Engineering Standard

SAES-T-911 25 August 2020

Telecommunications Conduit System Design

Document Responsibility: Communications Standards Committee

Contents

Previous Issue: 7 May 2019 Next Planned Update: 25 August 2025

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Summary of Change

Paragraph Number		Change Type (Addition, Modification, Deletion)	Technical Change(s)
Previous Revision (7 May 2019)	Current Revision (25 August 2020)		
Scope	Scope	Modification	This standard is in conjunction with the international standards listed below which define the mandatory requirements governing the engineering design, construction, and installation of telecommunications outside plant (OSP) pathway and spaces for IT (Information Technology) and non-IT applications …
4.5	4.5	Addition	In a situation when a duct bank is shared between Information Technology (IT) applications and non-Information Technology applications (fiber optics for Process control systems, Power system automation, Industrial Security, In-plant paging system, Video surveillance System, a special consideration is needed to count for future needs. A minimum of 20% for IT and 20% for non-IT future needs of spare sub-ducts plus one spare conduit for maintenance and repair purposes. The one spare conduit shall not be calculated as a future growth requirement.
4.6.3	4.6.3	Addition	Commentary Note: a) Information Technology (IT) FO cables and non-Information Technology FO cables (non-IT) shall not be on the same Conduit and the same sub-duct. The segregation is mandatory in the early stages of the project design and shall be reflected in the project proposal and detailed design prior to IFC design drawing, see figure 1. b) IT and non-IT conduits shall be labelled and numbered in the design drawings. c) Copper and Fiber Optic cables shall be in placed in a separate conduit. Also, a figure is added for segregation requirements of conduit and subducts.
5.1.4	5.1.4	Addition	Bullet # 10: High Density Polyethylene (HDPE) Pipes High-density polyethylene (HDPE) is a versatile material and it is ideal characteristics for use in telecommunications underground structures. d) Solid Wall HDPE pipes (see section for more details) e) Corrugated Wall HDPE pipes (see section for more details) Commentary Notes: (see section for more details)
None	5.3	Addition	5.3 Pedestal 5.3.1 Corrosive areas: A fiberglass type pedestal shall be used. (A stake mounting fiberglass length of 1066.8 mm, refer to SASD-T-AA-036748-001). *Commentary Note:* *Corrosive areas as defined in SAES-A-134.* 5.3.2: Additional requirements for pedestal shall be in accordance with SAES-T-632 standards.
5.1.3.6	5.1.3.6	Modification	Bullet 9: Solid Wall HDPE Pipe, (see section for more details)
5.1.3.6	5.1.3.6	Addition	Bullet 8: Corrugated Wall HDPE Pipe, (see section for more details)
3.1	3.1	Deletion	SAEP-309, SAEP-334, SAEP-1150, SAES-A-100, SAES-A-202, SAES-B-005, SAES-B-055, SAES-M-006, SAES-T-629, SAES-T-887, SAES-T-903, 18-SAMSS-493
3.1	3.1	Addition	SAES-A-134 & 01-SAMSS-051

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3.1	3.1	Modification	SAES-T-916, and BICSI (Building Industry Consulting Service International) – BICSI TDMM & BICSI OSPDRM
4.1	4.1	Addition	A sub-section was added: 4.1.2 Saudi Aramco standard drawings (SASD) shall be used to complement to this standard. 4.1.3 The industry standards listed in Section 3 of this standard shall be used for additional information such as definitions, abbreviations and explanation for further clarifications.
4.2	4.2	Modification	…This is to ensure that a minimum level of competency has been provided in the telecommunications outside plant (OSP) pathway and spaces design. … All related design drawings shall be reviewed and stamped by a valid certified RCDD during the detailed design phase before the package can be issued for construction (IFC).
4.7	4.7 (1), (2), (3)	Modification	-[revised] Replaced 18-SAMSS-493 (non-active standard) with UL listed materials and alignment with existing SAES-T standard. -[add] Central control building, and retained telecommunications spaces (TR/TER) shall comply with this standard. -[new] section 4.7.3 (see section for more details.
4.8	4.8	Modification	[revised] Replaced 18-SAMSS-493 (non-active standard) with UL listed materials and alignment with existing SAES-T standard.
5.1.3.5	5.1.3.5	Modification	[add] Commentary note: The definition of “OFFSET”
5.1.3.6 (c)	5.1.3.6 (c)	Modification	Bullet c, this is to aligned with SAES-T-928 standard: (c) It is mandatory when inside the plant facilities area, refer to SAES-T-928 standard
5.1.3.7	05.1.3.7	Modifcation	[revised] Bullet #5: … and measured from top of the concrete encasement to the grade level. [revised] Bullet #6: referencing to SAES-L-450 standard. [revised] Bullet #7: Orange colored detectable marker tape shall be place, in alignment with BICSI standard.
5.1.3.7 (7)	5.1.3.7 (7)	Modification	[revised] Bullet #5: All underground infrastructure or duct bank systems below in a concreted area and in an asphalt area, a surface marker and sign-template are mandatory, with 50 mm (2 inches)-wide. The lettering shall be engraved or stamped as per SASD-AB-036897-001-08, and shall be installed in surface mounted concrete block (surface marker) or equivalence".
5.1.3.8	5.1.3.8	Modification	[revised] Bullet #1: Conduit Design for Bridge Crossing [add] Bullet #3: (a) … solid wall types with 110 mm outside diameter, refer to 01-SAMSS-051. [revised] Bullet #1: Conduit Design for Bridge Crossing [add] Bullet #3: (a) … solid wall types with 110 mm outside diameter, refer to 01-SAMSS-051. [add] Bullet #3: (c) … This shall be equipped with pull rope, see section pull rope requirements in this standard. [new]Bullet #3 (c): Commentary note, mandrel testing requirement on a splice section, (see section for more details). Bullet #3 (c): The HDD method shall be performed and implemented by Saudi Aramco certified and approved contractor. [new] Bullet #4: Camel Crossing Requirement
5.1.3.9	5.1.3.9	Modification	A four (4)-inch diameter underground conduit that is being set up for fiber optic cable placement shall contain a four (4) pieces of one (1) inch - inside diameter sub duct. In addition, a one spare duct shall be reserved for maintenance and repair.
5.1.3.10 (3)	5.1.3.10 (3)	Mofification	Central control building as part of the requirements together with telecommunications spaces (TR/TER) in which it shall comply with this standard.

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5.1.1	5.1.1	Modification	Central control building as part of the requirements together with telecommunications spaces (TR/TER) in which it shall comply with this standard.
5.1.6	5.1.6	Modification	Central control building as part of the requirements together with telecommunications spaces (TR/TER) in which it shall comply with this standard.
5.2	5.2	Modification	[revised main title] Spaces (Maintenance Hole (MH, Vaults, Hand Hole (HH)
5.2.2	5.2.2	Modification	Central control building as part of the requirements together with telecommunications spaces (TR/TER) in which it shall comply with this standard.
5.2.8.4 (5)(b)	5.2.8.4 (5)(b)	Modification	Ensure that the MH opening/duct terminator shall not be covered by a concrete.
5.2.8.11	5.2.8.11	Modification	[revised] Bullet #1: Main telecommunications building /central office building (more than nine main entrance conduits required) require the construction of Cable vaults. [revised] Bullet #11: Replaced 18-SAMSS-493 (non-active standard) with UL listed materials and alignment with existing SAES-T standard. [add] Bullet 17: Watertight Requirements, the direction is to refer to BICSI OSPDRM (latest revision).
4.9	4.9	Modification	Revised section title, and deleted non-active standard (SSD).
4.9.6	4.9.6	Modification	Proper coordination shall be maintained with the proponent/s all the time when doing design or construction work in their areas of responsibility.
4.10	4.10	Modification	[editorial] All conduit pathway and spaces designs shall take into… [add] bullet (e).
4.13.1	4.13.1	Modification	Deleted handhole (HH), is not part of SAES-Q-001
5.1	5.1	Modification	The designer should design the most safe and economical OSP pathway and spaces….
5.1.2.6	5.1.2.6	Modification	Alignment with SASD-AA-036373-001, a size of 910 mm is required.
5.2.8.8	5.2.8.8	Modification	Bullet # 1: Simply the requirement to aligned with the SAES-T-795, and deleted SAES-T-887 (non-active standard).
7.3.1	7.3.1	Modification	To aligned with SASD: AA-036373 sheet 001, figure 2

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1 Scope

This standard is in conjunction with the international standards listed below which define the mandatory requirements governing the engineering design, construction, and installation of telecommunications outside plant (OSP) pathway and spaces, for IT (Information Technology) and non-IT applications. The infrastructure includes underground structure comprises of conduit, duct bank, maintenance hole (MH), hand hole (HH), and pedestal. Additional requirements and/or exceptions to the below three documents are outlined in this standard.

a) Building Industry Consulting Services International (BICSI) Telecommunications Distribution Methods Manuals (latest edition).

b) Building Industry Consulting Services International (BICSI) Outside Plant Design Reference Manual (latest edition).

c) TIA-758-B Customer-owned Outside Plant Telecommunications Infrastructure Standard.

2 Conflicts and Deviations

Any conflict between this document and other applicable Mandatory Saudi Aramco Engineering Requirements (MSAERs) shall be addressed in writing to the EK&RD Coordinator. Any deviation from the requirements herein shall follow internal company procedure SAEP-302.

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 Procedures

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

Saudi Aramco Engineering Standards

SAES-A-114	*Excavation and Backfill*
SAES-A-134	*External Corrosion Protection Requirements*
SAES-B-006	*Fireproofing for Plants*
SAES-B-008	*Restrictions to Use of Cellars, Pits, and Trenches*

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SAES-B-014	*Safety Requirements for Plant and Operations Support Buildings*
SAES-B-064	*Onshore and Nearshore Pipeline Safety*
SAES-B-068	*Electrical Area Classifications*
SAES-K-003	*HVAC Systems for Communications Facilities and Data Centers*
SAES-L-450	*Construction of On-Land and Near-Shore Pipelines*
SAES-L-460	*Pipeline Crossings under Roads and Railroads*
SAES-L-610	*Nonmetallic In-Plant Piping*
SAES-M-100	*Saudi Aramco Building Code*
SAES-P-111	*Grounding*
SAES-Q-001	*Criteria for Design & Construction of Concrete Structures*
SAES-Q-005	*Concrete Foundations*
SAES-Q-006	*Asphalt and Sulfur Extended 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-624	*Telecommunications: Fiber Optic Cables for Outside Plant (OSP) and Inter/Intra Building Applications*
SAES-T-629	*Telecommunications Outside Plant- Copper Cable*
SAES-T-795	*Grounding, Bonding, and Electrical Protection for Telecommunications Facilities*
SAES-T-916	*Telecommunications: Building Cable System, Pathways and Spaces*
SAES-T-928	*Telecommunications - OSP Buried Cable*

Saudi Aramco Materials System Specifications

01-SAMSS-051	*High Density Polyethylene (HDPE) Pipe and Fittings*
09-SAMSS-088	*Aggregates for Concrete*
09-SAMSS-097	*Ready-Mixed Concrete*
09-SAMSS-106	*Epoxy Coating of Steel Reinforcing Bars*

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

Saudi Aramco Standard Drawings

AA-036373 *Polyvinyl Chloride (P.V.C.) Plastic Direct Buried/Encased Conduit in Concrete*

AA-036748 *Buried Telephone Cable Distribution Wire Installation Details*

AA-036794 *Standard Communication MHs & Service MH (20 Tons)*

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

Saudi Aramco General Instructions

GI-0002.100 *Work Permit System*

GI-0002.709 *Use of Portable Gas Monitors*

GI-0005.002 *Loss Prevention Policy Implementation*

GI-0007.030 *Inspection and Testing Requirements for Elevating/Lifting Equipment*

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*

GI-0002.716 *Land Use Permit Procedures*

Saudi Aramco Construction Safety Manual

Safety Management System (SMS)

Operations Instruction Manual (Ch. 1.00 - 30.999)

Refinery Inst. Manual (Ch. 1.000 - 13.999)

Government Standards / HCIS & the Safety Directives

SAF 12 *Electrically Classified Area Maps*

SAF 03 *Buildings for Industrial Facilities*

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*

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

Telecommunications Industry Association

TIA-758-B	*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*

Building Industry Consulting Service International

BICSI TDMM	*Telecommunications Distribution Methods Manual (14th edition)*
BICSI OSPDRM	*Outside Plant Design Reference Manual (6th edition)*

4 General Requirements

4.1 OSP Design Drawings

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

4.1.2 Saudi Aramco standard drawings (SASD) and library drawings shall be used to complement to this standard.

4.1.3 The industry standards listed in Section 3 of this standard shall be used for additional information such as definitions, abbreviations and explanation for further clarifications.

4.2 OSP Designer Certification Requirements

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

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telecommunications outside plant (OSP) pathway and spaces design. For external design contractors, the RCDD shall be a direct employee of that company.

All related design drawings shall be reviewed and stamped by a valid certified RCDD during the detailed design phase 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, Camel crossing

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

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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 of 20% growth of spare subduct plus one spare conduit for maintenance and repair purposes for a non-sharing duct bank. Cables required for growth may include facilities necessary to cutover and relieve an existing cable that is at maximum capacity.

In a situation when a duct bank is shared between Information Technology (IT) applications and non-Information Technology applications (fiber optics for Process control systems, Power system automation, Industrial Security, In-plant paging system, Video surveillance System, a special consideration is needed to count for future needs. A minimum of 20% for IT and 20% for non-IT for future needs of spare sub-ducts plus one spare conduit for maintenance and repair purposes. The one spare conduit shall not be calculated as a future growth requirement.

The number of conduits shall be specified in the Project Proposal and in construction Work Orders.

4.6 Main and Lateral Conduits

4.6.1 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,

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.

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4.6.2 Sharing of the telecommunication MH, HH, and duct bank system by none-Saudi Aramco Organizations is not permitted without a prior review by IT Engineering Department.

4.6.3 Telecommunication MH, HH, and duct bank system can be shared between different Saudi Aramco proponents. The duct bank together with the cable location/cable assignment shall be established for easy identification, and be reflected in the design drawings.

A service level agreement (SLA) must be established between involved parties that includes roles and responsibilities.

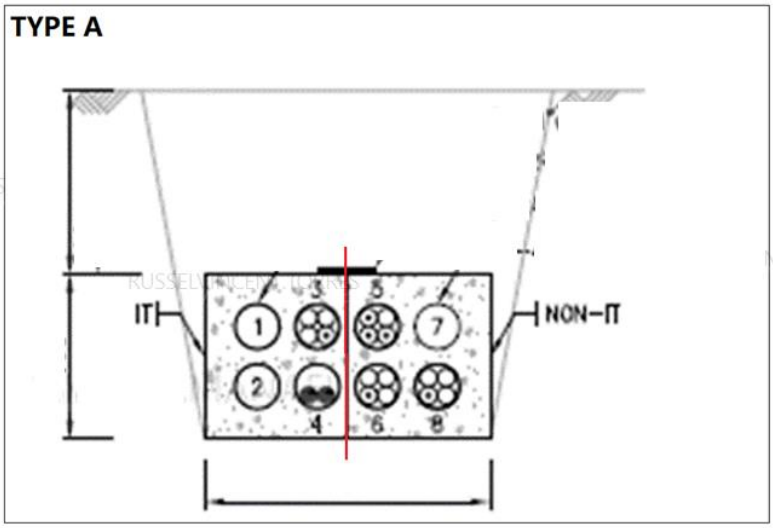
Commentary Note:

a) Information Technology (IT) FO cables and non-Information Technology FO cables (non-IT) shall not be on the same conduit and the same sub-duct. The segregation is mandatory in the early stages of the project design and shall be reflected in the project proposal and detailed design (concrete encasement or HDPE pipes) prior to IFC design drawing, see figure 1 (Segregation requirement).

b) IT and non-IT conduits shall be labelled and numbered in the design drawings.

c) Copper and Fiber Optic cables shall be placed in a separate conduit.

Figure 1 : Typical segregation requirements of conduit and subducts.



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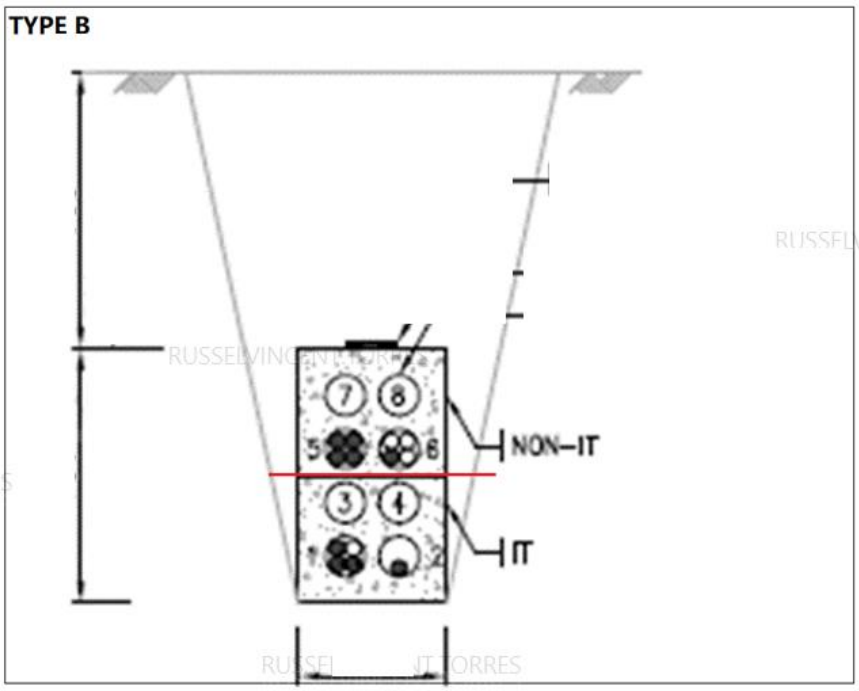

4.7 Conduit Plugs and Seals

4.7.1 All conduits between structures should be sealed to prevent intrusion of liquids and gases into the structure. The 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 (MH) or telecommunications facilities, also it must be listed as UL 94.

4.7.2 As soon as the conduit entrance installation is complete, all conduits (vacant or occupied) entering a building either a telecommunications/central office/central control shall have a watertight/gastight plugs or seals. It shall be placed both in 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.

4.7.3 All conduit ends (including road crossings, railroad crossing, Highway crossing – HDD method, pole risers, between pedestals and/or cabinets) shall be plugged or sealed to prevent sand or debris from entering the duct. Refer to SAES-T-629 (Underground Cable and Sealing Conduit - Installation and Removal), for additional requirements to comply.

4.8 Temporary Conduit Plugs

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When conduit installation is stopped for any length of time (overnight, etc.), temporary plugs shall be placed in the end of each installed conduit. 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.

4.9 Safety, Security and Environment

All Saudi Aramco Safety and Security Requirements and Policies shall be observed, refer to SAES-A-114 for "Excavation and Backfill", GI-0002.100, SAES-B-Series, HCIS & the Safety Directives, and the Saudi Aramco Safety Policy (Loss Prevention Policy Statement 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, 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 system/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 and compliance with the Saudi Aramco Construction Safety Manual.

4.9.4 Excavations Adjacent to Buildings

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When designing and installing telecommunication facilities, which require excavations adjacent to building foundations or footings, the following principles are to be observed. Additional requirements as per SAES-M-100 standard shall be address.

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.

c) Any planned excavation which could potentially undermine an existing foundation shall be braced, shored or the foundation shall be underpinned or otherwise protected against settlement or lateral movement, refer to SAES-M-100 for more details.

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. Proper coordination shall be maintained with the proponent/s all the time when doing design or construction work in their areas of responsibility.

4.10 Designing to Avoid Future Problems

All conduit pathway and spaces 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

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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 relocations.

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

e) Underground infrastructure (MH, HH, Vault) must be avoided in a location where the rain water pathway, rain water gathering areas or flooding areas.

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 GI-0887.000).

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).

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.

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h) The number and size of cable hooks required.

4.13 Structural and Mortar Requirements

4.13.1 Structural Requirements

The design and installation of telecommunication vaults and MH's 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, MH's and HH's, and pull boxes.

4.13.2 Mortar Requirements

Mortar used for placing brick masonry, MH frame and covers, etc., shall comply 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 with Saudi Aramco and Saudi Government procedures and guidelines.

5 Design

5.1 Underground Conduit Pathways

The designer should design the most safe and economical OSP pathway and spaces. A proper survey shall be conducted by the designer prior to the developing any OSP infrastructure engineering and 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

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- 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 building either a telecommunications/central office/central control or a 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 914 mm (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 (Underground Entrance).

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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 910 mm may be used as pole risers, or small building entrances, reference SASD-AA-036373-001 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

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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 permanently end-to-end while the cement is still wet, and it shall be installed end-to-end continuously (example: MH-to-MH or building-to-building).

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.

f) The conduit or pipe shall be free from sharp edges prior to connect or joined together, and before the mandrel test will be conducted. Filling of conduit or pipes sharp edges is required.

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-

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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.

5.1.3.5 Conduit Curves, Offsets, etc.

1. Minimum Radius - Main Conduit Sections

   Except for the minor curves involved when splaying/spreading 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:

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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. Hot bending shall be done only by the PVC manufacturer in the factory.

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, "User's 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

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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).

Commentary Note:

An offset is to be considered the equivalent to a 90° bend when designing conduit systems.

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.

c) It is mandatory when inside the plant facilities area, refer to SAES-T-928 standard

The requirements of this section 5.1.3.6 do not apply to isolated conduits placed in buried cable sections.

Commentary Note:

Isolated conduits section is a direct burial of 4 inches of PVC conduit type DB or HDPE pipes (PE 80 and PE 100), 110 mm diameter, black color, solid wall, with orange stripe, without concrete encasement, installed below high voltage overhead or buried power lines, under the fence or sidewalk, culvert, etc. See SAES-T-795 and SAES-T-928 for more details.

3. Lean Concrete Required

Concrete encasement (including a lean concrete) is

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required for telecommunication conduit systems. A lean concrete 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 conduits shall not be placed inside the same concrete encasement with electrical power cables or other underground utilities.

8. Corrugated Wall HDPE Pipe:

The Polyethylene Corrugated Ducts (PECD) or COD with factory built-in sub ducts can be used instead of concrete encased PVC conduits for protection, refer to section 5.1.4: Conduit Type and Accessories for specific requirements.

9. Solid Wall HDPE Pipe:

The High-Density Polyethylene (HDPE) pipes (PE 80 and PE 100), 110 mm diameter, black color, with orange stripe can be used instead of concrete encased PVC conduits as mechanical protection for pipeline crossing

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application, refer to 01-SAMSS-051 for materials selection.

Commentary Note:

a. HDPE pipes shall be mandrel testing in both directions before and after installation, this is to ensure no inside deformation (factory defect).

b. Additional requirements shall be complied as per to this standard (marker tapes, see section 5.1.3.6 & Table 2).

10. Refer to SAES-T-928 for the Industrial Security fiber optic cable direct buried installation design, when install around the plant facility fences.

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, and measured from top of the concrete encasement to the grade level.

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 this standard.

   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 mm^2. 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 hydro hammers is not permitted where the conduit cover is less than 1.3 m.

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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.

7. Marking and Identification

- The color orange shall be used to identify telecommunication facilities.
- Orange colored detectable marker 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 detectable marker tape is to be located 300 mm minimum below finished grade to provide an early warning during excavation, see SASD-03678.
- All underground infrastructure or duct bank systems below in a concreted area and in an asphalt area, a surface marker and sign-template are mandatory, with 50 mm (2 inches)-wide. The lettering shall be engraved or stamped as per SASD-AB-036897-001-08, and shall be installed in surface mounted concrete block (surface marker) or equivalence".

Commentary Note:

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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.

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 Design for Bridge Crossing

   Whenever conduit must cross a bridge, the design shall be in compliance with BICSI OSP Design Manual latest revision.

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 GI-0887.000).

3. Horizontal Directional Drilling (HDD)

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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, solid wall type with 110 mm outside diameter, refer to 01-SAMSS-051 for materials selection.

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

c) HDPE pipes shall be Mandrel tested in both directions before and after installation, this is to ensure no inside deformation (factory defect). Also, this shall be equipped with pull rope, see section pull rope requirements in this standard.

Commentary Note:

In an area with a splice or welded section, mandrel test using 3-⅝ inch diameter x 12-inch length is not compulsory due to small expanded inner access causing a blockage by the expanding inner materials. The use of a different size of the mandrel (smaller diameter) can be used to pass through the welded or spliced section. In addition, the subducts shall be installed without no inside deflection.

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

e) The HDD method shall be performed and implemented by Saudi Aramco certified and approved contractor.

4. Camel Crossing

For Pipeline Trench with Fiber Optic Cable, the fiber optic cables shall be installed in separate trench.

Commentary Note:

Fiber optic cable may be installed in the same pipeline trench at camel crossings if the cable is installed inside HDPE pipes in alignment with SAES-L-450.

5.1.3.9 Conduit Design Formations

1. MH Conduit Entrance Design Considerations

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Design proper conduit formations to facilitate orderly cable racking within the MH and to ensure minimal 5.1.2.10

changes in the formation when entering/exiting a MH. For the most efficient cable formation, the following recommendations should be adhered to:

a) Main conduit formations should enter the end walls of the MH in accordance with Saudi Aramco Standard Engineering Drawing No. AA-036794.

b) For wall racking considerations, design splayed duct bank entrances at the end walls in accordance with Saudi Aramco Standard Engineering Drawing No. AA-036794. If the total number of conduits 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.

c) 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 more than four conduits, shall be two or four conduits wide.

Commentary Note:

List of recommended conduit formations requirements shall comply with the BICSI OSPDRM latest revision.

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.

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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

A four (4)-inch diameter underground conduit that is being set up for fiber optic cable placement shall contain a four (4) pieces of one (1) inch - inside diameter sub duct. In addition, a one spare duct shall be reserved for maintenance and repair. 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 Engineering Department.

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

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toward the building either a telecommunications/central office/central control buildings. 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 section 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.

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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:

   $$d(e) = 1.1d(c)$$

   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.

   Establishing Coefficient of Friction Factors

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

   a) Only in fair condition,

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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:

$$f = \frac{T}{W}$$

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:

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

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

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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:

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

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

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:

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

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 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. Refer to Table 8 for lists of pulling tension limits.

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, which 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

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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. Mixing of different type of conduit is not permitted. For encasement in concrete, type EB-20 and EB-35 is preferred, and type DB-60, DB-100, DB-120 is for direct burial. Also, refer to BISCI OSPDRM, latest revision for additional information.

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The Main and Lateral section of conduit shall have four (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 6 m (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).

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8. Pull Rope Requirements

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

   b) Provide a plastic or nylon line with a minimum test rating of ≈90 kg (200 lbs.) pulling tension in all conduits. This facilitates the pulling of wire or cable.

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.

10. High Density Polyethylene (HDPE) Pipes:

    High-density polyethylene (HDPE) is a versatile material and it is ideal characteristics for use in telecommunications underground structures.

    a) Solid Wall HDPE pipes:

       The PE 80 and PE 100, 110 mm diameter, black color with orange stripe shall be use. Refer to section 5.1.3.8 for HDD requirement, and section 5.1.3.6 for pipeline crossing requirement, and refer to 01-SAMSS-051 for materials selection.

    b) Corrugated Wall HDPE pipes:

       For PECD/COD pipes: This pipe shall have a full circular cross section, with a ring-shaped corrugated surface both inside and outside. The Polyethylene Corrugated Ducts (PECD) or Corrugated Optical Duct (COD with factory built-in sub ducts, fuse together design shall comply the following.

       - Corrugated pipe: 110 mm outer diameter, orange color, and subduct shall be a factory made or built-in, fused together.
       - Subduct configuration: For FO cable (5 subducts) is preferred, and for copper cable (4 or 3 subducts) shall be used, sizing of subduct for the copper cable shall be determined as per cable diameter.

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- Depth: The HDPE pipe depth (cover) shall be 1000 mm below surface ground.
- Subduct color code: It shall comply with the Saudi Aramco standard color code [(1) blue, (2) orange, (3) green, (4) white], with an additional of black color for the # 5-subduct. In addition, a base spacer is required for segregation of 110 mm pipes.
- Marker tape: A detectable marker tape is mandated at 300 mm below surface ground and additional non-detectable marker tape shall be installed above the HDPE pipes.
- Added protection: A red concrete tile (50 mm thick) or concrete slab (50 mm thick) shall be provided at 500 mm above the surface ground.

Commentary Note:

For other types of HDPE corrugated wall pipes such as shapes, sizes and subduct configuration shall be designed to withstand loads created by a normal traffic flow. The following requirements to be considered and shall be submitted to communications standard chairman for review.

1. *Calculation of pipe/conduit depth (cover), these includes live or dynamic and dead or earth load calculation.*
2. *Typical design drawing(s) to be develop and to be submit.*
3. *Materials specification which include the availability of the accessories (for maintenance purposes).*

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, User's Manual or 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

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Ultraviolet (UV) 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/rubdown 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.

d) In a situation when the OSP cables is exposed to sunlight, in the transition or change over sections from below ground (conduit) to above (cable tray), the OSP cable shall be protected using non-metallic flexible conduit with UV rated and it shall extend at least 1000 mm (1m) both ends.

5.1.6 Underground Entrances

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

1. Cable Racking Plan

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

Commentary Note:

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

2. Design for Cable Vault Entrance Flexibility

The telecommunications/central office/central control 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.

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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 telecommunications/central office/central control 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 telecommunications/central office/central control 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 required to provide for the estimated ultimate capacity of the telecommunications/central office/central control building shall be installed in the vault wall initially. As a minimum, these conduits must extend out from the buildings to the first MH 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 Drain Slope

   The grade or slope of telecommunications /central office/central control building entrance conduits shall be away from the building structure at 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 telecommunications/ central office/central control buildings.

8. Telecommunications Buildings/Central Control Building Entrance Conduits

   All entrance conduits shall be provided with a minimum of six (6) underground (4 in) conduit entrance for connecting outside plant cables. If the number of conduits equal or exceeds nine (9), a cable

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vault or MH type 2 (refer to SASD: AA-036794-003) 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 telecommunications/central office/central control 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 (MH, Vaults, Hand Hole (HH)

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 telecommunications/central office/central control building shall be designed to provide conduit space for the ultimate size of the building. All MHs shall be designed and constructed to:

a) Support the heaviest anticipated traffic weight (see also SAES-Q-006 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 watertight

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Commentary Note:

1. For joints section, refer to SAES-Q-001 standard ""Water stops shall be provided in joints where watertight construction is required in accordance with SAES-Q-001. Water stop type shall be specified and shown on the drawings and shall satisfy the function and operation of the structure and shall be installed as per the manufacturer's recommendations".

2. MHs location must be avoided in a rain water pathway and rain water gathering areas.

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 MH's constructed in vehicular and non-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 BISCI OSPDRM latest revision.

Below table provides rating information.

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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

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, and petrochemical) 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

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MHs and Service Points 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*
SAF 12	*Electrically Classified Area Maps*
SAF 03	*Buildings for Industrial Facilities*
SAES-B-006	*Fireproofing for Plants*
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

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Design and Construction of Precast and Prestressed Concrete Structures."

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

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(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. Ensure that the MH opening/duct terminator shall not be covered by a concrete.

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

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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 38 mm in the MH or telecommunications/central office/central control building wall, refer to SASD: AA-036373.

e) Installed so that the nearest side of the MH main entrance conduits are located 1500 mm from the inside surface of the adjacent MH wall (side wall), refer to SASD: AA-036794.

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 No. 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

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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 GI-887.000).

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 appropriately 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

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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

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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 and covers shall meet the specification of SAP Stock No. 1000-077-854. The MH shall be equipped with MH frames and covers with minimum openings diameter of 30 inches.

All areas subject to vehicular traffic and non-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 in) apart, measured from inside surfaces. Its rungs have a ⅝ 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, 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). Ground resistance tests shall comply with the NEC, and for ground rod electrodes design specification, see SAES-T-795.

   a) 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 with a minimum separation of 1,828 mm (6 ft) and connected inside the MH with a bonding ribbon and/or wire (minimum of #6 AWG tinned solid copper). Refer to AA-036794.

   b) Installation of ground rod inside the MH is permitted, and shall comply with the BICSI OSPDRM latest revision.

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:

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1. Stenciled in the exterior rim of the frame, using ½ inch bold numbers/letters. Also, addition of bold letter paint inside the MH, which is located on the neck of MH is mandatory.

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

3. MH's should be numbered on the inside of the collar above the first step, it needs to be visible from above ground and when entering or leaving the MH.

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:

For SMHs traffic load design, per section above Service Maintenance Hole, 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.

5.2.8.11 Cable Vault

1. Cable Vault Requirements

   Main telecommunications building/central office building (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

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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 may vary; however, the minimum headroom shall not be less than 2 meters.

6. Splayed Conduit Entrance

   Horizontally splayed 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 building with cable vaults shall not be located in any area where they are prohibited by SAES-B-008.

8. Vault Atmospheric Monitoring and Testing

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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). The firestop shall be designed and constructed to meet SAES-M-100 (Saudi Aramco Building Code). All materials that are used to seal penetrations in fire rated walls and floors shall be listed for the specific application and comply with UL 1479 requirements, refer to SAES-T-916 for more details.

12. Materials for Cable Vaults

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

13. Steelworks and Structures

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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*

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.

17. Watertight Requirements

(Refer to section 5.2.4 to this standard).

18. Types of Vaults

A cable vaults is a telecommunications spaces located beneath, adjacent to, between buildings and used for distribution, splicing, and terminating cables.

Refer to BICSI OSPDRM (latest revison) for detailed information, such as:

a) Classification of vaults.

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b) Feautres of vaults, not limited to, environmental requirments, drainage, groundings, and etc.

5.2.8.13 Handhole (HH)

Handholes are used for placing and pulling cables. Splicing cables in the HHs shall not be permitted. HHs shall not be placed in the main conduit route. Additional requirements stated on TIA-758 shall be complied for HH design, location, sizing, and other requirements.

Commentary Note:

Typical handhole design drawing, and non-metallic materials handhole type design drawing shall be reviewed by the Chairman of Communications Standards Committee. The design drawing shall be in accordance to the Saudi Aramco standard drawing format.

5.3 Pedestal

5.3.1 Corrosive areas: A fiberglass type pedestal shall be used. (A stake mounting fiberglass length of 1066.8 mm, refer to SASD: AA-036748-001).

Commentary Note:

Corrosive areas as defined in SAES-A-134.

5.3.2 Additional requirements for pedestal shall be in accordance with SAES-T-632 standards.

6 Installation

All Saudi Aramco telecommunication conduit systems shall be designed and installed in accordance with these standard and other applicable standards as referenced in this standard (see Section 3 above). The installation safety methods shall be in accordance with the “Saudi Aramco Construction Safety Manual” and other applicable safety requirements (see Section 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 this standard. Quality assurance inspections shall be performed during all phases of

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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 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 after concrete encasement, then 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 on each end of the mandrel, see figure 2 in reference to SASD: AA-036373 sheet 001.

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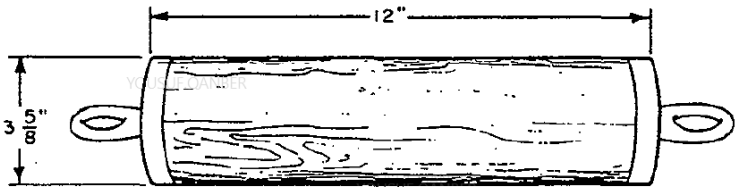

Figure 2: Typical Conduit Test - Mandrel

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 this standard.

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, and 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.

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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

30 April 2017	Major revision to include HH, remove MH-H40, allow HDPE conduits, and allow shared ductbank for communications cables.
1 January 2018	Editorial revision to modify and/or delete paragraphs 4.5, 5.1.3.4-2, 5.1.3.8 (2nd paragraph), 5.1.3.8 (1), 5.1.6 (5), 5.2.8.1, 7.1.3, and 7.3.4.
7 May 2019	Editorial revision as part of content confirmation assessment
25 August 2020	Alignment to the latest revision of the mother standards (BICSI OSPDRM 6th edition and BICSI TDMM 14th edition). Alignment to Saudi Aramco Engineering standards (01-SAMSS-051, SAES-A-134). Deletion of non-active Saudi Aramco Engineering standard, and standards which's not reflected, nor mention in the document body.

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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.

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Table 2 – Minimum Separation Chart

	Underground Telecommunication Pathway	
Between	**Parallel**	**Crossing**
Buried Power CATV & Instrumentation Cables, etc.	300 mm of well-tamped soil, 75 mm of concrete.	300 mm of well-tamped soil, 75 mm of concrete.
Water and Sewer Lines;	75 mm of concrete	75 mm of concrete
Oil/Gas Field Pipelines	1. Clearance between telecommunications service points (maintenance hole, pedestal, etc.) and process equipment/pipeline and shall comply with SAES-B-064 and SAES-B-068. 2. Separation for conduits in pipeline corridors, refer to SAES-T-928 standard.	1. 1000 mm below the pipeline in concrete encased conduit Or 1000 mm below the pipeline with HDPE pipes 2. Telecommunication cables shall be placed in concrete encased conduits that extend for a minimum distance of ten meters on each side of the pipeline. 3. The High-Density Polyethylene (HDPE) pipes (PE 80 and PE 100), 110 mm diameter, black color, solid wall, with orange stripe can be used instead of concrete encased PVC conduits as mechanical protection for pipeline crossing application. The burial depth shall be 1000 mm below the pipeline. The HDPE shall be extended for a minimum distance of ten meters on each side of the pipeline.

Table 3 – Separations from Telecommunication MHs and Other Substructures (1)

Between Telecommunication (MHs & Handholes)	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, Water canals or Waste Water Channel, etc.	300 mm Separation from the outside surface of the MH wall or roof
CATV & Instrumentation Cables, etc.	75 mm Separation from the outside surface of the MH wall or roof
Oil Field Pipelines	Clarence shall comply with SAES-B-008 and SAES-B-064

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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) = 200 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.*

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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

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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.
AWG = American Wire Gauge

Table 8 – Cable Pulling Tension Limits, When Wire Mesh Cable Grips are Used (1)

A	B	C (2)
Cable Limits	75%	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) Column C lists the maximum permitted pulling tensions for Saudi Aramco purposes.

Commentary Note:

For alternative approached on cable pulling tension requirements, utilized BISCI OSPDRM requirements, latest edition.

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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

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