.

5.7 Metallic Armor Use

Copper cables may include a metallic armor if required for direct buried applications but it is optional.

5.8 Composite Cable Use

Outside plant composite cable shall not be used.

5.9 Pulling Tension

The pulling tension on copper cables shall not exceed the approved tension by the cable manufacturer. When 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.

5.10 Cable Environment

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

6 Design

6.1 Cable Design

Copper OSP cable shall be sized (number of pairs in the cable) to meet the maximum expected requirements. Conductor gauge shall be specified based on the calculation of user loop requirements and cable limiting characteristics such as resistance, capacitance, and attenuation of the specified cable.

6.2 Underground Cable Engineering

6.2.1 This section prescribes the engineering and design of telecommunications copper cables for plant facilities to be installed in telecommunications conduit system. It is assumed that the conduit system is complete and has been designed, constructed, and tested in accordance with SAES-T-911.

6.2.2 Installation Rodding Ducts and Placing Pull Line (Rope) Underground Cable

All Fish line Ropes which are placed for future use shall be of non-biodegradable materials.

6.2.2.1 Placing a Pull Line or Cable

6.2.2.1.1 In all cases, where cable is to be placed in main conduit, thoroughly clean the ducts before the pull line or cable is placed.

6.2.2.1.2 Service laterals, which are old or which are suspected of being cluttered with sand or debris, must be thoroughly cleaned before cable is placed.

6.2.2.2 Mandrel Testing

Existing Conduits shall be tested in both directions with an appropriate size mandrel prior to placing an underground cable. Mandrels to be used for standard four inch (inside diameter) PVC conduits are as follows:

1. Where the proposed cable will be 69 mm or smaller, the duct must pass a standard 3 inch diameter mandrel (12" long x 3" diameter).

2. Where the proposed cable will be larger than 69 mm, the duct must pass a standard D mandrel (12" long x 3 - 5/8" diameter).

3. Conduits that fail the standard D mandrel (12" long x 3 - 5/8 " diameter) test may be suitable for subduct installations provided that:

   - The conduit pass a standard 3 inch diameter mandrel (12" long x 3" diameter) test

   - There are no difficulties during the subject installation due to narrow clearances or misaligned joints.

6.2.3 Underground Cable and Sealing Conduit - Installation and Removal

6.2.3.1 Overview

6.2.3.1.1 Conduit plugs in underground conduit protect the interiors of cable vaults (and other environments) by sealing them, preventing the unwanted entry of gases and foreign materials, water and moisture, rodents and insects.

There are two basic kinds of conduit plugs which are blank conduit plugs and split conduit plugs.

All conduits which enter maintenance hole, central office buildings, cable vaults and other buildings or enclosed areas shall be sealed with appropriate plugs or sealants.

All conduit ends (including road crossings, pole risers, between pedestals and/or cabinets) shall be plugged or sealed to prevent sand or debris from entering the duct.

6.2.3.1.2 All conduits entering central offices, cable vaults, or other buildings must be sealed at all times (except when work is in progress).

Commentary Note:

Whenever work extends overnight, a plug must be

installed into the conduit until work resumes.

All conduits entering maintenance hole shall be plugged or sealed.

All existing duct plugs that are not properly sealed constitute a potential safety hazard. When work is done in existing maintenance hole or buildings, all conduit seals and plugs shall be inspected and brought up to the current Saudi Aramco Engineering Requirements.

Commentary Note:

The intent of this standard is to insure that the maintenance hole and conduit system seals are maintained and safety hazards are highlighted and corrected. When an existing maintenance hole and conduit system is found to have seals damaged or missing, a report identifying each seal (maintenance hole no. and duct no., location) is to be issued promptly to the responsible maintenance and Operations agency so that immediate action can be taken to make repairs of these seals. The exception to this is when a project job order specifically calls for the repair of damaged seals in the scope of work and construction drawing.

6.2.3.1.3 After completing work in cable vaults, buildings and maintenance hole, re-examine all conduit seals and secure or replace those which have been weakened as a result of cable movement, or have otherwise become defective because of construction work.

6.2.3.1.4 Refer to below Table 1 to determine which type of conduit plug is appropriate to use under specific conditions.

Table 1 - Conduit Plug Types Guidelines

Condition	Seal With
Conduits entering Central Office (CO) cable vaults, Controlled Environmental Vaults (CEvs), and other buildings.	• Blank conduit plugs for unoccupied vacant conduits. • Simplex conduit plugs for sealing a single copper cable or fiber optic cable. • Triplex or Quadplex plugs for sealing multiple cables or innerducts within a conduit.
Conduits for drop wire and small entrance cables to buildings at maintenance hole (if it is impractical to seal the conduit in the building).	Split conduit plugs, simplex, triplex, or quadplex.
Ducts containing cable or innerduct that are terminated on poles or building walls.	Split conduit plugs.
Ducts terminating on poles or building walls mat are for unoccupied riser conduit.	Blank duct plugs with Hex nuts.
• Conduits entering or leaving maintenance hole. OR • Pull boxes whim contain electrical apparatus *such* as Pulse Code Modulation (PCM) carrier housings, etc.	• Split conduit plugs for conduit containing cable. • Blank plugs for unoccupied duct/innerduct, etc.
Conduit not connected to conduit system, such as: • Steel pipe clips under structures. • Submarine pipe crossings. • Between poles to buildings. • And similar construction.	• Split conduit plugs at both ends for occupied ducts with cable or innerduct. • Blank plugs at both ends for unoccupied ducts.

NOTE: Conduit plugs may be wed to seal riser conduit or other openings between cable vaults or other building areas. Cable plugs help support cables as the cables transit vertically between floors or horizontally between walk.

6.2.3.2 Conduit Plugs

6.2.3.2.1 All dirt, grease, and loosely adhering materials must be removed from the conduit and the plug before installing duct plugs.

6.2.3.2.2 Addition - Rubber conduit plugs and PR-851 Sealing Compound are not fire retardant and must not be used to seal cable riser or other openings between cable vaults and switch rooms or in other building areas except at the conduit building entrance.

6.2.3.2.3 Rubber duct plugs are not acceptable for sealing conduits that pass through classified or hazardous areas [Refer to (NFPA 70) NEC Articles 500 & 501].

6.2.3.2.4 Two part polyurethane duct sealant shall be used to seal conduit that passing through the classified or hazardous areas to prevent gases and other liquids from emerging out of the telecommunication conduit system and entering a maintenance hole or telecommunications facilities, also it must be listed as UL 94.

6.2.3.2.5 UL Classified Firestop Sealant, Fire Barrier Caulk, and Putty or equivalent are acceptable as fire retardant sealants for use inside the buildings. All fire sealants used inside building (except at the building conduit entrance from the outside) must be listed as complying with UL 1479.

6.2.4 Cable Underground Conduit Sealing Compound Types

The two part polyurethane duct sealant or a duct sealing compound type with UL listed (or equivalent) is acceptable in an underground conduit duct sealant. The is used to seal all ducts in a maintenance hole, handhole or pedestal and it shall also be used around cable in existing ducts, preventing gasses, water, and other foreign substances from entering:

- Cable vaults
- Buildings
- Maintenance hole, Handholes
- Pedestals/Cross Connect Cabinets
- Pull Boxes

6.2.5 Cable Underground Installation Precautions

This section provides safety precautions, which must be taken when working in underground maintenance hole for unvented cable vaults.

6.2.5.1 Protection of Maintenance Hole

6.2.5.1.1 Always protect open maintenance hole with standard manhole guards and warning devices such as those outlined in Saudi Aramco Construction

Safety Manual, the Construction Safety Manual, Roadworks Section II Part 8.1.8 and *GI-1021.000*.

6.2.5.1.2 Adequate protection must be placed around pulling lines and/or cable to protect the public and workers from bodily injury.

6.2.5.2 Testing for Combustible Gas in Maintenance Holes or Unvented Cable Vaults

6.2.5.2.1 Every maintenance hole or unvented cable vault to be opened or reopened after having been closed for any period of time shall be tested for combustible and toxic gas in accordance with Section 6.2.7 below. No maintenance hole or unvented cable vault shall be entered until the test indicates a 0% level.

6.2.5.2.2 If a dangerous amount of combustible or toxic gas is detected in maintenance hole or unvented cable vaults, the condition must be reported to the supervisor. The requirements of GI-0002.100, Work Permits must be followed.

6.2.5.2.3 Before entering maintenance hole, tests shall be made for detection of hazardous gases using the appropriate gas testing equipment as outlined in GI-0002.709, Gas Testing Procedures, and Saudi Aramco Construction Safety Manual.

6.2.5.3 Protection of Cables

Care shall be taken to prevent damage to existing cables in maintenance hole when setting up the pulling apparatus or placing tools of any kind. Do not step on cables or rack hooks when entering or leaving a maintenance hole; always use an approved ladder.

6.2.5.4 Open Flames and Arc Producing Devices

It is strictly prohibited to take matches, lighters, storage batteries or any items capable of producing a spark or flame (other than approved items or tools) into a maintenance hole, or to use torches, lanterns, lighted cigars, cigarettes, pipes, furnaces, or other types of open flame within 3 meters of an

open maintenance hole even though tests indicate the absence of gas. Refer to GI-0002.100, Work Permit Procedures.

6.2.5.5 Warning Devices on Cable Reels

Cable reels and equipment which must be left on the street overnight shall be properly lighted during the night. Approved warning devices shall be used as covered in paragraph 6.2.5.1.1 above.

6.2.6 Underground Cable Open Flames in Maintenance hole Procedures

6.2.6.1 This section provides instructions and safety precautions when using flames in maintenance hole.

6.2.6.2 These instructions are not applicable in locations where Saudi Aramco/Loss Prevention regulations prohibit the use of open flames in maintenance hole. Also, refer to Section 6.2.5.4 above.

6.2.6.3 Open Flames

6.2.6.3.1 The use of any item capable of producing a "hot spark" or flame in or around a maintenance hole is prohibited. Exceptions must be handled in accordance with GI-0002.100, Work Permits.

6.2.6.3.2 Hard hats, safety shoes, and approved eye protection must be worn by all persons working in the maintenance hole.

Reference: Construction Safety Manual I Administration Attachment I.9

6.2.7 Underground Maintenance Hole and Cable Vaults Testing and Ventilating Procedures

This section describes procedures for testing for the presence of combustible and toxic gas in manholes, unvented cable vaults, and buildings that have underground cable entrances and continuous manhole ventilation by means of power blowers.

6.2.7.1 Overview

6.2.7.1.1 The most common contaminants found in manholes include:

a) Vapors or gases which have escaped from underground storage or piping of liquids or gases such as gasoline, natural gas, liquefied petroleum gas, propane, and butane.

b) Gases from fermentation of naturally occurring organic matter such as methane, carbon dioxide, and hydrogen sulfide.

c) Gases created as by-product of combustion (from vehicles or equipment) such as carbon dioxide and carbon monoxide.

6.2.7.1.2 Pre-entry combustible gas tests are made to ensure that there is no risk of explosion while, or immediately after, removing a maintenance hole cover. Continuous forced ventilation ensures a continuing adequate oxygen supply and prevents possible buildup of combustible or toxic gases or vapors. Periodic combustible gas tests provide an additional margin of safety that ensures that no combustible gas is building up in the maintenance hole.

Refer to Work Permit Systems in GI-0002.100, and Gas Testing Procedures in GI-0002.709.

6.2.7.2 Safety Precautions

6.2.7.2.1 Prior to pre-entry tests, place warning devices, such as traffic cones, men-working signs, flags, and maintenance hole guards, at the maintenance hole. The work area protection setup operation shall be done with promptness to minimize exposure of personnel to traffic. (See Saudi Aramco Construction Safety Manual and GI-1021.000).

6.2.7.2.2 A maintenance hole cover shall not be removed until the maintenance hole has been tested (pre-entry) for combustible gases directly beneath the cover.

6.2.7.2.3 Maintenance hole shall not be entered until they have been thoroughly tested and proven safe for entry in accordance with GI-0002.709, and

ventilated with fresh air from a maintenance hole blower for a minimum purge time (see Table 2).

All electrical switching connections and disconnections must be made outside a maintenance hole, at least 3 meters from the maintenance hole opening.

6.2.7.3 Testing and Ventilating Maintenance hole

6.2.7.3.1 Combustible gas tests must be made by using one of the appropriate combustible gas detectors outlined in GI-0002.709 and Saudi Aramco Construction Safety Manual.

6.2.7.3.2 Using Combustible Gas Detector - Lower the sampling hose approximately 150 mm through a hole in the maintenance hole. Make the first pre-entry test. If there are no holes in the maintenance hole cover: Open the cover approximately 75 mm. Make the first pre-entry test. If maintenance hole or confined space entry has been proven to be safe per tests in accordance with GI-0002.709, perform the following:

a) Prior to entry, purge the maintenance hole with power blower having a minimum output capacity of 14.1 cubic meters per minute for the period of time shown on the maintenance hole ventilation chart (Table 2) prior to entry. Minimum ventilation time in all situations must not be less than 5 minutes.

Commentary Note:

Prior to placing output hose of a power blower into a maintenance hole, purge the hose by directing a flow of air through it at street level and away from the open maintenance hole. To minimize the intake of exhaust fumes from passing vehicles, the blower intake should be positioned away from the flow of traffic.

b) Subsequent tests for combustible gas must be made in accordance with GI-0002.709 or at least every 2 hours whichever is shorter. When a tent

is used over the maintenance hole, subsequent tests must be made at least every hour.

6.2.7.3.3 When plugged Cable Ducts are opened, additional tests for combustible gas must be made near the ducts to verify that combustible gas is not entering the maintenance hole.

6.2.7.3.4 Ventilation Set Up

Continuous forced-draft ventilation with a minimum of 14.1 cubic meters per minute must continue as long as the maintenance hole is open.

WARNING:

If the blower stops, the maintenance hole shall be vacated at once and the blower hose shall be removed from the maintenance hole. When the blower is reactivated, the blower hose shall be purged, prior to placing it back into the maintenance hole.

6.2.7.3.5 Upon entering the maintenance hole, arrange the outlet end of the blower hose on the cable rack to direct the flow of air horizontally, midway between the maintenance hole floor and roof toward an end wall and away from the work area if possible.

Table 2 – Maintenance Hole (MH) Ventilation Chart

Effective Blower Capacity Cubic Feet (Meter) Per Minute							
MH Volume							
Cubic Feet		**500**	**600**	**700**	**800**	**900**	**1,000**
(Cubic Meter)		**(14.1)**	**(17.0)**	**(19.8)**	**(22.6)**	**(25.5)**	**(28.3)**
100	(2.8)	5	5	5	5	5	5
200	(5.7)	5	5	5	5	5	5
300	(8.5)	5	5	5	5	5	5
400	(11.5)	6	5	5	5	5	5
500	(11.5)	8	7	6	5	5	5
600	(14.1)	10	8	7	6	5	5
700	(19.8)	11	9	8	7	6	5
800	(22.6)	13	10	9	8	7	6
900	(25.5)	14	11	10	9	8	7
1,000	(28.3)	15	12	11	10	9	8

6.2.7.3.6 Testing and Ventilating Cable Vaults and Unattended Telephone Equipment Buildings for Gas

Cable vaults, which do not have natural or mechanical ventilation and unattended building with an underground cable entrance must also be proven safe prior to entry or beginning work operation, in accordance with GI-0002.709.

If gas is detected, notify Supervisor and Fire Department.

6.2.8 Cable Underground Placing in Main Conduit

This section outlines the procedures for placing cables in conduits between maintenance hole.

6.2.8.1 Loading Cable Reel

In most instances, the cable reel should be loaded so that the cable may be fed from the top of it. In every instance caution must be exercised so that reverse cable bending is not encountered when placing the cable in the underground conduit system.

6.2.8.2 Positioning Equipment at the Job

Whenever possible, locate the trailer on the side of the maintenance hole nearest the conduit section in which the cable is to be placed. Position the trailer so the cable is fed from the top of the reel, in a long arc, into the cable feeder and duct.

WARNING:

Whenever a cable trailer is released from a truck, the prescribed safety chain shall be left attached to the truck and the trailer until the tongue of the trailer is placed on the ground. The truck shall be located so that exhaust fumes will not enter the maintenance hole.

Always use safety blocks under the trailer's wheels when it is detached from the truck.

Whenever it is necessary to place trailers on sidewalks or other areas not capable of supporting them, place planking under the trailer wheels and tongue to prevent surface damage.

6.2.8.3 Placing the Cable

6.2.8.3.1 Generously lubricate the first 20 feet of cable to reduce initial duct friction. The amount of the lubricant required during the remainder of the pull should be determined by the conditions being encountered. Bends, long pulls, pulling through maintenance hole, etc., may require more lubricant. Only lubricants specifically approved by Saudi Aramco may be used.

6.2.8.3.2 Pull cable slowly until at least two feet of it has entered the duct. This may be determined by measuring the distance from the duct face to the top of the cable feeder, plus two feet. An equal distance should then be measured from the end of the cable and marked with vinyl tape. When the tape marking reaches the funnel of the cable feeder, the required two feet of cable are in the duct. From this point, the cable may be pulled, steadily and continuously, at the rate of 80 to 100 feet per minute.

6.2.8.3.3 When the cable has been pulled to within 6 meters of the maintenance hole, as determined by the quantity of cable remaining on the reel, the pulling speed should be reduced. Continue pulling the cable at the reduced speed until the swivel link is 150 mm from the sheave located in the maintenance hole.

6.2.8.3.4 If it is necessary to stop cable between maintenance hole, because of reel trouble or other reasons, the tension on the winch line should be maintained unless the operator is asked to release the line tension. When continuing the pull, the speed must be increased gradually until the cable moves freely.

6.2.8.3.5 An approved luffing grip must be used to pull the additional specified quantity of cable into the maintenance hole.

WARNING:

Workmen shall not remain in the manhole during the luffing operation pulls unless so directed by the supervisor.

6.2.8.3.6 The cable ends in the maintenance hole shall be cleaned and placed on maintenance hole hooks or tied to the racks with lashing wire.

Commentary Note:

Avoid unnecessary bending of the cables in attaching them to cable hooks or racks. All cable bend radii shall be 10 times the cable diameter or greater.

6.2.9 Cable Guards - at Riser Poles and Buildings Installation

This section provides instructions for:

- Placing guards at riser poles and buildings.
- Clamping cable to riser poles.

6.2.9.1 Placing U-Cable Guard

6.2.9.1.1 Install U-Cable guards to protect cables which are leaving underground conduit systems or direct-buried at poles and buildings.

If installation is Required	Then install a(n)
Immediately above a conduit	2.50 meter (8') Guard.
In sites without a conduit	2.74 meter (9') Guard (One foot must be buried below the ground).

6.2.9.1.2 A minimum of two U-cable guard straps shall be placed on each U-cable guard. One strap shall be located 150 mm below the top of the U-cable guard and one 150 mm above the earth surface or the end of the conduit pipe bend. The cable shall be clamped to the pole or building at 600 mm intervals with the first clamp being placed 125 mm above the top of the U-cable guard.

6.2.10 Placing Underground Cable in Subsidiary Conduit

This practice covers the placing of cable in subsidiary conduit, that is, from a maintenance hole to a pole for building or between poles in an isolated dip.

6.2.10.1 Setting-up Equipment

6.2.10.1.1 When cable is to be placed in a duct which extends from a maintenance hole to a pole or to a building wall, it is preferable to set up the cable reel at the end of the duct nearest the bend so that the cable can be fed from the reel into the duct in a long smooth arc.

6.2.10.1.2 Cable can usually be placed in subsidiary ducts with only one 90 bend and less than 46 meters in length, without the use of lubricant. If the duct length exceeds 46 meters or if it contains the equivalent of more than one 90 degree bend, use an approved cable lubricant.

6.2.10.1.3 Leave sufficient cable at each end of the duct to permit setting up and splicing. Secure the cable to the pole, up to the strand level, with cable straps, leaving sufficient cable at the strand level to make the splice. If a short piece of fuse cable is to be placed at the pole, it is only necessary to leave enough cable to reach to the strand level, since the first splice out of the underground will be made a minimum of 600 mm below the strand level.

6.2.11 Splicing Arrangements in Maintenance holes

This section outlines splicing arrangement in maintenance hole.

6.2.11.1 Installation Principles

When racking cables in maintenance hole:

- Changes in cable level must be kept to a minimum.
- It shall be carefully determined that racking of a given cable in the proposed manner will not block or restrict the use of any vacant duct or racking position.
- When bending cables, make the radius of the bend as large as possible. The radius of the bend must be a minimum of 10 times the diameter of the cable.

6.2.11.2 Racking Space

6.2.11.2.1 A minimum space of 385 mm shall be maintained

in all maintenance hole between the roof of the maintenance hole and the center of the top main cable for racking stub and lateral cables.

6.2.11.2.2 A minimum space of 385 mm shall be maintained between the maintenance hole floor and the center of the bottom main cable.

6.2.11.2.3 The vertical spacing of splices shown in Table 3 should be observed where either single or double racking is employed.

Table 3 - Vertical Spacing of Splices

Staggered Splices	195 mm
Non-staggered Splices	230 mm

6.2.11.2.4 Hook hole positions in all maintenance hole number from the top of the cable rack down (refer to SAES-T-911).

6.2.11.3 Staggered Splices

Staggered splices are employed in those maintenance hole where there are a large number of entering ducts and the length of the maintenance hole is sufficient to place three racks.

6.2.11.4 Double Racking

Double racking is primarily used where a four-wide duct structure enters the maintenance hole.

6.2.11.5 Ducts Entering at Different Levels

Where the main conduit structures enter the maintenance hole different levels, the cable racks, and cables should be so arranged that an equal amount of the required bending will be done at each end.

6.2.11.6 Difference in Number of Ducts

When two main conduit structures having different numbers of ducts enter a maintenance hole, the racking positions in the maintenance hole must be based on the structure with the largest number of ducts.

6.2.11.7 Cable Hooks

The cable and the completed splice shall be supported with cable hooks at each cable rack.

6.2.11.8 Splice Closure

Where distance between cable racks is such that it appears that sagging might occur, the splice should be secured to a piece of pipe or other support material laid across the cable hooks. Secure the closure tightly to the pipe with lashed cable supports.

6.2.12 Cable Underground Removal

This section outlines procedures for removal of underground cable.

6.2.12.1 Cutting Cables

Underground cable that is to be removed will generally be cut out of service by the Saudi Aramco telecommunications proponent splicing forces. However, in certain cases, such as where several consecutive sections are involved, the PMT forces may be called upon to cut the cable in the intermediate maintenance hole. In these cases, the cable must be carefully identified before cutting, to ensure that a working cable is not cut.

6.2.12.2 Precautions

6.2.12.2.1 Before starting any pulling operations, the work area must be guarded with the appropriate warning devices as outlined in Saudi Aramco Construction Safety Manual. Testing of maintenance hole atmosphere must also be done prior to entering the maintenance hole (see Section 6.2.7 above).

6.2.12.2.2 A cable which has been in a duct for some time may require considerably more force to break loose than will be required to keep it in motion. Because of the severe strains which may be placed in the winch line, no workman will be permitted in the maintenance hole when the initial pull is made or at any other time when the winch appears to be heavily loaded.

6.2.12.2.3 When the cable removing apparatus has been set up and the grip has been placed on the cable, a slight tension should be pulled in the line to determine whether the grip will remain in place. Before full tension is applied, the workmen must leave the maintenance hole. He should be in the maintenance hole during the puling operation only if it is essential to the performance of the work and it is apparent that the tension in the winch line is normal. If the cable pulls in a succession of sharp jerks, there is a possibility of the line breaking, and no workman should be in the maintenance hole.

6.2.12.2.4 When a workman is in a maintenance hole, he must be the originator of the starting and stopping signals.

6.2.12.3 Removing Subsidiary Cable

Subsidiary cable should generally be removed at the maintenance hole end to reduce the strain on the riser bend.

6.2.13 Bonded ASP Cable Installation Underground Placing/Splicing

This section provides Outside Plant Engineering placing and splicing procedures unique to bonded ASP cable.

6.2.13.1 Bonded ASP (Aluminum Steel Polyethylene) cable consists of:

A core of dual expanded plastic insulated conductors (foam skin) which are color-coded, arranged in twisted pairs and binder groups.

- A plastic core wrap.
- A corrugated aluminum shield.
- A corrugated steel tape wrap.
- An outer polyethylene jacket bonded to the steel.

The core is filled with ETPR (Extended Thermal Plastic Rubber) 80 degrees centigrade compound.

6.2.13.2 Engineering Considerations

Bonded ASP cable should be the first choice for copper cable placement in underground conduit in the following situations:

New underground cable routes originating at the central office. Extensions of existing underground cable routes, including site laterals.

Bonded ASP cable offers the following advantages:

- Can be direct-buried.
- Not restricted in application.
- Can be spliced above ground in pedestals, cross-connect boxes, etc. Placed on riser poles.

6.2.13.3 Placing Considerations

During installation and splicing Operations of bonded ASP cables, bends with radii less than 10 times the cable diameter shall be avoided.

6.3 Direct Buried Cable Engineering

6.3.1 Direct buried telecommunication cables shall be placed at minimum depths in accordance with SAES-T-928.

6.3.2 Buried cable crossings of streets, roads, and highways shall comply with SAES-T-928.

6.3.3 Road and railroad crossings shall be constructed in accordance with SAES-T-911, SAES-T-928, and in accordance with any Government requirements when Government roads are involved.

6.3.4 Telecommunication cables which are placed in the vicinity of power facilities shall be installed in accordance with SAES-T-928.

6.3.5 Joint Buried Cable

6.3.5.1 The "Random Separation" joint trench method shall not be used in Saudi Aramco for joint trench construction with power facilities. Joint buried construction with power facilities requires fixed separation as indicated above and in SAES-T-928.

6.3.5.2 Joint pedestals for power and telecommunication cables shall not be used. Telecommunication terminal housings/pedestals located within 3 m (10') of power apparatus (transformer / pedestals, etc.), or vertical pole grounds (MGN) shall have their grounding systems bonded together. Refer to SAES-T-795.

6.3.5.3 All excavations and restorations shall be carried out in

accordance with the Saudi Aramco "Safety Management System (SMS)."

6.3.5.4 Electrical protection requirements shall be installed in accordance with SAES-T-795.

6.3.6 Optimized Direct Buried Cable Delivery System

This section is intended, primarily, as a guide to be used when ordering or purchasing cable plowing equipment; however, the following are mandatory requirements when telecommunication cables are to placed by the plowing-in method:

6.3.6.1 The diameter of the cable plow chute used shall provide a minimum clearance of 15% of the cable diameter on all sides of the cable being placed.

6.3.6.2 The minimum cable bending radius is ten times the cable diameter. A cable bending radius of less than ten times the cable diameter shall not be permitted in any part of the cable handling or placing operation. Therefore, the radius at the bottom of the cable plow chute shall be equal to or greater than ten times the cable diameter that is being placed. The arc of the radius of the cable chute used shall be extended so that the cable leaves the cable chute at a tangent to the arc.

6.3.6.3 To ease the tension placed on the cable as it is pulled off the reel during installation, the cable reel carrier shall be equipped with cam roller type bearings on which the spindle bar will be mounted.

6.3.6.4 When directed by Communications Engineering or by the Project Engineer, a cable shield fault alarm shall be used, during the plowing operation, to detect cable sheath damage. Use of a cable shield fault alarm should be considered when plowing cables in rough terrain (such as rocky areas) where there is concern of possible cable puncture or damage. All damaged cables shall be repaired or replaced.

6.3.6.5 The cable shall be supported or guided from the cable reel to the cable plow chute. Vendor approved cable plowing mechanism/equipment/ accessories shall be used.

6.3.6.6 The cable shall be positioned in such a way, during installation, that it will not come in close contact with extreme heat such as from a tractor's engine or exhaust pipe.

6.3.7 Buried Cable Signs - Description and Installation

Saudi Aramco Drawing AB-03689-001, "Buried/Underground Cable Route Marker Post and Signs", provides typical installation information. Marker post/sign locations shall be shown on the construction drawings. Marker/Identification tape shall be placed in accordance with SAES-T-928.

6.3.8 Joint Buried Cable - Maintenance/Emergency Safety Precautions

Existing communications facilities shall always be exposed by hand digging. Hand digging tools utilized shall have handles made of wood or other material having comparable insulating value. If power cables are to be exposed, Proponent should be on site prior to or during the excavation to advice as appropriate. Insulated rubber gloves, suitably certified, shall be worn while digging and while examining the markings and outside structure of the cables during the visual inspection of excavated cables.

6.3.8.1 After identifying the proper telecommunication cable and before breaking the cable metallic shield, a temporary bond shall be placed across the area to be opened to minimize difference in electrical potentials.

6.3.8.2 Telecommunications personnel shall not move or bend power cables at any time. As per Section 6.3.8 above, the Proponent must be requested to identify and reposition power cable as necessary.

6.4 Cable Splicing and Termination

6.4.1 Splicing of the cable closure selection shall be in accordance with SAES-T-632.

6.4.2 Never run more than 15 m (50 ft) of non-fire rated OSP cable in entrance room (ER) within a building. A transition splice point from outside plant non-fire rated to indoor fire rated cable shall be made to limit the exposed non-fire rated cable to 15 m or less.

6.4.3 OSP cables shall be spliced to fuse cable two gauges smaller when terminated inside building entrance room.

6.4.4 All exposed telecommunication cable conductors that enter buildings shall be protected with UL-listed protectors terminal. Solid state protectors terminal are preferred; however, other types of protectors are acceptable. The protected terminal shall be installed immediately

adjacent to the exposed cable point of entry. (Refer to SAES-T-795 for Grounding, Bonding and Electrical Protection for Telecommunications Facilities).

6.4.5 Only appropriate solvent shall be used when preparing the cable for splicing. Petrochemical materials used as fuel (such as Kerosene or Gasoline) shall not be used for cleaning the cables.

7 Installation

7.1 During construction, cables shall be protected from being driven over by highway traffic, construction equipment and other vehicles, and from any other activity that might damage the cable.

7.2 All conduit ends must be sealed and plugged after installation of cable is complete.

8 Testing and Inspection

The testing and acceptance of installed copper telecommunication OSP cables shall be done in accordance below requirements, as follows:

8.1 Acceptance Testing – Cable Facility

8.1.1 Acceptance tests shall be performed on all new cables, additions or re-arrangements to existing cables when:

1) Adding 305 meters or more of cable.

2) Altering the attenuation loss of a voice frequency circuit (loaded or non-loaded) by more than -0.5 dB at 1,004 Hz.

8.1.2 On-reel acceptance tests at least 80% shall be performed on the cable to confirm the manufacturer's tests before the placing operation begins.

8.1.3 For every pair with an irregularity, two or more pairs in the same complement shall be checked.

1) If one or both pairs show irregularities; then, all pairs in the complement shall be checked.

2) If 25% or more of the tested pairs show irregularities; then, all pairs of the cable shall be tested.

Exception:

If all irregular pairs are confined to one complement, test only the pairs in that complement.

8.2 Responsibilities

Engineering shall be responsible for:

1) Providing cable schematics showing:

- Test points
- Loading points
- Loop loss at 1,000 Hz
- Loop resistance

2) Identifying all special testing requirements.

3) Providing estimated measured loss for E1 Repeater sections.

4) Providing calculated resistance for E1 Repeater sections.

8.3 Outside Plant Construction shall be responsible for:

8.3.1 Performing the cable acceptance testing on all cables in accordance with:

Commentary Note:

This SAES and any other tests specified on the work order by Engineering.

8.3.2 Ensuring that 100% of constructed facilities meet Saudi Aramco mandatory requirements for the type of facility being tested.

8.3.3 Testing facility extensions from terminated point to terminated point.

8.3.4 Reporting cable troubles identified while testing in existing cables to the Communications Operations and Maintenance Department.

8.3.5 Repairing any trouble detected during cable acceptance testing in the new facilities.

8.4 Cable Facility Acceptance Test (FAT) Requirements

Before a cable is designated for voice frequency (VF) or E1 digital transmission, standard cable acceptance testing procedures shall be completed to verify DC and high frequency acceptability.

Commentary Note:

All cable acceptance tests from the central office must be performed from the cable side of the central office protector to the distribution terminal.

8.4.1 All cable pairs, including POTS, (Loaded & Unloaded), Special Service,

and E1 digital on cable, shall meet the minimum acceptance test requirements listed in Table 4.

Table 4 - Typical Testing Method

Test	Requirement
Continuity and Polarity	Continuity test shall be made on all pairs for shorts, grounds, and opens. Shorts, grounds, and opens in all new cables shall be corrected; pairs shall be properly grounded. Continuity troubles identified in the existing cables tested shall be reported to the Saudi Aramco Communications Operations and Maintenance Department.
AC Longitudinal Induced Voltage	AC longitudinal voltage shall be a maximum of 10 volt (rms)
Insertion Loss (Frequency Run)	Insertion loss shall be computed and measured over (Frequency Run) the frequency band from 500 Hz to 2,500 Hz. The 1 kHz-measured loss shall be within plus pair or minus 0.5 dB of the calculated loss value. A maximum loss of 8.5 dB (at 1 kHz) shall be acceptable.
Insertion Loss (Frequency Run)	For non-loaded cable, the measured loss at 2,500 Hz shall be within 6 dB of the measured 1 kHz loss. For H88 loaded cable, the loss over the frequency band from 500 Hz to 2,500 Hz shall be flat and be within: • Plus or minus 0.5 dB for up to four load points. • Plus or minus 1.5 dB for more than four load points.
Insulation Resistance (For POTS Service, 1 pair shall be tested in 25 pair group. For Special Services and Digital Systems, 100% of pairs shall be tested).	Insulation resistance shall be a minimum of 1,000 meg-ohm miles at a potential of 500 volts for one minute measured at increments of 6,000 feet or less.
Loop Resistance (100% of pairs shall be tested).	Loop resistance shall measure within plus or minus 10% of the actual calculated value, and all sample pairs shall measure within plus or minus 2% of the average.
Noise Metallic (For POTS Service, 1 pair shall be tested in 25 pair group. For Special Services, 100% of pairs shall be tested).	Circuit noise measurement shall not exceed 20 dBrnC.
Power Influence (For POTS Service, 1 pair shall be tested in 25 pair group. For Special Services, 100% of pairs shall be tested).	Power influence shall not exceed 80 dBrnC.
Resistance Unbalance (100% of vacant pairs shall be tested).	Resistance unbalance of exchange pairs shall not exceed 10 ohms.
Shield Continuity (100% of cable shield shall be tested).	Shield shall be continuous.

8.4.2 All POTs on loaded cable pairs only, shall meet the minimum Structural return loss test requirements listed in Table 5.

Table 5 - Structural Return Loss Test

Test	Requirement
Structural Return Loss (For POTS Service, 1 pair shall be tested in 25 pair group. For Special Services, 100% of pairs shall be tested).	19 gauge LC 23.0 dB 19 gauge HC 23.4 dB 22 gauge 25.6 dB 24 gauge 26.8 dB 26 gauge 28.1 dB LC = Low Capacitance HC = High Capacitance All facilities assume H-88 loading

8.4.3 All cable pairs on screened and/or non-screened cable used for E1 shall meet the minimum acceptance test requirements listed in Table 6.

Table 6 - E1 Acceptance Test Requirements

Test	Requirement
Resistance Unbalance (100% of pairs shall be tested)	Resistance unbalance shall not exceed 3 ohms or 0.5% of the loop resistance, whichever is greater.
AC Longitudinal Induced Voltage	AC longitudinal voltage shall be a maximum of 10 volt (rms)
Insertion Loss @ 772 kHz (100% of pairs shall be tested)	Measured loss with an all 1s signal must not exceed the calculated maximum loss by more than 2.5 dB of the loss at 772 kHz for T1. Considering each direction separately, the range of losses among all pairs measured must not exceed 3.5 dB at 772 kHz for T1.
Signal-to-Noise (T1 non-screened cable only)	The noise variance shall represent the difference between the reference and the measured readings using the Sierra 413 or equivalent equipment. Facility e/w Capacity — S/N Margin — Noise Variance 0 — 8 dB minimum — <1 </=49 — 4 dB minimum — <2 50-80 — 4 dB minimum — <2 >/=81 — 4 dB minimum — <2

8.5 Test Equipment

Provide a proof of certificate of calibration for all test equipment, this to ensure it have been periodically calibrated and certified by either the Original Equipment Manufacturer (such as an authorized manufacturer third party

commercial service center), a third party commercial calibration laboratory duly accredited internationally or a third party commercial calibration laboratory certified nationally by the Saudi Arabian Standards Organization (SASO).

8.6 Testing Procedures

Cable testing shall be done as outlined in Table 7.

Table 7 - Cable Testing Procedure

Test	Activity
Continuity and Polarity	1. Place the ground on the tip side of the pair at the far end. 2. Measure the dc resistance between the tip and ground. 3. Place a ground on the ring side of the pair at the far end. 4. Measure the dc resistance between the ring and ground.
AC Longitudinal Induced Voltage	1. Place the ground on the tip side of the pair at the far end. 2. Measure the AC voltage between the tip and ground. 3. Place a ground on the ring side of the pair at the far end. 4. Measure the AC voltage between the ring and ground.
Resistance Unbalance	1. Clear the ends of all conductors on the far end (opposite the tested end). 2. Remove all protective devices from test pairs. 3. Bunch and ground all conductors on the testing end. 4. Remove one conductor at a time and measure that conductor to the bunched and grounded conductors. 5. After a conductor is tested, return it to the bunched group and select another conductor for testing.
DC Loop Resistance	1. Place a short on the pair at the far end. 2. Measure the dc resistance across the tip and ring.
Resistance Unbalance	1. Ground the ring side of the cable pair at the far end. 2. Read the ring-to-ground value. 3. Ground the tip side of the cable pair at the far end. 4. Read the tip-to-ground value.
Shield Continuity	1. Bunch and ground cable pairs of the cable being tested at the near and far ends. 2. Make a power influence reading.

Test	Activity
	3. Compare this reading to the power influence reading made during the noise measurements.
Continuity and Polarity	1. Place the ground on the tip side of the pair at the far end. 2. Measure the dc resistance between the tip and ground. 3. Place a ground on the ring side of the pair at the far end. 4. Measure the dc resistance between the ring and ground.
Insertion Loss	1. Send a 0 dBm signal using an oscillator at one of the required frequencies. 2. Use a terminated meter to measure loss at the opposite end of the cable pair.
Noise Metallic	1. Terminate one end of the circuit or cable pair with a 600 or 900 ohm in series with a 2.16 micro-farad capacitor. 2. Measure noise at the opposite end of the cable using a noise measuring set.
Power Influence	1. Connect cable pair or circuit to the 600 or the 900 ohms termination in series with a 2.16 microfarad capacitor at the central office end. 2. Use noise measuring set to make noise measurement from the field.
Structural Return Loss	1. Build out the far end to a full section 1,829 meters with a BOC (build out capacitor). 2. Terminate the far end with a PN (precision network) representing the most dominant gauge or the cable being tested. 3. Terminate the near end with a BOC and PN which match the length and impedance of the near end section. 4. Measure the structural return loss with return loss test set.
Cable Shield or Shield/Armor Continuity	Cable shields or shield/armors are electrically continuous. Shield or armor shall be bonded to ground when this test is conducted.
Conductor Continuity	All pairs are free from grounds, shorts, crosses, and opens.
DC Insulation Resistance (IR) Measurement	The expected IR levels are normally greater than 500 mega ohm/km.
Loop Measurement	Insertion loss and noise measurements shall be performed on cable pairs as DCO subscriber loops.

Commentary Note:

For documentation, a copies of used test equipment list and completed Test Record (Exhibits 1, 2, & 3) shall be attached to the MCC and PAC Forms. (This information must be available for anytime for quality review).

8.7 Documentation

Copies of used test equipment list and completed Test Record (Exhibits 1, 2, & 3) shall be attached to the MCC and PAC Forms. (This information must be available for quality reviews by Inspection, IT Engineering Department, and the Operation and Maintenance Department).

8.8 Exchange Cable

Cable acceptance test shall be recorded according to the instructions listed in Table 8, Exchange Cable Acceptance Test Record (Exhibit 1).

Table 8 - Exchange Cable Acceptance Test Record Instructions

In Term	Specify
A	The exchange location
B	Work Order number
C	The assigned test point number
D	The assigned cable number
E	The assigned cable count
F	Temperature factor, if applicable
G	The assigned “from” location
H	The assigned “to” location
I	Shield continuity test Pass/Fair
	• Resistance unbalance (T-R) • Insulation Resistance: - Conductor (between tip and ring) - Shield(tip to ground and ring to ground)
J	• Structural Return Loss (SRL) • Insertion Loss from 500 Hz to 2,500 Hz • Conductor continuity tests, Pass/Fair • Signal-to-Noise margins: - Power Influence, Ng - Noise Metallic, Nm

8.9 Digital Line

After testing each pair between repeater housings, results shall be recorded on the Digital Test Data Acceptance Test Record (Exhibit 2) according to Table 9 instructions.

Table 9 – Digital Test Data Acceptance Test Record Instructions

In Term	Specify
A	Type of PCM Test Set used
B	Work Order number
C	Work Order number (use when different from B)
D	• Cable pair number • Loss at 772 kHz • Loop resistance • Resistance unbalance • Repeater slot number • Signal-to-noise • Shield continuity
E	• Cable number • Repeater housing number • Noise readings
F	• Cable section under test • Test rules of loaded pairs
G	• Transmit direction • Tester's names

Revision Summary

30 June 2014	Revised the Next Planned Update, reaffirmed the content of the document, and reissued as major revision.
18 October 2016	Stream line and optimize communications standards based on functionality and alignment to international standards. Consolidated/merged SAES-T-628 and SAES-T-629 into one standard document.
15 January 2018	Major revision to consolidate SAES-T-634 to this standard, adding requirements pertaining to testing of copper cables, see section 8, and adding section for Definition of Terms, see Section 4.
14 May 2019	Editorial revision as part of content confirmation assessment

Exhibit 1 – Exchange Cable Acceptance Test Record

Exchange:			Date:		Page: of
Street or Road Name:	Work Order No.:	Test Point:	Temperature:	**Cable No.:**	**Cable Count:**
From:		To:			**Shield Continuity** Pass/Fail-P/F:

Line No.:	Cable **Pair No.**	**Loop Res.** in Ohms **(** Must be within 10% of calcu. and 2 % of Avg. **)**	Res. **Unba** **(** T to R Max. 10 Ohms for POTS & 3 Ohms for E1 **)**	Cond. **Cont. Test:** **(** no shorts, opens, grnd's, or rever-sals **)** P/F	Insulation **Resistance**: **(** Minimum of 1,000 Megohm Per Mile **)** **(** Measured in increments of 6,000 feet or less **)** **(** For POTS, 1 pair per 25 pair Complement must be measured **)** T to R	T to G	R to G	**Insertion Loss:** **(** Maximum of 8.5 dB @ 1 kHz **)** **(**Measured 1 kHz +/- .5 dB of Calc.**)** **(**NL measured 2.5 kHz loss must be within 6 dB of measured 1 kHz loss**)** **(**For H88 - up to 4 Ld Pts - 500-2500 Hz. shall be flat, within .5 dB & for more than 4 Ld Pts within 1.5 dB**)** 500 Hz 0.8	1,000 Hz 1.1	1500 Hz 1.3	2000 Hz 1.5	2500 Hz 1.6	**Noise:** dBrnc **(** For POTS, 1 pr. per 25 pair complement must be measured **)** Power Infl. Ng Max. 80dBrnc	Metallic Nm Max. 20dBrnc	AC Longi-tudinal **Induc-ed Volts** **(** Max. 10 volts rms **)** T & R	**SRL:** **(** Ld'd Cable Only **)** **(** 22 = 25.6; 24 = 26.8; 26 = 28.1 min. **)**	**Load Coil Spacing** **(** Load Coil spacing must be within 2 % of std. & avg. & avg. dev. .5% of avg.**)** Note: As-Built Ldng. Chart.
Test/per 25 Complement		25	25	25	For POTS = 1; For Digital = 25			For POTS = 1; For Digital = 25					For POTS = 1; For Digital = 25			25	1 Ld. Avg. Dev.
1																	
2																	
3																	
4																	
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Avg. Res. =		< (Avg. Measured Loop Resistance)	(Show		< 1 kHz Calculated Loss)
Calc. Res. =		< (Calculated Loop Resistance)	Temperature at which measurements were made =		

Notes: 1- For loaded cables to be used for Special Svcs or Digital Systems, do Insertion Loss test @ 772 kHz and Signal-to-Noise test, also.
2- For every pair with irregularity, 2 or more pairs in same complement must be tested. If bad, all pairs in complement shall be tested.
3- If 25% or more of tested pairs show irregularities, then all pairs of the cable shall be tested.

Tested by [*Company Name* ***]*** **&** **[** Individual Tester Name(s) & Signature(s) **]:**

Exhibit 2 – Digital Test Data Acceptance Test Record

DIGITAL TEST DATA ACCEPTANCE TEST RECORDS Page ___ of ___

Date: _____

☐ (A) (A) ☐

W. O. # (B) _____ W. O. # (C) _____

CA PR NO	LOSS dB @772 kHz	LOOP RES	VARLEY (RES UNBAL)	SIGN TO NOS	SHLD CONT.		REPT. SLOTS	SIDE 2						
					Y	N		CA PR No.	LOSS dB	LOOP RES.	VARLEY (RES UNBAL)	SIGN TO NOS	SHLD CONT. Y	SHLD CONT. N
(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)

(E) (E) (E)

CABLE NO. _____ RPTR HOUSING # _____ NOISE METALLIC _____ dBrnc

NOISE GRND _____ dBrnc

(F)

CA SEC. BETWEEN _____ AND _____

ORDER WIRE PR. _____ - LOOP _____ - VARLEY _____

FAULT PR. _____ - LOOP _____ - VARLEY _____

MEG. TEST OK? YES _____ NO _____

(G)

SIDE ONE TRANSMITS FROM _____ TO _____

(G)

TESTED BY: _____ AND: _____