Engineering Standard

SAES-T-911 31 March, 2004

Telecommunication Conduit System Design

Saudi Aramco DeskTop Standards

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Previous Issue: 30 September, 2003 Next Planned Update: 1 April, 2009

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I Scope

This standard covers mandatory requirements governing the engineering, design and installation of telecommunications conduit and manhole (MH) systems.

II Conflicts and Deviations

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

III 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:

A. Saudi Aramco References

Saudi Aramco Engineering Procedure

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

Saudi Aramco Engineering Standards

SAES-A-100	*Survey Coordinates and Datum*
SAES-B-005	*Spacing and Diking for Atmospheric and Low-Pressure Tanks*
SAES-B-006	*Fireproofing in Onshore Facilities*
SAES-B-008	*Restrictions to Use of Cellars, Pits, and Trenches*
SAES-B-014	*Safety Requirements for Plant and Operations Support Buildings*
SAES-B-055	*Plant Layout*
SAES-B-064	*Onshore and Nearshore Pipeline Safety*
SAES-B-068	*Electrical Area Classifications*
SAES-K-003	*Air Conditioning for Communications Buildings*
SAES-L-046	*Pipeline Crossings Under Roads and Railroads*
SAES-L-060	*Nonmetallic Piping*

SAES-M-006	*Saudi Aramco Security and General Purpose Fencing*
SAES-M-100	*Saudi Aramco Building Code*
SAES-O-100	*General Requirements - Safety and Security*
SAES-O-109	*Buildings Housing Sensitive or Vital Equipment*
SAES-P-111	*Grounding*
SAES-Q-001	*Criteria for Design and Construction of Concrete Structures*
SAES-Q-005	*Concrete Foundations*
SAES-Q-006	*Asphalt Concrete Paving*
SAES-T-018	*Telecommunications - Symbols, Abbreviations and Definitions*
SAES-T-603	*Telecommunications - Safeguards and Warning Devices*
SAES-T-605	*Communications Protection and Bonding*
SAES-T-624	*Telecommunications Outside Plant - Fiber Optics*
SAES-T-628	*Telecommunications - Underground Cable*
SAES-T-629	*Telecommunications Buried Cable and Wire*
SAES-T-795	*Communications Facility Grounding System*
SAES-T-887	*Telecommunications Electrical Coordination-Protection*
SAES-T-903	*Communications Electrical Protection - Outside Plant*
SAES-T-906	*Telecommunications - Structural Coordination*
SAES-T-916	*Communications Building Cable*
SAES-T-928	*Telecommunications – OSP Direct Burial*

Saudi Aramco Materials System Specifications

09-SAMSS-016	*Concrete Masonry Units and Concrete Building Bricks*
09-SAMSS-088	*Aggregates for Concrete*
09-SAMSS-097	*Ready Mixed Portland Cement Concrete*
09-SAMSS-106	*Epoxy Coated Reinforcing Steel Bars*

Saudi Aramco Standard Drawings

AA-036373	*Telecommunications PVC Direct Buried/Encased Conduit*
AA-036794 (Sheet 1)	*Standard Communication Manholes - Service manhole*
AA-036794 (Sheet 2)	*Standard Communication Manholes - Manhole Type 1*
AA-036794 (Sheet 3)	*Standard Communication Maholes -Manhole Type V*
AA-036794 (Sheet 4)	*Standard Communication Manholes Bar Bending Schedule*

Saudi Aramco General Instructions

GI-0002.100	*Work Permit System*
GI-0002.716	*Land Use Permit Procedures*
GI-0005.002	*Loss Prevention Policy Implementation*
GI-0007.015	*Use of Explosives in Construction*
GI-0887.000	*Coordination of Saudi Aramco Projects with Non-Saudi Aramco Projects*
GI-1021.000	*Street and Road Closure: Excavations, Reinstatement and Traffic Controls*

Construction Safety Manual

Saudi Aramco Drafting Manual

Operations Instruction Manual (Ch. 1.00 - 30.999)

OIM Chapter 1.104	*Excavations and Pile Driving*
OIM Chapter 1.108	*Excavations*
OIM Chapter 1.110	*Control of Manhole Entry Abqaiq Plants*

Refinery Instructions Manual (Ch. 1.000 - 13.999)

RIM Chapter 1.801	*Work Permits*
RIM Chapter 1.805	*Excavations and Pile Driving*

Government Standards or Directives/Safety and Security Directives

SSD/12	*Communications*

SSD/19	*Work Permit Procedures*
SSD/26	*Blast Resistant Control Rooms*

Saudi Arabian Standards Organization

SASO SSA 413	*Cast Iron Manhole Covers*

B. Industry Codes and Standards

General Telephone and Electronics

American National Standards Institute

ANSI/NFPA 70	*National Electrical Code*
ANSI C2	*National Electrical Safety Code (NESC)*

NFC National Fire Codes, Volume 14

National Fire Protection Association

National Electrical Manufacturers Association

NEMA TCB2	*User's Manual for the Installation of Underground Plastic Conduit*
NEMA RN 1	*Type A-40, Polyvinyl-Chloride Externally Coated Galvanized Rigid Steel Conduit and Electrical Metallic Tubing*
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*

IV Modifications to GTE 911 and GTE 622 Series

The following paragraph numbers refer to GTE 911 and GTE 622 Series on Conduit, which is part of this standard. The text in each paragraph below is an addition, exception, modification, or deletion to GTE 911 and GTE 622 as noted. Paragraph numbers not appearing in GTE 911 and GTE 622 are new paragraphs to be inserted in numerical order.

4.1 GTE Section 911-000-070: Conduit - General Considerations; Issue 3/June, 1974

4.1.1 General

GTE 911-000-070, Paragraph 1.01 - This standard provides the basic requirements for the design and installation of an economical and practical telecommunications underground conduit system.

4.1.2 Expansions Due to Temperature

4.1.2.1 Use of Expansion Couplings

GTE 622-105-207, Paragraph 6.11 and Figure 3 - Conduit expansion-contraction couplings (expansion joints) shall be used in applications where temperature fluctuations in the conduit system requires compensation; such as bridge crossings, attachments to pipeline structures, and in other exposed applications. (Refer to NEMA TCB2).

4.1.2.1.1 GTE 622-105-207, Paragraph 6.11 - Modified - The manufacturers recommendations for installation shall be followed. Expansion joints shall be installed in each conduit at each bridge expansion joint location, or at intervals of no more than every 30 m. Greater distances will be allowed, where specifically permitted by the conduit manufacturer's installation recommendations. Expansion couplings for TC-8 PVC conduit shall comply with the requirements of NEMA TC 9.

4.1.2.2 Temperature Equalization

GTE 622-105-207, Paragraph 5.02 - All conduit and fittings must be exposed to the same temperature for a reasonable length of time (2 hours minimum) before assembly and installation to minimize problems caused by conduit expansion.

4.1.3 Split Conduit

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

4.1.4 Stationing

Addition**:** Stationing and center line tie down measurements shall be shown on all telecommunication conduit system construction drawings. Refer to the following standards:

a) *SAES-A-100* *Survey Coordinates and Datum*

b) *SAES-T-018* *Telecommunications - Symbols, Abbreviations and Definitions*

c) Saudi Aramco Drafting Manual

4.1.5 Growth Requirements

4.1.5.1 Number of Conduits

GTE 911-000-070, Paragraph 3.02 - The number of conduits required will be determined, or approved in writing, by the Saudi Aramco, Communications Engineering Division of IT. The number of conduits shall be specified in the Project Proposal and in construction Work Orders.

4.1.5.1.1 Main Conduits

GTE 911-000-070, Paragraph 8.01 - The total number of main conduits (includes fiber optic requirements as well as copper conductor requirements) to be placed in a proposed conduit installation shall be designed to care for:

a) Immediate requirements,

b) Expected growth over the economical period,

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

d) Plus one conduit to 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. The new maintenance/repair conduit must be cleared within two weeks of occupying the old maintenance/repair conduit. Any exceptions to the two weeks requirement must be approved in writing by the Saudi Aramco, Communications Engineering Division of IT.

4.1.5.1.2 Lateral Conduits

GTE 911-000-070, Paragraph 10.01 - The number of conduits provided in a conduit lateral as a minimum shall include:

a) The initial conduits required, plus

b) The number of conduits required for the ultimate growth, plus

c) One spare conduit, which shall be reserved for maintenance/repair purposes.

Commentary Note:

A minimum of two conduits shall be provided for all conduit system laterals.

4.1.6 Locating Conduit Runs

4.1.6.1 Construction Drawings

GTE 911-000-070, Paragraph 5.01 - The design/construction drawings must be comprehensive, detailing:

a) Location and alignment of proposed facilities,

b) Tie downs for conduit, manholes, etc., to center lines of streets/roads, etc.,

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

1. Gas,
2. Water, including AC coolant lines,
3. Sewer mains,
4. Oil field and Plant area Pipelines,
5. Other proponents' facilities, conduit runs, manholes, substructures, etc.

d) Special construction details, such as for:

1. Railroad crossings,
2. Attachment to bridges, etc.
3. Attachment to pipeline structures, cable trays, and other above ground conduit systems
4. See Paragraph 4.5 below also.

4.1.6.2 Existing Substructures

GTE 622-105-200, Paragraph 2.02. - Prior to starting any excavations, existing underground facilities must be identified, located and marked on the street or ground surface. See Paragraph 4.1.7 below also.

4.1.6.3 Conduit Outside Traveled Part of Street

GTE 911-000-070, Paragraph 5.03 - Where feasible, locate conduit systems outside the street or road paved areas under shoulders or sidewalks.

4.1.6.4 Conduit in Traveled Part of Street

GTE 911-000-070, Paragraph 5.04 - The traffic hazards to personnel working in manholes in the street cannot be over-stressed in this type of construction. If placing conduit in the traveled or paved portion of roads/streets is unavoidable, locate the structure not less than one meter from the curb to avoid present or future catch basins and to minimize surface water drainage into manholes. The conduit run must not be located so far out in the traveled portion of the highways so as to interfere with traffic, future or existing utilities, etc. Manholes shall be located so as to avoid being under parked vehicles to the extent possible.

4.1.7 Land Use Permits and Work Permits

4.1.7.1 Land Use Permits

GTE 911-000-070, Paragraph 7.01; GTE 622-105-209; GTE 622-500-200, Paragraph 1.06 - All necessary land use permits and property proponent approvals must be secured prior to starting construction. The Land Use Permit should be approved prior to the start of the detail design. Refer to GI-0002.716, "Land Use Permit Procedures".

4.1.7.2 Coordination - Non-Saudi Aramco Agencies

Coordination's with non-Saudi Aramco agencies are to be handled in accordance with GI-0887.000, "Coordination of Saudi Aramco Projects with non-Aramco Agencies".

4.1.7.3 Work Permits

Prior to starting any work, all required work permits must be obtained in accordance with GI-0002.100, "Work Permits and Other Proponent Requirements".

4.1.7.4 Blocking Services Access

GTE 622-105-200, Paragraph 3; GTE 622-500-200, Paragraph 1.05 - During the course of construction, do not block fire hydrants, fire alarm boxes, storm gutters/drains, catch basins, traffic flow, private driveways, etc.

4.1.7.5 Railroad Crossings

GTE 911-000-070, Paragraph 7.05 - When underground railroad crossings are planned, all necessary permits or approvals must be obtained from the railroad authority prior to starting any construction. Refer to SAES-T-906.

4.1.8 Main Conduits

4.1.8.1 Conduit Grade Down Points

GTE 911-000-070, Paragraph 8.09 - The size (number of conduits) of a conduit run shall not be diminished, except at points where branch conduit runs intersect the main conduit route.

4.1.8.2 Bridge, Freeway and Railroad Crossings

GTE 911-000-070, Paragraph 8.11 - When telecommunication conduit railroad crossings, bridge attachments, freeway crossings, etc., are designed, provide the ultimate required number of conduits on the initial installation.

4.1.9 Lateral Conduits

4.1.9.1 Lengths Permitted

GTE 911-000-070, Paragraphs 10.04-10.13 - The length of a lateral conduit is limited mainly by the size of the cable which will be pulled into it and the number of bends it contains. Lateral conduits must be a minimum of 4 inches inside diameter when serving buildings which contain more than 200 m^2 (see SAES-T-916).

4.1.9.2 Number of Bends Permitted

GTE 911-000-070, Figure 12 - Conduit laterals shall not have more than the equivalent of two 90 degree turns.

4.1.9.2.1 Addition - 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. (See Paragraph 4.7 below). Copies of these calculations must be included with the design package.

4.1.9.3 Termination's at Poles and Buildings

GTE 911-300-070, Paragraph 3.03 and Figure 3; and GTE 622-301-200 - Lateral conduits, when terminated on poles, shall be terminated on the field side away from traffic. Bends with a minimum radius of 91 mm may be used as pole risers, or small building entrances. Bends shall be:

1- Securely anchored PVC coated, galvanized, rigid steel conduit bends, which conform to NEMA RN1, "Type A-40, Polyvinyl-Chloride Externally Coated Galvanized Rigid Steel Conduit and Electrical Metallic Tubing", or

2- Concrete encased PVC conduit bends.

4.1.9.4 Minimum Radius Bends Permitted

GTE 911-300-070, Paragraph 3.03 - Conduit bends with less than a 36 inch radius shall not be used in conduit laterals.

4.1.9.5 Clearance from MH Roof and Wall

GTE 622-500-100, Paragraph 4.12 and Figure 2a - Lateral conduits shall enter the manhole so as to provide a minimum clearance of 100 mm from the manhole roof and the adjacent wall.

4.1.9.5.1 Addition - Lateral conduits shall not be permitted to enter through the side walls of manholes.

4.1.9.6 Minimum Depth (Cover)

GTE 622-105-200, Paragraph - Lateral conduits may be placed at a minimum depth (cover) of 610 mm 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.

4.1.9.7 Installed for Future Extensions

Addition - 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, 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. Stub out lateral conduits shall be sealed with plastic caps cemented onto the end of each conduit before backfilling the trench.

4.1.10 Safety and Security

4.1.10.1 Applicable Standards

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

4.1.10.2 Test Atmosphere in Deep Excavations

GTE 622-105-209, Page 7; GTE 622-500-200, Paragraph 7.02 - Test the atmosphere in excavations more than 1.2 m deep (if an oxygen deficiency or a hazardous atmosphere could reasonably be expected to exist), 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.

4.1.10.3 Safety Requirements for Excavations

GTE 622-500-200, Paragraph 2.04 & 8) - 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 and other applicable safety practices.

4.1.10.4 Excavations Adjacent to Buildings

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

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

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

4.1.10.5 Installations in Refineries Addition - Review the Refinery Instruction Manual, especially chapters:

RIM Chapter 1.801 *Work Permits - Refinery Areas*

RIM Chapter 1.805 *Excavations and Pile Driving,*

when designing/installing a manhole or telecommunication conduit system in a refinery area.

4.1.10.6 Installations in Plant Areas

Addition - Review the Operations Instruction Manual, especially chapters:

OIM Chapter 1.104 *Excavations and Pile Driving,*

OIM Chapter 1.108 *Excavations,*

OIM Chapter 1.110 *Control of Manhole Entry Abqaiq Plants,*

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

4.1.10.7 Trench Shoring and Sloping

Trenches or other excavations that are 1.5 meters or more in depth shall be safeguarded by shoring or sloping the trench walls in accordance with "GTE 622-105-209".

4.1.11 Temporary Conduit Plugs

GTE 911-300-070, Figure 9 and GTE 622-020-100, Figure 10) - When conduit installation is stopped for any length of time (overnight, etc.), temporary plugs shall be placed in the end of each installed conduit in the trench.

4.1.12 Main Conduit Stub-Outs for Future Use

GTE 911-300-070, Figure 8 and GTE 622-020-100, Figure 9 GTE 622-105-207, Paragraph 10 - Main Conduits stubbed out in the trench for future use shall use full 20 feet conduit sections for a minimum distance of 12 m from the central office or manhole wall and shall be sealed with plastic caps cemented onto the end of each conduit before backfilling the trench.

4.2 GTE Section 911-200-072: Manhole Design; Issue 2/July, 1975

4.2.1 General

GTE 911-200-072, Paragraph 1.01 - This section covers the requirements to be followed in the design of manholes installed in telecommunication underground conduit systems.

4.2.2 Preliminary Considerations

4.2.2.1 Sizing Manholes

GTE 911-200-072, Paragraph 2.01; and GTE 622-500- 100, Paragraph 3; - All manholes shall be designed (sized) to provide sufficient and suitable space for cables and associated equipment which will be installed during the life of the manhole. Manholes in conduit systems near the central office shall be designed to provide conduit space for the ultimate size of the central office. All manholes shall be designed and constructed to:

1. Support the heaviest anticipated traffic weight (see also SAES-Q-006, Paragraph 4 and ANSI C2, NESC, Section 323),
2. Provide sufficient racking space for the ultimate number of cables and other equipment that will be placed in the manhole.

4.2.2.1.1 GTE 911-200-072, Paragraph 2.02 - Manhole design requirements are based on the ultimate number of main conduits that can reasonably be expected to enter the new manhole on any one wall.

4.2.2.2 Sump Holes

GTE 622-500-203, Paragraph 2.04 - A sump hole shall be provided in the floor of all new manholes. The sump must be designed and sized in accordance with Standard Drawing AA-036794. See Paragraph 4.2.8.10 below.

4.2.2.3 Cable Rack Installation

GTE 622-500-100, Paragraph 6 and Figures 4-25 - Manhole cable racks shall be spaced at a maximum separation of 840 mm.

4.2.2.3.1 GTE 622-500-100, Paragraph 6 - 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.

4.2.2.4 Waterproofing Requirements

GTE 622-500-100, Paragraph 7.01 - Manholes constructed in wet or concrete corrosive environments (such as the Ras Tanura Refinery) shall be waterproofed. For assistance in waterproofing engineering design and installation, contact the Consulting Services Department, Materials Engineering & Corrosion Control Division. When waterproofing is required, it shall be placed on the top, sides and bottom of the manhole. Refer to SAES-Q-001, "Criteria for Design and Construction of Concrete

Structures" and 09-SAMSS-097, "Ready-Mixed Portland Cement Concrete" for other requirements. In all cases, new and rebuilt manholes and manhole systems shall be designed to be watertight.

4.2.2.5 Cover Required Above Manhole Roofs

GTE 622-500-200, Paragraph 5.05 - New manholes constructed in vehicular traffic areas shall have a minimum depth of cover of 355 mm. Additional cover may be required in areas where deep (more than 100 mm) road grading is anticipated in the future.

4.2.2.6 Traffic Loads

GTE 911-200-072, Paragraph 2.01; GTE 622-500-100, Paragraph 3.01; GTE 622-501-100, Paragraph 2.02 - All manholes (poured-in-place or precast) shall be designed and constructed to meet the heaviest traffic load conditions anticipated (as a minimum, meet the same traffic load requirements as the road or highway in which it is placed). Refer to SAES-L-046 and SAES-Q-006.

4.2.3 Locating Manholes

4.2.3.1 Tie Down Manhole Location on Drawings

GTE 911-200-072, Paragraph 3.01 - The specific location for each manhole shall be indicated on the work drawings (see Paragraph 4.1.6.1) by the engineer.

4.2.3.2 At Street Intersections

GTE 911-200-072, Paragraph 3.02 - Manholes shall be located at junction points that permit installation of main, branch and lateral conduits with minimum bending. (Refer to paragraph 4.5.10). Locate manholes just short of or just beyond street intersections so as to provide:

1. As little public inconvenience and traffic interference as possible,
2. A good safe set up position for cable construction and maintenance forces.

4.2.3.3 Hydrocarbon, Explosive Toxic and Power Lines

GTE 911-200-072, Paragraph 3.04 - WARNING: Fuel (including petroleum, hydrocarbons, petrochemical products) or any other toxic or explosive products or chemical lines shall never, under any circumstances, be permitted to pass through telecommunication manholes! Electrical cables or

facilities shall not be permitted inside any telecommunications manhole! Manholes shall be located so as to avoid these facilities.

4.2.3.4 Loading Manholes

GTE 911-200-072, Paragraph 4.07 - Cable loading point manholes shall be located as near the theoretical loading points as practical. The exact amount of load spacing variance shall be in accordance with the GTE 832 series of practices.

4.2.3.5 Classified or Hazardous Areas

Addition - Manholes 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.

4.2.3.5.1 Applicable Standards

Addition - When designing or constructing conduit and manhole systems in or near hydrocarbon facilities or other classified/hazardous facilities the engineer must be familiar with the following standards and directives:

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

Any Other Applicable Requirements

4.2.3.5.2 Classified Area Drawings

Addition - 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.

4.2.4 Standard Manhole Types and Sizes

4.2.4.1 Manhole Standards and Specifications

GTE 911-200-072, Paragraph 4.01 - manholes may be either a field constructed (poured in place) type or, where available and approved, precast concrete type. All manhole constructions shall comply with SAES-Q-001, "Criteria for Design and Construction of Concrete Structures", 09-SAMSS-088, "Aggregates for Concrete" and 09-SAMSS-097, "Ready-Mixed Portland Cement Concrete". Non-Standard Telecommunication manhole (hand hole, service hole, splice chamber, etc.) designs shall be presented in the Standard Drawing format to the Saudi Aramco Communications Standards Committee Chairman (Information Technology Planning Division) for review and approval, prior to being constructed.

4.2.4.2 Excavations for Pre-Cast Manholes

GTE 622-501-200, Paragraph 3.01-3.07 - Excavations for precast manholes must provide a minimum clearance of 205 mm between the exterior wall surfaces (ends and sides) of the manhole 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 manhole. The final manhole position must meet road grade, conduit entrance, manhole collar and frame and cover grade requirements. Equipment used to place precast manholes must have sufficient weight handling capacity for the extreme weight and size manhole being placed.

4.2.4.2.1 Setting Pre-Cast Manholes

GTE 622-025-010, Paragraph 10.02 - When precast manholes are being lowered into the prepared excavation, workmen shall not be permitted to be in the excavation or under the manhole as it is moved.

4.2.4.3 Service Manholes

GTE 911-200-072, Paragraph 4.04 and Figure 9 - Service manholes 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 manhole (Type 1 or Type V) shall be placed.

4.2.4.3.1 Design

GTE 911-200-072, Figure 9; GTE 622-500-100, Figure 3 - A service manhole shall have inside dimensions of 1.5m x 1.2m x 1.85m and shall permit cable racking on one wall only. Conduit entrances into service manholes will be permitted through end walls only. Refer to Standard Drawing AA-036794 (Sheet - 1), "Standard Communication Manholes, Service Manhole, Plan and Sections".

4.2.4.4 Main Line Manholes

GTE 911-200-072, Paragraph 4.05 - Modified - The following listed main line manholes shall be the basic standard main line manholes for Saudi Aramco telecommunications facilities:

a) Standard Drawing No. AA-036794 (Sheet-2), "Standard Communication Manholes", Manhole Type-1, The dimensions for Type-1 manholes are;

Type 1-a); 1.85m x 1.5m x 2.0m (Length x width x headroom).

Type (1-b); 2.75m x 1.5m x 2.0m

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

Type (1-d); 3.7m x 1.85m x 2.0m

b) Standard Drawing No. AA-036794 (Sheet-3), "Standard Communication Manholes", Manhole Type-V, The dimensions for Type-V manholes are;

Type (V-a); 3.5m x 2.9m x 2.0m

Type (V-b); 3.9m x 3.7m x 2.7m

c) All other Non-Standard Telecommunication manhole designs that are to be utilized for Saudi Aramco shall comply with this Standard, be designed and presented in the Standard Drawing format to the Saudi Aramco Communications Standards Committee Chairman (Information Technology Planning Division) for review and approval, prior to being constructed.

4.2.4.4.1 Increasing MH Conduit Capacity

GTE 911-200-072, Paragraph 7.08 - The maximum number of main conduits entering the end walls of each of these manholes may be increased, where necessary, by increasing the manhole depth (headroom).

4.2.4.4.2 Design for Cable Turns Outside MH

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

4.2.4.5 Use of Line Manholes

GTE 911-200-072, Paragraphs 4.06-4.07 - Line manholes shall be designed for use in main and branch conduit systems when more than six conduits will ultimately be required.

4.2.4.5.1 Housing Load Coils

GTE 911-200-072, Paragraph 4.07 - Line manholes 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 manhole. 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 manhole, above or below the cables as space permits.

4.2.4.6 Manhole and CO Vault Conduit Entrances

GTE 911-200-072, Paragraph 4.09, and Figure 18; GTE 622-105-207, Paragraph 7 and 10; GTE 622-105- 208, Paragraph 7.03 - 7.04; GTE 622-500-100, Paragraph 4.03 - Manhole and central office cable vault conduit entrances shall be:

a) Splayed conduit configurations.

b) Made with conduit terminators or conduit end bells (GTE 622-105-208, Paragraph 7.04-7.09). Conduit terminators or end bells shall be cast (encased) in the manhole walls at the time the concrete is installed (GTE 622-500-100, Paragraph 4.09).

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

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

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

4.2.5 Manhole Access Openings

4.2.5.1 Applicable Standards and Specifications

GTE 911-200-072, Paragraph 5 - Manhole access openings and working space shall comply with the requirements of the NESC (National Electrical Safety Code). Manhole frames and covers shall comply with the requirements of SASO Standard, SSA 413, "Cast Iron Manhole Covers".

4.2.5.2 Roof Opening and Neck

GTE 911-200-072, Paragraph 5.02 - The manhole roof opening and neck shall be constructed to accommodate the inside base measurements of the standard manhole frame and cover.

4.2.5.3 Minimum Opening

GTE 622-500-202, Paragraph 3.02 - The minimum opening for Saudi Aramco telecommunication manholes shall be 30 inches (Type B 30 inch frame and cover; SAMS 18-036-510). All telecommunication manhole covers shall be Type B, 30 inch frames and covers and shall have an identifying mark, "TELEPHONE", stamped in the cover to indicate ownership.

4.2.5.4 Clearance from Railroads

GTE 911-200-072, Paragraph 5.04 - The surface opening of a manhole shall have a clearance of not less than 10 m from the nearest rail of any type of railroad unless greater clearance is required by the railroad proponent (refer to SAES-T-906).

4.2.5.5 Locate to Avoid Traffic Hazards

GTE 622-105-200, Paragraph 4 - Manholes shall be located so the manhole opening will be located such that future work in the manhole will not create traffic hazards.

4.2.5.6 Location in MH Roof

GTE 622-500-204, Paragraphs 7.01-7.19 and Figures 22 - Each manhole frame and cover shall be supported and centered over the manhole 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".

GTE 622-500-202, Paragraph 2.05, 3 and Figure 4 - The manhole opening must be located over the center of the manhole, except:

Exception:

In manholes 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 manhole or an appropriate sized steel support beam will be required.

4.2.6 Manhole Length and Width

4.2.6.1 ServiceManholes (Refer to Standard Drawing AA-036794, Sheet 1 - Service manholes)

4.2.6.2 Manhole Type-I (Refer to Standard Drawing AA-036794, Sheet 2 - Manhole Type-I)

4.2.6.3 Manhole Type-V (Refer to Standard Drawing AA-036794, Sheet 3 - Manhole type-V)

4.2.7 Provision for Cable Racking

4.2.7.1 Maximum Change in Level

GTE 911-200-072, Paragraph 7.01; GTE 622-500-100, Paragraph 4.01 - Changes in the level of main cables passing through manholes shall be kept to a minimum, and shall not exceed 230 mm.

4.2.7.2 Blocking of Vacant Conduits

GTE 911-200-072, Paragraph 7.03 - Cables shall not be racked in a position that would block or restrict the use of any other conduit or racking position.

4.2.7.3 Minimum Bending Radius

GTE 911-200-072, Paragraph 7.04 - Manholes shall be constructed so as to permit plastic sheath cables to maintain a minimum bending radius of 10 times the cable diameter.

4.2.7.4 Minimum Spacing Between Cables and MH Ceiling

GTE 911-200-072, Paragraph 7.05; GTE 622-500-100, Paragraph 4.02 - A minimum space of 380 mm shall be maintained in all manholes between the roof of the manhole and the center of the top main cable position for racking load coil case cable stubs and/or lateral cables. A minimum of 535 mm shall

be used if load coil case cable stubs or lateral cables are to be spliced into the top racked cable.

4.2.7.5 Minimum Space Between Cables and MH Floor

GTE 911-200-072, Paragraph 7.06, GTE 622-500-100, Paragraph 4.02 - A minimum space of 380 mm shall be maintained between the manhole floor and the center of the bottom main cable.

4.2.7.6 Minimum Headroom

GTE 911-200-072, Paragraph 7.14; GTE 622-500-100, Paragraph 5.02 - Modified - The minimum headroom for telecommunication manholes (except for the service manhole listed in paragraph 4.2.4.3.1 above) shall be 2.00 meters.

4.2.7.7 Headroom Calculations

GTE 911-200-072, Paragraph 7.08 - Based on the dimensional requirements of the preceding paragraphs, the following three formulas (where HR = Headroom in mm; N = maximum number of cables to be racked on one wall) have been developed for computing minimum line manhole headroom requirements (See Paragraph 4.2.7.6 above):

a) Single racking, single bay; HR = 380 + 230 (N - 1) + 535. (1)

b) Single racking, double bay; HR = 380 + 90 (N - 1) + 535. (2)

c) Double racking, double bay; HR = 380 + 190 (N/2 - 1) + 535. (3)

Example: A manhole is to be constructed in a 24-conduit run (12 cables on each wall) and double racking, double bay is to be used. From formula c, the headroom is computed as follows:

HR = 380 + 190 (12/2 - 1) + 535 = 1,865 mm

Commentary Note:

Since the calculated headroom is less than the minimum headroom permitted (see Paragraph 4.2.7.6) the actual design headroom used would be 2,000 mm.

4.2.7.8 Numbering of Rack Hook Positions

GTE 911-200-072, Paragraph 7.10 - Cable rack hook positions in all manholes are numbered from the top down to the bottom of the uprights; starting with number one at the upper-most cable hook rack space.

4.2.7.9 Double Racking Cables

GTE 911-200-072, Paragraph 7.13 - Double racking of cables is used with staggered splices to obtain maximum use of available manhole wall space. No more than two cables may be racked side by side at any racking level.

4.2.7.10 Supporting Cables and Splices

GTE 911-200-072, Paragraph 7.18 - Cables and completed splices in manholes 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.

4.2.8 Manhole Hardware

4.2.8.1 Inserts, Bonding Ribbon, and Wire

GTE 911-200-072, Paragraph 3.05; GTE 622-500- 204, Paragraph 2.01 - At the time a manhole 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. A bonding ribbon (or minimum of # 6 AWG tinned solid copper wire) shall be installed in each bay on each wall, where cables are to be racked. A minimum of one 3.05 m x 16 mm copper coated steel ground rod shall be driven in the manhole floor and bonded to the bonding ribbon or wire with # 6 AWG tinned solid copper wire. See Paragraph 4.2.9 also.

4.2.8.2 Hardware Must Be Non-Corrosive Type

GTE 911-500-075, Paragraph 5.02 - Modified - All manhole hardware must be of the non-corrosive type (i.e., hot dipped galvanized or better).

4.2.8.3 Cable Racks and Rack Supports

GTE 622-500-204, Paragraphs 2.02-2.03 - Each manhole 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 manhole drawing (AA-036794, Sheet 1-4). The distance from the inside surface of the manhole wall to the first cable rack shall be 760 mm or less.

4.2.8.3.1 Rack Supports

GTE 622-500-204, Paragraph 2.05-2.10 - Cable rack supports (S-cable rack support for line manholes and L-cable rack supports for loading manholes and other special situation manholes) must be placed at the time of manhole

construction. Cable rack supports must be secured to the manhole 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 manhole roof. For mounting details, refer to GTE 622-500-204, Figures 1-6.

4.2.8.4 I-Beam Uprights

GTE 622-500-204, Paragraphs 3.01-3.04 - I - Beam uprights (3-inch, 5.7-pound) must be placed (extending between the manhole floor and roof), in center-rack manholes, to provide for mounting cable racks. Refer to GTE 622-500-204, Figure 9 for mounting details.

4.2.8.5 Pulling-In Irons

GTE 622-500-204, Paragraphs 4.01-4.04 and Figures 10-11 - A minimum of one pulling-in iron shall be set (cast in concrete) in the manhole wall opposite all manhole conduit entrances (windows). The pulling-in iron must extend far enough into the manhole 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 manhole entrance window. Pulling-in irons shall not be allowed to bear against the outside face of the manhole 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).

4.2.8.6 Platforms

GTE 622-500-204, Paragraphs 5.01-5.08 and Figure 13 - If a situation arises where Loading Manhole Platforms are required, refer to this GTE Section.

4.2.8.7 Frames and Covers

GTE 622-500-204, Paragraphs 6.01-6.18 and Figures 14-21 - All manholes shall be equipped with manhole frames and covers with minimum openings of 30 in. All areas subject to vehicular traffic shall use minimum of Type B, (10 in high) frames and covers. Each manhole frame and cover shall be equipped with two locking bolts located approximately 180 degrees apart on the cover's circumference. See paragraph 4.2.5 above also.

4.2.8.8 Ladders and Steps

GTE 622-500-204, Paragraphs 8.01-8.07, Table 3 and Figures 23-24 and 28-30 - Hot dipped galvanized (minimum) steel manhole ladders shall be installed in all newly constructed manholes, except the service manhole. A manhole step is to be set in the roof opening of all manholes (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.

4.2.8.9 Manhole Adjusting Rings

GTE 622-507-200; GTE 622-507-201 - Manhole adjusting rings may be used to adjust the grade of manhole covers of existing manholes in projects which involve the resurfacing of streets, that will raise the street grade by 2 to 3 inches. A manhole adjusting ring shall not be used if any portion of the ring will remain exposed above the finished grade.

4.2.8.10 Manhole Sumps

GTE 911-300-070, Paragraph 10.01 - Modified - Manufactured sumps, such as produced by Condux International Inc. and Pennsylvania Insert Corporation or equivalent may be used in telecommunication manholes. Sewer pipe may also be used in manholes to construct sump holes. See Paragraph 4.2.2.2 above for size and installation requirements.

4.2.8.11 Conduit Terminators

4.2.8.11.1 For Main Conduits

Addition - All manholes shall be constructed with conduit terminators being placed to provide conduit termination space for the ultimate number of conduits that the manhole can serve.

4.2.8.11.2 For Lateral Conduits

Addition - Terminators to serve a minimum of four (4) lateral conduits (minimum of 4 inch ID; 2 inch permitted if serving buildings of 200 m^2 or less) shall be placed in each end of the manhole.

4.2.8.12 Non-Metallic Hardware

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

4.2.9 Bonding and Grounding Requirements

4.2.9.1 MH Ground Electrodes

GTE 911-200-072, Paragraph 3.05 - Modified - A ground electrode which provides a ground resistance of 25 ohms or less shall be provided in each manhole along with the necessary bonding ribbon and/or wire (minimum of #6 AWG tinned solid copper). For ground electrode design references, see SAES-T-887. Where a ground rod is used as the electrode, it shall consist of a minimum of one ground rod which is a minimum of 5/8 inches in diameter by 10 feet in length. The ground rod shall be driven in the corner of the manhole floor (100-150 mm from side and end walls) after the hole has been excavated. See Paragraph 4.2.8.1 also. Ground resistance measurements shall be made in accordance with SAES-T-887.

4.2.9.1.1 More Than One Ground Rod Required

Addition - If a second ground rod is required to obtain the required minimum ground resistance, it shall be driven in the manhole 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.

4.2.9.2 Cables Passing Through Metallic Conduits

GTE 887-000-050, Paragraph 4.08 - In situations where steel building entrance conduits or bends are used, the conduits/bends shall be bonded together and grounded to the pole or building ground. (Refer to SAES-T-629, Paragraph 4.3.1.2). When outside plant cables, containing metallic members, are placed through metallic conduits or pipes, the cable shields, armors and metallic central strength members, etc., must be bonded (Cadweld method or mechanical connector/clamp which is UL listed for the intended use, i.e., direct burial) to each end of the metallic conduit or pipe.

4.2.9.2.1 Bonding Not Practical

Where the metallic conduit/pipe falls in the mid section of a PVC conduit run, and where it is impractical to bond the cable shield to the metallic pipe, this bond will not be required provided that this is concurred to by the Saudi Aramco Communications Standards Committee Chairman (Information Technology Planning Division).

4.2.9.2.2 Metallic Pipe Bends

Exception - Where it is necessary to install metallic pipe bends at building entrances, pole risers, etc., and the pipe bend is extended underground with

non-metallic conduits, the cable shield to metallic pipe bond may be omitted at the underground end of the pipe bend, provided that this is concurred to by the Saudi Aramco Communications Standards Committee Chairman (Information Technology Planning Division). 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.

4.2.10 CEV (Controlled Environmental Vaults)

GTE 622-009-500, "Controlled Environmental Vault (CEV): Guidelines for Entering a CEV", Page 2 - A CEV is an underground chamber that houses electronic equipment, which requires a controlled environment. When a CEV is designed or installed, it must be equipped with:

1. Air conditioning,
2. Electric heater,
3. Sump pump,
4. Dehumidifier,
5. Ventilation blower,
6. Florescent lights,
7. Atmospheric monitoring and testing devices, and an intrusion alarm, all of which permit monitoring of the CEV from a manned site.

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

4.2.11 Manhole ID Numbers

4.2.11.1 New Manholes

GTE 622-508-200 - All new manholes shall be assigned an identification number and have the manhole identification number:

1. Stenciled in the exterior rim of the frame, using ½ inch numbers/letters.
2. Centered evenly between the inner and outer edges of the rim, in the portion of the rim nearest the curb or roadside.

It is not necessary to stencil the letters "MH" as prefix letters.

4.2.11.2 Existing Manholes

Addition - If it has not already been done, existing manholes (in which project or job order work is required - i.e., manhole must be entered) shall also have the manhole identification number stenciled in the rim of the frame as indicated above.

4.2.12 Conduit Plugs/Seals

Addition - All conduits entering manholes shall be plugged or sealed in accordance with SAES-T-628. See Paragraph 4.8.3.5 below also if building entrance conduits are to be installed. When work is done in existing manholes and building entrances, all conduit seals and plugs shall be inspected and brought up to the current Saudi Aramco Engineering Requirements, i.e., SAES-T-628.

4.3 GTE Section 911-300-070: Underground Conduit Materials; Issue 5/September, 1977

4.3.1 Telecommunications Conduit Specification

4.3.1.1 Type NEMA TC 8 DB & EB Conduit

GTE 911-300-070, Paragraph 1.02; GTE 911-400-071, Paragraph 4.01 - Modified - All new and rebuilt Saudi Aramco telecommunication conduit systems shall use NEMA TC 8, Type DB or EB single bore, plastic (PVC) conduit. Main conduit sections shall be a minimum of 4 inches inside diameter. The minimum inside diameter of lateral conduits shall be in accordance with Paragraph 4.2.8.11 and TABLE # 1. All conduit placed in the underground conduit systems shall be concrete encased as specified in paragraph 4.5.12.2 "Concrete Encasement". Different types of conduit shall not be placed in a conduit section.

4.3.1.2 Type EB

Type EB and DB conduit shall use plastic conduit coupling as specified in GTE 622-020-100, paragraph 4.10, and NEMA TC 9.

4.3.2 Conduit Bends and Sweeps

4.3.2.1 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.

4.3.3 Conduit Fittings

4.3.3.1 GTE 911-300-070, Paragraphs 3.04-3.06 - Fittings for NEMA TC 8 conduit shall conform to the specification requirements of NEMA TC 9.

4.3.4 Markings for Conduit Materials

4.3.4.1 Conduit Sections

GTE 622-105-208, Paragraph 3.05 - Each conduit section (20 foot length) shall be marked as required by NEMA TC 8.

4.3.4.2 Bends, Couplings and Fittings

GTE 622-020-100, Paragraph 4.11 and Figures 4 and 17 -Plastic conduit bends, couplings and fittings shall be marked as required by NEMA TC 9.

4.3.5 Handling and Storage of Conduit Materials

GTE 622-105-207, Paragraph 3.02 - Modified - Handling and Storage of NEMA TC 8 conduits and NEMA TC 9 accessories shall be according to the manufacturers direction or NEMA TCB2, "Users Manual for the Installation of Underground Plastic Conduit".

4.3.5.1 UV Discoloration

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

4.3.6 Galvanized Steel Pipe

4.3.6.1 GTE 911-300-070, Paragraph 9.01; GTE 622-020-100, Paragraph 11 - Modified - For Saudi Aramco telecommunication outside plant conduit system purposes, galvanized (hot dipped, minimum) steel, PVC coated conduit may be used only when written approval is obtained from the Saudi Aramco, Communications Standards Committee Chairman (Information Technology Planning Division). Some conditions which may warrant consideration of the use of galvanized steel pipe are as follows:

a) When the space available for conduits is limited and subject to impacts from heavy traffic,

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

c) When placing exposed conduit runs on pipe racks.

4.3.7 Lateral Conduit Materials

4.3.7.1 GTE 911-300-070, Paragraph 12.01 - Modified - Lateral conduit shall be NEMA TC 8, Type DB single bore, plastic (PVC) conduit.

4.3.8 PVC Conduit Exposed to Sunlight

Addition - When plastic (PVC) conduit is used above ground in areas where it would be exposed to sunlight, it must be a type that is resistant to ultraviolet rays, or be treated as outlined below (refer to SAES-L-060):

1- Clean the conduit surface as required so that it is free of oil, grease, dirt, etc.

2- Abrade the conduit with medium to coarse grade sandpaper before the coating application.

3- 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.

4.4 GTE 911-301-075: Concrete, Mortar, and Reinforced Concrete Information; Issue 1/January, 1969

4.4.1 Structural Requirements

GTE 911-301-075, Paragraph 4.03 - Modified - The design and installation of telecommunication vaults, manholes, handholes and pull boxes shall comply with the requirements of SAES-Q-001 "Criteria for Design and Construction of Concrete Structures", with the following exception:

Exception:

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

4.4.2 Mortar Requirements

GTE 622-100-204, - Modified - Mortar used for placing brick masonry, manhole frame and covers, etc., shall be in compliance with SAES-M-100, "Saudi Aramco Building Code", SAES-Q-001, "Criteria for Design and Construction of Concrete Structures" and 09-SAMSS-097, "Ready Mixed Portland Cement Concrete".

4.4.3 Concrete Reinforcement

GTE 622-100-205, - Modified - Concrete reinforcement shall be placed in accordance with SAES-Q-001, "Criteria for Design and Construction of Concrete Structures".

4.5 GTE Section 911-400-071: Conduit - Design and Layout; Issue 2/December, 1974

4.5.1 Design Life

GTE 911-400-071, Paragraph 1.03 - A conduit system is to be designed and engineered with the expectation that it will continue in service for 75 to 100 years.

4.5.2 Special Construction Situations

GTE 911-400-071, Paragraph 1.05 - 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 is to be made to a specially designed structure.

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

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

4.5.3 Designing to Avoid Future Problems

GTE 911-400-071, Paragraph 2.01-2.03 - All conduit designs shall take into consideration the vulnerability to future disturbance and the degree of mechanical protection that is justified to safeguard the conduit and its contents. Problem areas, such as listed below, must be considered and avoided where it is feasible to do so:

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

b) Unstable soil Conditions.

c) Road rebuilds or relocation's.

d) Future grade changes.

e) Unusual heavy traffic loading or the possibility of future heavy traffic loading.

4.5.4 Corresponding Conduits Enter MH at Same Level

GTE 622-105-200, Paragraph 12.01 - Corresponding conduits of conduit entrances in opposite ends of manholes shall be at the same level and in the same position with respect to the side walls.

4.5.5 Construction Drawings Must Show

GTE 911-300-070, Paragraph 1.04 - Telecommunication conduit system design and construction drawings must show the location of:

a) All existing and proposed conduit,

b) Size and configuration of manholes,

c) Lineal distances and conduit meters of conduit,

d) Type of material,

e) Any special conduit fittings required,

f) Conduit formation,

g) Manner of entering manholes or cable vaults,

h) The location of existing substructures,

i) The location of other utilities,

j) See Paragraph 4.1.6.1 above also.

4.5.6 Conduit Joints

4.5.6.1 Solvents, Cements and Primers

GTE 622-020-100, Paragraph 4.02; GTE 622-105-208, Paragraphs 2.01-2.04, and 8 - 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. These items:

a) Must be kept covered when not in use,

b) Must be kept away from excessive heat and flames,

c) Must not be thinned.

d) Must not be placed in excess, to avoid having it forced to the interior conduit wall.

e) Must be the proper primer and cement as recommended by the manufacturer.

4.5.6.2 Conduit Preparations

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

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

b) Must be joined while cement is still wet.

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

d) In the trench, must be set back (separated) a minimum of 205 mm from the joint below it.

e) 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.

f) 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.

4.5.7 Conduit Section Lengths

GTE 911-400-071, Paragraphs 5.01-5.04 - So that costs can be minimized, the length of conduit sections between manholes shall be designed to be as long as is practical to reduce the:

a) Number of manholes,

b) Number of splices, and

c) Number of set ups required for cable pulling.

4.5.7.1 Other controlling factors to be considered in determining manhole spacing are:

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

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

c) Distribution cable points, junction points, etc.

4.5.8 Separations from Other Substructures

GTE 911-400-071, Paragraph 6.01; GTE 622-025-010, Paragraph 12; GTE 622-105-200, Paragraph 10 - Modified - For identification, protection from arcing, reduction of stray currents (especially those resulting from cathodic

protection on pipelines), etc., the minimum separations between other (non-telecommunication proponent facilities and non-Saudi Aramco facilities) substructures and telecommunication conduit substructures shall be as indicated in attached TABLE # 2. Separations between telecommunications manholes and other substructures shall be as indicated in attached TABLE # 3.

4.5.9 Separation From Oil Field Pipelines

4.5.9.1 Pipelines Included

Addition - Pipelines as referenced in this paragraph means hydrocarbon pipelines and other oil field pipelines (pipelines located outside plant area fences) used in the operation of the oil business.

4.5.9.2 Crossing Pipeline Corridors

Addition - All telecommunication cables that are installed across pipeline corridors shall be placed below the pipes inside concrete encased buried conduits which have been installed in accordance with this standard and SAES-B-064.

Commentary Note:

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

4.5.9.2.1 Requirements:

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

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

Commentary Note:

For single pipeline (flow lines, etc., where pipeline corridors have not been established) crossings, telecommunication cables shall be placed in concrete encased conduits that extend for a minimum distance of ten meters on each side of the pipeline.

c) No portion of any service point (manhole, pedestal , etc.) on Saudi Aramco telecommunication cables shall be closer than 25 m to any pipeline in the corridor (in accordance with SAES-B-064). When locating service points, the engineer must be sure to take into

consideration the location of proposed or future pipelines as determined by coordination with the pipeline's proponent.

d) The conduit system shall be identified by the color orange as indicated in Paragraph 4.5.13.6 below.

4.5.9.3 New Pipelines Crossing Existing Cables

Addition - When new pipelines cross existing telecommunication cables or conduits, the telecommunications cable(s)/conduits shall be provided the same mechanical protections and separations as outlined above, when telecommunications cables are placed across pipeline corridors; i.e., the telecommunication facilities must:

a) Be located 1 m below all pipelines in concrete encased conduits;

b) Be provided a minimum of one spare conduit in accordance with this standard;

c) Have prior approval from the telecommunications proponent before, these cables can be moved or relocated (coordinate with the Saudi Aramco, Communications Engineering Division of IT.

4.5.9.4 Cables Crossing Over Pipelines

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

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

Commentary Note:

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

b) The standard (see paragraph 4.5.13.3 and 4.5.13.4 below) ground cover can be maintained above the buried concrete encased telecommunication conduit structure, and

c) This design variation must be approved by Saudi Aramco, Pipeline Operations Engineering Division Superintendent and Saudi Aramco,

Communications Engineering Division, Outside Plant Unit, Supervisor.

4.5.10 Conduit Curves, Offsets, etc.

4.5.10.1 Minimum Radius - Main Conduit Sections

GTE 911-400-071, Paragraph 8.01 - Except for the minor curves involved when splaying main conduits at manhole 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.

4.5.10.2 Maximum Main Conduit Section Lengths

GTE 911-400-071, Paragraph 8.02 and Figure 3 - 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 attached TABLE # 4. Main conduit section lengths, which exceed those shown in TABLE # 4, must be proven with cable pulling tension calculations and side wall pressure calculations.

4.5.10.3 Bending of PVC Conduit

4.5.10.3.1 Hot Bending in the Field

GTE 622-105-208, Paragraph 10.10 - Modified - The hot bending of PVC (NEMA TC 8) conduit in the field will not be permitted because of the difficulty of quality control.

4.5.10.3.2 Bends of 10 - 45 Meters Radii

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

4.5.10.3.3 Greater Than 45 Meter Radius

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

4.5.10.3.4 Less Than 10 Meter Radius

Addition - Bends less than 10 meters must be constructed with the use of factory made bends or sweeps.

4.5.10.4 Conduit Offsets

GTE 911-400-071, Paragraph 8.03-8.06 - Offsets (i.e., 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 radius, to minimize the resistance offered by the sweeps when cable is pulled-in.

4.5.10.4.1 Offsets Not More Than 1.5 Meters

Where the offset distance is not more than 1.5 m and the radius of the sweep or curve is 30 meters or more, the offset may be disregarded in determining maximum section length. However, if the offset in an otherwise straight section of conduit is more than 5 feet, the length of the conduit section shall be shortened proportionately (up to one-third for extreme conditions). Refer to Paragraph 4.5.10 above for specific limitations.

4.5.10.5 Conduit Spacers

4.5.10.5.1 Areas Requiring Spacers

GTE 622-105-200, Paragraph 5; GTE 622-105-208, Paragraph 10.01 - Modified - Conduit spacers providing a minimum of 38 mm separation between conduits must be used in all concrete encased conduit sections. See paragraph 4.6.1 for a possible exception. All conduit encasements shall comply with the requirements of:

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*

4.5.11 Blasting

4.5.11.1 GTE 622-105-200, Paragraph 9.03; GTE 622-500-200, Paragraph 7.03 - Modified - Any blasting requirements for either trench or manhole

excavations shall be carried out in accordance with the "Construction Safety Manual" and GI-0007.015, "Use of Explosives in Construction".

4.5.12 Protection of Conduit Systems

4.5.12.1 Loads on Conduit

GTE 911-300-070, Paragraphs 11.01-11.02 - 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.

4.5.12.2 Concrete Encasement

GTE 911-400-071, Paragraph 9.01-9.02; GTE 622-105-207, Paragraph 4.02 - Modified - All new and rebuilt telecommunication conduit systems (including main and lateral conduits) shall be concrete encased (non-structural concrete per SAES-Q-001 and 09-SAMSS-097); to provide mechanical protection against:

a) Settlement of the conduits, or

b) Damage by excavating equipment.

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

4.5.12.2.1 Concrete Base Required

GTE 911-400-071, Paragraph 9.04 - Modified - Concrete encasement (including a concrete base) is required for telecommunication conduit systems. A concrete base is especially beneficial:

a) Whenever the ground is spongy or yielding, or

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

4.5.12.3 Minimum Concrete Requirements

GTE 911-400-072, Paragraph 3.02; GTE 622-105-207, Paragraph 6.08-6.09 - Modified - The minimum amount of concrete encasement used shall be 75 mm along the top, sides and bottom of the conduit formation.

4.5.12.4 Trench Walls Used as Forms

GTE 622-105-208, Paragraphs 6.01-6.04 - When concrete encasing conduit, the trench walls may be used as a form for the concrete, provided a

minimum thickness of 3 inches of concrete is provided on each side of the conduit bank.

4.5.12.5 Encasement Direction

GTE 622-105-208, Paragraph 11.04 - 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 (manholes). Never start at the ends and work toward the center.

4.5.12.6 Concrete Encasement with Other Utilities

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

4.5.13 Conduit Trenches

4.5.13.1 Trench Width

GTE 622-105-200, Paragraphs 7.01-7.03; GTE 622- 105-207, Paragraph 4.02; Typical Installation Drawing AA-036373, "Telecommunications Conduit Installation" - 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. Refer to the Saudi Aramco, Construction Safety Manual for other safety requirements.

4.5.13.2 Trench Bottoms

GTE 622-105-200, Paragraph 11; GTE 622-105-207, Paragraph 5.04 - Before receiving conduits, the trench bottom shall be:

1. Cleared of rock, rock protrusions and other items that could damage conduits,
2. 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.

4.5.13.2.1 Draining Conduit Sections

GTE 911-400-071, Paragraph 8.08; GTE 622-105-209, Page 22 - Conduit sections should be constructed so that they drain toward the manholes where practical. Grade the trench so that it has a fall of at least 75 mm in 60 m toward the lower manhole or from the high point (or midpoint if in a reasonably level area) of the section toward both manholes.

4.5.13.3 Minimum Cover in Traffic Areas

GTE 911-400-071, Paragraph 9.01; GTE 622-105-200, Paragraphs 7.04-7.11 - Modified - Telecommunication main conduit sections, placed in roadways and other traffic areas, shall provide a minimum ground cover of 760 mm. Where it is necessary to place conduit in traffic areas at depths of less than 760 mm, or where unusually heavy traffic loads (see paragraph 4.5.12) are likely, additional protective measures (PVC coated steel pipe, higher strength concrete for encasement, etc.) suitable to protect the conduit system from the expected traffic load shall be provided as required for specific situations.

4.5.13.3.1 Establishing Grades

GTE 911-400-071, Paragraph 8.09 - When designing and installing conduit in streets or roads without established grades, obtain the final grade from the street or road proponent, and install the conduit at the required depth to ensure that the minimum standard ultimate cover can be maintained. To avoid conflicts, a coordination of installation plans shall be carried out with all involved utility proponents during the design and installation stages of the project.

4.5.13.3.2 Trench Restoration

GTE 622-105-200, Paragraph 8 - Modified - All excavations shall be restored to original or better condition. Roadways and pavements areas shall be removed and restored in accordance with SAES-Q-006, "Asphalt Concrete Paving", and GI-1021.000, "Street and Road Closure: Excavations, Reinstatement and Traffic Controls".

4.5.13.4 Minimum Cover in Non-Traffic Areas

GTE 622-105-200, Paragraphs 7.04-7.11 - Main conduit sections may be placed at a minimum depth (cover) of not less than 610 mm under the following conditions, provided heavy duty power-activated equipment is not employed for backfill compaction:

a) Along streets/roads but outside the area reserved for present or future traffic.

b) In other non-traffic areas and other areas not subject to heavy vehicular traffic.

4.5.13.5 Backfill

GTE 622-105-200, Paragraph 13; GTE 622-105-207, Paragraph 8 - Modified - Conduit trench backfill shall comply with the following:

1. Immediately around conduits shall be concrete encasement in accordance with paragraph 4.5.12.2 above.
2. 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 rolled with heavy equipment as indicated below:
   a) A 5 ton vibrator roller,
   b) A dump truck or
   c) Other dual rear wheel truck).

   Commentary Note:

   In active sand areas, the trench must be stabilized. Refer to SAES-T-928, for acceptable methods.
3. If the conduits are located in a Saudi Aramco road or street, the balance of the trench backfill shall be in accordance with SAES-Q-006 and GI-1021.000, "Street and Road Closure: Excavations, Reinstatement and Traffic Controls".
4. In non-Saudi Aramco streets or roads, the balance of the backfill shall be as required by the street or road proponent. The requirements of item 3 may be followed if approved by the road proponent.
5. 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. Keep the machine moving steadily so that the tamping pad does not hit twice in the same spot.
6. Compaction with wheel rolling machines is not permitted with a cover of 1.1 m or less.
7. Compaction with hydrohammers is not permitted where the conduit cover is less than 1.3 m.

8. 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.

4.5.13.6 Orange Color Identification

Addition - The color orange shall be used to identify telecommunication facilities. For conduit systems, this may be accomplished by:

a) Placing an orange marker tape above the conduit concrete encasement surface. The marker tape is to be located 300 mm minimum below grade and 300 mm minimum above the conduit system upper surface,

b) Mixing orange dye with the concrete used for encasement (refer to SAES-Q-001), or by,

c) Mixing orange dye with the top layer of the concrete (refer to SAES-Q-001).

Commentary Note:

Placing an orange marker tape above the conduit concrete encasement surface is the preferred method. Orange marker tape above the conduit concrete encasement surface will provide an early warning.

4.5.13.7 Casing Installations

GTE 911-400-071, Paragraph 9.07 and Table 1 - 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, etc., it may be necessary to place the conduit in large steel casings as a means of protection or to otherwise facilitate a crossing. Upon completion of the conduit installation, the casing must:

1. Be filled with fine sand, blown in under air pressure,

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

4.5.13.7.1 Casing Wall Thickness

GTE 911-400-071, Paragraph 9.07 - The minimum wall thickness of the casing shall be as required by the highway or railroad proponent but never less than three-sixteenths inch.

4.5.13.7.2 Number of Conduits Per Casing

GTE 911-400-071, TABLE 1 - Attached 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-046, "Pipeline Crossings Under Roads and Railroads", unless greater cover is required by the highway or railroad proponent. (Refer to SAES-T-906 also).

4.5.14 Conduit on Bridges

4.5.14.1 GTE 911-400-071, Paragraphs 11.01-11.08; GTE 622- 105-207, Paragraph 6.11 - Modified - If it becomes necessary to attach a conduit system to a bridge, the GTE paragraphs referenced in this paragraph must be reviewed and complied with. Also, close coordination with the structural engineers of the bridge proponent must be maintained, and the final design must be approved by the bridge proponent. See Paragraphs 4.1.2.1 above also.

4.6 GTE Section 911-400-072: Conduit Design - Formations;
Issue 1 October, 1974

4.6.1 Conduit-to-Conduit Installations

GTE 622-105-207, Paragraph 5.05 - Modified - Conduit-to- Conduit installations of plastic conduit shall not be used unless specifically approved by the conduit manufacturer.

4.6.2 Standard Formations for Plastic Conduits

4.6.2.1 Formation Widths

GTE 911-400-072, Paragraph 3.01 and Figure 2; GTE 911-400-071, Paragraph 7.01 - Modified - Conduit trench formations, consisting of four or more conduits, shall be two or four conduits wide. See paragraph 4.6.2.2 also.

4.6.2.2 Formation Changes at Obstacles

GTE 622-105-208, Paragraph 10.13 - 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 (at exit of previous manhole) formation before entering the next manhole.

4.6.2.3 Formations in Rock

GTE 911-400-072, Paragraph 4.01-4.04 - Where rock or other unusually difficult excavation or space restrictions are expected, or are known to exist, it may be advisable to consider a formation other than the standard cross section, such as a shallower, wider formation. Prior approval for this type installation must be obtained from the Saudi Aramco, Communications

Standards Committee Chairman (Information Technology Planning Division).

4.6.2.4 Splay Conduits at Manhole Entrances

GTE 911-400-071, Paragraph 7.02; GTE 911-400- 072, Paragraph 5.01 and Figure 3 - Modified - Splayed conduit manhole entrances shall be used for all telecommunications manholes. Bottom manhole entrance holes shall be used first for conduit termination's.

4.6.2.4.1 Conduits Less Than One MH Wall Capacity

GTE 911-400-071, Paragraph 7.02 - If the proposed number of conduits is no greater than the racking capacity of one side of the manhole, only one side (the side nearest the roadway or pavement) shall be used and the conduits shall be placed from road side window to road side window. The field side of the manhole will be left for future conduits.

4.6.2.4.2 Minimum Splaying Distance

Addition - 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 manhole wall.

4.6.2.5 Subducts

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

4.7 GTE Section 911-400-073: Long Pulls of Underground Cable - Engineering Considerations; Issue 1 November, 1979

4.7.1 General

GTE 911-400-073, Paragraph 1.04 - Long (defined as those cable pulls, which exceed one conduit section - between two manholes, etc.) 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.

4.7.2 Cable Pulling Eyes

GTE 911-400-073, Paragraph 2.01 - 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:

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

Where: d(c) is the cable diameter.

4.7.2.1 Minimum Conduit Clearance

GTE 911-400-073, Paragraph 2.01 - The diameter of the conduit must be a minimum of 1.15 times the diameter of the cable, or 13 mm larger in diameter than the diameter of the cable, whichever provides the greater clearance. Actual clearance provided must be based on the actual diameter of the pulling-in eye used.

4.7.3 Conduit Coefficient of Friction

GTE 911-400-073, Paragraph 2.02 - The condition of the conduit must be considered, since the coefficient of friction will be dependent upon this factor. Some of the items which effect coefficient of friction are as follows:

a) Dirt or contamination.

b) Type of surface.

c) Lubrication of the cable.

d) Conduit deviations.

e) Conduit deformations.

4.7.3.1 Factors for Clean, Good Condition Conduits

GTE 911-400-073, Paragraph 2.02 and Table 1 - TABLE # 6, attached, 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.

4.7.3.2 Establishing Coefficient of Friction Factors

GTE 911-400-073, Paragraph 2.03 - To determine unknown coefficient of friction's, i.e., when conduits are:

a) Only in fair condition,

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

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

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

4.7.4 Pulling Tension Limitations

GTE 911-400-073, Paragraph 3.01 - Cable pulling tension limitations are as follows:

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

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

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

Where: n = The number of conductors in the cable,

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

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

Commentary Note:

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

4.7.5 Cable Pulling Tension Calculations

4.7.5.1 Straight and Curved Conduit Sections

GTE 911-400-073, Paragraphs 5.02 and 6.01-6.10 - 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:

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

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

Where: T = Pulling tension on cable in pounds

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

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.

Commentary Note:

The value of T(o) will never be zero. Typically 100 pounds should be used.

4.7.5.1.1 GTE 911-400-073, Paragraph 5.03 - Equation (b) (See Paragraph 4.7.5.1 above) requires the use of a calculator with hyperbolic functions.

4.7.5.2 Side Wall Bearing Pressure

GTE 911-400-073, Paragraph 5.04 - In addition to the above calculations, when curved sections are involved, it is necessary to calculate the cable bearing pressure [P(B)] against the side wall of the conduit. Side wall bearing pressure shall not be permitted to exceed 150 pounds per foot. This applies to lateral conduits as well as main conduits. The equation for calculating the side wall bearing pressure is as follows:

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

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

R = Radius of the involved curve in feet.

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

4.7.6 Use of Wire Mesh Grips

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

cables, when wire mesh cable grips are used. Listed in TABLE # 8, also, are the 75% limits for these cables.

4.7.7 Reel Length Limitations

GTE 911-400-073, Paragraph 4 and Table 4 - Refer to this section of the GTE Practices for information on calculating cable reel capacities.

4.7.8 Further Considerations

4.7.8.1 Cable Reel Set-Up Location

GTE 911-400-073, Paragraph 7.01 - 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.

4.7.8.2 Do Not Exceed 85% of T(max)

GTE 911-400-073, Paragraph 7.02 - Modified - Do not design long conduit sections or cable pulls, which would result in cable pulling tensions, that would be close to 85% of T(max), which is the value of the cable's maximum pulling tension as calculated per Paragraph 4.7.4 above.

4.7.8.3 Uphill Cable Pulls

GTE 911-400-073, Paragraph 7.04 - Avoid uphill cable pulls when practical. Where an uphill pull cannot be avoided, refer to GTE Paragraph 7.04 for equations that may be used for calculating uphill, straight conduit section pulls.

4.7.8.3.1 GTE 911-400-073, Paragraph 7.05 - Avoid long cable pulls (more than one conduit section) also when sharp dips or humps would be encountered.

4.7.9 Planning Cable Pulls

4.7.9.1 Work Order Drawings

GTE 911-400-073, Paragraph 8.01 - 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.

h) 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.

4.8 GTE Section 911-500-075: Underground Entrances to Central Office Buildings; Issue 2/November, 1975

4.8.1 General

GTE 911-500-075, Paragraph 1.01 - This section covers the design and installation of the basic types of underground cable entrances to telecommunications/central office buildings of various sizes.

4.8.2 Cable Racking Plan

GTE 911-400-071, Paragraph 10.01 - Conduits entering a telecommunications / central office building or cable vault shall be laid out so that they coincide with the cable racking plan for the office as determined or otherwise approved in writing by the Saudi Aramco Communications Standards Committee Chairman (Information Technology Planning Division).

4.8.3 Design for Cable Vault Entrance Flexibility

GTE 911-500-075, Paragraph 2.02 - The central office building conduit entrance shall be designed to provide full flexibility in carrying a cable from any entering conduit to any frame position without the need for crossovers or rearrangements in manholes outside the building.

4.8.3.1 Entrance From Opposite Side of Street

GTE 911-400-071, Paragraph 10.03 and Figure 7 - The most desirable arrangement for a conduit entrance results when the conduit run is located on the side of the street opposite the central office building. Under this condition, the conduits from both directions may be turned into the front wall of the cable vault with large (15 m and larger) radius curves or sweeps.

4.8.3.2 Entrance From Same Side of Street

GTE 911-500-075, Paragraph 2.04 - If the conduit run is on the same side of the street as the central office building and bends of an adequate radius are not possible, the cable vault should be extended under the sidewalk, grass plot, etc., and the conduits brought into the side walls of the cable vault.

4.8.3.3 Provide Ultimate Conduits Initially

GTE 911-500-075, Paragraph 2.03 - The ultimate number of conduits (to be determined/approved in writing by the Saudi Aramco Communications Engineering Division of IT, required to provide for the estimated ultimate capacity of the telecommunications/central office building shall be installed in the vault wall initially. As a minimum, these conduits must extend out from the office to a sufficient distance which should be determined by the Saudi Aramco Communications Standards Committee Chairman (Information Technology Planning Division) 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.

4.8.3.4 Entrance Conduit Grade or Slope

GTE 911-500-075, Paragraph 2.05 - The grade or slope of central office building entrance conduits shall be away from the building (minimum of 25 mm per 30 m).

4.8.3.5 Conduit Plugs and Seals

GTE 911-500-075, Paragraph 2.06; GTE 622-500- 100, Paragraph 7.04; NESC, Part 3, Section 32, Paragraph 322B - As soon as the conduit entrance installation is complete, all conduits (vacant or occupied) entering buildings (telecommunications / central offices and others) shall have watertight / gastight plugs or seals, placed in both the manhole 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, except, when actual construction is in progress. (Refer to SAES-T-628). Conduit laterals terminated on poles shall be sealed with watertight/gastight plugs or seals also.

4.8.3.6 Conduit Terminators at CO Entrance

GTE 911-500-075, Paragraph 2.07 and Figure 1 - Conduit terminators shall be used in concrete building walls to construct conduit underground entrances to telecommunication and central office buildings.

4.8.3.7 Ultimate of Four Entrance Conduits

GTE 911-500-075, Paragraphs 2.08, 3.01-3.02 and Figure 3 and 5 - All telecommunications/central office buildings shall be provided with an underground conduit entrance for connecting outside plant cables. In very small telecommunication / central office building locations, this may consist of only conduit/bends (maximum of 4) stubbed outside the building through the building floor for entrance of direct buried or underground cables. Where this type conduit entrance is used, a pulling-in iron shall be placed in the roof of the building, directly over the conduit entrance.

4.8.3.7.1 Vault or CO Manhole not Mandatory

GTE 911-500-075, Paragraph 2.10 and Figures 3 and 5 - A cable vault or office manhole is not mandatory, where a telecommunication or central office building's ultimate requirements will not exceed four entrance conduits (four main conduits - subducts not counted). The number of entrance conduits required will be determined and approved in writing by the Saudi Aramco Communications Standards Committee Chairman (Information Technology Planning Division).

4.8.3.7.2 Vertical Cable Entrance Splices

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

4.8.3.8 Ultimate of Six to Nine Entrance Conduits

GTE 911-500-075, Paragraphs 2.11 and 3.01- 3.02 - Where the telecommunications building ultimate requirements will exceed four main entrance conduits, [as determined and approved in writing by the Saudi Aramco Communications Engineering Division of IT, and approved by the Saudi Aramco Communications Standards Committee Chairman (Information Technology Planning Division)] a cable vault or a central office entrance manhole shall be provided. When a cable vault is installed, all requirements of Paragraph 4.8.3.9 are applicable.

4.8.3.8.1 Two Reverse Bends Exception

GTE 911-500-075, Paragraph 3.03 and Figure 6 - A central office building entrance using two reverse 45-degree conduit bends 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.

4.8.3.9 Ultimate of More Than Nine Entrance Conduits

4.8.3.9.1 Cable Vault Required

GTE 911-500-075, Paragraph 4.01 - Large telecommunications / central office buildings (more than nine main entrance conduits required) require the construction of cable vaults. The cable vault is to be reserved for the entrance of telecommunication outside plant cables and as the interface point between outside and inside type cables.

4.8.3.9.2 Seal From Rest of Building

Addition - 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.

4.8.3.9.3 Pulling-In Irons

GTE 911-500-075, Figure 11 - 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. 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

4.8.3.9.4 Lighting, Outlets and Ventilation

GTE 911-500-075, Paragraph 4.02 - Modified - 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)].

4.8.3.9.5 Headroom

GTE 911-500-075, Paragraph 4.02 and Figure 7 - The required headroom of a cable vault or central office manhole may vary, however, the minimum headroom shall not be less than 2 meters.

4.8.3.9.6 Splayed Conduit Entrance

GTE 911-500-075, Paragraph 4.03 and Figure 7 - Horizontally splayed central office building cable vault entrance conduits, of a maximum of two

conduits width per rack side, shall be provided. The entrance conduits shall also be splayed vertically so as to locate the conduits so that cables may enter at the levels of their respective cable rack hooks.

4.8.3.9.7 Vault Locations Prohibited

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

4.8.3.9.8 Vault Atmospheric Monitoring and Testing

Addition - 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.

4.8.3.9.9 Cable Vault Length

GTE 911-500-075, Paragraph 4.04 - 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. The actual cable vault design shall be concurred, too, in writing by the Saudi Aramco Communications Engineering Division of IT.

4.8.3.9.10 MDF Location in Relation to Cable Vault

GTE 911-500-075, Paragraph 4.06 - 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.

4.8.3.9.11 Cable Holes - Vault to MDF

GTE 911-500-075, Paragraph 4.07 - 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.

4.8.3.9.12 Fire Stop Cable Holes Vault to MDF

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

4.8.4 Materials for Cable Vaults

GTE 911-500-075, Paragraph 5.02 - All metallic hardware used in telecommunication cable vaults shall be hot dipped galvanized or better.

4.8.4.1 Steelworks and Structures

GTE 911-500-075, Paragraph 5 - Modified - Design and installation of concrete structures, including steel work and reinforcement of central office cable vaults and manholes, 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".

4.8.4.1.1 Building Structure

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

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

4.8.4.2 Vault Cable Racks

GTE 911-500-075, Paragraph 5 - Refer to Figures 22-29 of GTE 911-500-075 for examples of various cable vault cable racking construction materials and details. Cable rack installations in cable vaults shall comply with the manufacturer's directions.

4.8.5 Cable Protection

4.8.5.1 Electrolysis Protection

GTE 911-500-075, Paragraphs 6.01 - If cable insulating joints are required for electrolysis protection reasons, refer to this GTE section and paragraph.

4.8.5.2 Cable Entrance Ground Bar (CEGB)

Addition - 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.

4.8.5.3 Bond and Ground Cable Shields and Metallic Strength Members

GTE 911-500-075, Paragraph 6.02 - The shields/armors, metallic strength members, etc., of all cables entering a telecommunications/central office building cable vault shall be bonded together and connected to the CEGB in accordance with SAES-T-605, SAES-T-795, SAES-T-903 and other referenced standards.

4.9 GTE Section 911-500-100: Conduit - Conduit Selection and Cable Measuring; Issue 1 September, 1973

4.9.1 General

GTE 911-500-100, Paragraph 1.01 - This section outlines a method of selecting the proper conduits for cable installation in manholes and cable vaults.

4.9.2 Selection of Conduits

4.9.2.1 Blocking Vacant Conduits

GTE 911-500-100, Paragraph 2.01 - Do not assign a conduit, which, when occupied, will block other vacant conduits or block racking positions on the manhole wall. It must be kept in mind that, in some cases, a good assignment in one manhole may prove to be a poor assignment in the next manhole.

4.9.2.2 Conduit Assignments

GTE 911-500-100, Paragraph 2.02 - The Saudi Aramco standard for conduit assignments is that cables be assigned to bottom conduits 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.

Any exceptions to this must be approved in writing by the Saudi Aramco Communications Engineering Division of IT.

4.9.2.3 Double Racking of Cables

GTE 911-500-100, Paragraph 2.05 - Where double racking of cables is used in a manhole, occupy the conduits nearest the outside wall first. Exceptions to this must be approved in writing by the Saudi Aramco Communications

Standards Committee Chairman (Information Technology Planning Division).

4.9.2.4 Conduit Numbering

GTE 911-500-100, Paragraph 2.07 - Modified - Specific conduits and conduit locations in manholes and cable vaults are designated by numbers according to row and bank location, counting left to right, bottom to top, starting with the bottom left side conduit, with your back toward the central office. Refer to SAES-T-018, page 42 for an example of this.

4.9.3 Selection of Conduits for Pull-Throughs

GTE 911-500-100, Paragraph 3.01 - 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 manholes.

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

c) Sections of conduit having sharp bends are not suitable for pull-through. Long radius bends, including those in a conduit run following a gradual curve in a street may be included in a pull-through section, provided the limits of Paragraph 4.7 above 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.

4.9.4 Cable Measurements and Cutting Lengths

GTE 911-500-100, Paragraph 4 - 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 add:

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

b) The lengths of the cable ends required inside the two manholes, and

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

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.

4.9.5 Construction Drawings

GTE 911-500-100, Paragraph 5.01 and Figure 1 - The construction drawings must contain all the information necessary for completing the work as designed.

4.9.5.1 Data Required

GTE 911-500-100, Paragraph 4.06 - 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 manhole. (Refer to SAES-T-018, Page 42).

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 manholes.

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

h) Indicate whether or not the manhole contains gas, water, or other foreign material that require removal.

i) The number and size of cable hooks required.

4.9.5.2 As Built Drawings

GTE 911-500-100, Paragraph 5.03; GTE 622-100-503, Paragraph 7.01 - All record items and record measurements shall be verified and shown on the "As Built Drawings" prior to acceptance of the work.

5 INSTALLATION

All Saudi Aramco telecommunication conduit systems shall be designed and installed in accordance with this standard (SAES-T-911) and other applicable standards as referenced in this standard (See Paragraph 3 above). Installation methods shall be in accordance with the "Saudi Aramco

Construction Safety Manual" and other applicable safety requirements (see paragraph 4.1.10.1 above).

6 TESTING AND INSPECTION

6.1 Inspection Requirements

6.1.1 GTE 622-100-503 - All telecommunication conduit system installations shall be inspected by the Saudi Aramco Inspection Department to confirm that the work is performed with a high regard for safety, quality, and public relations and that the work has been completed in accordance with Saudi Aramco standards, specifications and detailed plans.

6.2 Inspection Department Notification

6.2.1 Addition - The Saudi Aramco Inspection Department must be notified a minimum of 48 hours in advance of required inspections or tests.

6.3 Trench Backfilling

6.3.1 GTE 622-100-503, Paragraph 3.08 - 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.

6.4 Concrete Tests and Inspections

6.4.1 Applicable Standards

GTE 911-301-075 - Modified - Concrete tests and inspections shall be done in accordance with:

SAES-M-006	*Saudi Aramco Building Code*
SAES-Q-001	*Criteria for Design and Construction of Concrete Structures*
SAES-Q-005	*Concrete Foundations*
SAES-Q-006	*Asphalt Concrete Paving*
09-SAMSS-016	*Concrete Masonry Units and Concrete Building Bricks*
09-SAMSS-088	*Aggregates for Concrete*
09-SAMSS-097	*Ready-Mixed Portland Cement Concrete*
09-SAMSS-106	*Epoxy Coated Reinforcing Steel Bars*

Concrete used to encase telecommunication conduits as a minimum shall meet the non-structural concrete requirements of SAES-Q-001 and 09-SAMSS-097.

6.4.2 Precast Manholes

GTE 622-501-200, Paragraphs 2.01-2.05 - Modified - All precast manholes 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 manholes to allow Saudi Aramco sufficient time to exercise their right to inspect.

6.5 Mandrel Tests

6.5.1 Tests Required

GTE 622-100-503, Paragraph 3.10; GTE 622-105- 207, Paragraph 9 and Figure 5; GTE 622-105-208, Paragraph 10.14 - 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.

6.5.1.1 All Conduits

GTE 622-105-207, Paragraph 9.01 - Modified - Before concrete encasement and again after concrete encasement, and before doing any paving work over the conduits:

a) Each new conduit must be cleaned and tested (in both directions) with the appropriate size test mandrel. Nominal Four inch inside diameter conduits must pass a 3-5/8 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 5/8 inch diameter, square edged steel plate or cap on each end of the mandrel.

6.5.1.2 Conduit Lateral Test Differences

Addition - 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.

6.5.1.3 Mandrel Tests for Existing Conduits

GTE 911-400-073, Paragraph 7.06 - Modified - Existing conduits in which cables are to be placed shall be tested with an appropriate size mandrel as required by SAES-T-628. Repair of existing conduits is covered in GTE 622-105-301, "Plastic Conduit - Replacement and Repair".

6.5.2 Field Fabricated Mandrels

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

6.5.3 Mandrel Test, Pass-Fail Requirements

GTE 622-105-207, Paragraph 9.02 - Modified - A conduit passes the mandrel test if the test mandrel passes through the entire length of the conduit without:

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

   Commentary Notes:

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

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

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

6.5.4 Failed Mandrel Tests

6.5.4.1 Replace or Repair

GTE 622-105-207, Paragraph 9.02 - Excavate and replace or repair any conduit that does not pass the mandrel test. A conduit that does not pass the test mandrel:

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

6.5.4.1.1 Re-test Replaced or Repaired Conduits

GTE 622-105-207, Paragraph 9.02 - 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

31 March, 2004	Revised the "Next Planned Update". Reaffirmed the contents of the document, and reissued with no other changes.

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The first level or primary item names are capitalized (i.e., BLASTING) and are listed in alphabetical order.

Second level item names are indented from first level item names, are preceded by an asterisk (i.e., * Vaults) and are listed in alphabetical order under their first level item name or category.

Third, fourth, fifth, etc., level item names are listed in alphabetical order under their respective level item name or category.

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Table 1 – Maximum Lateral Conduit Lengths (1)

Cable Diameter In Inches	Limiting Lengths Of Lateral Conduits In Meters Bends			Minimum Diameter of Conduits In Inches
	No 90 Deg	1-90 Deg	2-90 Deg (2)	
Up to 1"	275	135	23	2.0
1.01-1.20	230	137	30	2.0
1.21-1.40	183	96	36	2.0
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 4.1.9.2.1.
(2) Assumes 90 degree bends are located at opposite ends of lateral conduits.

Table 2 – Separation between Telecommunication Conduits and Other Substructures When Paralleling and Crossing (1)

Between Telecommunication Conduit Structure and:	Provide Minimum Separation of:	
Electric light, Power conduits/cables and other conduits	300 mm 75 mm 100 mm	Of well-tamped soil, of concrete, or of Masonry
Water and Sewer Lines, etc.; CATV, Instrumentation Cables, etc.	150 mm 300 mm	Clearance with supports on each side of crossing under When paralleling
Oil Field Pipelines (Outside of Plant Areas)	1000 mm 25 m Parallel	Below in concrete encased conduit when crossing Service point minimum separation from pipes in pipeline corridors Separation for cables/ conduits in pipeline corridors will be per proponent approval via Land Use Permits
Oil Pipelines (inside of Plant Areas)	300 mm	Minimum of well tamped soil, i.e., from surface of concrete encasement to nearest surface of pipeline when crossing

Note: (1) See Paragraph 4.5.8.

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

Between Telecommunication Manholes & Handholes and	Provide Minimum Separation (2)	of:
Electric Light, Power Conduits/Cables Other Conduits	75 mm	Separation from the outside surface of the manhole wall or roof
Water & Sewer Lines, etc.	300 mm	Separation from manhole wall or roof
CATV & Instrumentation Cables, etc.	75 mm	Separation
Oil Field Pipelines	25 m	Or more from any pipeline (see SAES-B-064, para. 10.5 and SAES-B-008).

Notes: (1) see paragraph 4.5.8.
(2) Refer to the latest issue of the 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 In Degrees	Radius in Meters				
	18.3	15.2	12.2	9.1	6.1
	Estimated Maximum Conduit Section Length				
0	366	366	366	366	366
10	351	347	320	236	152
20	328	325	297	221	140
30	309	308	277	204	133
40	288	287	256	191	122
50	271	268	242	178	114
60	255	251	226	166	105
70	239	236	212	154	99
80	224	221	198	145	91
90	213	209	186	136	87

Assumptions:
- Level Grade
- Clean Conduits Which Are in Good Condition
- Well Lubricated Cable
- T(0) = 100 lbs.
* - Curve located End of Conduit Nearest Pulling Equipment

Commentary Note:

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

Table 5 – Casing Size Requirements, When 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 4.5.13.7.2.

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 4.7.3.
(2) Based on clean, good condition conduits

Table 7 – Conductor Cross-Sectional Area by Wire Gauge (1)

Wire Gauge AWG	Wire Gauge Metric	Diameter mm	Cross Sectional Area 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

Notes: (1) See Paragraph 4.7.4.
AWG = American Wire Gauge

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

A Essed Limits Cable Size	B 75% of Essex In Pounds	C (2) Limits 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 4.7.6.
(2) Column C lists the maximum permitted pulling tensions for Saudi Aramco purposes.

Commentary Note:

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