Engineering Standard

SAES-T-911 21 May 2012

Telecommunication Conduit System Design

Document Responsibility: Communications Standards Committee

Saudi Aramco DeskTop Standards

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1 Scope

This standard covers mandatory requirements governing the engineering, design and installation of telecommunications outside plant (OSP) conduit pathway and space design systems.

2 Conflicts and Deviations

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

3 References

All referenced specifications, standards, codes, forms, drawings and similar material shall be of the latest issue (including all revisions, addenda and supplements) unless stated otherwise. Applicable references are listed below:

3.1 Saudi Aramco References

Saudi Aramco Engineering Procedure

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

Saudi Aramco Engineering Standards

SAES-A-100	*Survey Coordinates, Datum's and Data Formates*
SAES-A-114	*Excavation and Backfill*
SAES-B-005	*Spacing and Diking for Atmospheric and Low-Pressure Tanks*
SAES-B-006	*Fireproofing for Plants*
SAES-B-008	*Restrictions to Use of Cellars, Pits, and Trenches*
SAES-B-014	*Safety Requirements for Plant and Operations Support Buildings*
SAES-B-055	*Plant Layout*
SAES-B-064	*Onshore and Nearshore Pipeline Safety*
SAES-B-068	*Electrical Area Classifications*
SAES-K-003	*Air Conditioning for Communications Buildings*
SAES-L-450	*Construction of On-Land and Near-Shore Pipelines*

SAES-L-460	*Pipeline Crossings under Roads and Railroads*
SAES-L-610	*Nonmetallic Piping in Oily Water Services*
SAES-M-006	*Saudi Aramco Security and General Purpose Fencing*
SAES-M-100	*Saudi Aramco Building Code*
SAES-O-100	*General Requirements - Safety and Security*
SAES-O-109	*Buildings Housing Sensitive or Vital Equipment*
SAES-P-111	*Grounding*
SAES-Q-001	*Criteria for Design & Construction of Concrete Structures*
SAES-Q-005	*Concrete Foundations*
SAES-Q-006	*Asphalt Concrete Paving*
SAES-Q-012	*Criteria for Design and Construction of Precast and Prestressed Concrete Structures*
SAES-T-018	*Telecommunications - Symbols, Abbreviations and Definitions*
SAES-T-603	*Telecommunications - Safeguards and Warning Devices*
SAES-T-624	*Telecommunications Outside Plant - Fiber Optics*
SAES-T-628	*Telecommunications - Underground Cable*
SAES-T-629	*Telecommunications Buried Cable and Wire*
SAES-T-795	*Communications Facility Grounding System*
SAES-T-887	*Telec. Electrical Coordination - Protection at Power Plants and Radio Stations*
SAES-T-903	*Communications Electrical Protection - Outside Plant*
SAES-T-906	*Telecommunications - Structural Coordination*
SAES-T-916	*Communications Building Cable*
SAES-T-928	*Telecommunications - OSP Buried Plant*
SAES-T-938	*Telecommunications: Outside Plant Systems - Design*

Saudi Aramco Materials System Specifications

09-SAMSS-016	*Concrete Masonry Units and Concrete Building Bricks*
09-SAMSS-088	*Aggregates for Concrete*

09-SAMSS-097	*Ready Mixed Portland Cement Concrete*
09-SAMSS-106	*Epoxy Coating of Steel Reinforcing Bars*
18-SAMSS-625	*Outside Plant - Fiber Optic Cable Specifications (SM & MM)*
18-SAMSS-493	*Two Part Polyurethane Duct Sealant*

Saudi Aramco Standard Drawings

AA-036373	*Telecommunications PVC Direct Buried/Encased Conduit*
AA-036794	*Standard Communication MHs & Service MH (20 Tons)*
AA-036140	*Standard Communication MHs & Service MH (40 Tons)*
AB-036897	*Buried/Underground Cable Route Marker Post and Signs*

Saudi Aramco General Instructions

GI-0002.100	*Work Permit System*
GI-0002.709	*Gas Testing Procedure*
GI-0005.002	*Loss Prevention Policy Implementation*
GI-0007.015	*Use of Explosives in Construction*
GI-0887.000	*Coordination of S. A. Projects with Non-S. A. Projects*
GI-1021.000	*Street and Road Closure: Excavations, Reinstatement and Traffic Controls*

Safety Management System (SMS)

Operations Instruction Manual (Ch. 1.00 - 30.999)

Refinery Inst. Manual (Ch. 1.000 - 13.999)

Government Standards or Directives/Safety and Security Directives

SSD/12	*Communications*
SSD/26	*Blast Resistant Control Rooms*
SASO SSA 413	*Cast Iron MH Covers*

3.2 Industry Codes and Standards

American National Standards Institute / National Fire Protection Association

ANSI/NFPA 70	*National Electrical Code*
ANSI C2	*National Electrical Safety Code (NESC)*
NFC	*National Fire Codes, Volume 14*

Telecommunications Industry Association

TIA-758-A	*Customer-owned Outside Plant Telec. Infrastructure Standard*

National Electrical Manufacturers Association

NEMA TCB2	*User's Manual for the Installation of Underground Plastic Conduit*
NEMA TC 8	*Extra-Strength PVC Plastic Utilities Conduit for Underground Installation*
NEMA TC 9	*Fittings for ABS and PVC Plastic Utilities Conduit for Underground Installation*

Industry-Related Organizations

BICSI TDMM	*Telecom. Distribution Methods Manual (Latest Version)*
BICSI OSP	*Outside Plant Design Reference Manual (Latest Version)*

4 General Requirements

4.1 OSP Design Reference

The TIA-758-A and Building Industry Consulting Services International (BICSI) Outside Plant Design Reference Manual (current version) are 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 and BICSI.

4.2 OSP Designer Certification Requirements

All OSP telecommunications system designs by non-Saudi 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) 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).

4.3 Design Lifecycle

A conduit system shall be designed and engineered to remain usable for 75 to 100 years and fulfill design requirements and specifications.

4.4 Conduit Route Design Considerations

The design/construction drawings must be comprehensive, detailing:

a) Location and alignment of proposed facilities.

b) Stationing and tie downs for conduit, MHs, etc., to center lines of streets/roads, etc.

c) Size and configuration of MHs.

d) Total duct length.

e) Conduit formation and depth requirements.

f) Locations, as nearly as can be determined, of existing substructures such as:

i. Gas,

ii. Water, including AC coolant lines,

iii. Sewer mains,

iv. Oil field and Plant area Pipelines,

v. Other proponents' facilities, conduit runs, MHs, substructures, etc.

g) Special construction details, such as for:

i. Railroad crossings,

ii. Attachment to bridges, etc.

iii. Attachment to pipeline structures, cable trays, and other above ground conduit systems.

Commentary Note:

Where it is necessary to install metallic pipe bends at building entrances, pole risers, etc., and the pipe bend is extended underground with non-metallic conduits, the cable shield to metallic pipe bond may be omitted at the underground end of the pipe bend, *provided that this is concurred to by the Saudi Aramco Communications Standards Committee Chairman. However, if the metallic pipe bend is extended underground with metallic pipe, the cable shield/armor must be bonded to the metallic pipe at both ends.*

4.5 Number of Conduits

The number of conduits required in a proposed conduit system addition or extension depends on the number of cables necessary to provide for the installed service and its expected growth and maintenance. Cables required for growth may include facilities necessary to cutover and relieve an existing cable that is at maximum capacity.

The number of conduits required shall be approved in writing by the Saudi Aramco, Communications Engineering Department of IT. The number of conduits shall be specified in the Project Proposal and in construction Work Orders.

4.6 Main and Lateral Conduits

The total number of main and lateral conduits (includes fiber optic requirements as well as copper conductor requirements) to be placed in a proposed conduit installation shall be designed to care for:

a) Immediate requirements,

b) Expected growth over the economical period,

c) Other requirements (conduits to be used for non-telecommunication purposes, etc.),

d) Plus one conduit shall be reserved for maintenance and repair purposes. (This requirement applies to above grade telecommunications conduit systems as well; i.e., plant areas, including off-shore sites). This conduit shall not be used for new cable growth requirements unless a different conduit is to be cleared for maintenance/repair purposes by the same project,

e) Allowing minimum depth requirements for future main conduit pathways.

4.7 Conduit Plugs and Seals

All conduits between structures should be sealed to prevent intrusion of liquids and gases into the structure. Conduits plugs materials specification should conform to 18-SAMSS-493.

As soon as the conduit entrance installation is complete, all conduits (vacant or occupied) entering buildings (telecommunications/central offices and others) shall have watertight/gastight plugs or seals, placed in both the MH and the building ends, to prevent the entrance of gas or water and moisture into the building. These conduits shall be sealed at all times.

4.8 Temporary Conduit Plugs

When conduit installation is stopped for any length of time (overnight, etc.), temporary plugs shall be placed in the end of each installed conduit. Conduits Plugs materials specification should comply with 18-SAMSS-493 or equivalent.

4.9 Safety and Security

All Saudi Aramco Safety and Security Requirements and Policies shall be observed. Refer to GI-0002.100, SAES-T-603, SAES-T-628, the SAES-B-Series, the SSD's and the Construction Safety Manual. The Saudi Aramco Safety Policy (Loss Prevention Policy Statement) is presented in GI-0005.002.

4.9.1 Test Atmosphere in Deep Excavations

Testing the atmosphere in excavations shall be conducted when 1.2 m (4 ft) deep or more, per GI-0002.709 paragraph 3.1.1, before permitting anyone to enter. This would include excavations in areas such as the following:

a) Oil production areas, i.e., GOSP's, NGLs, Refineries, Plant areas, Pump Stations, pipeline corridors, etc.,

b) Near gasoline/fuel stations,

c) In areas where hazardous materials are stored nearby,

d) In landfill areas,

e) Near intersections with stop signs or signals.

4.9.2 Safety Requirements for Excavations

To insure safety of workmen, excavation work shall, at all times, be under the immediate supervision of someone with authority to modify shoring or other work methods and situations, as necessary, to maintain safe working conditions as outlined in the Saudi Aramco Construction Manual, SAES-A-114, Saudi Aramco Safety Management guide, and other applicable safety practices.

4.9.3 Trench Shoring and Sloping

Trenches or other excavations that are 1.2 meters (4 ft) or more in depth shall be safeguarded by shoring or sloping the trench walls per SAES-A-114 paragraph 5.5.2.3.

4.9.4 Excavations Adjacent to Buildings

When designing and installing telecommunication facilities, which require excavations adjacent to building foundations or footings, the following principles are to be observed:

a) Where possible, excavations adjacent to building foundations or footings are not to be deeper than the bottom of the foundation or footing.

b) When it is necessary to make excavations deeper than a building foundation or footing, the excavation shall not cross an imaginary line that extends down from the bottom outside edge of the foundation or footing at 30 degree angle.

4.9.5 Installations in Refineries

When designing/installing a Maintenance Hole (MH) or telecommunication conduit system in a refinery area, review the Refinery Instruction Manual, especially chapters:

RIM Chapter 1.801	Work Permits - Refinery Areas
RIM Chapter 1.805	Excavations and Pile Driving

4.9.6 Installations in Plant Areas

Review the Operations Instruction Manual, especially chapters:

OIM Chapter 2.031	Excavations,
OIM Chapter 7.188	Control of MH Entry Abqaiq Plants.

When designing/installing a MH or telecommunication conduit system in plant areas, NGL Plants, GOSP's, Refineries, Bulk Plants, etc. Close contact and coordination shall be maintained with the proper personnel of these organizations when doing design or construction work in their areas of responsibility.

4.10 Designing to Avoid Future Problems

All conduit pathway designs shall take into consideration the vulnerability to future disturbance and the degree of mechanical protection that is justified to safeguard the conduit and its contents. Problem areas, such as listed below, must be considered and avoided where it is feasible to do so:

a) Possibility of manmade troubles as determined by the likelihood of other underground activities in the vicinity.

b) Unstable soil Conditions.

c) Road rebuilds or relocation's.

d) Unusual heavy traffic loading or the possibility of future heavy traffic loading

4.11 Special Construction Situations

The method to be followed in constructing conduit in the situations listed below shall be covered in detail on the construction drawings:

a) Crossings of bridges, culverts, etc.

b) Any crossings where attachment requires a specially designed structure.

c) Crossings under railroad tracks or embankments by means of boring, jacking or tunneling methods. (Refer to SAES-T-906).

d) When the conduits are to be laid through unstable ground requiring piling or other means of support.

4.12 Construction Drawings

The construction drawings must contain all the information necessary for completing the work as designed.

The following information must be provided on construction drawings:

a) Size, type and location of conduit formations.

b) Conduit selected for use must be designated by using an exploded view of the MH. (Refer to SAES-T-018, Page 39).

c) Show whether conduits are vacant or occupied.

d) If conduit planned for use is occupied, state the work order that will clear it.

e) Length of cable required.

f) Determine if additional cable will be required in pull-through MHs.

g) Show whether or not any existing cables will interfere with the placement of the new cable and rearrangements that are necessary.

h) The number and size of cable hooks required.

4.13 Conduit Construction and Trench Work

4.13.1 Structural Requirements

The design and installation of telecommunication vaults, MHs, hand holes and pull boxes shall comply with the requirements of

SAES-Q-001 "Criteria for Design and Construction of Concrete Structures", with the following exception:

Exception:

Epoxy coated Fusion Bonded reinforcing steel bar shall be used in all geographical locations for the design and construction of telecommunications vaults, MHs, hand holes and pull boxes.

4.13.2 Mortar Requirements

Mortar used for placing brick masonry, MH frame and covers, etc., shall be in compliance with SAES-M-100, "Saudi Aramco Building Code," SAES-Q-001, "Criteria for Design and Construction of Concrete Structures" and 09-SAMSS-097, "Ready Mixed Portland Cement Concrete."

4.14 Blasting

Any blasting requirements for either trench or MH excavations shall be carried out in accordance Saudi Aramco and Saudi Government procedures and guidelines.

5 Design

5.1 Underground Conduit Pathways

The designer should design the most safe and economical plant possible. Proper survey shall be conducted by the designer prior to developing any OSP infrastructure design.

5.1.1 Main Conduits

The duct bank configuration of the main conduits shall not be changed, except at points where obstacles intersect the main conduit route. Other factors requiring consideration when determining the number of conduits to be placed in a system include:

- Routing changes
- Special Construction
- Public inconvenience caused by further expansion.
- Rearrangement of feed to different areas.
- Other existing buried substructures.

Main Conduit Stub-Outs for Future Use

Main Conduits stubbed out in the trench for future use shall use full 6 m (20 feet) conduit sections for a minimum distance of 12 m (40 ft) from the central office or MH wall and shall be sealed with plastic caps cemented onto the end of each conduit before backfilling the trench. Stub-outs shall be placed on top of the conduit structure.

Commentary Note:

Provision for future extension of the stubbed out conduits should be considered during the construction of the duct bank system to provide the minimum depth clearance from the grade level.

5.1.2 Lateral Conduits

When planning lateral conduits to distribution points, spare duct for future should be provided. Lateral duct length is limited by the size of cable to be pulled into it and the number of bends it will contain.

5.1.2.1 Number of Bends Permitted

Conduit laterals shall not have more than the equivalent of two 90 degree turns. Table 1 provides a guide for determining the maximum cable pulling distance for a lateral conduit system. Any conduit laterals which exceed the limits indicated in Table 1 attached must be proved to be within the limits of this standard by making cable pulling tension and sidewall bearing pressure calculations. Copies of these calculations shall be included with the design package.

5.1.2.2 Minimum Radius Bends Permitted

Conduit bends with less than 0.91 m (36 in.) radius shall not be used in conduit laterals for building entrance or at pole and pedestal.

The number and size of conduits extended into a building shall comply with SAES-T-916, paragraph 4.2.2 (Underground Entrance).

5.1.2.3 Clearance from MH Roof and Wall

Lateral conduits shall enter the MH so as to provide a minimum clearance of 100 mm (4 in.) from the MH roof and the adjacent wall.

Lateral conduits shall not be permitted to enter through the side walls of MHs.

5.1.2.4 Minimum Depth (Cover)

Lateral conduits shall be placed at a minimum depth (cover) of 610 mm (24 in) when located in areas where it is unlikely that they will ever be subject to vehicular traffic loads. In areas subject to vehicular traffic, the same depth and protection requirements used for main conduit runs are applicable.

5.1.2.5 Installed for Future Extensions

When lateral or stub-out conduits (installed for future connection/extension) are placed in the same trench line with the main conduits, they shall be extended a minimum distance of 12 m (40 ft), or to the point where they leave the main trench. If the lateral conduits leave the main trench line, they must be of sufficient length to clear the main trench line by a minimum of 600 mm (24 in). Stub out lateral conduits shall be sealed with plastic caps cemented onto the end of each conduit before backfilling the trench.

Commentary Note:

> *Provision for future extension of the stubbed out should be considered during the construction of the duct bank system by providing clear space for later extension of the stub-out conduits.*

5.1.2.6 Termination's at Poles and Buildings

When Lateral conduits terminated on poles, shall be terminated on the field side away from traffic. Bends with a minimum radius of 91 mm may be used as pole risers, or small building entrances. Bends shall be:

1- Securely anchored PVC coated, galvanized, rigid steel conduit bends, which conform to NEMA RN1, or

2- Concrete encased PVC conduit bends.

5.1.3 Conduit Design and Layout

5.1.3.1 Corresponding Conduits Enter MH at Same Level

Corresponding conduits of conduit entrances in opposite ends of MHs shall be at the same level and in the same position with respect to the side walls.

5.1.3.2 Conduit Joints

Under certain conditions, the use of solvents, cements and primers (used to join plastic conduit sections) can be dangerous (i.e., flammable, toxic to workers). All precautions of the manufacturer shall be complied with when these products are used.

5.1.3.3 Conduit Preparations

Conduit ends (Bell ends, joints, couplings, etc.):

a) Must be dry and free of all foreign matter.

b) Must be joined while cement is still wet.

c) Must be cured undisturbed for 30 minutes or as per vender's recommendations.

d) Curved sections, when constructed with straight sections of conduit, must be firmly staked immediately adjacent to and on each side of each joint. A conduit joint, which occurs in a curve or near its end, shall be made with the conduit straight and allowed to cure before bending.

e) Must be fully and properly seated and aligned in the conduit end bell socket of the conduit section to which it is being joined or in the joint coupling.

5.1.3.4 Separations from Other Substructures

For identification, protection from arcing, reduction of stray currents (especially those resulting from cathodic protection on pipelines), etc., the minimum separations between other (non-telecommunication proponent facilities and non-Saudi Aramco facilities) substructures and telecommunication conduit substructures shall be in accordance to Table 2 and SAES-B-064. Separations between MHs and other substructures shall be as indicated in Table 3.

1. Pipeline Crossing Requirements

When crossing pipeline the following shall be considered:

a) The minimum vertical distance between the bottom of any pipe and the top of the concrete encased conduit bank shall be 1.0 m.

b) The concrete encased conduits shall be continuous across the width of the pipeline corridor.

c) Provide a minimum of one spare conduit.

d) No portion of any service point (MH, pedestal, etc.) on Saudi Aramco telecommunication cables shall be closer than 25 m to any pipeline in the corridor (in accordance with SAES-B-064). When locating service points, the engineer must be sure to take into consideration the location of proposed or future pipelines as determined by coordination with the pipeline's proponent.

e) The directional drilling method may be used to place communications cables under pipelines corridors. The minimum vertical distance between the bottom of any pipeline in the corridor and the top of the HDPE pipes shall be 1.2 m (4 ft).
A written approval from Saudi Aramco, Pipeline Operations Engineering Superintendent and Saudi Aramco, Communications Engineering Division of IT is required.

2 New Pipelines Crossing Existing Cables

When new pipelines cross existing telecommunication cables or conduits, the telecommunications cable(s)/conduits shall be provided the same mechanical protections and separations as outlined above. Prior approval from the telecommunications proponent shall be obtained before these cables can be moved or relocated (coordinate with the Saudi Aramco, Communications Engineering Division of IT).

3. Cables Crossing Over Pipelines

In situations where it is impractical to place telecommunication cables below pipelines as required above, telecommunication cables may be buried over (above) the pipeline, provided the following conditions are satisfied:

a) One meter separation is maintained between the top of all subsurface pipelines and the bottom of the buried concrete encased telecommunications conduit structure

b) The one meter separation may be reduced with justification, followed by written approval from Saudi Aramco, Pipeline Operations Engineering Superintendent and Saudi Aramco Communications Standards Committee Chairman. However, under no circumstance, the separation should be less than 300 mm (12 in).

c) The standard ground cover can be maintained above the buried concrete encased telecommunication conduit structure.

5.1.3.5 Conduit Curves, Offsets, etc.

1. Minimum Radius - Main Conduit Sections

Except for the minor curves involved when splaying main conduits at MH entrances, curves in conduit runs should be avoided whenever possible. When curves are necessary in a main conduit section, the curve shall not:

a) Transverse more than 90 degrees.

b) Have a radius of less than 6 m.

Main conduit sections shall not have more than the equivalent of two 90 degree turns.

2. Maximum Main Conduit Run Lengths

The permissible length of a conduit section containing a bend or curve depends upon the angle between the straight conduit run on each side of the curve and the radius of the curve. Generally, main conduit section lengths for various degrees of curve and radii of curve should not exceed those indicated in Table 4. Main conduit section lengths, which exceed those shown in Table 4, must be proven with cable pulling tension calculations and sidewall bearing pressure calculations.

To minimize the costs, the length of conduit sections between MHs shall be designed to be as long as is practical to reduce the:

a) Number of MHs,

b) Number of splices, and

c) Number of set ups required for cable pulling.

Other controlling factors to be considered in determining MH spacing are:

a) The length of maximum size cable that can be placed on a standard size cable reel.

b) Load coil spacing (Saudi Aramco uses H-88 Type; 1829 m load coil spacing).

c) Distribution cable points, junction points, etc.

3. Bending of PVC Conduit

a) Hot Bending in the Field

The hot bending of PVC (NEMA TC 8) conduit in the field will not be permitted because of the difficulty of quality control.

b) Bends of 10 - 45 Meters Radii

Cold (Ambient Temperature) field bends may be constructed in the field for radii 10-45 meters per procedures outlined in NEMA TCB2, “Users Manual for the Installation of Underground Plastic Conduit.”

c) Greater than 45 Meter Radius

Construction of a PVC conduit bend with a radius greater than 45 m usually does not require any special procedures.

d) Less than 10 Meter Radius

Bends less than 10 meters (32.8 ft) can be constructed with the use of factory made bends or sweeps.

4. Conduit Offsets

Changing sides of the street with a conduit run in main conduit runs shall be constructed with large radius sweeps with a minimum of 30 meters (98.4 ft) radius, to minimize the resistance by the sweeps when cable is pulled-in.

Where the offset distance is not more than 1.5 m (5 ft) and the radius of the sweep or curve is 30 meters (98.4 ft) or more, the offset may be disregarded in determining maximum section length. However, if the offset in an otherwise straight section of conduit is more than 1.524 meters (5 feet), the length of the conduit section shall be shortened proportionately (up to one-third for extreme conditions).

5.1.3.6 Protection of Conduit Systems

1. Loads on Conduit

Underground conduit shall be designed to withstand external loads to which it will be subjected; caused by the weight of the backfill material and by dead loads, live (impact) loads and any other loads that may be applied at the surface of the fill.

2. Concrete Encasement

All new and rebuilt telecommunication conduit systems (including main and lateral conduits) shall be concrete encased (non-structural concrete per SAES-Q-001 and 09-SAMSS-097); to provide mechanical protection against:

a) Settlement of the conduits, or

b) Damage by excavating equipment.

The requirements of this paragraph do not apply to isolated conduits placed in buried cable sections.

Commentary Note:

Isolated conduits section is a 4" PVC conduit, without concrete encasement, installed below high voltage overhead or buried power lines, under fence or sidewalk, culvert, etc. See SAES-T-903 paragraph 5.1.6.7 and SAES-T-928 paragraph 6.3.2 for more details.

3. Concrete Base Required

Concrete encasement (including a concrete base) is

required for telecommunication conduit systems.
A concrete base is especially beneficial:

a) Whenever the ground is spongy or yielding, or

b) As a leveling medium under conditions where a sand base trench is subject to washing out.

4. Minimum Concrete Requirements

The minimum amount of concrete encasement used shall be 75 mm (3 in) along the top, sides and bottom of the conduit formation.

5. Trench Walls Used as Forms

When concrete encasing conduit, the trench walls may be used as a form for the concrete, provided a minimum thickness of 75 mm (3 inches) of concrete is provided on each side of the conduit bank.

6. Encasement Direction

Always concrete encase conduits by starting at one end and working toward the other end, or by starting in the center section and working toward the ends (MHs). Never start at the ends and work toward the center.

7. Concrete Encasement with Other Utilities

Telecommunication cables or conduits shall not be placed inside the same concrete encasement with power facilities or other underground utilities or facilities.

5.1.3.7 Open-Cut Trenches Guidelines

1. Trench Width

Trench width will be adjusted to the conduit formation being used; however, the minimum trench width for a trench in which a man is to work is 460 mm. A minimum space of 75 mm shall be provided on each side of communication conduit banks during installation.

2. Trench Bottoms

Before receiving conduits, the trench bottom shall be:

a) Cleared of rock, rock protrusions and other items that could damage conduits;

b) Uniformly graded and covered with a minimum of 50 mm leveled layer of sand. Sand is not required if conduit spacers will be used, and the conduit is not to be laid directly on the trench bottom.

The bottom of trenches shall be smooth and level and void of any items that could deform or damage the conduit.

3. Draining Conduit Sections

Conduit sections should be constructed so that they drain toward the MHs where practical. Grade the trench so that it has a fall of at least 75 mm in 60 m toward the lower MH or from the high point (or midpoint if in a reasonably level area) of the section toward both MHs.

4. Minimum Cover in Traffic Areas

Telecommunication main conduit sections, placed in roadways and other traffic areas, shall provide a minimum ground cover of 760 mm measured from top of encasement.

5. Minimum Cover in Non-Traffic Areas

Main conduit sections shall be placed at a minimum depth (cover) of not less than 610 mm.

6. Backfilling and Compaction

Conduit trench backfill and compaction shall comply with the following:

a) Immediately around conduits shall be concrete encasement in accordance with paragraph 5.1.3.6.2 above.

b) In non-traffic areas, where specific restoration requirements are not given by the proponent, the balance of the backfill shall be free of organic material and solid material greater than 200 mm in maximum dimension. Compaction shall be in accordance with the surrounding materials. As a minimum, the trench surface area shall be properly rolled.

c) In non-Saudi Aramco streets or roads, the balance of the backfill shall be as required by the street or road proponent.

d) Tamping with pneumatic hand-operated tampers, self-propelled impact tamping machines, etc., is not permitted until a minimum of 300 mm of fill material has been placed above the conduits. The tamping pad must cover a minimum of 90,000 mm². Keeps the machine moving steadily so that the tamping pad does not hit twice in the same spot.

e) Compaction with wheel rolling machines is not permitted with a cover of 1.1 m or less.

f) Compaction with hydrohammers is not permitted where the conduit cover is less than 1.3 m.

g) Compaction shall meet or exceed the requirements of SAES-Q-006 or the property proponent's requirements if non-Saudi Aramco facilities are involved, and his requirements are different.

h) In active sand areas, the top backfilled layer of the trench must be stabilized in accordance with SAES-L-450, paragraph 14.8, using either sand/oil mix or sprayed oil materials.

7. Marking and Identification

- The color orange shall be used to identify telecommunication facilities.

- Orange colored marker/identification tape shall be placed in the trench above the cable and the specification shall be in accordance with Standard Drawing AA-036748, “Buried Telephone Cable/Distribution Wire - Installation Details”. The following black legend shall be printed on the tape in both Arabic and English: “CAUTION! - TELECOMMUNICATION CABLE BELOW).” Marker posts and signs shall be placed in accordance with Standard Drawing AB-036897, "Buried/Underground Cable Route Marker Posts and Signs."

- For conduit systems, this shall be accomplished by placing an orange marker tape above the conduit concrete encasement surface. Additional marker tape is to be located 300 mm minimum above the conduit system upper surface to provide an early warning. This is considered the preferred method. The specifications of the marker tape materials shall conform to SAMS Stock No. 18-070-890 (SAP No. 1000-078-516) or equivalent.

Commentary Note:

Mixing orange dye with the top layer of the concrete (refer to SAES-Q-001) may be used to replace the marker tape on top of the conduit concrete encasement surface.

5.1.3.8 Special Methods Guidelines

Where it is not possible to provide an open trench, when constructing a conduit system, such as at crossings of railroads and major highways or freeways, pipelines, etc., special methods are recommended bellow.

In the case where other construction methods (not referenced) in this standard shall be exploited, detailed designs shall be presented to Saudi Aramco Communications Standards Committee Chairman for review and approval, prior to the use of the proposed construction method.

The crossing for all roads shall be made as nearly perpendicular to the road or railroad axis to achieve the shortest path. The crossing angle shall not be less than 45 degrees.

1. Conduit on/under a Bridges

   Whenever conduit must cross a bridge, the design shall be in compliance with BICSI OSP Design Manual latest edition and approved by IT Communications Engineering.

2. Thrust Boring (Casing Installation)

   Upon completion of the conduit installation, casing must:

a) Be filled with fine sand, blown in under air pressure,

b) Have the inside of both casing ends sealed with a minimum of 75 mm wall of concrete.

c) Casing Wall Thickness

The minimum wall thickness of the casing shall be as required by the highway or railroad proponent but never less than three-sixteenths inch.

d) Number of Conduits per Casing

Table 5 provides an indication of the number of conduits that can be installed inside different casing sizes. The minimum cover over the casing in railroad crossings shall be 1.4 m as specified in SAES-L-460, "Pipeline Crossings under Roads and Railroads," unless greater cover is required by the highway or railroad proponent. (Refer to SAES-T-906).

3. Horizontal Directional Drilling (HDD)

This method uses a liquid chemical mixture that, when forced through the end of the boring head, craves a hole in the earth. The following guidelines shall be considered:

a) Directional drilling shall be using the HDPE (High Density Poly-Ethylene) pipes with 4.0-inches inside diameter.

b) The pipes at the crossing will not be connected to other underground communications conduit system.

c) HDPE pipes shall be Mandrel testing in both directions.

d) The pipes at the crossing shall be placed with a minimum cover of 1200 mm.

5.1.3.9 Conduit Design Formations

1. MH Conduit Entrance Design Considerations

Design proper conduit formations to facilitate orderly cable racking within the MH and to ensure minimal changes in the formation when entering/exiting a MH.

For the most efficient cable formation, the following recommendations should be adhere to:

a) Preferably, main conduit formations should enter the end walls of the MH at a point approximately halfway between the floor and the ceiling.

b) For wall racking considerations, design splayed duct bank entrances at the end walls rather than center placement.

c) If the total number of conduit being placed is significantly less than the capacity of the terminating MH or cable entrance, conduit should enter at the lowest level within the MH. The upper should be reserved for future conduit additions.

d) The conduit entrance into the MH should be sized for the ultimate number of conduits to prevent the need for future wall breakout.

2. Formation Changes at Obstacles

In some situations, main conduit formations may have to be changed to clear obstructions. When this happens, the conduit formation must return to the original formation as soon as obstruction is cleared.

3. Formation Widths

Conduit trench formations, consisting of four or more conduits, shall be two or four conduits wide.

4. Splay Conduits at MH Entrances

Splayed conduit MH entrances shall be used for all telecommunications MHs. Bottom MH entrance holes shall be used first for conduit terminations.

Minimum Splaying Distance

The splaying of conduits shall start at a point, which is located at a minimum distance of 12 m from the outside surface of the MH wall.

5. Subducts

Refer to SAES-T-624 for subduct design engineering and installation information.

5.1.3.10 Conduit Selection and Cable Measuring

1. Blocking Vacant Conduits

Do not assign a conduit, which, when occupied, will block other vacant conduits or block racking positions on the MH wall. It must be kept in mind that, in some cases, a good assignment in one MH may prove to be a poor assignment in the next MH.

2. Conduit Assignments

The Saudi Aramco standard for conduit assignments is that cables be assigned to bottom conduits and nearest to the outside wall first, for the following reasons:

a) Cable Splicers will not have to work underneath cables placed at higher levels.

b) If damage is done to the conduit system, the empty top conduits will usually be hit first, thus helping to protect cables in lower conduits.

Existing conduits shall not be utilized unless assignments are approved by IT Communications Engineering.

3. Conduit Numbering Scheme

Specific conduits and conduit locations in MHs and cable vaults are designated by numbers according to row and bank location, counting left to right, bottom to top, starting with the bottom left side conduit, with your back toward the central office. Refer to SAES-T-018, MH conduit numbering.

5.1.3.11 Selection of Conduits for Pull-Through

When checking a conduit system to determine if a cable pull-through can be made, the following requirements must be observed:

a) No splice shall be planned at pull-through MHs.

b) Conduits in opposite ends of pull-through MHs should be in the same vertical and horizontal plane. Where this is not possible, a variation of 300 mm shall not be exceeded.

c) Sections of conduit having sharp bends are not suitable for pull-through. Long radius bends, including those in a conduit run following a gradual curve in a street may be included in a pull-through section, provided the limits of Paragraph 5.1.3.12 are not exceeded.

d) Where other conditions are favorable, the length of cable that can be handled as a pull-through is limited by the cable pulling tension limit and the quantity of cable that can be shipped on a reel.

e) Cable Measurements and Cutting Lengths

When cable is to be ordered by cable cutting length, sufficient cable for proper racking and splicing must be provided. To obtain the length of cable required for a conduit section added:

i) The actual length of the conduit section (from inside wall of 1st MH to inside wall of 2nd MH),

ii) The lengths of the cable ends required inside the two MHs, and

iii) The amount of excess cable required for splicing, testing, and pulling-in.

If pulling eyes are not furnished and a core hitch is to be used in pulling the cable, add one half meter more to the required length of cable.

5.1.3.12 Calculating Cable Pulling Tension

Underground cable pulls must be based on joint engineering and construction evaluations which consider theoretical, practical and job experience factors. Cable pull calculations will be required for these situations and must be included with the design package. The results of the calculations must be listed on the construction drawings. This section contains information on how to make the necessary calculations.

1. Cable Pulling Eyes

The conduit must be large enough to permit the cable to be pulled through it; the general rule has been that the diameter of the conduit must be at least 13 mm larger than the cable diameter. However, it is the diameter of the pulling eye that is more important and except for small cables the diameter of the pulling eye [d(e)] can be estimated as follows:

$$d(e) = 1.1d(c) \qquad (4)$$

Where: d(c) is the cable diameter.

2. Conduit Coefficient of Friction

The condition of the conduit must be considered, since the coefficient of friction will be dependent upon this factor. Table 6 shows estimated coefficients of friction for different types of conduits (when conduits are clean and in good condition) in which polyethylene sheathed cable is to be pulled. Some of the items which affect coefficient of friction are as follows:

a) Dirt or contamination.
b) Type of surface.
c) Lubrication of the cable.
d) Conduit deviations or deformations.

<u>Establishing Coefficient of Friction Factors</u>

To determine unknown coefficient of frictions, i.e., when conduits are:

a) Only in fair condition,

b) A type of conduit exists, which is not shown in Table 6, or

c) The outer cable jacket is something other than polyethylene, develop a coefficient of friction, by pulling a piece of lubricated test cable of weight (W) through the conduit and recording the pulling tension (T) during the normal pulling speed. The coefficient of friction can be calculated by using the following equation:

$$f = \frac{T}{W} \qquad (5)$$

3. Pulling Tension Limitations

Cable pulling tension limitations are as follows:

a) The maximum pulling tension must not exceed the rated working load for winch ropes (i.e., 6,500 pounds for 7/16-inch non-rotating wire ropes).

b) The cable pulling tension must not exceed the maximum allowable pulling tension [T(max)] for the specific cable being placed. When manufacturer installed cable pulling-in eyes or core hitches are used, this value is determined by the maximum allowable pulling tension per cross sectional area of the pairs used to make up the pulling eye or core hitch; it can be calculated by using the following equation:

$$T(max) = .6nAk \qquad (6)$$

Where:

N = The number of conductors in the cable,

A = The cross-sectional area of a conductor in circular mils and

K = The allowable tension per conductor. For copper, k equals 0.008 pounds per circular mil.

Commentary Note:

Table 7 attached to this document provides conductor cross-sectional areas (A) by conductor gauge.

4. Cable Pulling Tension Calculations

a) Straight and Curved Conduit Sections

Two equations are used to determine telecommunications cable pulling tensions. Equation (a) is used for straight conduit sections and equation (b) is used for curved conduit sections. The equations are as follows:

$$T = T(o) + Lwf \qquad (a) \quad (7a)$$

$$T = wR\sinh\left(\frac{fL}{R} + \frac{\sinh(-1)T(o)}{wR}\right) \quad \text{(b)} \quad \text{(7b)}$$

Where:

T = Pulling tension on cable in pounds

T(o) = Holdback tension at reel end in pounds (see Note below)

L = Section length in feet.

W = Cable weight in pounds per foot.

F = Coefficient of friction (see Table 6)

R = Radius of the bend in feet.

***Notes**: The value of T(o) will never be zero. Typically, 200 pounds should be used.*

Equation (b) requires the use of a calculator with hyperbolic functions.

b) Side Wall Bearing Pressure

In addition to the above calculations, when curved sections are involved, it is necessary to calculate the cable bearing pressure [P(B)] against the side wall of the conduit. Side wall bearing pressure shall not be permitted to exceed 150 pounds per foot. This applies to lateral conduits as well as main conduits. The equation for calculating the side wall bearing pressure is as follows:

$$P(B) = \frac{T}{R} \quad \text{(8)}$$

Where:

T = Pulling tension in pounds (at the end of the curve nearest the pulling equipment).

R = Radius of the involved curve in feet.

P(B) = Side wall bearing pressure in pounds per foot.

5. Use of Wire Mesh Grips

When wire mesh cable grips (e.g., Kellems grips) are used, the pulling tension on cables must not exceed 75% of the maximum pulling tension limits specified by the cable manufacturer and specified specifically for wire mesh grips. Table 8 of this standard lists pulling tension limits which were provided by ESSEX GROUP INC. for ESSEX manufactured cables, when wire mesh cable grips are used. Listed in Table 8, also, are the 75% limits for these cables.

6. Reel Length Limitations

Refer to Table 4 for more information to calculate cable reel capacities.

7. Further Considerations

a) Cable Reel Set-Up Location

For cable pulls involving conduit curves or bends, the direction of the pull is important. Normally, the cable set up location (cable reel location) should be at the end closer to the bend. This is especially important when there is an offset, since bearing pressures can rise quickly.

b) Do Not Exceed 85% of T(max)

Do not design long conduit sections or cable pulls, which would result in cable pulling tensions, that would be close to 85% of T(max), which is the value of the cable's maximum pulling tension as calculated per Paragraph 5.1.3.12.3 above.

c) Uphill Cable Pulls

Avoid uphill cable pulls when practical. Avoid long cable pulls (more than one conduit section) also when sharp dips or humps would be encountered.

d) Curved Sections

In designing curved sections, continuous lengths of straight individual plastic conduit can be formed into shallow curves if a curvature radius of minimum 6 m (20 ft) or more is used.

8. Planning Cable Pulls

So that the cable pull can be planned and made as efficiently as possible, the following information shall be provided on the construction drawings:

a) Total pull length.

b) Cable reel set up location.

c) Direction of pull.

d) Pull Locations.

e) Final pulling tension, when the limits of Table 4 are exceeded.

f) Side wall bearing pressure for curves/bends, when the limits of Table 4 are exceeded.

Commentary Note:

This paragraph does not apply to short (less than 80 meters) isolated conduit sections placed in buried cable routes.

5.1.4 Conduit Type and Accessories

1. Regular PVC Conduit

All new and rebuilt Saudi Aramco telecommunication conduit systems shall use NEMA TC 8, Type DB or EB single bore, plastic (PVC) conduit. Main and lateral conduit sections shall be 4 inches inside diameter.

2. Split PVC Conduit

Split conduit installations shall be used to repair existing conduits which contain existing cables. These conduits are ready made and shall be installed in accordance with the manufacturer's recommendations or NEMA TCB2, "User's Manual for the Installation of Underground Plastic Conduit".

3. Conduit Bends and Sweeps

Conduit bends or sweeps used in telecommunications conduit systems built with NEMA TC 8 conduits shall comply with the specification requirements of NEMA TC 9.

4. Markings for Conduit Materials

Each conduit section is 6m (20 ft) long shall be marked as required by NEMA TC 8.

5. PVC Bends, Couplings and Fittings

Plastic conduit bends, couplings and fittings shall be marked as required by NEMA TC 9.

6. Galvanized Steel Pipe

For Saudi Aramco telecommunication outside plant conduit system purposes, galvanized (hot dipped, minimum) steel, PVC coated conduit may be used. Some conditions which may warrant consideration of the use of galvanized steel pipe are as follows:

a) When the vertical space available for conduits is limited.

b) Conduit will be subjected to impact loads from heavy traffic.

c) The pipe is to be placed by means of a pipe pusher.

d) When placing exposed conduit runs on pipe racks.

e) Proper grounding & bonding.

7. Lateral Conduit Materials

Lateral conduit shall be NEMA TC 8, Type DB single bore, plastic (PVC).

8. Pull Rope Requirements

The design and installation of conduit shall include pull rope (size ¼ inches) in all conduits.

9. Conduit Spacers

It is recommended that manufactured plastic spacers be used. Typically, spacers are placed 1.5 to 2.4 meters (5-8 feet) apart. Conduit spacers providing a minimum of 38 mm separation between conduits must be used in all concrete encased conduit sections.

5.1.5 Handling and Storage of Conduit Materials

Handling and Storage of NEMA TC 8 conduits and NEMA TC 9 accessories shall be according to the manufacturers' direction or

NEMA TCB2, "Users Manual for the Installation of Underground Plastic Conduit."

1. UV Discoloration

   Conduit sections which have become discolored because of prolonged exposure to sunlight/ultraviolet rays (UV) shall not be used in telecommunication conduit systems.

2. PVC Conduit Exposed to Sunlight

   When plastic (PVC) conduit is used above ground in areas where it would be exposed to sunlight, it must be a type that is resistant to ultraviolet rays, or be treated as outlined below (refer to SAES-L-610):

   a) Clean the conduit surface, so that it is free from oil, grease, dirt, etc.

   b) Abrade the conduit with medium to coarse grade sandpaper before the coating application.

   c) Apply two coats of exterior grade, water based acrylic latex paint. Since acrylic is being used, a primer base is not required. The paint color shall be either white with orange stripes or light orange. The color orange will indicate that the conduit contains telecommunications facilities.

5.1.6 Underground Entrances to Central Office Buildings

This section covers the design and installation of the basic types of underground cable entrances to telecommunications/central office buildings of various sizes.

1. Cable Racking Plan

   Conduits entering a telecommunications/central office building or cable vault shall be laid out so that they coincide with the cable racking plan for the office.

   Commentary Notes:

   Cables lay out shall utilize conduits from a bottom-up, left-right basis configuration.

2. Design for Cable Vault Entrance Flexibility

   The central office building conduit entrance shall be designed to provide full flexibility in carrying a cable from any entering conduit to any frame position without the need for crossovers or rearrangements in MHs outside the building.

3. Entrance from Opposite Side of Street

The most desirable arrangement for a conduit entrance results when the conduit run is located on the side of the street opposite the central office building. Under this condition, the conduits from both directions may be turned into the front wall of the cable vault with large (15 m and larger) radius curves or sweeps.

4. Entrance from Same Side of Street

If the conduit run is on the same side of the street as the central office building and bends of an adequate radius are not possible, the cable vault should be extended under the sidewalk, grass plot, etc., and the conduits brought into the side walls of the cable vault.

5. Provide Ultimate Conduits Initially

The ultimate number of conduits (to be determined/approved in writing by the Saudi Aramco Communications Engineering Division of IT, required to provide for the estimated ultimate capacity of the telecommunications/central office building shall be installed in the vault wall initially. As a minimum, these conduits must extend out from the office to a sufficient distance to ensure that the conduit approach will not be blocked by foreign substructures that may be placed at a later date. Consideration must be given to initially placing any portion of the conduit run which may cross the street or road.

6. Entrance Conduit Grade or Slope

The grade or slope of central office building entrance conduits shall be away from the building (minimum of 25 mm per 30 m).

7. Conduit Terminators at CO Entrance

Conduit terminators shall be used in concrete building walls to construct conduit underground entrances to telecommunication and central office buildings.

8. C.O. Entrance Conduits

All telecommunications/central office buildings shall be provided with a minimum of six (6) underground (4 in) conduit entrance for connecting outside plant cables. A pulling-in iron shall be placed in the roof of the building, directly over the conduit entrance for CO without cable vault. If the number of conduits equal or exceeds nine (9), a cable vault or C.O. MH shall be provided.

9. Vertical Cable Entrance Splices

Vertical cable entrance splices will only be permitted in small telecommunication buildings which require six (6) or less entrance conduits. Provision for horizontal racking of entrance cables and splices shall be made in all larger telecommunication buildings.

10. Two Reverse Bends Exception

A central office building entrance may be used in offices with ultimate requirements of no more than nine entrance conduits. When this type conduit entrance is used, a door, pull hole or pulling-in iron must be placed in the building wall opposite the conduit entrance wall to accommodate cable placement. Provision shall be made for horizontal racking of cables and splices.

5.2 Spaces/ Maintenance Hole

5.2.1 Maintenance Hole (MH)

This section covers the requirements to be followed in the design of MH installed in telecommunication underground conduit pathway systems.

MH is considered a confined space.

5.2.2 MHs Standard Sizes

All MHs shall be designed (sized) to provide sufficient and suitable space for cables and associated equipment which will be installed during the life of the MH. MHs in conduit systems near the central office shall be designed to provide conduit space for the ultimate size of the central office. All MHs shall be designed and constructed to:

a) Support the heaviest anticipated traffic weight (see also SAES-Q-006, Paragraph 4 and ANSI C2, NESC, Section 323),

b) Provide sufficient racking space for the ultimate number of cables and other equipment that will be placed in the MH.

c) Be reasonably watertight

d) MH design requirements are based on the ultimate number of main conduits that can reasonably be expected to enter the new MH on any one wall.

5.2.3 Cable Rack Installation

MH cable racks shall be spaced at a maximum separation of 840 mm. In all cases, space shall be provided to adequately rack and support the ultimate (for feeder route) cables and splice closures and to make cables turns when required. This includes allowing for a minimum straight section length of cable beyond the end of the splice closure of 150 mm. Additional cable racks must be required to support splice closures.

5.2.4 Watertight Requirements

New and rebuilt MHs shall be designed to be watertight. Refer to SAES-Q-001, "Criteria for Design and Construction of Concrete Structures" and 09-SAMSS-097, "Ready-Mixed Portland Cement Concrete."

5.2.5 Cover Required Above MH Roofs

New MHs constructed in vehicular traffic areas shall have a minimum depth of cover of 355 mm. Additional cover may be required in areas where deep (more than 100 mm) road grading is anticipated in the future.

5.2.6 Traffic Loads

All MHs (poured-in-place or precast) shall be designed and constructed to meet the heaviest traffic load conditions anticipated (as a minimum, meet the same traffic load requirements as the road or highway in which it is placed). Refer to SAES-L-460 and SAES-Q-006.

Below table provides rating information.

This rating…	**is used for…**
Light duty	Pedestrian traffic only
H-5	Sidewalk applications and occasional no deliberate traffic
H-10	Driveways, parking lots, and off-road application subject to occasional non deliberate heavy vehicles
H-20	Deliberate heavy vehicular traffic
H-40	Deliberate extremely heavy vehicular traffic

Note: The suffix denotes the ability to withstand a gross vehicle weight rating (GVWR) in tons (e.g., H-5 represents 5000 kilograms (kg [13,396 pounds (lbs)]).

5.2.7 Locating MHs

1. Tie down MH Location on Drawings

The specific location for each MH shall be indicated on the work drawings (see Paragraph 4.12).

2. At Street Intersections

MHs shall be located at junction points that permit installation of main, branch and lateral conduits with minimum bending. (see paragraph 5.1.3.5). Locate MHs just short of or just beyond street intersections to provide:

a) As little public inconvenience and traffic interference as possible,

b) A good safe set up position for cable construction and maintenance forces.

3. Hydrocarbon, Explosive Toxic and Power Lines

WARNING: Fuel (including petroleum, hydrocarbons, petrochemical products) or any other toxic or explosive products or chemical lines shall never, under any circumstances, be permitted to pass through telecommunication MHs. Electrical cables or facilities shall not be permitted inside any telecommunications MH. MHs shall be located so as to avoid these facilities.

4. Loading Cables into MHs

Cable loading point MHs shall be located as near the theoretical loading points as practical.

5. Classified or Hazardous Areas

MHs shall not be located in classified or hazardous areas (see SAES-B-068) or in other areas where prohibited by SAES-B-008 or SAES-B-064. Close contact and coordination shall be maintained at all times with plant area, oil production and processing proponents, when doing designs and installations in their areas.

a) Applicable Standards

When designing or constructing conduit and MH systems in or near hydrocarbon facilities or other classified/hazardous facilities the engineer must be familiar with the following standards and directives, but not limited to:

NEC	*National Electrical Code, Article 500*
NESC	*National Electrical Safety Code, Sec. 127*
NFC	*National Fire Codes, Volume 14*
SSD/12	*Communications*
SSD/26	*Blast Resistant Control Rooms*
SAES-B-006	*Fireproofing in Onshore Facilities*
SAES-B-008	*Restrictions to Use of Cellars, Pits and Trenches*
SAES-B-064	*Onshore and Nearshore Pipeline Safety*
SAES-B-068	*Electrical Area Classification*

b) Classified Area Drawings

When doing conduit system designs in hazardous environments, (i.e., plant areas, refineries, NGL's, GOSP's, etc.) drawings showing the locations and dimensions of classified areas, shall be provided as a part of all telecommunication Project Proposals and construction work packages.

5.2.8 Standard MH Types and Sizes

5.2.8.1 MH Standards and Specifications

MHs may be either a field constructed (poured in place) type or, where available and approved, precast concrete type. All MH constructions shall comply with SAES-Q-001, "Criteria for Design and Construction of Concrete Structures," Precast concrete shall also comply with SAES-Q-012, "Criteria for Design and Construction of Precast and Prestressed Concrete Structures." Non-Standard Telecommunication MH (hand hole, service hole, splice chamber, etc.) designs shall be presented in the Standard Drawing format to the Saudi Aramco Communications Standards Committee Chairman for review and approval, prior to being constructed.

5.2.8.2 Excavations for Pre-Cast MHs

Excavations for precast MHs must provide a minimum clearance of 205 mm between the exterior wall surfaces (ends and sides) of the MH and the surfaces of the walls of the excavation. A minimum of 100 mm of sand or other base material shall be placed in the bottom of the excavation and compacted and graded to level prior to placement of a precast MH. The final MH position must meet road grade, conduit entrance, MH collar and frame and cover grade requirements. Equipment used to place precast MHs must have sufficient weight handling capacity for the extreme weight and size MH being placed.

5.2.8.3 Setting Pre-Cast MHs

When precast MHs are being lowered into the prepared excavation, workmen shall not be permitted to be in the excavation or under the MH as it is moved.

5.2.8.4 Main Line MHs

All main line MHs for Saudi Aramco telecommunications facilities shall be design and constructed to meet traffic load as follow:

1. MH Standard Sizes

The standard MH sizes shall follow:

a) For MHs traffic load design, per paragraph 5.2.6, using H-20 (up to 20 Tones): Saudi Aramco Standard Engineering Drawing No. AA-036794 (Sheet 2), “Standard Communication MHs,” MH Type-1. The dimensions for Type-1 MHs are in terms of (Length x width x headroom):

Type (1-A); 2.75 m x 1.85 m x 2.0 m

Type (1-B); 3.1 m x 1.85 m x 2.0 m

b) For MHs traffic load design, per paragraph 5.2.6, using H-20 (up to 20 Tones): Saudi Aramco Standard Engineering Drawing No. AA-036794 (Sheet 3), “Standard Communications MHs,” MH Type 2. The dimensions for Type 2 MHs are:

Type (2-A); 3.5 m x 2.5 m x 2.0 m

Type (2-B); 3.9 m x 2.5 m x 2.3 m

c) For MHs traffic load design, per paragraph 5.2.6, using H-40 (up to 40 Tones): Saudi Aramco Standard Engineering Drawing No. AA-036140 (Sheet 2), "Standard Communication MHs," MH Type-1. The dimensions for Type-1 MHs are in terms of (Length x width x headroom):

Type (1-A); 2.75 m x 1.85 m x 2.0 m

Type (1-B); 3.1 m x 1.85 m x 2.0 m

d) For MHs traffic load design, per paragraph 5.2.6, using H-40 (up to 40 Tones): Saudi Aramco Standard Engineering Drawing No. AA-036140 (Sheet 3), "Standard Communications MHs," MH Type 2. The dimensions for Type 2 MHs are:

Type (2-A); 3.5 m x 2.5 m x 2.0 m

Type (2-B); 3.9 m x 2.5 m x 2.3 m

2. Increasing MH Conduit Capacity

The maximum number of main conduits entering the end walls of each of these MHs may be increased, where necessary, by increasing the MH depth (headroom).

3. Design for Cable Turns Outside MH

Conduit systems are to be designed so that cable turns can be made outside the MH with conduit sweeps (i.e., in main conduits and laterals out the end of MH) rather than inside a MH.

4. Housing Load Coils

Line MHs may also be used to house a minimum number of load coil cases if the number of loaded cable complements in the run is insufficient to justify the construction of a loading type MH. When the number and size of load coil cases to be installed are small, they may be located in corners, attached to side walls, or placed on the end walls of the MH, above or below the cables as space permits.

5. MH Conduit Entrances

MH conduit entrances shall be:

a) Splayed conduit configurations.

b) Made with conduit terminators or conduit end bells. Conduit terminators or end bells shall be cast (encased) in the MH walls at the time the concrete is installed.

c) Constructed with full 20 feet conduit sections for a minimum distance of 12 m from the MH/CO entrance. If it is necessary to use shorter lengths (less than full 20 feet sections) of conduit, they must be installed more than 40 feet away from the MH/CO wall on undisturbed soil.

d) Installed so that conduits are separated from each other, both horizontally and vertically, a minimum of 50 mm in the MH or central office wall.

e) Installed so that the nearest side of the MH main entrance conduits are located 150 mm from the inside surface of the adjacent MH wall (side wall).

5.2.8.5 MH Access Openings

1. Applicable Standards and Specifications

MH access openings and working space shall comply with the requirements of the ANSI C2 NESC (National Electrical Safety Code). MH frames and covers shall comply with the requirements of SASO Standard, SSA 413, and "Cast Iron MH Covers."

2. Roof Opening and Neck

The MH roof opening and neck shall be constructed to accommodate the inside base measurements of the standard MH frame and cover. Each frame, with which the manhole is equipped, shall be positioned so that its opening is centered with the opening in the manhole roof and supported by one of the following methods:

a) A brick collar or tapered neck

b) Precast concrete grade ring

c) Precast concrete manhole collars

3. Minimum Opening

The minimum opening for Saudi Aramco telecommunication MHs shall be 30 inches (Type B 30 inch frame and cover; SAP Stock number 1000-077-854). All telecommunication MH covers shall be Type B, 30 inch frames and covers and shall have an identifying mark, "TELEPHONE or TELECOMM," stamped in the cover to indicate ownership. MH cover shall be painted in orange color.

4. Clearance from Railroads

The surface opening of a MH shall have a clearance of not less than 10 m from the nearest rail of any type of railroad unless greater clearance is required by the railroad proponent (refer to SAES-T-906).

5. Location in MH Roof

Each MH frame and cover shall be supported and centered over the MH opening with a collar of a minimum of 100 mm height. The top surface of the frame and cover shall be even with the final grade. Cement mortar used for construction of the collar must conform to the requirements of SAES-M-100, "Saudi Aramco Building Code."

The MH opening must be located over the center of the MH, except:

Exception:

In MHs more than 3 m long one opening must be provided for each 2.5 m or fraction thereof. The minimum distance between the openings must be ½ the width of the MH or an appropriate sized steel support beam will be required.

5.2.8.6 Provision for Cable Racking

1. Maximum Change in Level

Changes in the level of main cables passing through MHs shall be kept to a minimum, and shall not exceed 230 mm.

2. Minimum Bending Radius

MHs shall be constructed so as to permit plastic sheath cables to maintain a minimum bending radius of 10 times the cable diameter.

3. Minimum Spacing between Cables and MH Ceiling

A minimum space of 380 mm shall be maintained in all MHs between the roof of the MH and the center of the top main cable position for racking load coil case cable stubs and/or lateral cables. A minimum of 535 mm shall be used if load coil case cable stubs or lateral cables are to be spliced into the top racked cable.

4. Minimum Space between Cables and MH Floor

A minimum space of 380 mm shall be maintained between the MH floor and the center of the bottom main cable.

5. Minimum Headroom

The minimum headroom for telecommunication MHs shall be 2.00 meters.

6. Double Racking Cables

Double racking of cables is used with staggered splices to obtain maximum use of available MH wall space. No more than two cables may be racked side by side at any racking level.

7. Supporting Cables and Splices

Cables and completed splices in MHs shall be supported with cable rack hooks at each cable rack location. Auxiliary support shall be provided for small cables, which sag between cable racks.

5.2.8.7 MH Hardware

All MH hardware must be of the non-corrosive type (i.e., hot dipped galvanized or better).

1. Inserts

At the time a MH is constructed, non-metallic concrete inserts shall be placed in the walls to provide a means for attachment of the ultimate number of cable rack supports, brackets and any other surface-mounted equipment.

2. Cable Racks

Each MH is to be fully equipped with cable racks and rack supports at the time of construction. Cable racks are to be spaced at a maximum distance of 838 mm and as illustrated in standard MH drawing (AA-036794, Sheets 1-4). The distance from the inside surface of the MH wall to the first cable rack shall be 760 mm or less.

3. Rack Supports

Cable rack supports (S-cable rack support for line MHs and L-cable rack supports for loading MHs and other special situation MHs) must be placed at the time of MH construction. Cable rack supports must be secured to the MH walls by means of ½ by 2½ inch corrosion protected (hot dipped galvanized, stainless steel, etc.) machine bolts screwed into concrete inserts that have been cast in place. The top cable rack support (type S or L) concrete insert is to be located 230 mm below the MH roof.

4. I-Beam Uprights

I - Beam uprights (3-inch, 5.7-pound) must be placed (extending between the MH floor and roof), in center-rack MHs, to provide mounting cable racks support.

5. Pulling-In Irons

A minimum of two pulling-in iron (one at the top and one at the bottom of the windows) shall be casted in concrete in the MH wall opposite all MH conduit entrances (windows). The pulling-in iron must extend far enough into the MH to provide a minimum clear opening of 75 mm. Locate pulling-in irons 150-300 mm below the conduits with which they are associated and in line with the centerline of the conduits. Pulling-in irons shall not be placed closer than 150 mm to any MH entrance window. Pulling-in irons shall not be allowed to bear against the outside face of the MH wall (come in contact with earth), but must have adequate cover of concrete in accordance with SAES-Q-001. Pulling-in irons shall be placed during the fabrication stage (before concrete is poured).

6. Frames and Covers

All MHs frame & covers shall meet the specification of SAP Stock number 1000-077-854. The MH shall be equipped with MH frames and covers with minimum openings of 30 in. All areas subject to vehicular traffic shall use minimum of Type B, (10 in high) frames and covers. Each MH frame and cover shall be equipped with two locking bolts located approximately 180 degrees apart on the cover's circumference. See paragraph 5.2.8.5 above also.

7. Ladders and Steps

Hot dipped galvanized (minimum) steel MH ladders shall be installed in all newly constructed MHs, including service MH. MH ladder side rails are 5 mm thick and spaced 300 mm (12 inches) apart, measured from inside surfaces. Its rungs have a 5/8 inch diameter; the rungs are spaced 12 inches apart. A MH step formed from ¾ -inch diameter steel rod of hot-dipped galvanized is to be set in the roof opening of all MHs (with standard 4 inch depth collar) to provide a support for the ladder. An additional step shall be placed for each additional (more than 4 inch standard) 305 mm of neck depth.

8. MH Adjusting Rings

MH adjusting rings may be used to adjust the grade of MH covers of existing MHs in projects which involve the resurfacing of streets, that will raise the street grade by 2 to 3 inches. A MH adjusting ring shall not be used if any portion of the ring will remain exposed above the finished grade.

9 MH Sumps

A sump hole must be designed and sized in accordance with Standard Drawing AA-036794.

Manufactured sumps, such as produced by Condux International Inc. and Pennsylvania Insert Corporation or equivalent may be used in telecommunication MHs.

Sewer pipe may also be used in MHs to construct sump holes.

10 Conduit Terminators

All MHs shall be constructed with conduit terminators being placed to provide conduit termination space for the ultimate number of conduits that the MH can serve.

11. Non-Metallic Hardware

In corrosive areas or other areas where appropriate, the non-metallic MH products of Underground Devices, Inc. (or equivalent) may be used.

5.2.8.8 Bonding and Grounding Requirements

1. MH Ground Electrodes

A ground electrode which provides a ground resistance of 25 ohms or less shall be provided in each MH along with the necessary bonding ribbon and/or wire (minimum of #6 AWG tinned solid copper). For ground electrode design references, see SAES-T-887. Where a ground rod is used as the electrode, it shall consist of a minimum of one ground rod which is a minimum of 5/8 inches in diameter by 10 feet in length. The ground rod shall be installed outside the MH (100-150 mm) from the finished ground level, with a minimum outside horizontal clearance of 150 mm from the MH sidewall. A minimum of two (2) ground rods shall be installed at opposite side of the MH end walls and connected inside the MH with a bonding ribbon and/or wire (minimum of #6 AWG tinned solid copper). Refer to AA-036794.

2. More than One Ground Rod Required

The second ground rod is required to obtain the required minimum ground resistance; it shall be driven in the MH corner diagonally opposite to the first ground rod. If calculations indicate that a minimum of 25 ohms ground resistance cannot be obtained with two ground rods other design action must be taken to assure a minimum of 25 ohms ground resistance.

5.2.8.9 Assign MH ID Numbers

All new MHs shall be assigned an identification number and have the MH identification number:

a) Stenciled in the exterior rim of the frame, using ½ inch numbers/letters

b) Centered evenly between the inner and outer edges of the rim, in the portion of the rim nearest the curb or roadside.

5.2.8.10 Service Maintenance Hole (SMH)

SMHs are designed for use as splicing or pulling points in conduit laterals, where at least two main conduits (one conduit for cable and subducts and one conduit for maintenance/repair) but not more than six main conduits will ultimately be required. If more than six main conduits are required, an in-line MH types shall be placed. It shall permit cable racking on one wall only. Conduit entrances into service MHs will be permitted through end walls only.

SMH Standard Size and Types

The standard SMH size shall follow:

a) For SMHs traffic load design, per paragraph 5.2.6, using H-20 (up to 20 Tones): Saudi Aramco Standard Engineering Drawing No. AA-036794 (Sheet 1), "Standard Communication SMHs." The SMH inside dimensions are in terms of (Length x width x headroom) is 1.838 m x 1.500 m x 2.000 m.

b) For MHs traffic load design, per paragraph 5.2.6, using H-40 (up to 40 Tones): Saudi Aramco Standard Engineering Drawing No. AA-036140 (Sheet 1), "Standard Communications SMHs." The SMH inside dimensions are in terms of (Length x width x headroom) is 1.838 m x 1.500 m x 2.000 m.

5.2.8.11 Cable Vault

1. Cable Vault Requirements

Large telecommunications/central office buildings (more than nine main entrance conduits required) require the construction of cable vaults. The cable vault is to be reserved for the entrance of telecommunication outside plant cables and as the interface point between outside and inside type cables.

2. Seal from Rest of Building

The cable vault is to be set apart from the rest of the building by fire walls or floors to provide protection against gas entry, fire and/or mechanical damage.

3. Pulling-In Irons

At the time the cable vault is constructed, two pulling-in irons shall be placed in the cable vault wall located opposite each conduit entrance window (i.e., 4 pulling-in irons for each conduit window). One pulling-in iron shall be located in approximate alignment with the top conduits and the other in approximate alignment with the bottom conduits of the window they serve.

4. Lighting, Outlets and Ventilation

The cable vault must provide sufficient working space for all phases of cable placement and splicing operations. Ventilation, (in accordance with SAES-K-003) adequate lighting arrangements, and conveniently located utility outlets must be provided [in accordance with the SAES-P-Series and the ANSI/NFPA 70, National Electrical Code (NEC)].

5. Headroom

The required headroom of a cable vault or central office MH may vary; however, the minimum headroom shall not be less than 2 meters.

6. Splayed Conduit Entrance

Horizontally splayed central office building cable vault entrance conduits, of a maximum of two conduits width per rack side, shall be provided. The entrance conduits shall also be splayed vertically, so as to locate the conduits so that cables may enter at the levels of their respective cable rack hooks.

7. Vault Locations Prohibited

Telecommunication/central office buildings with cable vaults shall not be located in any area where they are prohibited by SAES-B-008.

8. Vault Atmospheric Monitoring and Testing

All cable vaults shall be equipped with approved, permanently installed and maintained atmospheric monitoring and testing devices with alarms located at a manned point/s.

9. Cable Vault Length

The cable vault, as a minimum, must extend the full length of the ultimate Main Distributing Frame (MDF) plus whatever additional space that may be required for cable racking and splicing. The cable vault shall be large enough to accommodate the ultimate number of building outside plant entrance cables, racking and splicing needs, etc.

10. MDF Location in Relation to Cable Vault

Locate the central office MDF (Main Distribution Frame) and CO protection verticals over the cable vault so that tip cables or connector/protector stubs can descend from the MDF to the cable vault with little or no bending.

11. Cable Holes - Vault to MDF

Cable holes must be provided to extend cable from the cable vault to the MDF. Holes must be 4 inches in diameter, on 8-inch centers and located under the MDF vertical which the hole will serve.

All holes between cable vaults and the rest of telecommunications/central office building shall be fire stopped (sealed) in accordance with the ANSI/NFPA 70, NEC (National Electrical Code) and 18-SAMSS-493.

12. Materials for Cable Vaults

All metallic hardware used in telecommunication cable vaults shall be hot dipped galvanized or better.

13. Steelworks and Structures

Design and installation of concrete structures, including steel work and reinforcement of central office cable vaults and MHs, shall comply with SAES-Q-001, "Criteria for Design and Construction of Concrete Structures," 09-SAMSS-088, "Aggregates for Concrete," 09-SAMSS-097, "Ready-Mixed Portland Cement Concrete."

14 Building Structure

Construction of Telecommunication/central office buildings shall comply with all Saudi Aramco applicable standards, including:

SAES-B-014	*Safety Requirements for Plant and Operations Support Buildings*
SAES-M-100	*Saudi Aramco Building Code*
SAES-K-003	*Air Conditioning for Communications Buildings*
SAES-O-100	*General Requirements - Safety and Security*
SAES-O-109	*Buildings Housing Sensitive or Vital Equipment*

15. Vault Cable Racks

Cable rack installations in cable vaults shall comply with the manufacturer's directions.

16. Cable Entrance Ground Bar (CEGB)

A Cable Entrance Ground Bar (CEGB) must be installed in each cable vault and connected to the Master Ground Bar (MGB) in accordance with SAES-T-795.

5.2.8.12 CEV (Controlled Environmental Vaults)

A CEV is an underground chamber that houses electronic equipment, which requires a controlled environment. When a CEV is designed or installed, it must be equipped with:

- Air conditioning,
- Electric heater,

- Sump pump,
- Dehumidifier,
- Ventilation blower,
- Florescent lights,
- Atmospheric monitoring and testing devices, and an intrusion alarm, all of which permit monitoring of the CEV from a manned site.

During construction and power outages, the normal MH safety requirements, precautions and pre-entry tests must be observed (see SAES-T-603 and SAES-T-628).

6 Installation

All Saudi Aramco telecommunication conduit systems shall be designed and installed in accordance with this standard and other applicable standards as referenced in this standard (See Paragraph 3 above). Installation methods shall be in accordance with the "Saudi Aramco Construction Safety Manual" and other applicable safety requirements (see paragraph 4.9).

7 Testing and Inspection

7.1 Inspection Requirements

7.1.1 The testing and acceptance of telecommunication OSP conduit pathways and spaces shall be done in accordance with SAES-T-911. Quality assurance inspections shall be performed during all phases of construction by Saudi Aramco Inspection Department Inspector.

7.1.2 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.

7.1.3 As Built Drawings

All record items and record measurements shall be verified and shown on the "As Built Drawings." As-Built drawings shall be provided to and approved by the Saudi Aramco Communications Engineering Division of IT before the Mechanical Completion Certificate (MCC) is approved.

7.1.4 Trench Backfilling

Concrete encasement and trench backfilling operations shall not be carried out until the installation has been reviewed by the appropriate Saudi Aramco Inspection Department inspector.

7.2 Precast MHs Inspection

All precast MHs shall be inspected by the Saudi Aramco Inspection Department during fabrication and construction, and prior to being placed in the ground to verify compliance with Saudi Aramco standards. The contractor shall provide 14 working days (Saudi Aramco work days) written notice prior to casting telecommunications MHs to allow Saudi Aramco sufficient time to exercise their right to inspect.

7.3 Mandrel Tests

Each conduit (main and lateral) in telecommunication conduit systems must pass the mandrel test as specified below. A Saudi Aramco communications inspector must be present during mandrel tests.

7.3.1 All Conduits

Before concrete encasement and again after concrete encasement, and before doing any paving work over the conduits:

a) Each new conduit must be cleaned and tested (in both directions) with the appropriate size test mandrel. Nominal Four inch inside diameter conduits must pass a 3-⅝ inch diameter x 12 inch length mandrel. (Refer to NEMA TCB2, P-11, this mandrel will pass through straight sections and curved sections with 20 feet minimum radius).

b) Wooden mandrels must have a round, 3-⅝ inch diameter, square edged steel plate or cap on each end of the mandrel.

7.3.2 Conduit Lateral Test Differences

Tests for lateral conduits are the same as for main conduits, except that the length of the mandrel may be 6-3/16 inches (for 4 inch ID Conduits) if the lateral contains bends with radii between 915 mm (minimum permitted) and 6 m.

7.3.3 Mandrel Tests for Existing Conduits

Existing conduits in which cables are to be placed shall be tested with an appropriate size mandrel as required by SAES-T-628.

7.3.4 Field Fabricated Mandrels

Field fabricated (made outside work- shops where the necessary tools are available) mandrels will not be acceptable. Mandrels, which are fabricated locally in work-shops, must be reviewed during fabrication and approved by the Saudi Aramco, Inspection Department, Communications Inspector.

7.3.5 Mandrel Test, Pass-Fail Requirements

A conduit passes the mandrel test if the test mandrel passes through the entire length of the conduit without:

1. Hanging up (stops momentarily but can be restarted by flipping pull rope, etc.) or

   Commentary Notes:

   a) If the mandrel hangs up on the first pass, the conduit must be mandrel tested a second time in the same direction. If the mandrel hangs up on the second pass, the conduit fails the mandrel test.

   b) If the mandrel does not hang up on the second pass, the Saudi Aramco telecommunications inspector may require a third test. If the mandrel passes without hanging up on the third pass, this point passes the mandrel test.

2. Stopping (mandrel hangs up and will not pass further through the conduit).

7.3.6 Failed Mandrel Tests

1. Replace or Repair

   Excavate and replace or repair any conduit that does not pass the mandrel test. A conduit that does not pass the test mandrel:

   - Is mis-aligned or deformed,
   - Contains a curve with a radius of 6 m or less, or
   - Is obstructed in some other way.

2. Re-test Replaced or Repaired Conduits

   Replaced or repaired conduits and other conduits that were disturbed during the repair operation must be re-tested with and pass the appropriate test mandrel.

	Revision Summary
28 June 2009	Major revision.
24 January 2010	Minor revision: Reference new SAED that can withstand 40 tons truck in heavy traffic areas. Provide more clarification on paragraph 5.2.8.5 related to positioning the MH opining. Update MH standard sizes.
3 November 2010	Clarify the post marker requirement and remove committee member list.
15 January 2011	Clarification for pipelines crossing and lineup maintenance hole sizes with SAED.
21 May 2012	Editorial revision to change the primary contact.

Appendices

Table 1 – Maximum Lateral Conduit Lengths [1]

Limiting Lengths of Lateral Conduits in Meters				
Cable Diameter	**Bends**			**Minimum Diameter of Conduit**
In Inches	**No 90 Deg**	**1-90 Deg [2]**	**2-90 Deg [2]**	
Up to 1	275	135	23	4.0
1.01-1.20	230	137	30	4.0
1.21-1.40	183	96	36	4.0
1.41-1.60	160	76	29	4.0
1.61-1.80	137	53	21	4.0
1.81-1.99	114	41	17	4.0
2.00-2.61	91	29	12	4.0
2.62-2.96	91	20	9	4.0

Assumes:
- T(o) = 100 lbs
- Clean Conduits
- Cables well lubricated
- All cable conductors are tied into cable pulling eye or core hitch

Notes: (1) See Paragraph 5.1.2.
(2) Assumes 90 degree bends are located at opposite ends of lateral conduits.

Table 2 – Minimum Separation Chart

	Buried Telecommunication Cables	
Between	**Parallel**	**Crossing**
Buried Power	300 mm of well-tamped soil, 75 mm of concrete, or 100 mm of masonry	300 mm of well-tamped soil, 75 mm of concrete, or 100 mm of masonry
Water and Sewer Lines; CATV & Instrumentation Cables, etc.	300 mm	150 mm clearance with supports on each side of crossing under
Oil Field Pipelines Outside Of Plant Areas and pipeline corridors has been established	1. Telecommunications service point (maintenance hole, pedestal, buried splice, etc.) shall not be closer than 25 m to any pipeline in the corridor. 2. Parallel separation for cables in pipeline corridors will be per proponent approval via land use permits. 3. Telecommunication cables should not be placed in the same trench with the pipeline	1. 1000 mm below in concrete encased conduit 2. Telecommunications cables shall not be closer than 5 m to any pipeline when crossing roads, streets, wadi and railroads.
Oil Field Pipelines Outside Of Plant Areas and pipeline corridors has NOT been established	1. Telecommunication cables shall not be closer than 5 m to any Pipeline 2. Telecommunication cables should not be placed in the same trench with the pipeline	3. 1000 mm below in concrete encased conduit 4. Telecommunications cables shall not be closer than 5 m to any pipeline when crossing roads, streets, wadi and railroads. 5. Telecommunication cables shall be placed in concrete encased conduits that extend for a minimum distance of ten meters on each side of the pipeline.
Oil Pipelines (Inside of Plant Areas)	300 mm minimum of well tamped soil	300 mm minimum of well tamped soil

Table 3 – Separations from Telecommunication MHs and Other Substructures [1]

Between Telecommunication MHs & Handholes and		Provide Minimum Separation [2] of:
Electric Light, Power Conduits/Cables Other Conduits	75 mm	Separation from the outside surface of the MH wall or roof
Water & Sewer Lines, etc.	300 mm	Separation from MH wall or roof
CATV & Instrumentation Cables, etc.	75 mm	Separation
Oil Field Pipelines	25 m	Or more from any pipeline (See SAES-B-008 and SAES-B-064)

Notes:

(1) See paragraph 5.1.3.4.

(2) Refer to the latest issue of the ANSI C2 NESC, National Electrical Safety Code for additional information on separations.

Table 4 – Estimated Maximum Lengths for Main Conduit Sections Containing One Curve

Angle of Curve	Radius in Meters				
In Degrees	18.3	15.2	12.2	9.1	6.1
	Estimated Maximum Conduit Section Length				
0	366	366	366	366	366
10	351	347	320	236	152
20	328	325	297	221	140
30	309	308	277	204	133
40	288	287	256	191	122
50	271	268	242	178	114
60	255	251	226	166	105
70	239	236	212	154	99
80	224	221	198	145	91
90	213	209	186	136	87

Assumptions:
- Level Grade
- Clean Conduits which are in Good Condition
- Well Lubricated Cable
- T(0) = 100 lbs.

* - Curve Located End of Conduit nearest Pulling Equipment

Commentary Note:

* *This would be worst condition - Normally curve should be located at distant end from pulling equipment.*

Table 5 – Casing Size Requirements, 4 Inch Conduits are Used [1]

Number of Conduits to be Placed	Casing Size Required (if Board Used) Inside Diameter (In Inches)	Board Size Required (In Inches)
6	16	1 x 6
7	16	1 x 6
8	20	2 x 10
9	20	2 x 10
10	20	2 x 10
11	22	2 x 10
12	22	2 x 10
14	26	2 x 14
15	26	2 x 14
16	26	2 x 14
17	26	2 x 10
18	26	2 x 10
20	30	2 x 10

Note: (1) See paragraph 5.1.3.8.2.

Table 6 – Estimated Coefficients of Friction for Conduit Types [1]

Type of Conduit	Coefficient of Friction (f) [2]	
	Dry	Lubricated
Concrete	0.60	0.42
Fiber	0.47	0.44
Plastic	0.43	0.38
Rigid Steel	0.61	0.50

Notes:

(1) See Paragraph 5.1.3.12.2.

(2) Based on clean, good condition conduits

Table 7 – Conductor Cross-Sectional Area by Wire Gauge [1]

Wire Gauge		Diameter	Cross Sectional Area
AWG	**Metric**	**mm**	**Circular Mils**
19		0.9116	1290
	9	0.9000	1255
22		0.6438	642
	6	0.6000	558
24		0.5106	404
	5	0.5000	388
26		0.4049	254
	4	0.4000	248

Note: (1) See Paragraph 5.1.3.8.2.
AWG = American Wire Gauge

Table 8 – Cable Pulling Tension Limits in Pounds for ESSED Cables, When Wire Mesh Cable Grips are Used [1]

A	B	C [2]
ESSED Limits	**75% of ESSEX**	**Limits In Pounds**
Cable Size	**In Pounds**	
25-22P	1,360	1,020
50-22P	1,918	1,438
100-22P	3,280	2,460
200-22P	3,280	2,460
300-22P	3,280	2,460
400-22P	3,280	2,460
600-22P	5,434	4,075
900-24P	5,434	4,075
900-22P	6,592	4,944
1200-24P	6,592	4,944
1800-26P	6,592	4,944
1800-24P	8,201	6,151
2700-26P	8,201	6,151

Notes: (1) See Paragraph 5.1.3.8.2
(2) Column C lists the maximum permitted pulling tensions for Saudi Aramco purposes.

Commentary Note:

This Data (except column C) Was Provided By Dr. James S. Tyler, ESSEX, Director of Engineering & Quality Assurance in a letter dated July 16, 1993.

Outside Plant (OSP) Design Checklist

1. Title Block
- ☐ 1.1 Reference number
- ☐ 1.2 Service date
- ☐ 1.3 Geographic location
- ☐ 1.4 Exchange/campus site
- ☐ 1.5 Issue date
- ☐ 1.6 Municipality
- ☐ 1.7 County
- ☐ 1.8 Township
- ☐ 1.9 Section
- ☐ 1.10 Location and description
- ☐ 1.11 Street names
- ☐ 1.12 Initials of drafter
- ☐ 1.13 Initials of designer
- ☐ 1.14 Designer telephone number
- ☐ 1.15 Plant locator record (PLR) number
- ☐ 1.16 North arrow
- ☐ 1.17 Accounting data

2. Required Information
- ☐ 2.1 Cable ID and count
- ☐ 2.2 Telecommunications equipment room direction
- ☐ 2.3 Streets (at least two)
- ☐ 2.4 Loop and count qualification
- ☐ 2.5 Facilities lifecycle
- ☐ 2.6 Regroup
- ☐ 2.7 Splice to splice measurements
- ☐ 2.8 Terminals involved
- ☐ 2.9 Balanced twisted-pair wiring limits
- ☐ 2.10 Permits and right-of-way (R/W)
- ☐ 2.11 Fill boxes
- ☐ 2.12 Conductor/transmission study

3. Electronic Telecommunications Equipment
- ☐ 3.1 Equipment information
- ☐ 3.2 Relay rack/bay
- ☐ 3.3 Remote terminal (RT), controlled environmental vault (CEV) information

4. Notes
- ☐ 4.1 Assignment
- ☐ 4.2 Construction

5. Aerial Environment
- ☐ 5.1 Anchor/guy
- ☐ 5.2 Lash/strand/self-support
- ☐ 5.3 Pole information
- ☐ 5.4 Span measurements
- ☐ 5.5 Pole load calculations
- ☐ 5.6 Expansion loops

6. Direct-Buried Environment
- ☐ 6.1 Direct-buried/direct-buried jobs
- ☐ 6.2 Pedestal or splice vault information
- ☐ 6.3 Station marker/components
- ☐ 6.4 Underground (UG) utilities identified

7. Conduit Environment
- ☐ 7.1 Conduit description
- ☐ 7.2 Conduit configuration
- ☐ 7.3 Innerduct description
- ☐ 7.4 Tie-in measurements
- ☐ 7.5 Wall-to-wall measurements

8. Underground Environment
- ☐ 8.1 Air pressure information
- ☐ 8.2 Buffer information
- ☐ 8.3 Conduit selection
- ☐ 8.4 Cable type information
- ☐ 8.5 Optical fiber cable selections
- ☐ 8.6 Maintenance hole numbers

9. Miscellaneous
- ☐ 9.1 Grounding (earthing) and bonding information
- ☐ 9.2 Caution information
- ☐ 9.3 Transfer splicing
- ☐ 9.4 Balanced twisted-pair crossconnect box information
- ☐ 9.5 Lightning protection
- ☐ 9.6 Optical fiber patch panel