Engineering Standard

SAES-T-916 31 December, 2003

Telecommunications Building Cable Systems

Saudi Aramco DeskTop Standards

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1 Scope

This standard covers mandatory requirements governing the engineering, design and installation of telecommunication building pathway and cable systems.

2 Conflicts and Deviations

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

3 References

The selection of material and equipment, and the design, construction, maintenance, and repair of equipment and facilities covered by this standard shall comply with the latest edition of the references listed below, unless otherwise noted.

3.1 Saudi Aramco References

Saudi Aramco Engineering Procedures

SAEP-103	*Metric Units of Weights and Measures*
SAEP-125	*Saudi Aramco Engineering Standards*
SAEP-302	*Instructions for Obtaining a Waiver of a Mandatory Saudi Aramco Engineering Requirement*

Saudi Aramco Engineering Standards

SAES-A-105	*Noise Control*
SAES-B-006	*Fireproofing for Plants*
SAES-B-008	*Restrictions to Use of Cellars, Pits, and Trenches*
SAES-B-014	*Safety Requirements for Plant and Operations Support Buildings*
SAES-B-019	*Portable, Mobile and Special Fixed Firefighting Equipment*
SAES-B-068	*Electrical Area Classifications*
SAES-K-002	*Air Conditioning Systems for Essential Operating Facilities*
SAES-K-003	*Air Conditioning Systems for Communications Buildings*
SAES-L-060	*Nonmetallic Piping*

SAES-M-100	*Saudi Aramco Building Code*
SAES-O-100	*General Requirements Safety and Security*
SAES-O-107	*Security and Emergency Exit Doors*
SAES-O-108	*Locks Used on Security Doors, Perimeter Fences and Emergency Exits*
SAES-O-109	*Building Housing Sensitive or Vital Equipment*
SAES-O-111	*Power Supplies*
SAES-O-112	*Communications*
SAES-O-119	*Work Permit Procedures*
SAES-O-126	*Blast Resistant Control Buildings*
SAES-P-100	*Basic Power System Design Criteria*
SAES-P-111	*Grounding*
SAES-Q-001	*Criteria for Design and Construction of Concrete Structures*
SAES-T-018	*Telecommunications - Symbols, Abbreviations and Definitions*
SAES-T-151	*Communications DC Power System*
SAES-T-243	*Telecommunications - Protection Equipment In Communications Buildings*
SAES-T-435	*Telecommunications: Station Protection*
SAES-T-625	*Inter And Intra-Building Fiber Optic Communication Cables*
SAES-T-628	*Telecommunications - Underground Cable*
SAES-T-629	*Telecommunication Buried Cable and Wire*
SAES-T-631	*Communications Cable Terminals*
SAES-T-633	*Communications Splice Closure*
SAES-T-634	*Telecommunications - Cable Testing and Acceptance*
SAES-T-795	*Communications Facility Grounding Systems*
SAES-T-887	*Telecommunications: Electrical Coordination – Protection at Power Plants and Radio Stations*
SAES-T-903	*Communications - Outside Plant Electrical Protection and Grounding*

SAES-T-911	*Telecommunications Conduit System Design*
SAES-T-912	*Telecommunications Feeder Cable*
SAES-T-914	*Telecommunications Distribution Cable*
SAES-T-928	*Telecommunications – Outside Plant Direct Burial*
SAES-T-938	*Telecommunications - Outside Plant System Design*

Saudi Aramco Materials System Specification

09-SAMSS-097	*Ready-Mixed Portland Cement Concrete*

Saudi Aramco Standard Drawings

AA-036373	*PVC Direct Buried/Encased Conduit*
AA-036748	*Buried Telephone Cables*
AA-036897	*Buried/Underground Cable Route Marker Posts and Signs*
AA-036899	*Standard Specifications for Shoring Trenches*

Saudi Aramco General Instructions

GI-0002.100	*Work Permit System*
GI-0002.710	*Mechanical Completion and Performance Acceptance of Facilities*
GI-0002.716	*Land Use Permit Procedures*
GI-0005.002	*Loss Prevention Policy Implementation*
GI-0520.001	*Confined Space Entry Procedure*
GI-0887.000	*Coordination of Saudi Aramco Projects with Non-Saudi Aramco Agencies*
GI-1021.000	*Street and Road Closure: Excavations, Reinstatement and Traffic Controls*

Saudi Aramco Construction Safety Manual

Saudi Aramco Drafting Manual

Saudi Aramco Operations Instruction Manual (Ch. 1.00 - 30.999)

Chapter 1.104	*Excavations and Pile Driving*
Chapter 1.108	*Excavations*

Chapter 1.110 *Control of Manhole Entry Abqaiq, Plants*

Refinery Instructions Manual (Ch. 1.000 - 13.999)

Chapter 1.801 *Work Permits*

Chapter 1.805 *Excavations and Pile Driving*

3.2 Industry Codes and Standards

American National Standards Institute

ANSI C2 *National Electrical Safety Code (NESC)*

American Society for Testing And Materials

ASTM A153/A153M *Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware*

ASTM D4565 *Physical and Environmental Properties of Insulation and Jackets for Telecommunication Wire and Cable*

ASTM D4566 *Electrical Performance Properties of Insulation and Jackets for Telecommunications Wire and Cable*

ASTM E814 *Fire Test of Through-Penetration Fire Stops*

ASTM E119 *Fire Tests of Building Construction and Materials (for fire-rated architectural barriers)*

Electronic Industries Association

EIA IS-43AA *Cable For LAN Twisted Pair Data Communications, (Type I, Outdoor Cable)*

EIA IS-43AB *Cable For LAN Twisted Pair Data Communications, (Type I, Non-Plenum Cable)*

EIA IS-43AC *Cable For LAN Twisted Pair Data Communications, (Type I, Riser Cable)*

EIA IS-43AD *Cable For LAN Twisted Pair Data Communications, (Type I, Plenum Cable)*

EIA TIA-TSB 67 *Transmission Performance for Field Testing of Unshielded Twisted Pair Cabling Systems*

EIA TIA-472CAAA *Detail Specification for All-Dielectric (Construction 1) Fiber Optic Communications Cable for Indoor Plenum Use, Containing*

	Class 1a, 62.5 micron Core Diameter/125 Micron Cladding Diameter Class Optical Fiber(s)
EIA TIA-492AAAA	*Detail Specification for 62.5-µm Core Diameter/125-µm Cladding Diameter Class 1a Multi-Mode Graded Index Optical Waveguide Fibers*
EIA TIA-492BAAA	*Class IVa Dispersion Un-Shifted Single-Mode Optical Fiber*
EIA TIA-568A	*Commercial Building Telecommunication Wiring Standard*
EIA TIA-569	*Commercial Building Standard for Telecommunications Pathways and Spaces*
EIA TIA-570	*Residential and Light Commercial Telecommunication Wiring Standard*
EIA TIA-606	*Administration Standard for the telecommunication Infrastructure of Commercial Buildings*
EIA TIA-607	*Commercial Building Grounding and Bonding Requirements for Telecommunications*

Building Industry Consulting Services International

BICSI	*Building Industry Consulting Services International, TDMM (Telecommunications Distribution Methods Manual)*

General Telephone and Electronics

GTE Practices	*General Telephone and Electronics Practices*
ICEA S-80-576	*Communications Wire & Cable for Wiring Premises*

International Electrotechnical Commision

IEC 603-7, Part 7	*Detail Specification for Connectors, 8-Way, Including Fixed and Free Connectors with Common Mating Features*
IEC 874-14	*Sectional Specification for Fiber Optic Connector Type SCFOC/2.5*
IEC 874-10	*Sectional Specification for Fiber Optic Connector Type BFOC/2.5*

IEC 8802.5 — *Token Ring Access Method and Physical Layer Specifications*

Institute of Electrical and Electronics Engineers

IEEE 802.5b — *Recommended Practice for use of Unshielded Twisted Pair Cable (UTP) for Token Ring Data Transmission at 4 Mbit/s*

IEEE 802.3i — *Twisted-Pair Medium Attachment Unit (MAU) and Baseband Medium, Type 10BASE-T*

International Organization for Standardization

ISO 8877 — *Information Processing Systems - Interface Connector and Contact Assignments for ISDN Basic Access Interface Located at Reference Points "S" and "T"*

National Electrical Manufacturers Association

NEMA WC 63 — *Performance Standard for Premises Telecommunications Cables*

National Fire Protection Association

NFPA 70 — *National Electrical Code (NEC)*

NFPA 101 — *Life Safety Code*

NFPA 251 — *Standard Method of Fire Tests of Building Construction and Materials*

NFPA 255 — *Surface Burning Characteristics of Building Materials*

NFPA 780 — *Lightning Protection Code*

Underwriters Laboratories, Inc.

UL 444 & 13 — *UTP) Adopted Test and Follow-up Service Requirements for the Optional Qualification of 100-Ohm Twisted-Pair Cables)*

UL 444 & 13 — *STP) UL Listed Cables Classified to IBM LAN Cable*

UL 497 — *Underwriters Laboratories, Primary Protectors for Communication Circuits*

UL 497A — *Underwriters Laboratories, Secondary Protectors for Communication Circuits*

UL 497B	*Underwriters Laboratories, Protectors for Data Communication and Fire Alarm Circuits*
UL 1459	*Underwriters Laboratories, Safety - Telephone Equipment*
UL 1863	*Underwriters Laboratories, Safety - Communication Circuit Accessories*

3.3 Other References

Saudi Arabian Standards Organization

SSA 413/1985	*Cast Iron Manhole Covers*

4 Design

The GTE 916 Series, "Building Cable" and the BICSI (Building Industry Consulting Services International) TDMM (Telecommunications Distribution Methods Manual) manuals are hereby recognized as Saudi Aramco Engineering Standard SAES-T-916, Telecommunications Building Cable Systems as modified below. Mandatory items are listed herein. The GTE Practices and the BICSI (TDMM) may be referenced for more detailed information. Design drawings shall use conventional symbols as specified in SAES-T-018 Telecommunications - Symbols, Abbreviations and Definitions and BICSI.

4.1 General Information

4.1.1 Communications Distribution Designer

In an effort to improve the quality of building telecommunications cable system designs, and to help establish minimum levels of competency, BICSI established the RCDD program for testing and measuring the knowledge and qualifications of candidates. Many large international corporations now require Registered Communications Distribution Designer (RCDD) for those who design their building or campus telecommunications cable networks. Saudi Aramco shall require RCDD registration or equivalent (qualified in the design of building cable and pathway systems) for those doing company telecommunications office building cable systems designs.

BICSI Offers Training programs and conducts examinations for the RCDD certification in the following;

- RCDD, Registered Communications Distribution Designer
- RCDD/LAN Specialist, Registered Communications Distribution Designer/Local Area Network Specialist

- Installation Training Program

4.1.2 Review and Approval

When required in this standard, the review and/or approval authority for the proponent organization is, Saudi Aramco, Computer, Communications and Office Services, Computer & Communications Engineering Department, Computer & Communications Engineering Division, Facility and Outside Plant Unit, Supervisor.

4.1.3 Designing Telecommunications Distribution

The building/campus cable network designer shall identify and include in the design present and future needs for voice, data, and video communications, and provide a design that provides the capability to handle all future communication requirements without the need to completely rebuild the cable network or distribution system.

4.1.4 Choosing The Transmission Medium

The media transmission options include the following:

- Copper cable.
- Fiber optics.
- Coaxial cable (coax).

Commentary Note:

Use of this media must be approved in advance in writing by the Saudi Aramco, communications proponent.

- Wireless (microwave, satellite, etc.).

4.1.5 Local Exchange Carrier (LEC)

Definition:

Saudi Post & Telephone and Telegraph is identified as the Local Exchange Carrier. Saudi Aramco will not be considered as a Local Exchange Carrier unless otherwise specified.

4.1.6 Support Structure

All the necessary support structures for protecting and provisioning of the building/campus cable network shall be provided. This includes items such as:

- Conduit.
- Raceways.
- Equipment space.
- Other facilities that are part of the building structure itself.

Telecommunications support structures and equipment shall comply to the requirements of:

SAES-A-015	*Noise Control*
SAES-B-006	*Fireproofing in Onshore Facilities*
SAES-B-068	*Electrical Area Classifications*
SAES-O-111	*Power Supplies*
SAES-O-112	*Communications*
EIA TIA-569	*Commercial Building Standard for Telecommunications Pathways and Spaces*
NFPA 70	*NEC National Electrical Code*

4.1.7 Disaster Requirements

Structural reinforcement and extra environmental protection shall be provided for the equipment room design when Communication facilities are subject to being exposed to geographical locations and conditions highlighted in the following Saudi Aramco Engineering Standards:

SAES-A-112	*Meteorological and seismic design data*
SAES-O-100	*General Requirements Safety and Security*
SAES-O-112	*Communications*
SAES-O-109	*Buildings Housing Sensitive Or Vital Equipment*

4.2 Telecommunications Service Entrance and Termination

4.2.1 Service Entrance and Termination Space

Telecommunication cable building entrances may be by one of the following methods:

a) Underground entrances

Inside a conduit connected to a conduit system.

b) Buried entrances

Direct buried, with an adequate number of conduits stubbed through building floor.

c) Aerial entrances

Permitted only when approved per SAES-T-914, paragraph 4.1.3.6.

Commentary Notes:

1) *Aerial type construction must have prior written approval from Saudi Aramco. See SAES-T-914, Telecommunications Distribution Cable paragraph 4.1.3.6.*

2) *Aerial telecommunication cable entrances shall not be allowed in Saudi Aramco plant facilities.*

Entrance rooms that are located in blast resistant control buildings shall comply to the requirements of SAES-O-126, "Blast Resistant Control Buildings" in addition to the requirements of this standard.

4.2.1.1 Telecommunications Service Entrance Room or Space

The entrance room or space is a component of the entrance facility that provides space for the entrance and termination of feeder and backbone cables (twisted pair copper and fiber optic). In some cases this room may contain telecommunications equipment (e.g., PBX) and network interface devices. When this occurs, additional wall and floor space will be required when placing equipment and interface devices in the entrance room. This space shall be sufficient in size to accommodate the equipment installation in addition to having space for future expansion.

Communication entrance rooms shall have as a minimum one hour fire rated walls. These walls shall be continuous from the floor level to the permanent ceiling or roof level. The wall height shall not stop at the normal false or drop ceiling levels. Overhead routing of other utilities (HVAC equipment, water lines, drains pipes, conduits) shall be avoided to prevent obstruction to communication entrance facility above ceiling access. Refer to NFPA 101 (Life Safety Code), SAES-B-014 (Safety Requirements for Plant and Operations Support Buildings) and SAES-M-100 (Saudi Aramco Building Code) for conditions that require a higher fire rated wall.

An enclosed room (telecommunication closet, equipment room, entrance facility), with lockable doors shall be provided for buildings exceeding 2000 m² (20,000 ft²) of usable floor. Buildings having 10,000 m² (100,000 ft²) or more of usable floor space shall have a dedicated entrance facility room.

Buildings with less than 2000 m² (20,000 ft²) may use a telecommunication closet or equipment room to accommodate the entrances of cables provided that the conditions of paragraph 4.2.1.4 and 4.2.1.5 are met.

Cable splices shall not be mounted or placed in over head cable trays. Cable splices shall be accessible to cable technicians at floor level

4.2.1.2 Bonding, Grounding and Protection

All Cables entering a building shall comply to the bonding and grounding requirements specified by SAES-T-903 (Communications Electrical Protection Outside Plant), NEC 800-30 (Protective Devices) and NEC 800-40 (Grounding Methods). Refer to SAES-T-795 (Communication Facility Grounding Systems) when the structure or building will house a main telecommunication switch.

Refer to paragraph 4.6 "Grounding, Bonding, and Electrical Protection" below for additional information.

4.2.1.3 Telecommunication Service Entrance Facility Design Considerations

When designing or constructing an entrance room or space the following shall be accomplished:

- Maintain the same size pathways between the entrance point and the entrance room or space.
- Antenna cable entrances shall be isolated from other entrance and backbone cables.
- Be located in an area that is dry and not subject to flooding.
- Be as close as practicable to the vertical backbone pathways.

- Be placed so that the maximum distance to the building entrance service ground no longer than 6 m (20 ft). (Refer to paragraph 4.6, Grounding, Bonding and Electrical Protection.)
- Be free from being used as a storage room/area for any materials (e.g., janitorial supplies/tools, chemicals, equipment, office supplies)

A vertical mounted wall frame protector shall be provided for buildings exceeding 6,000 m^2 (60,000 ft^2) of usable floor space. This applies to facilities having more than a 600 pair building terminal. Free standing frames may also be considered for cable terminations.

4.2.1.4 Terminating Space for Telecommunications Entrance Facilities

Terminating Space Shall Be:

a) Near or at the point where the facilities enter the building. Never run more than 15 m (50 ft) of exposed nonfire-rated entrance cable within a building (see illustration 0515). One of the following actions shall be taken if a situation requires more than 15 m (50 ft) of entrance cable between the entry point and the termination point:

    1. Relocate the cable entrance point so that it is within 15 m (50 ft) of the termination point.
    2. Relocate the termination point so that it is within 15 m (50 ft) of the cable entrance point.
    3. Place the entrance cable inside rigid metallic conduit from the entrance point to within 15 m of the termination point. Fire rated tape, in lieu of rigid metallic conduit, is not acceptable.
    4. Wrap short lengths (15 m or less)of non-fire rated entrance cable (Polyethylene sheath) with fire rated tape at locations where the cable exits the entrance conduit and terminates.

b) On a bearing or permanent wall.

c) Physically protected. Larger terminations require a separate room set aside for the use of telecommunications purposes (voice, data, broadband, etc.) only. Buildings 100 m² or smaller may have terminations placed inside metallic cabinets such as the Type 3A cabinet (SAMS #18-084-135). The 3A cabinet interior dimensions are 1,220 mm (H), 495 mm (W) & 127 mm (D).

d) Continually accessible by Saudi Aramco, Computer, Communications and Office Services operations and maintenance personnel.

e) Safe and environmentally clean. The telecommunications service entrance room/space shall not be used for storage material or other obstructions. The area shall be free of excess moisture and heat conditions or possible submersion in case of flooding. Rooms with hot water heaters, water supply line/pipes and drains shall not be used for entrance facilities. Fire sprinkler systems are the exception when these systems are required by Saudi Aramco building codes. The type and critical classes of services shall be reviewed prior to accepting a specific location for telecommunication entrance facilities.

4.2.1.5 The following tables specify the minimum allowable space for all telecommunications entrance rooms or space for splice cases, equipment and associated cross-connections.

Table I – Minimum Equipment and Termination Wall Space

Usable Floor Space		Wall Length	
m²	ft²	mm	in.
500	5,000	1230	48
1,000	10,000	1230	48
2,000	20,000	1230	48
4,000	40,000	2460	96
5,000	50,000	2460	96
6,000	60,000	2460	96

Note: The above information is based on terminations and equipment mounted on 2.5 m (8 ft) high wall.

Table II – Minimum Equipment and Termination Room Space

Usable Floor Space		Room Dimensions	
m²	ft²	mm	ft
7,000	70,000	3660 X 2012	12 X 6.6
10,000	100,000	3660 X 2012	12 X 6.6

20,000	200,000	3660 X 2750	12 X 9
40,000	400,000	3660 X 3970	12 X 13
50,000	500,000	3660 X 4775	12 X 15.6
60,000	600,000	3660 X 5670	12 X 18.6
80,000	800,000	3660 X 6888	12 X 22.6
100,000	1,000,000	3660 X 8412	12 X 27.6

Note: The above information is based on twisted pair copper conductor terminations and equipment mounted on free standing and or vertical racks. Space adjustments are allowed when fiber optic feeder cable is utilized.

4.2.1.6 As a minimum each Telecommunication Service Entrance or space shall be provided with the following:

- An approved ground source. This is a ground bus connected to the building ground grid by a conductor (minimum size #4 AWG) with a maximum length of 6 m (20 ft) placed in a ¾ inch trade size PVC conduit when. Refer to EIA TIA-607, (Commercial Building Grounding and Bonding Requirements for Telecommunications) and paragraph 4.6 (Grounding, Bonding and Electrical Protection) below for specific bonding and grounding information.
- Provide wall space for current and future cable mounting, splicing (vertical or horizontal mounted splice cases) and termination.
- A minimum of two walls covered with rigidly fixed 19 mm (¾ in.) thick x 2440 mm (8 ft) high trade, size A-C plywood, capable of supporting attached equipment.
- Lighting that measures a minimum of 540 Lux (50 foot candles) at 1 m above the finished floor level, and mounted a minimum of 2600 mm (8.5 ft) above the finished floor level.
- Access door that measures a minimum of 910 mm (36 in.) wide and 2000 mm (80 in.) high, fitted with a lock. The door should open outward (where Building Code permits).
- Open ceiling, (no false ceiling permitted).
- Floors, walls and ceiling treated to eliminate dust. Finished in a light color to enhance room lighting.

- Convenience duplex 120 V outlets spaced at 1.8 m (6 ft) intervals around the perimeter walls at a height of 150 mm (6 in.).
- At least one emergency power duplex outlet if it is available to the building.
- Be free from water pipes, drains, & hot water heaters or the possibility of flooding.
- Have a minimum of one hour fire rated wall.
- Buildings larger than 9,300 m² (100,000 ft²) must provide a dedicated room for telecommunication entrance facilities.
- Provide the following when telecommunications terminal equipment is to be installed.
- Two dedicated 20 AMP, 120 VAC ac duplex electrical outlets, each on separate circuits for equipment power. Outlet(s) shall be mounted on the equipment rack that it is serving or at ceiling level mounted directly above the equipment rack being served.
- Cable splices shall not be mounted or placed in over head cable trays. Cable splices shall be accessible to cable technicians at floor level.

4.2.2 Underground Entrance

4.2.2.1 Sizing Underground Entrance Conduits

The number and size of conduits extended into a building shall be based on the number and type (twisted pair copper and fiber optic cables) of telecommunications circuits which will ultimately be required in the building. For conduit sizing purposes, assume a minimum of one entrance cable pair (copper conductor) will be provided for each 9 m² (100 ft²) of usable office space. With this assumption, the minimum number and size of conduits will be as follows:

Table III – Sizing Entrance Conduit

Estimated Entrance Pairs & Square Meters of Usable Office Space	Minimum Required Conduits for copper cables and copper cable with optical fiber cables
1-25 (up to 200 m²)	2 (One 2-inch conduit plus 1 spare)

26-1,000 (201-9,000 m²)	3 (Two 4-inch conduits [one equipped with three 1-inch subduct/innerduct] plus 1 spare)
1,001-2,000 (9,001-18,000 m²)	4 (Three 44-inch conduits [one equipped with three 1-inch subduct/innerduct] plus 1 spare)
2,001-3,000 (18,001-27,000 m²)	5 (Four 4-inch conduits [one equipped with three 1-inch subduct/innerduct] plus 1 spare)
3,000-5,000 (27,001-45,000 m²)	6 (Five 4-inch conduits (one equipped with three 1-inch subduct/innerduct) plus 1 spare)
5,001-7,000 (45,001-63,000 m²)	7 (Six 4-inch conduits (one equipped with three 1 inch subduct/innerduct) plus 1 spare)
7,001-9,000(63,001-81,000 m²)	8 (Seven 4-inch conduits (one equipped with three 1-inch subduct/innerduct) plus 1 spare)

Notes:

1. A minimum of one additional 4-inch conduit shall be provided for each additional 25-1800 entrance pairs (90-16,200 m²).
2. The above listed number of conduits list only minimum requirements. The communications proponent may specify additional conduits for other needs, such as video, tie cables, dual feeds and other miscellaneous requirements.
3. A spare conduit shall always be left vacant for maintenance and repair operations.
4. All entrance conduits (including subducts/innerducts) shall be equipped with pull ropes.
5. All conduits (including subducts/innerducts) shall be sealed in accordance with SAES-T-628.

4.2.2.2 Buildings with Only Fiber Optic Cable Entrances

Buildings that have been identified as only having fiber optic cable services provide to them will not be required to comply to the requirements of Table III. However, there shall be a engineering review conducted to verify the ultimate number of conducts that are required to provide service to the facility. Additionally, there shall always be one spare conduit provide for maintenance purposes. Conduit that contains fiber optical cable shall be provided with subduct.

4.2.2.3 Dual Entrances

For information regarding dual entrances refer to the latest issue of the BICSI TDMM.

4.2.2.4 Conduit Design and Installation

Outside plant conduit design and installation shall be done to SAES-T-911, "Telecommunication Conduit System Design" requirements.

4.2.3 General Requirements for Underground Entrances

4.2.3.1 Sizing Indoor Pull Boxes

Use the following table to determine the minimum pull box size when constructing a pull box for entrance conduits:

Table IV – Sizing Indoor Pull Boxes

Maximum Trade Size of Conduit Inches	Size of Box			For Each Additional Conduit Increase Width
	Width	Length	Depth	
2.0 in.	203 mm (8 in.)	914 mm (36 in.)	102 mm (4 in.)	127 mm (5 in.)
3.0 in.	305 mm (12 in.)	1,219 mm (48 in.)	127 mm (5 in.)	152 mm (6 in.)
4.0 in.	381 mm (15 in.)	1,524 mm (60 in.)	203 mm (8 in.)	203 mm (8 in.)

4.2.3.2 Indoor Conduit Bends

Conduit bends must be long, sweeping bends. Conduits shall have a minimum bending radius of ten (10) times the internal conduit diameter.

4.2.3.3 Choosing Pull Points

Refer to SAES-T-911 ("Telecommunication Conduit System Design") for determining the pull point locations for the placement of entrance cables.

4.2.3.4 Reaming Conduit

All ends of metallic conduit shall be reamed and bushed.

4.2.3.5 Preventing Conduit Shearing

Sleeves through foundation walls must extend to undisturbed earth to protect against shearing.

4.2.3.6 Encasement

Direct buried entrance conduits shall be encased in concrete.

Unless specified conduits are to be encased with Non-Structural Concrete with a minimum strength of 2000 PSI. (Refer to SAES-Q-001 "Criteria For Design And Construction Of Concrete Structures & 09-SAMSS-097, Ready-Mixed Portland Cement Concrete).

Consider using reinforced concrete at any location subject to extreme stress, (Refer to SAES-Q-001, Criteria For Design And Construction Of Concrete Structures & 09-SAMSS-097, Ready-Mixed Portland Cement Concrete).

Refer to SAES-T-911 (Telecommunications Conduit System Design) for design and construction information regarding conduit and manhole systems.

4.2.4 Terminating Conduit In a Building

Sealing Entrance Conduit Inside a Building

All building entrance conduits shall be plugged or sealed in accordance with the requirements of SAES-T-628 "Telecommunications Underground Cable". Conduits shall be sealed at all times or resealed immediately after cables are installed.

4.2.5 Buried Entrances

Direct buried entrance design and construction shall be done in accordance to SAES-T-629 (Telecommunication Buried Cable and Wire), SAES-T-911 (Telecommunication Conduit System Design) and SAES-T-928 (Telecommunications - OSP Buried Cable).

4.2.5.1 Joint Trench Required Separations

Random Joint Trench (vertical placement) Design and Construction methods shall not be permitted with electrical power facilities in Saudi Aramco. Refer to SAES-T-903 (Telecommunications Outside Plant Electrical Protection And Grounding and SAES-T-928, Telecommunications - OSP Buried Plant) for more information regarding direct buried cable design and installation.

4.2.5.2 Clearing Foundation Landscaping

All buildings entrance conduits, which are stubbed out for buried cable entrances, shall extend a minimum of one meter beyond the foundation or landscaping border.

4.2.6 Outside Building Terminals Pedestals and Cabinets

Refer to the latest issue of the BICSI TDMM and SAES-T-631 (Communication Cable Terminals) for information regarding the design and installation of building terminal pedestals and cabinets.

4.2.7 Other Telecommunications Service Entrance Considerations

4.2.7.1 Planning for Campus Arrangements and Core-Building Arrangements

Designs for tracts of land designated for Saudi Aramco development normally consist of several buildings rather than one single high-rise structure. Some may consist of several structures tied together by bridge or hallway type pathways to give an appearance of being one structure. Some may consist of a wing structured arrangement connected together. These are often referred to as "Campus" arrangements.

The service requirements for these buildings (Campus arrangement) shall be addressed in the initial planning, design, and construction phases in order to assure that these structures have entrances facilities to accommodate initial and ultimate service requirements. Each building shall be treated as an integral part of the developed area that is inter-connected to the other surrounding buildings or structures.

Refer to the latest BICSI TDMM for information regarding, "Campus Back Bone Systems".

4.2.7.2 Inter Building Pathways

Buildings as described in paragraph 4.2.7.3 above shall be inter-connected by the most direct route (straight line) to provide inter-connectivity. This shall be accomplished by installing a minimum of two (2) four (4) inch PVC conduits. This requirement is in addition to the normal building entrance requirements. Both pathway ends shall terminate in equipment rooms, TCs or entrance facilities of the connected buildings. All conduit design and construction shall comply with SAES-T-911, (Telecommunication Conduit System Design).

4.2.7.3 Loop Diversity

Loop diversity is the placing of alternate facilities (copper or fiber, microwave, satellite) to back up the main telecommunication system in case of failure.

Some facilities (security/public safety, prime telecommunication centers, etc.) within Saudi Aramco may require loop diversity due to special service provisioning.

Refer to the latest issue of the BICSI TDMM for additional information regarding Loop Diversity.

4.3 Telecommunication Equipment Rooms

4.3.1 Definition

An equipment room is a special purpose room that shall provide space and maintain an operating environment for:

- Communications and/or computer equipment.
- Terminating and cross-connecting telecommunications distribution cables.
- Working space for telecommunications personnel.

Rooms that are classified as "Computer Rooms" are those that usually are designed to house a computer system for a proponent or user department that serves a specific business line. "Computer Rooms" should be located as close as possible to the equipment rooms or TCs that provide network connectivity.

A telecommunication equipment room may contain some or all of the following equipment:

- Voice
- Data
- Distribution (cabling)
- TC Function

4.3.2 Design

A telecommunication equipment room may serve an entire building, some building designs may require more than one equipment room to provide one or more of the following:

- Separation of communications and computer equipment.
- Redundant facilities and disaster recovery strategies.
- A separate facility for different proponents in a multi-proponent building.

- Other proponent or communications needs.

The telecommunication equipment room may also include the Telecommunications Service Entrance Facility Room. Space shall be added to the initial size of the equipment room to accommodate the additional space requirements of the Telecommunications Service Entrance (refer to paragraph 4.2.1.5 for space requirements).

Telecommunication equipment room design shall be based on the following:

EIA TIA-568A	*Commercial Building Telecommunication Wiring Standard*
EIA TIA-569	*Commercial Building Standard for Telecommunications Pathways and Spaces*

Telecommunication equipment rooms that are located in blast resistant control buildings shall comply to the requirements of SAES-O-126, "Blast Resistant Control Buildings" in addition to the requirements of this standard.

Required Information

The design specification for a telecommunication equipment room shall include:

- User requirements.
- Total usable floor space.
- Horizontal and vertical pathway locations.
- Environment/facility conditions and resources.
- Logical equipment layout that is flexible enough for equipment to be added without structural renovations.
- Assure that the access route to the telecommunication equipment room will allow for the delivery and installation of equipment.
- Review and approval by the proponent organization.

4.3.3 Design Considerations

4.3.3.1 Voice Equipment

Voice service on the proponent's premises may be provided by one or more of the following systems:

- Central-office based service provided by CC&OS using direct lines, carrier equipment, or remote switching.
- Small key telephone systems.
- Private Branch Exchange (PBX) systems.
- Adjuncts (Voice mail, Automatic Call Distribution, etc.).

4.3.3.2 Data Equipment

Data service on the proponent's premises may be provided by one or more of the following systems:

- Mainframe and minicomputers using LANs, RS-232, or other approved terminal communications interfaces.
- Personal computers, servers, and LANs.
- Modems for data over voice grade telecommunication facilities.
- Multiplexes for wideband service (and aggregate voice and data) over telecommunications facilities.

4.3.3.3 Distribution Frames

Communications distribution cables (usually backbone cables) may be terminated in the equipment room at a cross-connect. Depending on its role in distribution, this cross-connect may be a:

- Main Distribution Frame (or Main Cross-Connect).

  OR

- Intermediate Distribution Frame (or Intermediate Cross-Connect).

A telecommunication equipment room may have multiple distribution frame types. The most common combination is unshielded twisted pair wire and fiber optics.

4.3.3.4 Building Facilities

The telecommunication system designer shall coordinate with other facility designs (e.g., fire protection, electrical, HVAC) to avoid conflicts in design and construction of telecommunications systems.

4.3.4 Locating the Telecommunication Equipment Room

4.3.4.1 Major Considerations

The following factors shall be considered and reflected in the final design when choosing the location for an equipment room:

- Space requirements for equipment.
- Access to horizontal and vertical cable pathways.
- Building facilities
- Access to the building entrance facility.
- Communication proponent requirements.
- As close as possible to an approved ground source (Refer to paragraph 4.6 below, Grounding, Bonding & Electrical Protection). Refer to paragraph 4.2 (Telecommunications Service Entrance & Termination) when the telecommunication equipment room includes the entrance facility.

Commentary Note:

Final design shall be reviewed and approved by the communications proponent organization.

4.3.4.2 Provide Adequate Equipment Space

The floor space shall allow the telecommunication equipment room to provide sufficient space for the initial installation, future growth (minimum 20%) and changes.

Commentary Note:

There are likely to be many equipment changes during the useful life of any telecommunication equipment room. Therefore, space shall be provided to support equipment changes with minimal disruption.

4.3.4.3 Access to Cable Pathways

Place the telecommunication equipment room at a location which:

- Minimizes the size and length of the backbone and horizontal distribution cables.
- Is accessible to cable routing pathways.

4.3.4.4 Access to the Telecommunications Equipment Room

Consider the availability, size, and weight capacity of doors, hallways, elevators (or hoists), loading docks, and any other access routes to the telecommunication equipment room when choosing a location and designing the layout. Also, consider any potential difficulties in scheduling the use of these routes and facilities for large equipment during installation or future changes.

4.3.5 Space Allocation and Layout

4.3.5.1 Working Clearances

Telecommunication equipment rooms shall be designed to allow for the minimum 91 cm (36 in.) clear work space in front of the terminal or equipment when wall mounted. A clear work space of 91 cm (36 in.) shall be provided for terminals and equipment mounted on floor racks and floor support structures. Sufficient access space shall be provided in the rear of the equipment to allow access for maintenance purposes.

A minimum clearance of 30 cm (12 in) shall be provided between the top rail of cable trays and ceilings.

4.3.5.2 Work Location Space

Work location space shall be provided in the telecommunication equipment room for system administrators and other operations and maintenance personnel. This includes space for workstations, displays, desk and printers.

4.3.5.3 Equipment Installation Methods

Equipment mounting and installation in the telecommunication equipment room shall be one of the following methods:

Wall Mounting:

In this method, a rigid plywood (19 mm x 2440 mm) backboard painted with two coats of a non-conductive, fire retardant, white paint is permanently attached to the wall.

Floor Standing Racks, Frames, or Bays:

Floor space is to be allocated in rows. Provide space for change and growth. Locate the rack, frame and bay equipment so that electrical and telecommunications cable routing can be done efficiently. Secure and ground the hardware according to the manufacturer's instructions and EIA TIA-607 "Commercial Building Grounding and Bonding Requirements for Telecommunications".

Cabinets:

Floor space is allocated in rows. This is typical for large electronic telecommunications equipment (e.g., voice and data switching systems, computer equipment). Cabinets are used to provide:

- Physical protection.
- Electromagnetic compatibility.
- Dust and contaminant protection.

Cabinets shall be secured to the building structure and grounded in accordance with the manufacturer instructions and EIA TIA-607.

Commentary Note:

> *NEC Article 318 and NEC Sections 800-52 and 800-53 also apply to the equipment installation. SAES-T-795 (Communications Facility Grounding Systems) shall also apply when there is a major communications switch located in the telecommunications equipment room.*

4.3.5.4 Cable Installation Methods

The following are acceptable installation methods:

Sleeves/Slots:

This method is used to route cable through building floors and walls. (See paragraph 4.5.5.2 below for detailed information)

Conduits:

This method may also be used for routing cable through floors and walls. Bushings shall be placed on the ends of metallic conduit to protect cable sheaths from damage.

Other Raceways:

Other raceways approved by NEC. Strapping, Lashing, and Hooking:

If these methods are used the designer shall:

- Verify the hardware ratings against the cable weights.
- Ensure spacing that will prevent cable sag or buckling.
- Use only hardware listed for its purpose.

Overhead Cable Trays:

This method is acceptable for routing equipment cable to the cross-connect and for routing backbone cables to the backbone pathway. Tray locations must be coordinated with lighting, air handling systems, fire extinguishing systems, etc., so that trays will not obstruct or impede system operation. There shall be a minimum of twelve (12) inches of clearance between the top rail of the tray and the ceiling.

Tray installations and ratings shall comply with the requirements of NEC Article 318 and EIA TIA-569.

Commentary Note:

> *Cable trays shall not house or support cable splice closures. Provide adequate wall space for mounting splice closures vertically or horizontally.*

Under Raised Floor:

Typically used when large equipment rooms house both telecommunications and computer equipment.

4.3.6 Electrical Requirements

4.3.6.1 Power Requirements

Each equipment rack shall be provided with a minimum of two (2) dedicated 20 AMP, 120 VAC duplex electrical outlets, each on separate circuits for equipment power. Outlet(s) shall be mounted on the equipment rack that it is serving or at ceiling level mounted directly above the equipment rack being served. Future power requirements shall be considered when designing equipment rooms.

Electrical designs and installations shall comply with the requirements of Saudi Aramco Electrical Engineering Standards (SAES-P indexed standards).

Commentary Notes:

1. *Additional outlets (power stripes) may be required based on the equipment plan for the closet. Consideration should be given to providing backup, standby, or emergency power sources that has automatic switch over capability.*

2. *All outlets shall be on non-switched circuits (circuits that are not controlled by a wall/light switch or other device that may inadvertently cut power to the telecommunication systems).*

3. *Power panels for dedicated electrical service shall be provided in an ER when active equipment is planned or installed.*

4.3.6.2 Coordinate with Electrical Facilities

Avoid unwanted electrical exposure and contact to telecommunication systems by coordinating the location and placement of telecommunication equipment and cables with the electrical utility proponent or by the project management team. The telecommunication distribution designer shall be responsible for coordinating the electrical exposures and influences on telecommunication equipment and cable.

4.3.6.3 Maintaining Power Quality

Since telecommunications equipment can be very sensitive to power abnormality, dedicated feeder/branch circuits and power conditioning shall be provided. Allocate space for power conditioning, backup, or standby systems as required for the equipment.

Coordinate with HVAC designers to assure required HVAC loading will serve the equipment needs. Refer to the paragraph 4.3.7 below for additional information and requirements.

4.3.6.4 Batteries

When batteries are required for backup systems, assure the design and installation complies with SAES-T-151, (Communications DC Power System) and manufacturer requirements.

Caution:

Design all battery rooms so that they are properly ventilated.

4.3.7 Environmental Requirements (HVAC)

HVAC systems shall comply with:

SAES-K-001	*Heating, Ventilation and Air Conditioning (HVAC)*
SAES-K-002	*Air Conditioning for Essential Operating Facilities*
SAES-K-003	*Air Conditioning Systems for Communications Buildings*

4.3.7.1 Introduction (HVAC)

The equipment manufacturer environmental requirements shall be followed to ensure reliable equipment operation and to keep warranties valid. This typically includes:

- Temperature control.
- Humidity control.
- Dust and contaminant control.

4.3.7.2 Continuos HVAC Operation

A stand-alone HVAC unit with independent controls shall be specified for the telecommunication equipment room when the building's air conditioning (HVAC) equipment cannot ensure continuous operation (including weekends and holidays).

4.3.7.3 Typical Telecommunication Equipment Room Requirements

The HVAC requirements of each piece of equipment must be considered. The table below list the equipment requirements and shall be considered minimum for all equipment rooms:

Table V – Equipment Room HVAC Requirements

Environmental Factor	Minimum Requirements
Temperature range	18 to 24°C 64 to 75°F
Humidity range relative	30 to 55%
Heat dissipation hour	750 to 5,000 BTUs per cabinet

Each telecommunication equipment room shall have an independent HVAC system control to control it's own environment.

The design package shall include information identifying the maximum expected heat dissipation from each piece of equipment. Additionally, the HVAC system shall be designed to allow for a 20% minimum increase in equipment.

4.3.8 Structural Requirements

4.3.8.1 Wall

Telecommunication equipment room walls shall:

- Extend from the finished floor to the structured roof or ceiling level.
- Be covered with two coats of a non-conductive, fire-Retardant white paint.
- Be fire resistant rated.

Communication equipment rooms shall have as a minimum one hour fire rated walls. These walls shall be continuous from the floor level to the permanent ceiling or roof level. The wall height shall not stop at false or drop ceiling levels. Overhead routing of other utilities through the telecommunication equipment room space shall be avoided to prevent obstruction to communication equipment. Refer to NFPA 101 (Life Safety Code), SAES-B-014 (Safety Requirements for Plant and Operations Support Buildings) and SAES-M-100 (Saudi Aramco Building Code) for conditions that require a higher fire rated wall for these types of rooms.

4.3.8.2 Floor

Actual weights of equipment cabinets (e.g., racks, bays etc.) and power systems (i.e., transformers, batteries) shall be used for designing the floor live loads in telecommunication equipment rooms. This shall be applied when designing for a new facility and upgrading or rehabilitating an existing one. All designs for floor loading shall be done for the maximum possible loading of the telecommunication equipment room floors in accordance to SAES-M-100, "Saudi Aramco Building Code".

The following types of floor finishes shall be used:

- Asphalt tile
- Linoleum tile

4.3.8.3 Ceiling

Ceilings shall be at least 2.6 m (8 ft, 6 in) high to provide space over the equipment frames for suspended racks and cables. There shall be no false or drop ceilings in telecommunication equipment rooms when the telecommunications equipment room is to contain the telecommunications closet. This is required so that free access can be made to place horizontal support structures and cabling.

4.3.8.4 Access

A double door access to the equipment room shall be provided. The access route shall be adequate for future equipment changes.

4.3.8.5 Security

A secure room shall be provided as specified by the communications proponent. The minimum shall be a key locked door.

4.3.9 Miscellaneous Requirements

4.3.9.1 Lighting

Telecommunication equipment rooms shall have adequate and uniform lighting with a minimum intensity of 50 footcandles (LM/ft^2) measured 91 cm (3 ft) above the floor level. Light fixture positions shall be coordinated with the equipment layout, and overhead cable trays to ensure that lighting is not obstructed to any area in the equipment room.

4.3.9.2 Fire Protection

An ionization fire detector or equivalent shall be provided in telecommunication equipment rooms when:

- Specified by the communications proponent.
- There is a fire detection system present in the building.

The detector shall have a remote light extended from it's circuit to a location outside the main entrance door. This is required so it may be identified as the equipment room detector when activated. The proponent shall inspect and maintain the detector in accordance to manufacture guidelines.

Portable fire extinguishers or fire extinguishing systems shall be provided in accordance with SAES-B-019 (Portable, Mobile And Special Fixed Firefighting Equipment). Also, refer to SAES-M-100 (Saudi Aramco Building Code) for additional information.

Coordinate the placement of fire protection systems with the equipment layout to avoid obstructing access to the alarm or other protective measures.

Emergency exits in the building shall be provided and identified in accordance with:

SAES-M-100	*Saudi Aramco Building Code, Chapter 33 Exits*
SAES-O-100	*General Requirements Safety and Security*
SAES-O-107	*Security and Emergency Doors*
SAES-O-108	*Locks Used on Security Doors, Perimeter Fences and Emergency Exits*

4.3.9.3 Unsatisfactory Locations

Equipment rooms shall not be located in any place subject to:

- Water infiltration (to include below grade locations).
- Steam infiltration.
- Humidity from nearby water or steam.
- Heat (e.g., equipment, direct sunlight).
- Any other corrosive atmospheric or environmental conditions.

Or adjacent to:

- Boiler rooms
- Washrooms
- Janitor closets
- Any space that contains:
  - Steam pipes
  - Drains
  - Clean-outs

4.3.9.4 Exposure to Unsatisfactory Materials

The equipment room shall not be used to store corrosive, combustible or explosive substances. Examples of prohibited substances include:

- Cleaning chemicals such as acid, ammonia, and chlorine.
- Office and computer supplies such as paper and copier/printer fluids.

- Grounds keeping chemicals such as fertilizers, insecticides, and salt.
- Combustible dust or other airborne particles.
- Petroleum products (fuels).

4.3.9.5 Room Usage

Telecommunication equipment rooms shall not be used as storage rooms or as access to storage rooms. The equipment room must be kept clear of all items not related to its operation or function.

4.3.9.6 Noise Levels

Noise levels in telecommunication equipment rooms shall comply with SAES-A-105, (Noise).

4.3.9.7 Sensitive Equipment and EMI

Telecommunication circuits and equipment, shall not be located next to electrical devices or equipment that can cause Electromagnetic Interference (EMI). Separation from electrical circuits, motors, transformers (Equipment that produces EMI) shall be maintained such that sensitive equipment and its associated circuits shall not be influenced by EMI. Likely sources of EMI, which must be avoided are heavy-duty electromechanical equipment (e.g., copiers, door openers, elevator systems, factory equipment). Some locations may require that action (shielding, increased separation, additional grounding) be taken by the distribution designer to mitigate unwanted interference.

4.3.9.8 EIA TIA-569 Equipment Room Parameters

Equipment room designs shall comply with the following list of requirements.

- Avoid locations that restrict or limit expansion.
- Actual weights of equipment cabinets (e.g., racks, bays etc.) and power systems (i.e., transformers, batteries) shall be used for designing the floor live loads minimum capacities (see paragraph 4.3.8.2, above). Do not exceed the distributed floor loading >12 kPa (250

lb./ft²) and a maximum concentrated floor loading >404 kN (1000 lb).

- Location shall be free of water infiltration (see paragraph 4.3.9.3, above).
- Maintain continuous HVAC, 17.7-23.8°C (64-75°F), 30-55% relative humidity, positive pressure. (See paragraph 4.3.7 above).
- Vibration levels shall comply to SAES-M-100, (Saudi Aramco Building Code).
- Room size; provide a minimum 0.07 m² space for every 10 m² of Individual Work Area (IWA). The minimum size for a telecommunication equipment room shall not be less 14 m² regardless of the number of IWAs.
- Minimum light levels are 540 lux (50 footcandles) measured 91 cm (3 ft) above the floor level in front of and in the back of equipment racks.
- Restrict personnel access to the telecommunication equipment room by installing a combination door lock.
- Provide interior finishes to reduce dust, enhance lighting, and provide static-free environment.
- Provide emergency lighting.

Refer to the latest issue of EIA TIA-569, (Commercial Building Standard for Telecommunications Pathways and Spaces) for additional information.

4.4 Telecommunications Closets

4.4.1 General

Telecommunication Closets (TC) differ from telecommunication equipment rooms and entrance facilities in that they are considered to be floor-serving (as opposed to building serving) facilities that provide a connection point between backbone and horizontal distribution pathways. TC designs shall consider incorporation of other building information system when approved by the communications proponent. These may include; CATV, alarms, security, audio, and other telecommunications systems.

TCs provide a safe, environmentally-suitable area for installing:

- Cables
- Wires
- Premises equipment
- Terminal and cross-connect fields

The design of a TC depends on:

- Size of the building
- Number of floors
- Tenancy characteristics
- Telecommunications services used

A dedicated telecommunications distribution facility is necessary because of increased:

- Desktop automation
- Voice and data integration
- Desk-to-desk information exchange

Structured wiring systems are the required method of providing communication wiring for buildings within Saudi Aramco. This will require dedicated floor serving TCs to service flexible, high-density horizontal distribution systems in floors and ceiling to facility work areas.

4.4.1.1 Responsibility of the Distribution Designer

It is the responsibility of the Distribution Designer to become familiar with the building structure and requirements in order to optimize the utilization of the telecommunication closet for current and future requirements.

4.4.1.2 General

A telecommunication closet is a floor-serving facility for housing telecommunications:

- Equipment
- Cable termination
- Cross-connect wiring

The two cable types serviced by the telecommunication closet are:

- Horizontal cable
- Backbone cable

Horizontal cabling is the portion of the wiring system that extends from the TC to the work area telecommunications outlet (refer to paragraph 4.7 "Horizontal Cabling Systems", below for detailed information).

Backbone cabling is the portion of the wiring system between telecommunications service entrance rooms, telecommunication closets and telecommunication equipment rooms (see paragraph 4.5, "Building Backbone Systems" for detailed information on backbone wiring).

Commentary Note:

> *The telecommunication closet is the recognized connection point between the backbone and horizontal pathway facilities.*

Buildings larger than 100 m² (1076 ft²) in size (usable office space) shall have a telecommunication closet as a minimum space requirement. In multi-story buildings a minimum of one telecommunication closet shall be provided for each floor level. There is no maximum number of TCs that may be provided within a building. See paragraph 4.4.2.18 "Size requirements and Smaller Buildings" below for specific information concerning closet sizes.

Three applications served by TCs are:

- Horizontal cable connections.
- Backbone systems interconnection.
- Entrance facilities.

4.4.1.3 Horizontal Cable Connections

Telecommunication closets require that provisions be made for connecting portions of horizontal and backbone wiring systems. Passive and active devices are used to interconnect these wiring systems. To meet this requirement, the telecommunication closet shall as a minimum provide the following space for:

- Termination blocks/devices (passive devices)
- Space for current and future needs
- LAN and Wan system equipment
- Power
- Grounding

4.4.1.4 Backbone System Interconnection

The telecommunication closet may also contain a main cross-connect (MC) or intermediate cross-connects (IC) for portions of the backbone wiring. Passive and active devices are used to interconnect two or more portions of the backbone wiring system. To meet this requirement, the telecommunication closet shall as a minimum provide sufficient space for the following:

- Termination blocks/devices (passive devices)
- Space for current and future needs
- Wall space to mount cable splice closures vertically or horizontally, (not on top of a cable tray or rack)
- LAN devices (active devices)
- Power
- Grounding

4.4.1.5 Combined With An Entrance Facilities

A telecommunication closet may serve as or contain a building telecommunication service entrance facility. For this application, the telecommunication closet shall as a minimum provide the following space and facilities for housing the appropriate telecommunication equipment:

- Cable splice and associated hardware to rack, mount, secure cable and splice case
- Protection devices
- Termination blocks/devices (passive devices)
- LAN devices (active devices)

- Space for current and future needs
- Power
- Grounding

Commentary Note:

Refer to paragraph 4.2, (Telecommunications Service Entrance and Termination) for information on entrance facility requirements.

4.4.2 Minimum Design Requirements for Telecommunication Closets

Telecommunication Closets shall have as a minimum one hour fire rated walls. The wall height shall extend from the finished floor to the structured roof or ceiling level. Overhead routing of other utilities shall be avoided to prevent obstruction to telecommunication closets above ceiling access. Refer to NFPA 101 (Life Safety Code), SAES-B-014 (Safety Requirements for Plant and Operations Support Buildings) and SAES-M-100 (Saudi Aramco Building Code) for conditions that require a higher fire rated wall for these types of rooms.

The following table provides the color scheme for telecommunication closets.

Table VI – Backboard Field Termination Color Scheme

The Color	**Identifies**
Orange	Demarcation point (i.e., to MOPTT/Saudi Telecom.).
Green	Network connection (Saudi Aramco Service) i.e., network and auxiliary equipment).
Purple	Common equipment, PBX, LANs, Muxes (i.e. switching and data equipment).
White	First level backbone (i.e., main cross-connect to a horizontal cross-connector or to an intermediate cross-connect. telecommunication closet or to intermediate cross-connect).
Gray	Second level backbone (i.e., intermediate cross-connect TC).
Blue	Station Cable (i.e., horizontal cables and wires.) **Note:** Brown takes precedence over white or gray for inter building runs.
Brown	Inter-building backbone (i.e., campus cable termination's).
Yellow	Miscellaneous (i.e., auxiliary, alarms, security, etc.).
Red	Key telephone systems

Notes:

1. Methods for color coding termination fields include the use of colored backboards, connections, covers, or labels.
2. These color assignments identify termination and cross-connection fields only. They do not apply to protection apparatus or other elements of the wiring systems for which other color schemes may be used. Refer to the illustration (0406) for color code scheme.

4.4.2.1 Locating Conduits and Slots/Sleeves

Conduits and slots/sleeves systems shall be located in places where pulling and termination can be accomplished safely and without damaging cable, (see illustration "Typical Telecommunication Closet"). Conduits, slots/sleeves shall not be located more than 5 cm (2 in) from the wall. Telecommunications closets that contain entrance facilities for large entrance cables (600 pair or larger) shall have pulling eyes or support brackets incorporated into them (wall, floor or ceiling) for the purpose of installing cables safely and with out damage.

Conduits and slots/sleeves shall be sealed with an approved seal or firestop material immediately after cable installation. Firestop and seals shall be sealed in accordance to paragraph 4.8 (Firestopping), SAES-T-628 (Telecommunications - Underground Cable), SAES-M-100 (Saudi Aramco Building Code) and SAES-B-068 (Electrical Area Classifications).

4.4.2.2 Quantity & Size for Conduits and Slots/Sleeves

A minimum of three 100 mm (4 in) sleeves or conduits shall be provided for the backbone pathways. One (1) 100 mm (4 inched) sleeve or conduit shall be provided for every 5000 m² (50,000 ft²) of usable floor space served by the backbone system. There shall be an additional two (2) spares (100 mm sleeves/conduit) provided in addition to the initial requirement.

Requirements for horizontal pathways are covered in Section 4.5 (Building Backbone Systems) of this standard. Use these requirements for conduits, raceways, and ducts.

A minimum of 2-three inch conduits shall be provided when linking two telecommunication closets (TC) to each other. Larger conduits are to be provided when required by the service demands.

The minimum size and number of conduits that shall be provided between the TC and each Individual Work Area (IWA) or dwelling (occupant, tenant, etc.) is one 19 mm (¾ in) conduit. A minimum of one square inch (cross sectional area) of distribution trunk or raceway shall be provided to the TC from the IWA interface. This is required in order that horizontal cables can be installed and maintained.

Overhead pathway (trays, conduits, trunks, etc.) entries into the TC shall protrude into the closet a distance of 5 cm (2 in) at a minimum height of eight (8) feet.

4.4.2.3 Doorways

Closet Designs shall have the following features for doorways:

- Fully opening
- Equipped with combination locks
- Having a minimum width of 91 cm (36 in)
- Having a minimum height of 2.0 M (80 in)
- The hinges shall allow the door to do one of the follow:
  - Open outward (if allowed by fire code)
  - Slide side-to-side
  - Be removable

Commentary Note:

Do not use door sills and center post for TC doors.

4.4.2.4 Dust and Static Electricity

Use the following for reducing dust and static electricity:

- Install tile instead of carpet
- Coat or treat floors and walls with paint or coatings that minimize static electricity and dust

4.4.2.5 Environmental Control

Closets shall be provided with heating, ventilation, and air conditioning that will maintain:

- Temperature range of 10°C (50°F) to 35°C (95°F), within + 5°C (+ 9°F).
- Continuous environmental control (24 hours per day, 356 days per year).

Maintain positive pressure with minimum of one air change per hour in the telecommunication closet. Air handling equipment must:

- Dissipate the heat generated by active devices.
- Satisfy applicable building codes.

Commentary Note:

This does not apply to shallow closets (refer to paragraph 2.4.2.24) that will only contain passive equipment and terminations.

4.4.2.6 False Ceilings

False ceilings shall not be permitted in telecommunication closet (s).

4.4.2.7 Fire Protection

Provide fire protection for each telecommunication closets in accordance to SAES-B-014 (Safety Requirements for Plant and Operations Support Buildings).

Fire sprinkler (wet) systems shall not to be used (unless required by fire or building codes) in the telecommunication closets. Dry type of fire sprinkler systems and fire extinguishers shall be considered.

All terminal mounting surfaces (plywood, etc.) shall be painted with two coats of white non-conductive, fire retardant paint.

Firestops shall be provided when fire rated walls and floors are penetrated. The firestop shall be designed and constructed to meet SAES-M-100 (Saudi Aramco Building

Code). All materials that are used to seal penetrations in fire rated walls and floors shall be listed for the specific application and comply to UL 1479 requirements. Refer to paragraph 4.8 for additional information for Firestopping.

Exception:

> *Silicone Foam fire seal products shall not be used for permanent (in excess of five years) fire seals. However, it may be used as a temporary seal (less than a 5 year period) during a construction period or for seals that are frequently changed out.*

4.4.2.8 Flood Prevention

Telecommunication closets and rooms shall not be located where there is a threat from flooding.

Telecommunication closets and rooms shall not have water lines, drains, etc., located inside the room or in the over head ceiling.

4.4.2.9 Floor Loading

Floors of a telecommunication closet shall be designed to withstand a minimum loading of 2.4 kPa (50 lbf./ft^2).

Note: *When large cables are being placed in multi-level structures with mechanical wenches/hoist, consideration shall be given to the maximum allowable load that the floor would be subjected to.*

4.4.2.10 Grounding

All telecommunication cable and equipment shall be properly grounded in accordance with Saudi Aramco Engineering Standards and EIA TIA-607 Commercial Building Grounding and Bonding Requirements for Telecommunications.

Provide a copper ground bar in Telecommunication Closets when multiple bonds are to be used.

Bond communication grounds to approved ground points (e.g., Master Ground Bar, Power Entrance Ground, Cable Entrance Ground Bar). The metallic structural members of a building can be used provided that the conductive pathways are continuous. All telecommunication grounds and telecommunication ground systems for buildings and other structures shall be designed and constructed in accordance to EIA TIA-607 (Commercial Building Grounding and Bonding Requirements for Telecommunications). Connections to the electrical ground system shall be made and comply to SAES-P-111 (Grounding).

Refer to Paragraph 4.6, "Grounding, Bonding, and Electrical Protection" below for additional information.

4.4.2.11 Requirements for Quantity of Telecommunication Closets

Corporate buildings (single or multi-level) shall have as a minimum one telecommunication closet (TC) on each floor level.

The number of required TCs shall be based on the usable office space. A TC shall be provided in each corporate building (office, hospital, dormitory) for every 1,000 m^2 (10,000 ft^2) of usable floor space. Individual TC (s) shall not serve more than 1,000 m^2 or 100 IWA's.

An additional TC shall be placed when distances between the IWA and the telecommunication closet exceed the maximum length (90 m [295 ft]) for horizontal cabling.

4.4.2.12 Lighting

Lighting of closets shall be a minimum of 540 lux (50 footcandles) measured 91 cm (3 ft) above the finished floor level.

Locate light fixtures a minimum of 2.6 m (8 ft 6 in) above the finished floor.

Use white paint to enhance room lighting.

It is recommended that telecommunication closets have emergency lighting.

4.4.2.13 Location

The following shall be observed when positioning a telecommunication closet:

- Shall not be more than 6 m (20 ft) away from an approved ground source when the closet is to be used to accommodate the entrance cable and protected terminal.
- Horizontal cable runs shall not exceed 90 m (295 ft).

  Commentary Note:

  > *Some equipment (voice, data, or video communications) wire limits may require shorter distances.*

- Ensure common access to TCs in buildings (single or multi-story). A closet shall not be placed in a manner which requires access through a locked room (s).
- Place TCs in the core area of multi-level building so that they are arrange directly above and below connecting TCs.

Telecommunication Closets that are located in "blast resistant control buildings" shall comply to the requirements of SAES-O-126, (Blast Resistant Control Buildings) in addition to requirements of this standard.

4.4.2.14 Power

Telecommunications closets shall be equipped with:

- A minimum of two dedicated 3-wire 120 VAC duplex electrical outlets which are:
  - On separate circuits
  - 20 ampere rated service breakers.
- Two (2) dedicated 20 AMP, 120 VAC duplex electrical outlets, each on separate circuits for equipment power when equipment rack(s) are installed. Outlet(s) shall be mounted on the equipment rack that it is serving or at ceiling level mounted directly above the equipment rack being served.
- Separate duplex 120 VAC convenience outlets (for tools, test sets, etc.) which are:
  - Located at least 45 cm (18 in) above the floor
  - Placed at 1.8 meter (6 foot) intervals around perimeter walls

Commentary Notes:

1. *Additional outlets (power stripes) may be required based on the equipment planned for the closet. Additionally, consideration should be give to providing backup, standby, or emergency power sources that has automatic switch over capability.*
2. *All outlets shall be on non-switched circuit (circuits that are not controlled by a wall/light switch or other device that may inadvertently cut power to the telecommunication systems).*
3. *Power panels for dedicated electrical service shall be provided in a TC when active equipment is planned or installed.*

Electrical designs and installations shall comply with the requirements of Saudi Aramco Electrical Engineering Standards (SAES-P indexed standards).

4.4.2.15 Wall Linings

Walk-in closets (minimum 1.3 m x 1.3 m) shall have a minimum of two walls lined with 20 mm x 1.22 m x 2.44 m (¾ in x 4 ft x 8 ft) A-C plywood. The plywood shall be:

- Rigidly fasten to the wall framing members.
- Plywood shall be painted with two coats of a non-conductive, white fire retardant paint, that is low gloss and light colored.

Commentary Note:

Consider using fire-rated, void free plywood.

4.4.2.16 Wall and Rack Space for Terminals

Locate space for terminations of each separate cable types on one continuous wall or rack, whenever possible. Plan for:

- A minimum clear space of 13-15 cm (5-6 in) above and below the top and bottom connecting blocks for cable handling.
- Additional rack or backboard space for routing cables and/or cross-connect jumpers.

Commentary Note:

Corners result in 15-20 cm (6-8 in) of lost space on each wall and make ring runs necessary.

Always provide space for splice case mounting at a floor working level.

Cross-connect fields, patch panels, and active equipment in the TC shall be placed to allow interconnection via jumpers/patch cords and equipment cables whose combined length does not exceed:

- 6 m (20 ft) per link for horizontal cross-connections and interconnections. (TC)
- 20 m (66 ft) per link for other cross-connections and interconnections. (IC, MC)

4.4.2.17 Administration

Records and other documentation pertaining to the design, layout and specifications of telecommunication pathways, spaces, and wiring systems shall be processed and completed in accordance to EIA TIA-606 (Administration Standard For The Telecommunication Infrastructure Of Commercial Buildings) and Saudi Aramco Drafting Standards. These records and as-built drawings shall be forwarded with the Mechanical Completion Certificate (MCC).

These records and drawings shall consist of but are not limited to:

- Outside Plant drawings.
- Terminations of media located in work areas, TC (s), equipment rooms & entrance facilities.
- Telecommunications media between terminations.
- Pathways between terminations that contain media.
- Spaces where terminations are located.
- Telecommunications bonding/grounding.

These records and drawings will serve paper based administration systems in addition to those computer based systems.

4.4.2.18 Size Requirements

The minimum service requirements shall be based on distributing telecommunications service to one individual work area (IWA) per 10 m² (100 ft²) of usable floor space. The minimum telecommunication closet sizes are shown in the following table below:

Table VII – Telecommunications Closet (TC) Size

If A Serving Area Is	Then The Closet Shall Be At Least
500 m² (5000 ft²) or less	3.0 m X 2.2 m, (10 X 7 ft)
Larger than 500 m² and less than or equal to 800 m² (>5,000 ft² to < 8,000 ft²)	3.0 m X 2.8 m, (10 X 9 ft)
Larger than 800 m² and less than of equal to 1000 m² (>8,000 ft² to < 10,000 ft²)	3.0 m X 3.4 m, (10ft X 11 ft)

4.4.2.19 Smaller Buildings

The following table list the minimum closet sizes for small buildings.

Table VIII – Telecommunications Closets for Smaller Buildings

If The Building Is Smaller Than	It May Be Served By
500 m² (5,000 ft²)	Shallow closet that measures 760 mm X 2.600 mm x 2.600 (30 in. x 8.5 ft x 8.5 ft (see par. 4.4.1.2 & 4.4.2.23)
100 m² (1076 ft²)	Wall cabinets Self containing cabinets Enclosed cabinets **Note:** These shall not be use when active equipment is to be used. A walk in closet shall be required.

For buildings where the floor area served is less than 500 m² (5,000 ft²):

- Walk-in closets shall be at least 1.3 m x 1.3 m (4.5 x 4.5 ft) in size.
- Shallow closets shall be at least 0.76 m deep x 2.6 m wide (30 in. deep x 8.5 ft wide). Refer to paragraph 4.4.2.23 below. Shallow closets shall be provided with double doors with out a center post.

Commentary Notes:

1. *Key systems or data equipment relay racks require a depth of at least 75 cm (30 in).*
2. *All utility cabinets shall be listed and marked in accordance with applicable electrical codes.*

4.4.2.20 Layout Considerations

The design of a telecommunication closet shall include the following:

Table IX – Telecommunications Closet Layout Considerations

If:	Then:
A substantial portion (>40%) of the closet is dedicated to backbone cable distribution	Space shall be provided for splicing and ladder racking
Special telecommunication services are provided	Allow additional space for termination hardware and (possibly) active equipment.

Telecommunication closet layouts shall allow a minimum of 91 cm (3 ft) of clear work space in front of equipment and termination fields. It is important to note that the clearance is measured from the outermost surface of equipment. A minimum access of 76 cm (30 in) shall be provided to the rear of equipment for maintenance purposes.

4.4.2.21 Existing Facilities

When conducting installations and rehabilitation in existing facilities it may be difficult to adhere to the size and configuration requirements called for in this standard. To avoid this situation, new facilities should allow for future expansions in order to serve the life of the building.

4.4.2.22 Termination Space

The table below lists the minimum requirements for estimating space requirements when planning for cable terminations:

Table X – Space Requirements for Cable Termination's

For	Allocate
UTP cable cross-connects or patching (see note 1)	26 cm² (4 in²) for each 4-pair circuit to be patched or cross-connected (allows for two 4-pair cable termination's and or two 4-pair modular patch connections per circuit).
STP cable cross-connects or patching (150 ohms)	26 cm² (4 in²) for each two-pair circuit to be patched or cross-connected (allows for two mated sets of LAN connectors.
Optical fiber cross-connects or patching	13 cm² (2 in²) for each fiber pair to be patched or cross-connected (allows for two cable/patch connections per channel).

Commentary Notes:

1. *When cable terminations require surge protection, the recommended space allocation is two to four times larger than the space for regular cross-connections/patching.*

2. *These space allocations do not include cable runs to and from the termination fields. Up to 20% more space may be required for proper routing of cables, jumper wires, and patch cords.*

4.4.2.23 Typical Closet Diagram

The illustration 0418 shows a typical layout of a telecommunications closet.

4.4.2.24 Typical Shallow Closet Diagram

The illustration 0419 shows a typical layout of a telecommunication shallow closet. This closet is to be used only in small buildings of 500 m² (5382 ft²) or smaller.

4.5 Building Backbone Systems

4.5.1 Definition of a Backbone System

A backbone system (also known as a "Riser System") is the part of a premises distribution system that provides physical interconnection between equipment rooms, TCs, and service entrance facility. This system usually consist of one or more copper and or fiber optic cable systems with associated equipment.

A backbone system normally provides:

- Horizontal interconnections in campus-like environments.

- Vertical interconnections between floors in multi-story buildings.

4.5.1.1 Components of a Backbone System

A backbone system consist of:

- Cable pathways
- Telecommunications closets.
- Transmission media.
- Miscellaneous support facilities.

These four components are described below.

Cable Pathway:	Shafts, conduits, raceways, and floor penetrations (i.e., sleeves or slots) which provide routing space for cables.
Telecommunications Closet:	Areas or locations that contain telecommunications equipment for connecting the horizontal wiring to the backbone wiring.
Transmission Media:	Actual cabling, which may be fiber optic or twisted-pair copper.

Additional support materials that are needed for the proper termination and facilities installation of the backbone cables include:

- Connecting blocks and patch panels.
- Cable support hardware.
- Firestopping.
- Grounding hardware.

4.5.2 Physical Topology for Backbone Systems

4.5.2.1 Star Topology

A backbone system using a physical star wiring topology is preferred for use within Saudi Aramco. Star Topology applies to the physical transmission media (i.e., optical fiber, twisted-pair cables). Refer to the illustration (0504) for a typical Backbone Star Wiring Topology for Inter and Intra-building Communications.

4.5.2.2 Cross-Connects

Star wiring topology shall have no more than two levels of cross-connections. Connections between any two telecommunication closets shall not pass through more than three cross-connects (not including the cross-connects between the backbone and the horizontal wiring in the TCs, as shown in the illustration (0505).

4.5.2.3 Other Topologies

Certain system are designed for topologies such as bus, ring, and tree. By using interconnections and adapters in the cross-connects and TCs, these other topologies can be accommodated within a star topology.

4.5.3 Transmission Media

4.5.3.1 Cable Types

The four recognized and most suitable cable types that shall be used for backbone systems are:

- 62.5/125 microns optical fiber.
- Single mode optical fiber.
- 100 ohms unshielded twisted pair.
- 150 ohms shielded twisted pair

The cable listed above may be used individually or in any combination.

Other cable types that may be used for special applications only, are:

- 100 ohm shielded twisted pair.
- 75 ohm coaxial cable (CATV, broadband, MAP/TOP).

Refer to EIA TIA-568A for additional information.

4.5.3.2 62.5/125 Microns Multimode Optical Fiber Cable

Multi-mode graded-index optical fiber cable with a nominal 62.5/125 microns core/cladding diameter that shall conform to:

EIA TIA-568A, (Commercial Building Telecommunication Wiring Standard)

EIA TIA-492AAAA, (Detail Specification for 62.5 micron Core Diameter/125 Micron Cladding Diameter Class Ia Multi-Mode, Graded-Index Optical Waveguide Fiber For On-Premises Applications).

EIA TIA-472CAAA, (Detail Specification for All-Dielectric (Construction 1) Fiber Optic Communications Cable for Indoor Plenum Use, Containing Class 1a, 62.5 micron Core Diameter/125 Micron Cladding Diameter Class Optical Fiber (s).

EIA TIA-S-83-596 (Fiber Optic Premise Distribution Cable).

EIA TIA-S-83-640 (Fiber Optic Outside Plant Communications Cable).

4.5.3.3 Single Mode Optical Fiber Cable

Single-mode optical glass is a Class IVa Dispersion-Unshifted Single-mode optical fiber stepped indexed with a core diameter between 8 and 10 microns which supports the propagation on only one mode. Fiber optic cables used for indoor use shall comply to:

- EIA TIA-568A, (Commercial Building Telecommunication Wiring Standard)
- EIA TIA-492BAAA (Detail Specification for Class IVa Dispersion-Unshifted Single Mode Optical Waveguide Fibers Used Communication Systems).
- EIA TIA-S-83-596 (Fiber Optic Premise Distribution Cable).
- EIA TIA-S-83-640 (Fiber Optic Outside Plant Communications Cable).

4.5.3.4 100 Ohm Unshielded Twisted Pair Cable

- This cable consists of 24 or 22 AWG round solid copper conductors with a characteristic impedance of 100 ohms + 15% at 1 MHz. This cable shall conform to the requirements specified in:
- EIA TIA-568A, (Commercial Building Telecommunication Wiring Standard)
- ICEA publication S-80-576 (Communications Wire & Cable For Wiring Premises).
- ASTM D-4566 (Electrical Performance Properties of Insulation and Jackets for Telecommunications Wire and Cable).

4.5.3.5 150 Ohm Shielded Twisted Pair Cable

This cable consists of 22 AWG round solid copper twisted pairs enclosed in a braided or corrugated metallic shield with a characteristic impedance of 150 ohms ± 15% at 1 MHz. This cable shall conform to EIA TIA-568A, (Commercial Building Telecommunication Wiring Standard) and the specifications below:

Detail Specification	Cable Type Or Application
EAI IS-43AA	Outdoor
EAI IS-43AB	Non-plenum
EIA IS-43AC	Backbone (Riser)
EIA IS-43AD	Plenum

4.5.4 Backbone Cable Lengths

The following distance limitation specifications are provided to ensure that the backbone can accommodate data transmission applications. These specifications do not necessarily apply to backbones designed solely for voice traffic and low speed data.

From Telecommunication Closet to Intermediate Cross-Connect.

The total length of transmission cable between the TC cross-connect and the intermediate cross-connect shall not exceed 500 m (1640 ft) for data applications.

From Telecommunications Closet to Main Cross-Connect

The total length of transmission cable between the TC or equipment room and the main cross-connect (including to and from any intermediate cross-connects) depends upon the cable type shown below.

Table XI – Backbone Distances

If The Transmission Cable Is	Then The Maximum Length From The Closet To The Main Cross-Connect Is
62.5 Micron Fiber	2,000 m (6,560 ft).
100-Ohm Unshielded Twisted Pair (UTP)	800 m (2,630 ft).
150 Ohm Shielded Twisted Pair (STP) repeater at IC	1,200 m (3,940 ft) with repeater at IC. 700 m (2,300 ft) with no IC or repeater.
Single-Mode Fiber	3,000 m (8,200 ft)

4.5.5 Types of Backbone Cable Pathways

4.5.5.1 Vertically Aligned Telecommunication Closets

Multi-level TCs shall be vertically aligned with connecting sleeves or slots.

Note: *Ensure that proper firestopping is maintained at all times. See paragraph 4.8 below for additional information.*

4.5.5.2 Sleeves and Slots

Cable sleeves or slots shall be vertically aligned in multi-level telecommunication closets. Sleeves or slots shall be positioned adjacent to a wall on which the backbone cables can be supported (as shown in the illustration 0511). Sleeves or slots shall not be placed in such a manner as to obstruct wall termination space or areas for mounting cable splice cases. Sleeves or slots are not be to placed above or below wall space areas that are to be used for termination fields. Wall space shall be provided at a floor working level for splice case mounting and cable racking. Vertical ladder racks shall be placed on the wall at each opening (slot or sleeve) to provide support for cabling and splice cases.

Construct all:

- Slots and sleeves to be sized for current and future requirements (see paragraph 4.5.5.3 below).
- Slots with a minimum 2.5 cm (1 in) high curb that is not to exceed 5 cm (2 in) height.
- Sleeves shall extend 2.54 cm (1 in) above the floor level (as shown in illustration 0511).

Note: *Ensure that proper firestopping is maintained at all times. See paragraph 4.8 for additional information.*

4.5.5.3 Sizing Floor Sleeves and Slots

The table below provides information for determining the minimum number of 10 cm (4 in.) floor sleeves that are required to serve a facility. This ratio can be increased as necessary to provide for specific needs to the area being served.

Structural changes and floor penetrations shall be accomplished in accordance to SAES-M-100, (Saudi Aramco Building Code). Major structural modifications to floors shall be reviewed by the Saudi Aramco Communications Standards Committee Chairman (Information Technology Planning Division).

Note: *Design all sleeves with a minimum diameter of 10 cm (4 in.) and all slots with a minimum opening of 16 cm (6 in.) by 23 cm (9 in.).*

Table XII – Sleeves

Sleeves	
Total Square Meters (Feet)	**Minimum Quantity of Sleeves**
UP to 5,000 (50,000)	3
5,000 (50,000) to 10,000 (100,000)	4
10,000 (100,000) to 30,000 (300,000)	5-8
30,000 (300,000) to 50,000 (500,000)	9-12

Listed below are the minimum acceptable slot sizes according to the usable floor space. All slots and sleeves shall be sealed with an approved firestop.

Table XIII – Slots

Total Usable Area Served By Slot In Square Meters (Feet)	Size of Slot In Centimeters (Inches)
Up to 25,000 (250,000)	15 (6) x 23 (9)
25,000 (250,000) to 50,000 (500,000)	15 (6) x 46 (18)
50,000 (500,000) to 100,000 (1,000,000)	23 (9) x 51 (20)
100,000 (1,000,000) to 140,000 (1,400,000)	30 (12) x 51 (20)
140,000 (1,400,000) to 200,000 (2,000,000)	38 (15) x 61 (24)

4.5.5.4 Open Shafts

Open shafts are used when available and where large quantities of cables are required to serve a floor that is distant from the main equipment room. When shafts are utilized for running communications cables they shall be run in such a manner as to keep them organized and away from exposure to electrical circuits (ref. NEC, Article 800). The cable shall be supported by suitable methods (e.g., tray, ladder, and/or straps). The space that is allocated in shafts for communications services should be coordinated with Office Services or the building owner/proponent. All openings (ports, sleeves, slots, conduit, windows, etc.) to and from the shaft shall be sealed with and approved firestop.

4.5.6 Miscellaneous Support Facilities

4.5.6.1 Supporting Strand

Where large heavy backbone cables are used (e.g., 1200 pr. copper and larger), clamp the cable to a support strand suspended between the highest floor of the building and the basement. In addition, cables shall be clamped to vertical cable rack in each closet for support.

Steel strands used for supporting riser cables are available in various sizes designated by the letter "M" which indicates the tensile breaking point in thousands of pounds (e.g., 2.2M, 6M, 10M, etc.). The loads expressed on the steel strands shall not exceed 25% of its rated capacity.

Cable shall be secured with wire ties, straps, wraps that have specific application for securing cable vertically to the support strand. Consult the cable manufacturer for sheath strength characteristics.

4.5.6.2 Other Methods for Securing Vertical Backbone Cable.

Listed below are other methods used to properly secure vertical backbone cable:

- Brackets
- Toggle bolts
- Clamps
- Straps (steel or plastic)
- Masonry hardware

4.5.6.3 Bonding and Grounding

All designs shall provide for the bonding and grounding of all metallic members of backbone cable an associated equipment to a TGB or TMGB. All design drawings shall clearly show all grounding conductors (size and length) and connectors (type and size). A ground busbar shall be provided where there is a requirement to bond or ground more than one connection. The ground busbar shall be sized (minimum thickness 1/8 inch) to carry the maximum ampere capacity during a fault condition. It shall also be large enough to connect 6 AWG (solid copper conductors) using a listed double hole connector, from:

- Backbone cable
- Cable splice closure
- Approved power ground on the floor in the TC or IC
- Structural steel
- Any telecommunication equipment in the closet
- Main equipment room ground bar (TMGB)

Commentary Note:

Proper bonding and grounding is essential element of a building backbone system. Refer to paragraph 4.6 (Grounding and Bonding & Electrical Protection).

4.5.6.4 Firestopping

Firestopping is a critical element in a backbone system design.

Commentary Note:

Refer to paragraph 4.8 (Firestopping) below for firestopping requirements.

4.5.7 Cable Markings and Material

4.5.7.1 Cable Markings

All cabling shall be identified and marked with one of the following. The following table summarizes Table 800-50 of the 1996 National Electrical Code:

Table XIV – Copper Conductor Cable Markings

Cable Marking	Type	Reference Sections
MPP	Multipurpose Plenum Cable	800-51, 800-53
CMP	Communication Plenum Cable	800-51, 800-53
MPR	Multipurpose Riser Cable	800-51, 800-53
CMR	Communication Riser Cable	800-51, 800-53
MPG	Multipurpose/General Purpose Cable	800-51, 800-53
CMG	Communications General Purpose Cable	800-51, 800-53
MP	Multipurpose Cable	800-51, 800-53
CM	Communications General Purpose Cable	800-51, 800-53
CMX	Communication Cable, Use Limited	800-51, 800-53
CMUC	Undercarpet Comm. Wire & Cable	800-51, 800-53

4.5.7.2 Cable Substitutions

See illustration (0517) for Cable Substitution Hierarchy. The following table summarizes Table 800-53 of the 1996 National Electrical Code:

Table XV – Copper Conductor Cable Substitution

Cable Type	Permitted Substitution
MPP	None
CMP	MPP
MPR	MPP
CMR	MPP, CMP, MPR
MPG/MP	MPP, MPR

CMG/CM	MPP, CMP, MPR, CMR, MPG, MP
CMX	MPP, CMP, MPR, CMR, MPG, MP, CMG, CM

4.5.7.3 Fiber Optic Cable Markings

All fiber optic cabling shall be identified and marked with one of the following. The following table (Table 770-50 of the 1996 National Electrical Code) summarizes cable markings for optical fiber cables:

Table XVI – Fiber Optic Cable Markings

Cable Marking	Type	Reference Sections
OFNP	Nonconductive O.F. Plenum Cable	770-51,770-53
OFCP	Conductive O.F. Plenum Cable	770-51,770-53
OFNR	Nonconductive O.F. Riser Cable	770-51,770-53
OFCR	Conductive O.F. Riser Cable	770-51,770-53
OFNG	Nonconductive O.F. General Purpose Cable	770-51770-53
OFCG	Conductive O.F. General Purpose Cable	770-51,770-53
OFN	Nonconductive O.F. General Purpose Cable	770-51,770-53
OFC	Conductive O.F. General Purpose Cable	770-51,770-53

4.5.7.4 Fiber Optic Cable Substitutions

See 0518 below for cable substitution hierarchy. The following table summarizes Table 770-53 of the 1996 National Electrical Code:

Table XVII – Fiber Optic Cable Substitution

Cable Type	Permitted Substitution
OFNP	NONE
OFCP	OFNP
OFNR	OFNP
OFCR	OFNP, OFCP, OFNR
OFNG, OFN	OFNP, OFNR
OFCG, OFC	OFNP, OFCP, OFNR, OFCR, OFNG, OFN

4.5.8 Backbone Arrangements

4.5.8.1 Combined Fiber and Copper Backbone

See illustration 0520 for a typical backbone arrangement for an installation requiring both voice and data services at the user stations.

Backbone cables shall not be spliced in pathways (raceways, conduits, trays, trunking) in ceilings and under raised floors. Cable splice points shall be placed in an area designated for cable splice closures in telecommunication room (entrance facility, equipment room or TC). The splice point shall be accessible to cable technicians at floor level and supported by cable racks.

4.5.8.2 Backbone Wiring Alternatives

There are two basic methods utilized to run backbone cabling from the main equipment room to each floor. Method A uses a dedicated cable to deliver service from the main equipment room to each floor. While method B utilizes a large multi-wired cable from the main equipment room to a splice point where it is branched off to smaller cables that serve each floor. See illustration 0522 for the two methods (A or B) when installing backbone cabling in a multi-story building.

4.5.9 Backbone Cabling and Connectors Performance Testing and Inspection

Performance testing and inspection for Backbone Cabling (UTP, STP and Fiber Optic) and connectors shall be accomplished in accordance to EIA TIA-568A. Test results shall be documented by recording the test data on as-built drawings and documentation package. These documents shall be forwarded with the Mechanical Completion Certificate (MCC) to the telecommunication proponent. Refer to paragraph 6 (Testing & Inspection).

4.6 Grounding, Bonding and Electrical Protection

4.6.1 Safety

4.6.1.1 Primary responsibilities of the telecommunications distribution designer is safeguarding personnel, property, and equipment from foreign electrical voltages and currents. "Foreign" refers to electrical voltages or currents that are not normally carried by the communications systems.

The results of such disturbances could be:

- Death or injury
- Destruction of electronic equipment

- Destruction of cable network
- Down time
- Work and/or process degradation
- Loss in assets

The designer shall consider the following conditions when designing a building cable system:

- Lightning (storms)
- Ground potential rise
- Contact with power circuits
- Induction

4.6.1.2 Planning.

High priority shall be given to designing electrical protection for a telecommunication distribution system. Not all protection systems for a building are a direct responsibility of a telecommunication distribution designer. The distribution designer shall provide the necessary input during the design stage to insure that the Saudi Aramco Telecommunications Engineering requirements are met. Design drawings shall illustrate the specific electrical protection requirements (bonding, grounding, connectors, conductors and protection devices) for the distribution system. Additionally, it shall show the ground connector types and cable sizes. The telecommunication protection system can be severely compromised without the coordination effort between the Distribution Designer, electrical engineers and designers involved with the building design. This also applies to existing structures that undergo rehabilitation or renovation.

During the design phase of a facility the following considerations shall be reviewed and provided for:

- Identify areas of electrical exposure to telecommunication plant.
- Access to an approved ground source.
- Location of the telecommunications rooms and closets.

- Insure that there is adequate space to place and splice to the protection system components.

Upgrade the existing grounding to comply with current Saudi Aramco Engineering requirements.

4.6.2 Key Terms

4.6.2.1 Electrical Exposure (Exposed)

When a communication circuit may come in contact with any of the following sources of hazardous potentials and currents it is to be considered "EXPOSED":

- Lightning
- Power Induction (60 Hz induction exceeding 300 V RMS)
- Power contacts with circuits operating at more than 300 V RMS
- Earth potentials (Ground Potential Rise), exceeding 300 V RMS
- Switching transients in power lines

Commentary Notes:

1. *Primary protection is required at both ends of the communications circuit when it is classified "Exposed".*
2. *Saudi Aramco Outside Plant cable (circuits), and facilities are to be considered "Exposed".*

For specific information concerning risk refer to NFPA 780, Appendix I (Risk Assessment Guide), SAES-T-435 (Telecommunications - Station Protection) and SAES-T-903 (Communications - Electrical Protection Outside Plant).

The Isokeraunic Level of 10 shall be used for Saudi Arabia when computing the assessment of Risk Index (ref. SAES-P-111).

4.6.2.2 Approved

The word "Approved" is used in a variety of ways:

- Approved components, devices, and equipment have been tested by a Testing Laboratory that is recognized by Saudi Aramco.
- Often components, devices, and equipment are referred to as "Listed" when they have been tested and inspected by a "recognized" Testing Laboratory. This is also recognized as a form of approval when the laboratory is found to be acceptable to Saudi Aramco.

4.6.2.3 Standards and Code

It is the responsibility of the distribution system designer to know what standards and codes apply to the design and construction of telecommunications facilities.

These consist of company and international standards and codes. Refer to paragraph 3 above.

4.6.2.4 Bonding

Bonding conductors are not intended to carry electrical load currents under normal conditions, but must carry fault currents so that electrical protection methods (circuit breakers) will properly operate.

Bonding limits hazardous potential differences between different systems during lightning or power faults. Bonding also protects against arcing between different system grounds and protects personnel that may be in contact with both systems.

Bonding shall be done as specified by this section and EIA TIA-607 (Commercial Building Grounding and Bonding Requirements for Telecommunications).

4.6.3 Personnel Protection

Preventing Electric Shock

Use electrical safety measures and appropriate test equipment to verify the absence of dangerous voltages on all exposed:

- Cables
- Strands
- Wires

- Metal

All work activities that involve working in around electrical equipment and conductors shall be coordinated with the appropriate power distribution and maintenance agency prior to beginning any work. A work permit is required prior to initiating work. The distribution designer shall indicate the presence of electrical hazards on all drawings where electrical hazards may exist.

4.6.4 Basic Protection Systems

General

The systems listed below shall be recognized as performing a unique function within a building. The combination of these systems provide the overall protection for the building and its occupants. Proper design, coordination, and installation of the following systems shall be required:

- Lightning Protection System
- Grounding Electrode System
- Electrical Bonding and Grounding
- Electrical Power Protection
- Communications Bonding and Grounding
- Communications Circuit Protectors
- Site/System Grounding Topologies

4.6.5 Lightning Protection System

General

When a lightning Protections System is present the communications grounds shall be bonded to the lightning protection system grounding if within 3.7 m (12 ft) of the base of the building and may need additional bonding depending on:

- Spacing
- Building dimensions
- Construction

Commentary Note:

Refer to NFPA 780 for specific details and information regarding lightning protection systems.

Communications conductors shall not be routed closer than 1.8 m (6 ft) from any lightning protection system conductors. This separation does not apply when the building structural steel is used as the lightning down conductors. Refer to NEC Section 800-13 for specific information.

4.6.6 Electrical Power Systems

A power equipment ground shall consist of a conductor that has continuity from a receptacle (120 V duplex, etc.) through a branch circuit, to an electrical service panel, via a master ground bar to all or either of:

- Grounding electrode system.
- Building structural steel.
- Foundation ground electrode.

Refer to SAES-P-100 (Basic Power System Design Criteria) for additional information regarding electrical power systems.

4.6.6.1 Grounding Electrode System

Refer to the NEC, Section 250-54 and SAES-P-111 (Grounding) for information regarding common grounding electrode system for different electrical services within a building.

An intersystem bonding connection shall be accessible at the electrical service entrance or building ground grid. This is the primary choice for establishing a communication ground.

4.6.6.2 Electrical Bonding and Grounding

Electrical bonding and grounding is the bonding of metallic panels and raceways to an equipment grounding conductor which are in turn bonded to the grounded electrical service neutral.

Refer to NEC Section 250 and SAES-P-111 (Grounding) for information regarding bonding and grounding.

4.6.7 Communications Bonding and Grounding

Communication bonding and grounding is additional bonding and grounding specifically for communications systems.

This does not replace the requirement for electrical power grounding, but supplements them with additional bonding that generally follows communications cable pathways among telecommunications entrance facilities, equipment rooms, and TCs.

Telecommunication conduits, raceways, trunks (pathways) shall be bonded and grounded to limit hazardous voltages due to:

- Electrical power faults
- lightning
- Other electrical transients

4.6.8 Communications Grounding Practices

4.6.8.1 General

Establishing a suitable communications ground is critical in grounding communications equipment. A communication ground shall always be required, and is typically found in one of the following:

- Telecommunication entrance facility for sites with exposed cable (all Outside Plant cable within Saudi Aramco is classified "Exposed").
- Equipment room.
- Telecommunication equipment closet.

Commentary Note:

It is the responsibility of the Distribution system designer to insure that a suitable ground point (busbar) be made available in each of the facilities listed above.

4.6.8.2 Grounding Choices

Direct attachment to the closest point in the building electrical service grounding electrode system shall be used when grounding the entrance facility. (**Note:** The maximum allowable length for a 6 AWG conductor shall be six meters [twenty feet]). Do not connect telecommunication grounds to power distribution supply panels. See illustration 0618 for typical arrangement.

Select the nearest accessible location to one of the following:

- An accessible electrical service ground.
- The ground electrode system, building ground grid.

If no electric service exits, use one of the following:

- 5/8 inch diameter, 8 foot long ground rod that measures 25 ohms or less.
- Another grounding electrode system provided that it complies with the requirements called out in the NEC 250, EIA TIA-607, and this section.

Commentary Note:

A measured reading of less than 3 ohms will be required for sites that contain:

- Switching equipment.
- PABX
- Radio microwave equipment.
- Large Antenna
- Power stations/plants

Refer to the following Saudi Aramco Standards for additional information regarding grounding requirements of less than 25 ohms:

- SAES-T-887 Telecommunications: Electrical Coordination Protection at Power Plants and Radio Stations.
- SAES-T-795 Communications Facility Grounding Systems.

4.6.8.3 Using the Electrical Service Ground

A direct electrical service ground shall be the choice for grounding communications systems. An accessible means to allow for the connection of the telecommunications grounding system shall be provided for by the building design engineer (Saudi Aramco PMT or Maintenance engineer). This accessible means shall be external to enclosures for connecting inter-systems bonding and grounding conductors and be provided at the electrical service equipment by one of the following means (1993, NEC 250-71 b):

- Exposed metallic service raceways.
- Exposed grounding electrode conductor.
- Approved means for the external connection of a copper or other corrosion-resistant bonding or grounding conductor to the service raceway or equipment.
- A direct connection to the building ground grind.

  Refer to the NEC, NFPA 70 for conductor and conduit sizes.

  Commentary Note:

  For equipment ground conductors refer to NEC, NFPA 70, Section & Table 250-95).

  Exception:

  The electrical service ground conductor is critical to the safety of the electrical power system. Do not remove, modify, or disconnect without the direct participation and approval of the building design engineer or the utilities/maintenance engineer (proponent, PDD, etc.) in the case of existing structures.

- Approved external connection on the power service panel.

  Commentary Note:

  The NEC allows direct connection to a provided 6 AWG copper conductor.

4.6.8.4 Installing a Ground Electrode

The installation of a communication electrode is allowed when:

- There is no electrical service ground.

  OR

- Additional grounding is needed (refer to NEC section 800-40-b). The newly installed electrode shall be bonded to the existing ground electrode system.

The following conditions shall be maintained.

- Any installed grounding electrode must be at least twice the length of the grounding electrode away from other existing electrodes.
- Electrodes or down conductors that are part of a lightning protection system are not allowed for use as an electrode for the purpose of bonding telecommunication ground systems.
- Gas pipes, and steam pipes, or hot water pipes shall not be considered for use as a ground electrode.
- Cold water (sweet/raw) metallic pipes shall not be considered as a ground electrode due to the extensive use of plastic pipe in these systems.

4.6.8.5 Physical Protection

Physical protection shall be provided for grounding conductors when there is a possibility that it will be subjected to damage from surrounding activities or vehicular traffic. If a metallic conduit or raceway is used to provide mechanical protection for ground conductors, it shall be bonded at both ends to the ground conductor.

A #6 size conductor is the minimum sized conductor that shall be run in metallic conduit or race way.

4.6.8.6 CATV

Bond the established ground, the intended ground termination, or the outer conductive shield of a CATV coaxial cable in the same manner as other communications cables to help limit potential differences between these systems and other metallic systems.

4.6.8.7 Water Pipes

Do not use metallic water pipes for grounding electrodes or intersystem bonding conductors.

4.6.9 Communications Bonding Practices

4.6.9.1 Communications bonding relies on short direct paths that have a minimum resistive and inductive impedance. The components used in the bonding of communications systems shall be of approved or listed materials. Telecommunication grounding and bonding infrastructure shall provide safe and reliable protection for users and equipment in office (permanent and temporary), medical, dormitory, and support facilities. It also shall be the basis for providing safe and reliable protection when designing and upgrading existing facilities.

4.6.9.2 Communication Bonding Conductors

The Communication bonding conductors shall meet the following conditions:

- Made of copper.
- Routed with a minimum number of bends or changes in direction.
- Minimum size to be used, is an insulated (green) no. 6 AWG (bare tinned wire for direct buried applications).
- The bending radius of bonding conductors shall be:
    - 6 inch minimum for #6 AWG.
    - 12 inch minimum for 4/0 AWG.
    - 24 inch minimum for sizes greater than 4/0 AWG.
- Not to be placed inside a ferrous metallic conduit.
- To be made directly to the points being bonded.
- Have no splices in the bonding conductors. However, when unusual circumstances (exceptionally long conductor runs or physical constraints) dictate the need to have a splice point, the connector shall be listed (equivalent or better), approved for that use, accomplished in accordance to 1996 NEC 250-91 (a) and accessible for maintenance and inspection.

Refer to the NEC, NFPA 70, Section & Table 250-94 for conductor size, and conduit sizes.

Commentary Note:

For equipment ground conductors refer to NEC, NFPA 70, Section & Table 250-95).

Each telecommunication bonding conductor shall be labeled. The label shall be located on the conductor as close as possible to the termination point. Labels should be non-metallic and depict the following information:

Exception:

If this connector or cable is loose or must be removed contact Saudi Aramco Communication Operations representative.

4.6.9.3 Communication Bonding Connectors and Hardware

Connectors used for making connections and splicing shall be made of one of the following:

- Copper
- Copper Alloy
- Tin-plated copper

Connectors shall be listed and may consist of the following:

- Mechanical clamps or lugs. (Do not use for Direct Buried Applications)
- Compression type fittings. (Do not use for direct buried applications)
- Exothermic welding

Commentary Notes:

1. *Exothermic welding usually is used in areas subject to corrosion, systems that carry high current, receive little or no maintenance, and within a direct buried ground electrode system.*
2. *Connectors shall be listed for the application and environment in which they are to be placed.*

4.6.9.4 Inspection.

Grounding and Bonding systems shall be inspected for:

- Compliance to design

- Compliance to material requirements (codes & standards)
- Corrosion
- Loose connections
- Physical damage

Grounding and bonding systems shall be re-inspected:

- When any alteration to the system has been made
- Periodically by the operating department

4.6.9.5 Small Systems.

Connect the telecommunication equipment (protector panels, PBX cabinets, splice cases, etc.) directly to an approved ground source when:

- Installed in small equipment rooms and entrance facilities that serve an area less than 100 m^2 (1076 ft^2)
- The cable terminal is one hundred (100) pair or smaller
- Entrance facilities

Bond and ground cables directly to the approved ground source.

Commentary Note:

Only qualified electricians may enter electrical panels.

When more than one bonding conductor connection is required to be made, a ground bar is to be installed to accommodate multiple connections.

See illustration 0626 for the bonding and grounding arrangement of telecommunication equipment and cable in small buildings and facilities.

4.6.9.6 Large Systems

These facilities usually are defined as having one or more of the following:

- Large or separate entrance facilities
- Vertical or horizontal splice bay

- Multiple protector cabinets/blocks or protectors mounted on a vertical wall frame
- Distribution system connecting to TCs
- PBX and associated equipment
- LAN equipment (file server, gateway, Router, bridge, etc.)
- Fiber Optic equipment (terminals, patch panel, concentrator, repeater, etc.)

Busbar or multiple ground busbars for bonding and grounding telecommunications equipment rooms shall be provided for these types of installations.

Busbars shall be directly bonded to an approved ground source. The equipment grounding conductor shall be sized to carry the amount of electrical fault current that the equipment is exposed to. A solid number 6 AWG copper wire shall be the smallest size conductor used between an approved ground source and busbar.

Refer to the NEC, NFPA 70, Section 250-94 and Table 250-94 for conductor size. (**Note:** For equipment ground conductors refer to NEC, NFPA 70, Section & Table 250-95).

Busbars shall be positioned:

- Adjacent to protectors
- Directly between the protectors and the approved building
- ground
- Near the telecommunication equipment location

When terminating to a busbar the connections from the various types of telecommunications equipment shall be grouped accordingly:

- Protectors, busbar bonding, and approved building ground conductors toward one end
- Sensitive equipment ground conductors on the opposite end

Commentary Note:

> *Some equipment manufactures require that there be no bonding to their equipment (busbar, frame, etc.) such that it becomes an intermediate connection between other equipment (splice case, protectors, cable shields, power supplies, etc.) and the ground source.*

See paragraph illustration 0627 for an arrangement of Telecommunications Grounding and Bonding Structure for large buildings and facilities.

4.6.9.7 Telecommunications Closets

An approved ground source shall be provided to each Telecommunications Closet (TC). The ground source may be provided by one of the following:

- Telecommunication Main Ground Busbar (TMGB), See paragraph 4.6.9.5 illustration 0626 for arrangement of Telecommunications Grounding and Bonding Structure for small buildings and facilities.
- Telecommunications Bonding Backbone System (grounding and bonding infrastructure). See paragraph 4.6.9.6 illustration 0627 for arrangement of Telecommunications Grounding and Bonding Structure for large buildings and facilities.
- Power service entrance ground (electrode).
- Approved ground source (building ground grid).

The equipment ground of an electrical panel shall be bonded to the telecommunication ground system of a TC when located in a TC.

4.6.10 Equipment Grounding

4.6.10.1 Equipment Protection

Equipment manufactures rely on bonding, grounding, and protection of exposed circuits to limit the severity of surges that reach equipment. Three design methods that are acceptable for protecting large telecommunications equipment from the residual communications circuit surges are:

- Communications circuit isolation
- Equipment protection and bonding
- Isolated communications circuit grounding

Commentary Note:

When Isolated Communication Circuit Grounding is used to protect equipment from power surges, the length of isolated grounding conductor should be limited to the most direct path to ground and avoid being attached to other components or equipment.

4.6.10.2 Receptacle Outlet Grounding

Receptacle grounds shall not be used as a grounding or bonding substitute for telecommunication equipment (protectors, frames, cable, cable splices, etc.).

Receptacles that are located in a TC or used by telecommunication equipment shall be bonded to the electrical building ground system.

Commentary Note:

Isolated ground receptacles (orange in color) shall not be used for the purpose of providing for an equipment ground.

4.6.10.3 Equipment Manufacturer Warranty

The telecommunications distribution design engineer shall report any conflicts between the Saudi Aramco Engineering Standards and the manufacturer grounding and bonding requirements. All conflicts regarding the grounding and bonding of telecommunications equipment shall be resolved by the Saudi Aramco Communications Standards Committee Chairman (Information Technology Planning Division).

4.6.11 Backbone Cable Protection

4.6.11.1 Telecommunication cable systems within Saudi Aramco are considered "Exposed".

The following are to be applied when designing and constructing telecommunications systems:

- Electrical power cabling shall not be routed directly alongside communications cable (electrical cabling is usually in conduit, providing additional shielding).
- Route communications cable near the middle (core) of the building when practical to be surrounded by structural building steel that provides shielding.
- Avoid placing telecommunication cable near outer columns of the building. Usually, lightning currents from direct strikes tend to flow down through the outer columns of building structural steel.
- Telecommunication cable shall not be placed within 1.8 m (6 ft) of any lightning protection system components.
- Protect and ground all "Exposed Cables" that enters a building.
- A bonding conductor shall be installed along a non-shielded backbone cable pathway and as shown in illustration 0626 and 0627 for the arrangement of Telecommunications Grounding and Bonding Structure for buildings and facilities.

4.6.11.2 Protective measures and devices shall be provided for Saudi Aramco facilities and structures (buildings) as specified by SAES-T-887 (Telecommunications: Electrical Coordination - Protection At Power Plants And Radio Stations) and SAES-T-903 (Telecommunications Outside Plant Electrical Protection And Grounding). Extra measures (as specified by SAES-T-887 & 903) shall be reviewed and implemented when facilities and structures (buildings) are located geographically in or near:

- High lightning areas.
- High soil resistivity areas.
- Power substations.
- High voltage overhead lines.
- Heavy industrial facilities.

4.6.11.3 Telecommunications Bonding Backbone

A Telecommunications Bonding Backbone (TBB) is a conductor (6 AWG or larger) that provides direct bonding between different locations in a building, typically between the telecommunication equipment rooms and TCs. The TBB is part of the telecommunication bonding and grounding infrastructure independent of equipment or cable. The telecommunications system within a building shall have a Telecommunications Grounding Busbar (TGB) in each telecommunication room and closet. See illustration 0626 (paragraph 4.6.9.5) and 0627 (paragraph 4.6.9.6) for a typical arrangement of Telecommunications Backbone Bonding (TBB) structure for buildings and facilities.

Where two or more vertical Telecommunication Bonding Backbone (TBB) conductors are used within a multistory building, the TBBs shall be bonded together with a TBB Interconnecting Bonding Conductor (TBBIBC) at the top floor and at a minimum of every third floor, (see illustration 0627, paragraph 4.6.9.6).

Note: *Refer to EIA TIA-607 for additional information.*

4.6.11.4 Coupled Bonding Conductor

A Coupled Bonding Conductor (CBC) is a bonding conductor that provides equalization like a TBB, but also provides a different form of protection through electromagnetic coupling (close proximity) with the telecommunications cable.

There are two basic forms of CBC:

- A cable shield.
- Separate copper conductor (6 AWG or larger) tie wrapped at regular intervals to an unshielded cable.

See illustration 0630 for a typical arrangement of Coupled Bonding Conductor (CBC) for buildings and facilities.

Commentary Note:

> *In order for the CBC to work properly, it must be connected directly to the protector ground and to the ground at the equipment end.*

4.6.11.5 Backbone Cable Shield

Backbone cable shields shall be directly bonded to the nearest approved ground at each end.

Commentary Note:

Cable shields do not satisfy requirements for TBB.

4.6.11.6 Unshielded Backbone Cable

Unshielded backbone cable routed more than two stories or longer than 100 m (328 ft) across, shall have a co-routed bonding conductor (CBC) installed as follows:

- Route a 6 AWG copper conductor along each backbone cable route. (Ensuring a minimal separation between the conductor and the cables along the entire distance may satisfy equipment requirements for a CBC.)
- Bond each end at the nearest approved ground in the area that the associated cables terminate or is spliced/cross-connected to other cables. Such bonding shall be done by using a busbar.

4.6.11.7 Tie Cable Bonding

Some installations have backbone cables that terminate in a TC with pairs feeding:

- Up and down to adjacent floors.

  OR

- Horizontally to another closet serving a different area.

To equalize electrical potential as much as possible, additional bonding shall be included to the other floor or closets that are being fed. The backbone cable bonding shall be extended as directly as possible to each approved floor ground (e.g., TGB, TMGB).

4.6.11.8 Shielded Cable Systems

Some indoor cabling systems (most notably those with coax, twinax, or shielded twisted pair wire) rely on shielding as an integral factor in their signal transmission performance. The cable shields are typically grounded through standard cable connectors to a connector / administration panel at each end, so that even after administration changes the cable shields are grounded at both ends. The administration panels shall be bonded to the nearest approved ground with a direct minimum length grounding conductor. At the user terminal end, these cable shields are commonly terminated by the user terminal, which relies on the nearest power plug third wire (safety ground) instead of direct bonding.

Use manufacturer instructions and apparatus for terminating and grounding these cable types.

4.6.12 Commercial Building Grounding and Bonding Requirements for Telecommunications

Buildings shall have bonding and grounding systems for telecommunications equipment or systems. Uniform telecommunications grounding and bonding infrastructure (refer to illustrations 0626 paragraph 4.6.9.5 and 0626 paragraph 4.6.9.6) is required to ensure that telecommunications equipment and systems can be readily deployed in a building environment. This infrastructure provides the basic support for different forms of telecommunication (e.g., voice, data, video, alarms, environmental control, security, audio, etc.). It is the responsibility of the Distribution Design Engineer to assure that an approved ground system is made available for the grounding of telecommunications cabling and equipment. A building grounding and bonding system shall consist of the following:

- A permanent telecommunications grounding and bonding infrastructure independent of telecommunications cable. Design and installed as required by this standard.
- Placing telecommunications bonding connections in accessible locations with approved (listed) components.
- Copper bonding conductors (minimum 6 AWG) are installed through every major telecommunications pathway (backbone pathway) and directly terminated on a grounding busbar (a rigid copper bar) in each telecommunication equipment location. The bonding bus is also directly bonded to a TGB which is bonded to the building structural steel and other permanent metallic systems (when accessable). The busbar shall be visibly labeled and physically marked.
- A main busbar that is directly bonded to the electrical service grounding electrode system.

4.6.13 Communications Circuit Protectors

4.6.13.1 The basic functions of protectors are:

- Arresting surges or overvoltages that come from exposed circuit pairs (diverting them to ground).
- Protecting against sustained hazardous currents that may be imposed.

Communications Cables within Saudi Aramco are considered "Exposed" and require primary protection devices. Secondary protection devices shall be installed where excessive exposure levels are identified or called for by manufacturers. All station protectors shall be listed for the specific application that they are selected for.

Commentary Note:

NEC Article 800 Part C covers communications circuit protection.

4.6.13.2 The three types of communications circuit protectors that are approved for use within Saudi Aramco are:

- Primary protectors as qualified by UL 497.

  These are intended for application on exposed circuits according to NEC requirements. These must be installed as near as possible to the point at which the exposed cables enter the building, and the grounding conductor must safely carry lightning and power fault currents.

- Secondary protectors as qualified by UL 497A.

  These are used for additional protection behind primary protectors. This type protects against sneak current. Sneak current can be caused by:

  - Power faults that are too low in voltage to operate arresters.
  - Station equipment that allows current to overheat inside wire or the equipment.

- Data and fire alarms protectors as qualified by UL 497B.

These are not required by the NEC (like secondary protectors), but perform primary protection against lightning transients without the ability to protect against power faults. When used these shall be installed as close as possible to the exposed cable entrance because the are intended to divert lightning currents.

4.6.13.3 The following rules apply when selecting station protection:

- Where a circuit is exposed to electrical power faults and lightning, a primary protector is required. Other protector types are not qualified to protect under these conditions.
- Where a circuit is exposed to lightning surges, a primary protector or a data/alarm protector is required as dictated by equipment manufacturers.
- Where sneak currents are hazardous, a secondary protector or primary protector with secondary protection is required as dictated by equipment manufacturers.
- Additional protection may be included as part of the protector's functions, sometimes called enhanced protection, for specific applications.

Exception:

Manufacturers may not provide the necessary primary, secondary, or enhanced protection devices for equipment. Therefore, it is the telecommunications engineer's (e.g., Outside plant, distribution designer, data, central office, transmission, or switching engineer) responsibility to assure that the equipment is adequately protected. It is recommended to verify that all equipment is protected (primary, secondary or both) based on the environment and level of exposure that the equipment will be subjected to.

4.6.14 Protector Technology

4.6.14.1 Primary Protectors

Solid State (electronic) arresters qualified by UL 497 shall be used within Saudi Aramco for primary protection devices when designing or constructing new facilities where the ground potential rise (GPR) does not exceed 350 V. Refer to SAES-T-903 (Telecommunications Outside

Electrical Protection And Grounding) for design information concerning protection devices.

See the illustration 0625 for a typical station protector, bonding and grounding, installation for a small building.

4.6.14.2 Fuses and Fuse Links

The two types of primary protectors are fused and fuseless. In case of extended overcurrent situations, the exposed side must fuse open without damaging the ground conductor or indoor circuit. The fused type accomplishes this with an integral line fuse. The fuseless type shall be installed with a fine-gauge fuse wire (a fuse link) on the exposed line side.

4.6.15 Protection Installation Practices

Warning:

> *Do not locate protectors in a hazardous classified area as defined by NEC Article 500 (see NEC 501-14) or locations that have ignitable materials.*

The following list contains mandatory protection device installation practices:

- Before selecting any form of protection, the telecommunications distribution designer shall review:
  - Customer requirements
  - Equipment manufacturer requirements
  - Protector specifications
- Primary protectors shall be installed immediately adjacent to the exposed cable point of entry. The associated ground conductor shall be routed as straight as possible directly to the closest approved ground and not exceed 20 ft in length (refer to SAES-T-903, Telecommunications Outside Plant Electrical Protection and Grounding).
- Adequate lighting is important for personnel safety at protector locations (see paragraph 4.2.1.6 above).
- When a protector is installed in a metal box, bond the box with an approved ground conductor directly to the protector ground.
- When a new cable and/or protectors are installed in a building beside existing protectors, directly bond the new protectors and

cable to the communication ground system. The existing telecommunication ground system shall be required to comply with the most recent grounding requirements.

- Provide a minimum of 32 cm² (5 in²) of space to terminate each circuit pair. Make certain there are no obstructions around or in front of the protectors and that protector locations (Telecommunication Closets, Rooms, etc.) will not be used for any type of storage (see paragraph 4.2.1.3 above).
- The telecommunications distribution designer shall allocate additional space (wall, frame, etc.) in the building entrance facility and in the equipment room to accommodate protection devices for future needs (see paragraph 4.2.1.6 above).
- For the purpose of avoiding environmental degradation to protectors, use cabinets, boxes, and mounting hardware that specifically are listed for each application.

4.6.16 Specific Site/System Grounding Topologies

4.6.16.1 Isolated Ground

Under high lightning conditions, an "isolation gap" may be designed and installed. The cable sheath routed within the building is thus isolated from the cable sheath that enters the building. Both sides of the isolation gap are grounded with individual grounding conductors. The isolated grounding conductor shall be bonded to the ground electrode system at the source.

The use of an isolated ground arrangement shall be reviewed by CSD/ESD Communications & Computer Networks Unit. Isolated grounds shall be marked so that it is recognizable from a distance of at least four feet.

Note: *Refer to NEC Section 250-74 (Exception 4) and 250-75 for additional information regarding isolated grounding conductors.*

4.6.16.2 Insulating Joint

Under conditions causing DC ground currents, an "insulating joint" may be designed and installed. An insulating gap is made in the cable sheath similar to the isolation gap, but the field (outside) side is not grounded directly, instead it is grounded through a capacitor that blocks DC current.

4.6.16.3 Data Center Grids

Provide a ground grid or signal reference grid within a data center or equipment room that provides a low impedance between cabinets or racks of sensitive equipment. Typically, a grid of bonding cable or flat copper strips is used. The floor's steel reinforcement may provide such a grid (or plane) provided that access for maintenance and inspection of the bonding attachments are possible.

Use only products manufactured and listed for this purpose.

4.6.16.4 Enhanced Grounding Electrode System

Enhanced grounding electrode systems are required at sites with:

- Antenna towers or other tall metal structures
- Large amounts of sensitive electronic equipment
- Many exposed cables
- No soil or poor soil resistance

Improved grounding may be accomplished by integrating the telecommunication ground system to other approved ground sources at the site.

4.6.16.5 Antenna Towers

Towers are especially susceptible to lightning. Antennas with feed cables (coax) entering a building shall be protected. Refer to SAES-T-795 (Communications Facility Grounding Systems), SAES-T-887 (Telecommunications: Electrical Coordination Protection At Power Plants And Radio Stations) and NFPA 780 (Lightning Protection Code) when designing or constructing antennas. In Addition, the antenna manufacturers design and installation guidelines shall be considered.

A lightning protection system consist of:

- Lightning protection system for both the tower, base, and associated buildings. The (fully bonded) steel tower is typically used as the tower's down conductor.
- Ring ground electrode systems surrounding the tower and building, typically enhanced with multiple ground rods.
- Both systems bonded together.
- Protection measures on all communications and power services to the building.

4.6.16.6 Telecommunication Switching Centers

Telecommunications central offices (electronic switching) and computer systems have several unique requirements due to substantial powering and extensive communications circuit applications. For grounding requirements refer to SAES-T-795 (Communications Facility Grounding Systems) when structures (e.g., office and administration buildings, hospitals), house telecommunications central offices (switching) and computer systems.

4.7 Horizontal Cabling Systems

4.7.1 General

Horizontal Cabling, systems consist of two basic elements.

- Horizontal Cable and Connecting Hardware (also called "Horizontal cabling") provide the means for transporting telecommunications signals between the individual work area (IWA) and the TC. These components are the "contents of the horizontal pathways and spaces".
- Horizontal Pathways and Spaces (also called "horizontal distribution systems") are used to distribute and support horizontal cable and connecting hardware between the IWA (work area outlet) and the TC. These pathways and spaces are the "container" for the horizontal cabling.

4.7.1.1 The Horizontal cabling system includes:

- Telecommunications outlets in the work area.
- Cables and transition connectors installed between work area outlets and the TC.

- Cross-connect blocks, patch panels, jumper wires and patch cords used to configure horizontal cable connections in the TC.
- Spaces, pathways and structures used to distribute and support horizontal cabling.

Commentary Note:

The cables that extend directly from premises equipment to work area outlets or cross-connect facilities (e.g., connecting blocks and patch panels) in the TC are not considered to be part of the horizontal cabling system. However, the length and type of cable required to connect premises equipment to the horizontal cabling system will significantly affect the end to end system and shall be taken into account when designing any system.

4.7.1.2 Responsibility of the Distribution Designer

The distribution designer shall ensure that the system's design:

- Makes optimum use of the ability of the horizontal cabling system to accommodate change.
- Is as unconstrained as possible by vendor-dependence.

When designing horizontal distribution systems, the distribution designer shall observe the requirements of the applicable Saudi Aramco Engineering Standards. All engineered Scopes of Work and Design Drawings shall be reviewed and approved by the telecommunication proponent organization.

4.7.2 Horizontal Cabling and Connection Hardware

4.7.2.1 Introduction

The requirements in this section comply with the horizontal cabling requirements specified in EIA TIA-568A (Commercial Building Telecommunication Wiring Standard). Other related standards that have a direct bearing on this section shall include:

- EIA TIA-569, Commercial Building Standard for Telecommunications Pathways and Spaces.

- EIA TIA-568A, Commercial Building Telecommunication Wiring Standard.
- EIA TIA-570, Residential and Light Commercial Telecommunication Wiring Standard.
- EIA TIA-606, Administration Standard for the Telecommunication Infrastructure of Commercial Buildings.
- EIA TIA-607, Commercial Building Grounding and Bonding Requirements for Telecommunications.

4.7.2.2 Design Consideration

Horizontal cabling shall be designed to accommodate diverse user applications, including:

- Voice communications.
- Data Communications.
- Local area network (LAN).

The designer should also consider incorporating other building information systems (e.g., CATV, alarms, security, audio, other communications systems) when selecting and designing horizontal cabling.

Horizontal distribution pathways and spaces shall be designed with a minimum of 20% spare capacity for the system expansion, maintenance, and relocation activities.

4.7.2.3 Cable Lengths

The limits listed in the table below reflect the maximum lengths of horizontal distribution cables for offices with and without office cluster configurations. This is also referred to as "multi user outlet/connector arrangement". A multi-user outlet serves an entire office cluster which allows for work area cables to be extended beyond 3 m (10 ft).

Table XVIII – Horizontal Distribution Cable Lengths

Horizontal Distribution Cables...	Maximum Length Of Work Area Cables....
90 m (295 ft)	3 m (10 ft)
85 m (280 ft)	7 m (23 ft)
80 m (260 ft)	11 m (36 ft)

75 m (250 ft)	15 m (50 ft)
Note: Patch cords and cross connect jumpers in the (TC).	6 m (20 ft) long

These limits apply to all types of horizontal cable.

Other horizontal cable configurations will not have these varied cable lengths which allow for longer work area cables and shorter horizontal cable lengths. The normal 90 m horizontal cable length and 3 m work area cable length shall be maintained for areas that do not have multi user outlet/connector arrangements.

Commentary Note:

> *All equipment cables shall meet the same performance requirements as the patch cords, connectors, and jacks/plugs.*

4.7.2.4 Topology

Horizontal cabling shall be installed in a star topology. Each work area outlet shall be cabled directly to a TC.

Commentary Note:

> *Bridged taps (multiple appearances of the same cable pair at several distribution points) shall not be permitted in horizontal distribution wiring.*

Cabling between TCs is considered part of the backbone cabling. Such inter-closet connections may be used for configuring "virtual bus" and "virtual ring" cabling schemes using a star topology.

4.7.2.5 Transition Points

Horizontal cabling shall not contain transition points between different forms of the same cable type (i.e., from round cable to flat undercarpet cable).

Horizontal cabling shall not contain a splice point between termination points (cross-connects and outlets). Horizontal cable sections that are to short to reach outlets or cross-connects shall not be spliced to add length to them.

4.7.2.6 Horizontal Cabling Schematic

The illustration (0712) represents horizontal cabling to two individual work areas:

Commentary Notes:

1. *Provided that the minimum requirements are met for horizontal cabling to each individual work area, additional cables and outlets may be provided to support other applications such as CATV.*

2. *Label all cables in walls or other horizontal spaces according to the requirements of EIA TIA-606. Cables that extend to outlet boxes must be covered with an outlet face plate and identified for telecommunications use only.*

Although only two cable runs are required, the pathway (min. one ¾ inch conduit) design shall allow for at least three cable runs per individual work area, to facilitate additions and changes as user needs evolve.

4.7.2.7 Cable Slack

When cable runs are being installed, provide additional slack at both ends to accommodate future cabling systems changes. Although the exact amount of slack required depends on the size and layout of the TC and the work area termination. The following amount is allowable provided that it is neatly organized and does not drape down over other components of the terminal area:

- 3 m (10 ft) of slack at the TC.
- 30 cm (12 in.) of slack at the outlet.

Include the slack in all length calculations to ensure that the horizontal cable does not exceed 90 m (295 ft)

4.7.2.8 Electromagnetic Interference (EMI)

The distribution designer shall treat potential sources of electromagnetic interference (EMI) as a primary consideration when selecting types of horizontal cabling and designing the layout of horizontal pathways. Typical sources of EMI include:

- Electric motors, transformers, and fluorescent lighting that share distribution space with telecommunications cabling.
- Copiers that share work area space with line cords and terminals.
- Power cable that supports such equipment.

Physical separation between possible sources and the telecommunications cabling is the best way to avoid electromagnetic interference, (see "Avoiding Electromagnetic Interference [EMI]", paragraph 4.7.11.3).

Shielded cable traditionally is the choice for buildings with high levels of ambient EMI (e.g., industrial facilities with large inductive loads), performance-enhanced unshielded twisted-pair (UTP) cables offer a degree of noise immunity that make shielding unnecessary in most environments. When UTP cabling is placed in conduits and trunking (completely enclosed) additional noise immunity from EMI is achieved.

4.7.2.9 Grounding Considerations

Horizontal cabling and connecting hardware shall be grounded in compliance with:

- NFPA 70
- EIA TIA-607, Commercial Building Grounding and Bonding Requirements for Telecommunications.

When grounding telecommunications cabling, ensure that:

- The installation complies to paragraph 4.6 "Grounding, Bonding and Electrical Protection".
- Saudi Aramco Mandatory Engineering Standards.
- An approved ground shall be provided in each TC for:
  - Cross-connect frames.
  - Patch panel racks.
  - Active telecommunications equipment.
  - Test apparatus used for maintenance and testing.

- Grounding requirements of equipment manufacturers are properly followed (when compatible with required electrical codes).

Warning! *Improper grounding of telecommunications cabling poses serious safety risk.*

4.7.2.10 Administration

Systematic methods and procedures for proper labeling and management of horizontal cabling shall be followed. Refer to EIA TIA-606 for details on guidelines and requirements related to the administration of horizontal cabling systems.

4.7.2.11 Crossovers

A cabling system crossover is a transposition of pairs or optical fibers that permits each pair or fiber to connect to a transmitter on one end and a receiver on the other. When cabling system crossovers are required, they must be documented (as-built) and labeled accordingly.

4.7.3 Horizontal Cable

4.7.3.1 Cable Types

The three types of cables recognized for use in horizontal distribution cabling are:

- Four-pair 100-ohm unshielded twisted-pair (UTP).
- Two-pair 150-ohm shielded twisted-pair (STP)
- Two-fiber 62.5/125 um optical fiber cable. (Two is the minimum size, may contain more fibers)

Important: *Having one of these generic names does not guarantee that the cable meets the requirements of EIA TIA-568A.*

The wire gauge used for 100-ohm UTP cabling is typically 24 AWG (0.50 mm). UTP wires that are 22 AWG (0.63 mm) are also permitted for horizontal cabling. Horizontal cabling shall comply with EIA TIA-568A.

The wire gauge used for 150-ohm STP cabling is typically 22 AWG (0.63 mm).

4.7.3.2 Horizontal Media Selection

To support both voice and data communications in a building, a minimum of two approved cables shall be run to two telecommunications outlets at individual work area locations. The two outlets at each work area typically allow one to be used for voice communications, and the other for data communications.

Twisted pair copper conductor cables shall comply with the material and cable marking requirements of NEC (1996) 800-50. Refer to paragraphs 4.5.7.1 and 4.5.7.2 for information regarding the use and substitution of these cables.

The horizontal cabling runs to each individual work area (IWA) shall consist of telecommunications outlets wired to:

- Four-pair 100-ohm UTP cable for voice (suitable for a category 3 service as a minimum).

  AND

- Any one of the following for data (depending on the anticipated needs of work area occupants):
  - Four-pair 100-ohm unshielded twisted-pair (UTP category 5)
  - Two-pair 150-ohm shielded twisted pair (STP)
  - Two-fiber 62.5/125 um optical fiber cable

4.7.3.3 Optical Fiber

When projected needs include optical fiber, fiber may be installed in addition to the two required outlets. Use a dedicated cable to distribute optical fiber (rather than using a hybrid cable).

Fiber optic cables shall comply with the material and cable marking requirements of NEC (1996) 770-50. Refer to paragraphs 4.5.7.3 and 4.5.7.4 for information regarding the use and substitution of these cables.

4.7.3.4 Hybrid Cables

A hybrid cable is a cable composed of two or more cable types under a common sheath. Hybrid cables are not recommended for horizontal cabling because they tend to limit flexibility of the cabling system and occupy excess pathway space unnecessarily if one of the hybrid components becomes unused. However, hybrid cable may be used if:

- Crosstalk meets EIA TIA-568A requirements.
- Each cable type within the sheath meets the appropriate:
  - Transmission requirements. (Refer to paragraph 4.7.6, (Cable Performance Testing and Inspection)
  - Color code requirements

4.7.4 Horizontal Connecting Hardware

Connecting hardware for horizontal cabling includes:

- Outlet connectors.
- Transition connectors.
- Connectors used for cross-connection and/or patching.

Connecting hardware used for horizontal cable connections shall meet the requirements for reliability, safety, and transmission performance specified in:

- EIA TIA-568A
- EIA TIA-70

4.7.4.1 Equipment Connections

Do not connect horizontal cables directly to premises equipment. Instead, use suitable connecting hardware and cable to make the connection. Locate patch panels and cross-connect blocks so that the combined length of cables and line cords used to connect equipment in the work area and TC, plus the patch cable, do not exceed 10 m (33 ft).

Note: *Connector ratings shall be of same category (e.g., category 3 or 5) as the cable that is selected.*

4.7.4.2 Work Area Outlets

Design work area outlets so that:

- Outlets are securely mounted at work area locations
- Horizontal cables are terminated with a standard outlet connector which is specified for the same category as the cable type (category 3 or 5, fiber, etc.)
- Locate work area outlets so that the cable required to reach work area equipment will be no more than 3 m (10 ft) long

Commentary Note:

Coordinate furniture layouts with the Office Services Department representative and building occupant.

4.7.4.3 Outlet Adapters

Electrical components (e.g., impedance-matching devices) which some applications require at the telecommunications outlet shall not be installed as a part of the horizontal cabling. When these components are used, they must be located outside the faceplate via a standard plug connection.

4.7.4.4 100-Ohm UTP Cable Outlets

Each four-pair 100-ohm UTP shall be terminated in an eight-position modular jack at the work area. The outlet shall meet the standard interface and reliability requirements of the specification IEC 603-7. Terminate the outlet connector directly to the horizontal cable (preferably with insulation displacement connections) and mount it in the outlet faceplate so that it is accessible for work area connections.

Connections that provide electrical connections between 100-ohm UTP cables shall meet the requirements of EIA TIA-568-A and EIA TSB-67.

The jack and pin/pair assignments for these modular jacks are shown in the illustration 0717. Pin/pair assignments are compatible with the requirements of ISO 8877. Optional pin/pair assignments of T568B (to accommodate other eight-pin cabling systems) are also shown in the illustration 0717.

Commentary Note:

> *The colors indicated are associated with horizontal UTP cable. Color coding for work area line cords, patch cables, and jumper wires may vary.*

4.7.4.5 150-Ohm STP Cable Outlets

Each 150-ohm STP cable shall be terminated with the outlet and cable pair assignments specified by ISO/IEC 8802.5 for the media interface connector. Terminate the outlet connector directly to the horizontal cable from the TC and mount it on the outlet faceplate so that it is accessible for work area connections. The 150-ohm STP outlet connector is designed to be "hermaphroditic", meaning that two identical units will connect when oriented face-to-face at an angle of 180° to each other.

Connectors that provide electrical connections between 150-ohm STP cables shall meet the requirements of EIA TIA-568A.

4.7.4.6 62.5/125 um Optical Fiber Outlets

Horizontal 62.5/125 um optical fiber cable shall be terminated by a duplex SC-style or ST-style outlet connector (as specified in Sectional Specifications IEC 874-14, Type SCFOC/2.5 and IEC 874-10, Type BFOC/2.5 respectively). For new installations and installations with no existing installed fiber, the preferred choice is the SC connector.

For methods and guidelines on the proper installation and connection of horizontal runs of optical fiber cabling, refer to EIA TIA-568A.

4.7.5 Performance Categories

Performance categories are intended to assure compatibility of horizontal cabling with a variety of telecommunications signaling applications. Two cable types that offer more than one standard performance grade are 100-ohm UTP and 150-ohm STP. The requirements for and applicability of these categories are defined below.

4.7.5.1 100-Ohm UTP Categories

Five performance categories currently exist for horizontal 100-ohm UTP cabling systems. Only cable and connecting hardware rated for Category 3 and 5 performance shall be used for horizontal cabling within Saudi Aramco.

Connecting hardware used for horizontal cable runs shall be rated for the same category or higher when using UTP cable from a given category (as specified in EIA TIA-568A). Specific performance requirements for these categories have been matched and are consistent with UTP "Level" designations specified NEMA WC 63 Underwriters Laboratories Subjects 444 and 13 (UTP).

All cabling shall be tested and accepted for the specific category rating of the cabling.

4.7.5.2 Approved UTP Categories

Category	Definition
Category 3	This category consists of cables and connecting hardware currently specified in the EIA TIA-568A standard. The characteristics of those components are specified up to 16 MHz. Category 3 components are typically used for voice and data transmission rates up to 10 Mb/s. (e.g., IEEE 802.5b [4 Mb/s UTP annex] and IEEE 802.3I [10BASE-T]). Category 3 (Level 3) components represent the minimum transmission performance acceptable for horizontal cabling systems.
Category 5	This category consists of cables and connectors specified up to 100 MHz. The cables and connecting hardware are specified in the EIA TIA-568A standard. Category 5 components are intended to be used for applications with transmission

rates up to 100 Mb/s. (e.g., ANSI X3T9.5 100 Mb/s TP-PMD working group).

4.7.5.3 Category Selection

Category 3 & 5 UTP are the only acceptable UTP cabling for use within Saudi Aramco. The selection of the UTP category that is to be installed is primarily a budgetary decision. Selecting the highest performance UTP components that the budget will allow offers the best long-term investment by minimizing change over the life of the cabling system. If possible, install only one category of UTP cabling throughout the system to minimize the long-term expense and confusion of administering multiple UTP cable plants.

4.7.6 Category 3 & 5 UTP Cable Performance Testing And Inspection

The performance testing of category 3 and 5 horizontal cable is required to ensure that the combination circuit is capable of supporting high speed LAN applications and equipment. The following two configurations are the only acceptable test configurations that can be used on these horizontal cable systems;

Channel: The channel configuration includes up to 90 m (maximum) of horizontal cable, a telecommunications outlet, an optional transition connection close to the work area, and 2 connections at the cross-connect in the TC. The total length of equipment cords, patch cords and jumpers is 10 m. The connections to the equipment at both ends of the channel are not included in the channel definition. The channel test is intended to be used by systems designers and the operating proponent to verify performance of a channel.

Basic Link: This configuration is defined for the permanently installed cabling. It consist of up to 90 m of horizontal cabling without the optional transition connector, a connector at both the local and remote end, up to 2 m long equipment cord from the main unit of the field tester to the local connector, and up to 2 meter long equipment cord from the remote connector to the remote unit of the field tester. The basic link assumes that there is one connector at each end of the link. The connections to the equipment at both ends of the link are not included in the link definition.

All cabling shall be tested and accepted for the category rating (category 3 or 5) of the cabling. Refer to EIA TIA-568A and EIA TSB-7 for required performance testing.

4.7.7 Field Measurement Procedures

The NEXT and attenuation of the mated connection at the test equipment shall not be included when making field measurements of installed cabling.

The following field test and procedures shall be performed on horizontal cable systems:

- Wire Map
- Length
- Attenuation
- NEXT
- Propagation delay

Test results shall be documented by recording the test data on as-built drawings and in the documentation package. This information shall be forwarded with the Mechanical Completion Certificate (MCC).

4.7.7.1 Consistency Checks for Field Test Instruments

Field test instruments shall have a means to verify the operation of the test tool in the field. All equipment shall have a current calibration sticker based on the manufactures operational requirements.

4.7.7.2 Pair Reversals

Measure NEXT of a 100 m category 5 link when transmitting on pair X and Receiving on pair Y. Then using only the internal switching matrix to reverse transmit and receive pairs, measure NEXT when transmitting on pair Y and receiving on pair X. No cabling shall be moved during this test. Reversal is done internal to the measurement apparatus. This test is performed for all pair combinations. Internal consistency agreement shall be within (±) the NEXT accuracy specification of the instrument.

4.7.7.3 Tip Ring Reversals

When tip and ring conductors are reversed on either the transmitting or receiving pairs of both ends of a link, the agreement between the two measurements shall be within (±) the NEXT accuracy specification of the instrument.

4.7.7.4 Attenuation Symmetry

Attenuation measurements made on the same link by interchanging the near-end and far-end measuring devices shall differ no more than the (±) attenuation accuracy of the test instrument over the frequency band 1- 100 MHz. This applies to each conductor pair of a four pair cable.

4.7.7.5 NEXT Measurements

Field tests of NEXT shall be done at both ends of the cable to ensure that far-end connections are verified for compliance.

4.7.7.6 Administration

In addition to pass/fail indications, the actual measured values (frequencies) shall be documented by recording the test data in the as-built drawing and documentation package. This documentation package shall be forwarded with the Mechanical Completion Certificate (MCC). Additionally, records may be used by the administration system for use in future configuration or analyses of the premise network.

4.7.7.7 Test Equipment Cords

Only approved adapters cords that are suitable for testing Channel and Basic Links shall be attached to test instruments during Field Measurement Test.

4.7.7.8 User Patch Cords

User patch cords shall be tested in place. User patch cords may be verified by inserting the user cords in the link under test at the cross-connect.

4.7.8 Cross-Connect Wires And Patch Cords

4.7.8.1 General

Cable used to configure additions, moves, and changes are as critical to transmission performance as imbedded horizontal cable runs. Cross-connect jumpers and cables used for patch cords and equipment access shall meet the performance requirements described in EIA TIA-568A. UTP cabling shall meet or exceed the near-end crosstalk requirements for the category of the embedded horizontal cables that they are connected to.

4.7.8.2 Length Requirements

Horizontal cross-connect wires and patch cords shall not exceed a length of 6 m (20 ft). Systems designers shall plan for a combined maximum cable length of 10 m (33 ft) for patch cords and for equipment connections in the work area and TC. This length is in addition to the 90 m (295 ft) of cable allowed between the TC and work area outlet.

4.7.9 Cabling Practices

4.7.9.1 General

Connector and cable components shall be installed in such a manner as not to degrade the performance of the telecommunications system. Therefore, consideration is to taken for the installation of:

- Connector termination.
- Cable management.
- Use of cross-connect jumpers/patch cords.
- Multiple connections in close proximity.

4.7.9.2 Cable Management Practices

Performance specifications for cable and connecting hardware are based on proper installation and wire management.

The following wire and cable management practices shall be followed:

- Eliminating cable stress caused by tension in suspended cable runs and tightly clinched cable bundles.

- Reducing untwisting of wire pairs by stripping back only as much cable jacket as is required to perform connecting hardware termination (with allowance for excess length that may be removed during termination).
- Ensuring that cable bend radii in horizontal spaces and pathways are no less than six times the cable diameter for:
  - UTP
  - STP
- For optical fiber, the minimum bend radius is 10 times the cable diameter. Consult with cable manufacturers to determine if an additional bend allowance is required for specific cable brands and type.

4.7.9.3 Connector Termination Practices

The amount of untwisting for UTP cabling shall not exceed the requirements of EIA TIA-68A (no greater than 13 mm [0.5 in] for Category 5 cables and no greater than 25 mm [1.0 in] for Category 3 cables).

Commentary Note:

> *This requirement is intended to minimize untwisting of wire pairs and the separation of conductors within a pair. It is not intended as a twist specification for cable or jumper wire construction.*

The installation requirements specified in EIA TIA-568A shall be observed for all categories of connecting hardware.

4.7.10 Work Area Cables

Work area cables (also called "line cords" or "station cords") extend from the telecommunications outlet to the work area equipment. The work area equipment may include (but is not limited to):

- Telephones
- Data terminals
- Computers

The components and cabling practices in the work area shall comply to the transmission requirements of EIA TIA-568A for system performance. Work area cabling is critical to assuring good horizontal link performance, it is often subject to wiring abuses (e.g., sub-grade cables, line cords whose lengths exceed 3 m [10 ft]).

4.7.10.1 Work Area Cables/Cords

Line cords and other equipment cables that connect to the horizontal cabling shall meet the performance requirements described in EIA TIA-568A.

The combined length of cables and line cords used to connect equipment in the work area and telecommunication closet, plus the patch cable, shall not exceed 10 m (33 ft).

4.7.10.2 Wiring Adapters

Wiring adapters shall be made outside (beyond) the telecommunications outlet. Typical adaptations that shall be made outside the outlet include but are not limited to:

- Adapters and cord assemblies required when equipment outputs differ from the outlet connector.
- "Y" adapters that allow two devices to be served from a single horizontal cable.
- Baluns, resistors, and other passive or active components that convert media or support other special applications.

4.7.11 Horizontal Pathways and Spaces

4.7.11.1 Horizontal pathways and spaces consist of structures that conceal, protect, and support horizontal wires and cables between the:

- Outlet interface used to connect work area equipment (voice, data, and video) at the work area.

  AND

- Serving TC.

Horizontal pathways and spaces are referred to as "horizontal distribution systems".

When designing a building, the layout and capacity of the horizontal distribution systems shall be thoroughly documented in floor plans and other building specifications.

4.7.11.2 Design Considerations

Horizontal distribution systems shall be able to:

- Minimize occupant disruption when horizontal pathways and spaces are accessed.
- Facilitate ongoing maintenance of horizontal cabling.
- Accommodate future additions to and changes in cabling, equipment, and services.
- Be accessible.

The pathway design shall allow for a minimum of three cable runs to be placed between the each individual work area (IWA) and the telecommunication closet or room.

4.7.11.3 Avoiding Electromagnetic Interference (EMI)

The following minimum distances shall be maintained between devices (e.g., motors, transformers and copiers) that cause electromagnetic interference to the telecommunications distribution system (pathways and spaces).

- 1.2 m (4 ft) from large motors or transformers.
- 0.3 m (1 ft) from conduit and cables used for electrical power distribution (220, 120 V).
- 12 cm (5 in.) from fluorescent lighting. Pathways should cross perpendicular to fluorescent lighting and electrical power cables or conduits.

For additional clearance requirements, see EIA TIA-569 and NFPA 70.

4.7.11.4 Administration

Use systematic methods and procedures for labeling and managing horizontal pathways. For details and requirements for the administration of horizontal pathway and spaces refer to EIA TIA-606.

4.7.12 Types of Horizontal Pathways

4.7.12.1 The main types of horizontal pathways are:

- Underfloor ducts (one-level or two-level)
- Cellular floors
- Conduit
- Access (raised) floors
- Ceiling zones and grids
- Undercarpet (restricted to use with flat, undercarpet cables)

Commentary Note:

Many buildings require a combination of two or more of these systems to meet all distribution needs.

4.7.12.2 Refer to the BICSI Telecommunications Distribution Methods Manual, for the disadvantages, advantages and illustrations of each type of horizontal pathway.

4.7.13 Sizing of Horizontal Pathways

The size requirements for horizontal distribution pathways depend on the following considerations:

- Usable floor space served by the pathway.
- Maximum occupant density (i.e., floor space required per individual work area).
- Cable density (i.e., quantity of horizontal cables planned per individual work area).
- Cable diameter.
- Pathway capacity (requires that fill factor be taken into account).

The minimum sized pathway design shall allow for a minimum of three cable runs to be placed between the each individual work area (IWA) and the telecommunication closet or room.

4.7.13.1 Usable Floor Space

The usable floor space (also called "office space") is considered to be the building area used by occupants for their normal daily work functions. Areas and spaces that have distribution systems (horizontal pathways and spaces) such as floor ducting, trays and conduit shall be considered usable floor space. For planning purposes, include these spaces and hallways, but not other common areas of the building (e.g., door entrances, entrance halls, elevator, waiting areas, rest rooms, stairways, mechanical equipment rooms).

4.7.13.2 Occupant Density

The standard floor space allocation used in an office environment is one individual work area (IWA) for every 10 m^2 (100 ft^2) of usable floor space. This is the maximum space size that shall be used for determining occupancy space numbers in a Saudi Aramco facility (e.g., community or business building and permanent or portable office). Smaller space sizes shall be used when determining occupancy spaces for buildings or offices with:

- High workstation saturation.
- High density of engineering work areas (cubicles).
- High density of Computer Aided Drafting (CAD) stations.
- High density of knowledge workers.
- Professional and other educational facilities.
- Or identified by proponent, DBSP (Design Base Scoping paper) or Scope of Work.

4.7.13.3 Cable Density

The distribution designer shall plan for a pathway capacity that accommodates a minimum of three horizontal cable runs per individual work area (IWA). Although only two cable runs are required, additional capacity will facilitate additions and changes to horizontal cabling as user needs and applications evolve. The same pathway capacity shall apply to additional IWA outlet boxes and distribution conduit.

4.7.13.4 Cable Diameter

The following table lists typical ranges of cable diameter for four recognized horizontal cabling media. These values are provided for planning purposes only. It is strongly recommended that the distribution designer check the actual diameter of the cable being used before determining pathway size requirements.

Table XIX – Horizontal Cable Diameter

Horizontal Cable Type...	Typical Range of Overall Diameter....
Four-pair 100-ohm UTP	0.36 cm to 0.61 cm (0.14 in. to 0.24 in.)
Two-Pair 150-ohm STP	0.79 cm to 1.1 cm (0.31 in. to 0.43 in.)
62.5/125 um Optical Fiber Cable	0.28 cm to 0.46 cm (0.11 in. to 0.18 in.)

4.7.13.5 Conduit Capacity

Table XX provides cable capacity for conduits having cross-sectional areas ranging from 2 cm² (0.3 in²) to 82 cm² (12.7 in²), (refer to EIA TIA-569).

Table XX provides information on the maximum allowable communication cable capacity for horizontal conduits that have no more than two 90-degree bends (180 degrees total). Conduit fill percentages are also subject to the requirements of NFPA 70.

4.7.13.6 The maximum conduit fills allowed by NFPA 70 are shown in the table below. Other limitations apply (refer to NFPA 70).

Table XXI – Maximum Conduit Fills for Horizontal Cabling

Number of Cables Per Conduit	Maximum Fill Allowed
One	53%
Two	31%
Three	40%

4.7.13.7 Determining Conduit Size

In the following table is a sample calculation to determine the size of a horizontal conduit, based on the preceding information and guidelines:

Table XXII – Determining Conduit Size

Step	Determining The Floor Space That A Conduit Can Serve	Example (Ft./In.)
1	Measure the usable floor space to be served by the horizontal conduit.	100 m² (1000 ft²)

2	Divide the usable floor space by the maximum occupant density (required per individual work area [IWA])	100 m^2 (1000 ft^2) ÷10 m^2 (100 ft^2) = 10 IWAs
3	Multiply by the maximum number of cables per individual work area.	10 IWAs x 3 cables per IWA = 30
4	Determine the maximum diameter of the horizontal cable to be used.	ϕ 0.61 cm (0.24 in)
5	Use the table in Para. 4.7.13.5 "Conduit Capacity" to determine the conduit size that is most suitable for holding a quantity of 30 cables with a diameter of 0.61 cm (0.24 in.)	63 cm (2½ in.)

4.7.13.8 Determining Raceway Size

The design capacities of raceways are typically based on a 28% fill factor. This figure is obtained by de-rating the raceway by 15% for each of two 90° bends. The resulting 70% is multiplied by the NFPA 70 requirement of 40% for conduits with more than two cables. The product of 70% and 40% is 28% (0.70 x 0.40 = 0.28).

This percentage fill is used to determine the total number of cables of a known cross-sectional area that may be housed in a raceway of a given size. See paragraph 4.7.22.3, "Typical Overhead Ceiling Raceway System" below.

Most raceways are provided with design guidelines, including fill factors. Verify which article applies in NFPA 70, Chapter 3, because different types of raceways have different requirements. See "raceway" definition in NFPA 70, Article l00.

4.7.13.9 Determining Duct Size

The minimum size feeder and distribution duct or tray (rectangular/square) shall be determined on a duct capacity of 6.5 cm^2 (1.0 in^2) of cross-section for each 10 m^2 (100 ft^2) of usable floor space. This relationship applies to both feeder and distribution ducts and is based on the assumption of 3 cables per individual work area and one individual work area for every 10 m^2 (100 ft^2) of usable floor space.

Note: *Special occupant needs or floor plans may require additional duct space. See paragraph 4.7.13.2 "Occupant Density", above.*

4.7.14 Underfloor Duct System

4.7.14.1 Underfloor duct systems are a network of metal raceways embedded in concrete which facilitates the distribution of horizontal cables (i.e., between TCs and work areas). These types of systems are acceptable for Saudi Aramco telecommunication infrastructure.

Ducts are rectangular and may be used in:

- Single, double, or triple runs.
- Combinations of large and small ducts, mixed to provide a larger or smaller capacity to match the needs of specific areas in a building.

Underfloor duct systems are made up of:

- Feeder (header) ducts, which carry cables from the TC or work area outlet boxes to the distribution ducts.
- Distribution ducts, which distribute wires and cables from a feeder duct to specific floor areas.

Refer to the latest issue of the BICSI TDMM for additional information regarding Under Floor Duct Systems.

4.7.14.2 Duct Distribution

Distribution ducts shall have preset inserts between 61 cm (2 ft) to 92 cm (3 ft) centers. Feeder ducts shall not have preset inserts.

Depending on the floor structure, ducts may be designed in one-level or two-level systems to:

- Distribute wires and cables from a feeder duct to specific floor areas.
- Provide access to wires and cables in a specific floor area.

4.7.14.3 Junction Boxes

Place junction boxes at planned locations in a duct system to:

- Permit changes in the direction of the run.
- Provide access to the system for pulling wires.

A maximum space of 18 m (60 ft) between junction boxes and other access points shall be maintained.

4.7.15 Design Requirements For Underfloor Ducts

Refer to the BICSI TDMM for general information in addition to the requirements listed below in this section.

4.7.15.1 Feeder Duct Size

The pathway design shall allow for a minimum of three cable runs to be placed between the each individual work area (IWA) and the telecommunication closet or room.

Feeder ducts normally range from 49 cm^2 to 57 cm^2 (7.6 in^2 to 8.9 in^2) in cross-sectional area. A duct in this range serves an area of approximately 80 m^2 (800 ft^2).

Commentary Note:

Avoid "Electromagnetic Interference (EMI)", refer to paragraph 4.7.11.3.

4.7.15.2 Feeder Duct Capacity

Duct capacity shall be determined by measuring the cross-sectional area of a feeder duct to verify that its capacity is adequate for the area it will serve. There shall be 6.5 cm^2 (1 in^2) of cross-sectional area in a feeder duct for each IWA (10 m^2 [100 ft^2] of usable floor space) served by the duct.

To determine the usable floor space that a feeder duct can serve, follow the steps listed in the table below.

Table XXIII – Determine Feeder Duct Capacity

Step	Determining The Floor Space That A Feeder Duct Can Serve	Example
1	Measure the inside height of the duct.	5.1 cm (2 in.)
2	Measure the inside width of the duct.	10.2 cm (4 in.)
3	Multiply the height by the width to determine the cross-sectional area of the duct.	5.1 cm (2 in.) x 10.2 cm (4 in.) 52 cm^2 (8 in^2)
4	Multiply its cross-sectional area by 1.54 m^2/cm^2	52 cm^2 (8 in^2) x

(10 m /6.5 cm²) or 100 ft²/in². (See Paragraph 4.7.13.9 "Determining Duct Size".)	1.54 m²/cm² (100 ft²/in²) 80 m² (800 ft²)

Note: *Select a different size feeder duct when the cross-sectional area indicated by these steps is too large or too small for the floor space served by the duct.*

4.7.15.3 Distribution Duct Sizes

Standard distribution duct size range from 21.3 cm² to 25.2 cm² (3.3 in² to 3.9 in²) in cross-sectional area. Use larger distribution ducts when serving a floor area between 18 m and 24 m (60 ft and 80 ft) long.

Plan for one individual work area (IWA) per 10 m² (100 ft²) of usable floor space (this value takes into account space for corridors and other common traffic areas) that will be served by a minimum of three cables per individual work area.

The minimum allowable cross-sectional area of distribution duct for each IWA is 6.5 cm² (1 in²).

A larger distribution duct shall be used where the demands for more than three cable per individual work area (IWA) are required or when larger cables are used to serve this space size.

Distribution ducts are available in the sizes listed in the following table.

Table XXIV – Distribution Duct Size

Duct Size	Range of Cross-Sectional Areas
Standard	21 cm² to 25 cm² (3.3 in² to 3.9 in²)
Large	49 cm² to 57 cm² (7.6 in² to 8.9 in²)

4.7.15.4 Standard and Large Duct Sizes

Representative cable capacities of standard 21 cm² (3.3 in²) duct and large 57 cm² (8.9 in²) duct are shown in the table below. These values are based on a pathway fill factor of 28%.

Table XXV – Standard Large Duct Sizes

Horizontal Cable Type	Standard Duct Capacity (21 cm² [3.3 in²])	Large Duct Capacity (57 cm² [8.9 in²])
Four-pair UTP (ϕ 0.56 cm [ϕ 0.22 in.])	24	65
Two-Pair 150-ohm STP (ϕ 0.94 cm [ϕ 0.37 in.])	8	23
62.5/125 µm Fiber (ϕ 0.33 cm [ϕ 0.13 in.])	69	180

4.7.15.5 Installing Distribution Duct

To install distribution duct, follow the procedure in the table below.

Table XXVI – Installation Procedures for Distribution Duct

Step	Installing Distribution Duct
1	Space preset inserts at regular intervals, with insert markers approximately every 15 m (50 ft). **Note:** The distribution duct system shall be installed such that horizontal cables extending from the termination in the TC to the outlet are not more than 90 m (295 ft) long.
2	Install and center the distribution duct between building module lines (space between the joists).
3	Locate a single run of distribution duct within 45 cm to 61 cm (18 in. to 24 in.) of the outside wall. **Note:** This duct serves the credenzas and desk on the outside walls commonly located in prime private offices.

4.7.16 Telecommunications Closet (TC) Considerations (For Underfloor Ducts)

Feeder and distribution ducts shall be physically linked to a TC either directly or through no more than one feeder duct. TC shall not be inter linked or connected by making a transition in the floor feeder duct to an overhead arrangement of tray, duct or conduit. This shall be accomplished by having the floor feeder duct enter the TC at floor level. Ensure that the closet is:

- Located centrally within the zone.

- Large enough for the required quantity of feeder ducts.

Commentary Note:

For more information on the termination of horizontal pathways in the telecommunication closet, see paragraph 4.4, "Telecommunications Closets" and paragraph 4.7.16.3, "Terminating Feeder ducts in Telecommunications Closets" below.

4.7.16.1 Telecommunications Closets in the Core of a Multistory Building

TC (s) shall be located in or adjacent to the core area of a multi-story building when the core area is centrally positioned in the structure.

Other floor serving TC (s) may be provided in locations away from the core area of a building due to excess horizontal cable lengths or zone serving configurations. TC (s) shall be inter-connected to TC (s) serving the same floor.

When the core area is not centrally positioned in a multi-story building the TC (s) may be positioned away from the core area so long as the TC (s) is centrally positioned in a serving area or zone.

Refer to illustration 0751 for typical layout of this arrangement.

4.7.16.2 Telecommunications Closet Occupying One-Quarter of a Floor

The illustration 0755 shows a telecommunications closet serving one-quarter of a typical floor.

4.7.16.3 Terminating Feeder Ducts in Telecommunication Closets

Choose the method for terminating feeder ducts in a TC(s) according to the guidelines in the table below.

Note: *A step-by-step design procedure for terminating underfloor duct is given in paragraph 4.7.16.4 "Underfloor Duct Design for Telecommunications Systems".*

Table XXVII – Choosing a Method for Terminating Feeder Duct

If Ducts Enter The Tc And....	Then . . .
Do not pass within the closet floor slab.	Terminate the ducts in a floor trench 13 cm (5 in.) wide. **Notes:** • Do not make the length of the trench less than the overall width of the feeder duct band that terminates in it. • Close the end of the ducts with removable caps.
Passes within the closet floor slab	Use Duct elbow fittings to terminate the ducts at the plywood lined wall. **Note:** Terminate the elbow 5 cm (2 in.) above the finished floor.

4.7.16.4 Underfloor Duct Design for Telecommunications Systems

The steps in the table below show the procedure for designing underfloor duct systems for telecommunications facilities.

Table XXVIII – Designing an Underfloor Duct System

Step	Designing Underfloor Duct for Telecommunications Systems
1	Determine the total usable floor area (hallways included).
2	Divide the floor area (m^2 [ft^2]) by 1.54 m^2/cm^2 (100 ft^2/in^2) to get the total feeder duct area (cm^2 [in^2]) required for telecommunications. i.e., Floor area (m^2) ÷ 1.54 (m^2/cm^2) = Total feeder duct area (cm^2) Floor area (ft^2) ÷ 100 (ft^2/in^2) = Total feeder duct area (in^2)
3	Determine the minimum number of feeder ducts required by dividing the total feeder duct area required by the cross-sectional area of one feeder duct. i.e., Total feeder duct area (cm^2) ÷ Area per feeder duct (cm^2) =Minimum no. of feeder ducts Total feeder duct area (in^2) ÷ Area per feeder duct (in^2) =Minimum no. of feeder ducts **Note:** Since building layouts do not always permit all feeders to be filled to their maximum recommended capacity, additional feeders may be needed. The additional quantity required will depend on the floor plan and on the location of the TC.
4	Select a spacing for the distribution duct by following the steps in paragraph 4.7.16.5, "General Rule for Spacing". Ducts".
5	Establish sub-zones that best use the distribution design.
6	Establish telecommunications zones with usable floor areas of greater than 1000 m^2 (10,000 ft^2) to be

served by each closet.

7 Divide the zones into strips equal in width to the spacing of the distribution ducts.

Note: Usually, a distribution duct run extends to a point 30 cm (12 in.) to 45 cm (18 in.) from the outside wall. However, the floor area that they serve extends to the wall.

8 Compute the minimum allowable length of the distribution duct.

Note: Base the calculation on the telecommunications requirements of 6.5 cm^2 (1 in^2) of cross-sectional duct area per 10 m^2 (100 ft^2) of usable floor space.

1.54 (m^2/cm^2) x Area of 1 duct (cm^2) Spacing of ducts (m) = Allowable length of distribution duct (m)

OR

100 (ft^2 in^2) x Area of 1 duct (in^2) Spacing of ducts (ft) = Allowable length of distribution duct (ft)

9 Determine if the length found in Step 8 is less than the planned distance from the end of the distribution duct to the feeder duct. If it is, select a larger duct size or closer spacing and recalculate.

Note: The distribution duct system must be designed so that horizontal cables extending from the termination in the TC to the outlet are not more than 90 m (295 ft) long (this is to include slack and service loops).

4.7.16.5 Rule for Spacing Ducts

Determine the spacing for telecommunications distribution ducts by following the procedure in the table below.

Table XXIX – Spacing Telecommunications Distribution Ducts

1 Place ducts parallel to the longest outside walls.

Note: Layouts for desks are less difficult if the design locates distribution duct parallel to the outside walls. (See Illustration 0755, paragraph 4.7.16.2)

2 Space the ducts either in the center of each building module (space between joists) or at 1.5 m (5 ft) to 1.8 m (6 ft) intervals. The maximum interval for distribution duct spacing shall be six (6) feet.

Note: 1.5 m (5 ft) spacing provides the maximum flexibility per unit of floor area over the life of the building. Increased spacing:

- Beyond 1.8 m (6 ft) dramatically restricts the system's flexibility.
  AND
- Does not offer dramatic cost reductions within normal design limits.

3 Continue with Step 2 for the entire usable floor, regardless of the proposed or intended use of a particular area.

Note: Experience shows that building-use plans are subject to numerous changes over the life of a building.

4.7.16.6 Duct Capacity

To maintain sufficient floor duct capacity the maximum length of distribution floor duct shall not exceed 20m (60 ft).

Allow 6.5 cm^2 (1 in^2) of duct for every 10 m^2 (100 ft^2) of floor area when designing floor duct systems.

4.7.16.7 Allocating Feeder Duct to Distribution Duct

Follow the steps in the table below to allocate feeder duct to distribution duct.

Table XXX – Allocation of Feeder Duct to Distribution Duct

1	Write a fraction, using the number of: • Feeder ducts required to serve a floor area as the numerator. • Distribution ducts served as the denominator.
2	Reduce the fraction to a ratio of small whole numbers, such as: • 1/1, 1/2, 1/3, etc. • 2/3 • 3/4 (use this ratio only as a last resort). If the fraction cannot be reduced to one of the ratios listed above: • Deduct 1, 2, or 3 from the number of distribution ducts (i.e., the denominator) and reduce the fraction to a simple ratio. (These ducts are treated as a separate zone and served by additional feeders.) OR • Add 1 to the number of feeder ducts (the numerator) and reduce the fraction to a simple ratio. If the fraction can not be reduced to one of the ratios listed at the beginning of Step 2 when either option is used separately, use both options together and try to reduce the fraction again.
3	If the numbers of feeder and distribution ducts are nearly equal, increase the feeder ducts by 1, 2, or 3 so they are equal. (It is economical to do this.) **Note:** It is usually more costly to add handholes than feeder ducts.

4.7.16.8 Using Preset Inserts

Distribution duct with preset inserts are preferred. These inserts:

- Have a 5 cm (2 in.) nominal inside width.
- Are factory installed (or equivalent).
- Should have a center spacing of 61 cm (24 in.) or less.

Preset inserts are available in 1.3 cm (½ in.) increments from 2.2 cm (7/8 in.) to 7.6 cm (3-3/8 in.) in height. The recommended height is 2.5 cm (1 in.) to 6.4 cm (2½ in.)

maximum. If the preset inserts are higher than 6.4 cm (2½ in.), de-rate the capacity of the duct.

4.7.16.9 Determining Insert Spacing

If the standard insert spacing of 0.6 m (2 ft) is not adequate for a custom design, spacing may be determined by simply dividing the building module spacing by the number of inserts per module.

For example, in a 1.5 m (5 ft) module, the insert spacing can be:

- 150 cm (60 in.) ÷ 2 = 75 cm (30 in.) spacing (too long).
- 150 cm (60 in.) ÷ 3 = 50 cm (20 in.) spacing (good).
- 150 cm (60 in.) ÷ 4 = 38 cm (15 in.) spacing (better).
- 150 cm (60 in.) ÷ 5 = 30 cm (12 in.) spacing (very good, but probably too expensive).

The recommended spacing is 38 cm (15 in.) or 50 cm (20 in.), with the inserts an equal distance from the module lines.

4.7.16.10 Afterset Inserts

Afterset inserts may be used provided that the following procedure is used:

- Provide a smooth surface at the edge of the metal for pulling in cables.
- Have a 5 cm (2 in.) nominal inside measurement.
- Be designed to be capped flush with the concrete floor and left in place for future use.

4.7.16.11 Performing a Final Design Check

After designing an underfloor duct system, perform a final design check by following the procedures in the listed in the table below.

Table XXXI – Design Check List for Underfloor Duct System

1 Check the cross-sectional area of each feeder duct.

2 Determine if it is adequate for the area it serves.

Note: The cross-sectional area of the duct, in square centimeters (square inches) multiplied by 1.54 m^2/cm^2 (100 ft^2/in^2) must be greater than or equal to the floor area, in square meters (square feet) that it serves.

3 Check the spacing requirements of the feeder ducts.

4 Determine if there are any obstructions or length limitations that may affect the layout and installation of the required ducts.

Notes:

1) The maximum distance between any location on a telecommunications distribution duct and the nearest junction box shall not exceed 18 m (60 ft).

2) The underfloor duct system shall be designed and installed such that horizontal cables extending from the termination in the closet to the outlet are not more than 90 m (295 ft) long.

5 Insure that the size of the telecommunication closets comply with the requirements of paragraph 4.4, "Telecommunication Closets".

4.7.17 Designing a Two-Level Duct System

For the design and installation of an Underfloor Two Level duct system refer to the latest issue of BICSI TDMM.

4.7.18 Cellular and Underfloor Floor Systems

4.7.18.1 Design and Installations

For the design and installation of Underfloor and Cellular floor systems (Distribution cells and Feeder [header] ducts) refer to the latest issue of the BICSI TDMM.

Coordinate cellular-floor planning with the building design agency (architect, structural engineer).

4.7.18.2 Systems Under Carpets

In carpeted areas, all junction boxes must be accessible. Carpet openings which are cut when the carpet is installed shall:

- Ensure accessibility

  And

- Shall blend into the carpet design and color

Junction boxes must be accessible through carpet openings. Carpet openings shall be firmly secured and not loose so as to impede pedestrian traffic or cause a safety hazard to pedestrians.

4.7.19 Distribution Conduit Systems

A conduit system consists of conduits radiating from the TC or junction box to the work area outlets in the floor, walls, or columns of a building.

This system is an underfloor or overhead conduit system which furnishes cable support for small buildings that will not have a high number of IWAs or a high rate of moves, adds and changes (MACs).

The Distribution Conduit system provides:

- Home run conduits.
- Looping of user locations.

4.7.19.1 Design Considerations for Conduit Distribution

The types of conduit suitable for use in buildings are:

- Rigid metal conduit (steel pipe).
- Rigid non-combustible polyvinyl chloride (if allowed by building code).
- Fiberglass (if allowed by building code).

4.7.19.2 Flexible Conduit

Flexible conduit is not suitable for pathways (such as metal flex conduit) and shall not be use in telecommunications conduit systems except to feed Individual Work Areas (IWA). The maximum length of flexible conduit is 1.2 m (4 ft) and may only be placed between the distribution raceway (i.e., trunk, tray, conduit junction box) and riser (pole or conduit) to outlet box. Refer to paragraph 2.7.24.1, (Overhead Ceiling Raceway Method) below for additional information on the use of flexible conduit.

4.7.19.3 Conduit Runs

Conduit runs shall be designed to:

- Run in the most direct route possible (usually parallel to building lines), with no more than two 90° bends between pull points or pull boxes.
- Contain no 90° condulets (also known as LB).
- Contain no continuous sections longer than 30 m (100 ft).

A length of 45 m (150 ft) or less (including the sections through pull boxes).

Commentary Note:

> *For runs that total more than 30 m (100 ft) in length, insert pull points or pull boxes so that no segment between points/boxes exceeds the 30 m (100 ft) limit.*

4.7.19.4 Unacceptable Conduit Runs

Do not run conduit:

- On top of cellular floor cells.
- Crosswise to cellular floor cells.
- Through areas in which flammable material may be stored or handled (Hazardous Classified Area).
- Over or adjacent to:
  - Boilers.
  - Incinerators.
  - Hot water lines.
  - Steam lines.

Conduit shall not be used in lieu of header ducts:

- Between the distribution ducts and the TC.

  OR

- To supplement the feeder capacity of the system.

Aluminum or thin-walled plastic conduit shall not be placed in concrete floors.

4.7.19.5 Conduit Cable Capacity

To ensure proper capacity for cabling, a ¾ inch conduit from a terminal or telecommunications shall not serve more than two outlets in offices, commercial sites/buildings, exhibition halls, dormitories, hospital rooms or offices. Conduit capacities shall adhere to the cable fills in the "Conduit Capacity" chart (paragraph 4.7.13.5).

The conduit size for horizontal cable must accommodate:

- Multiple building occupants.
- Cables placed at different times.

To determine the cross-sectional area of a cable or conduit from its nominal diameter, use the following formula:

$$\text{Cross Sectional Area} = (0.785) \times (\text{Diameter})^2$$

Treat multi-conductor cables (i.e., two or more conductors under a shared jacket) as a single cable for calculating percentage conduit fill area.

For cables with an elliptical cross section, use the larger diameter of the ellipse as the diameter in the equation above.

4.7.19.6 Bend Radii for Conduits

The radius of a conduit bend shall be at least 10 times the diameter of the conduit.

Choose the bend radii for conduits according to the Table below:

Table XXXII – Conduit Bend Radius

If The Conduit Has	The Bend Radius Must Be At Least
An internal diameter of 5.1 cm (2 in.) or less.	10 times the internal conduit diameter
An internal diameter larger than 5.1 cm (2.0 in.)	10 times the internal conduit diameter
Optical fiber inside(regardless of diameter).	10 times the internal conduit diameter

4.7.19.7 Adapting to Conduit Bends

The following table provides information for adapting designs to conduits with bends.

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

Table XXXIII – Conduit Bends/Pull Box

If A Conduit Run Requires	Then
More than two 90° bends.	Provide a pull box between sections with 2 bends or less.
A reverse bend (between 100° and 180°)	Insert a pull point or pull box at each bend having an angle from 100° to 180°.
More than two 90° bends between pull points or pull boxes.	For each additional bend: • De-rate the design capacity by 15%. or • Use the next larger size of conduit.

4.7.19.8 Three Bends In Conduit

A third bend will be acceptable in a pull section without de-rating the conduit's capacity if:

- The run is not longer than 10 m (33 ft).
- The conduit size is increased to the next trade size.
- One of the bends is located within 30 cm (12 in.) of the cable feed end. (This exception only applies where cable can be pushed around the first bend.)

4.7.19.9 Conduit Entering Telecommunication Closets

A conduit that enters a TC shall:

- Terminate near the left corner of the closet to allow for proper cable racking and splicing.
- Be terminated 10 cm (4 in.) above the finished floor.
- Be reamed or bushed and terminated as close as possible to the wall where the backboard is mounted (to minimize the cable route inside the closet).

4.7.19.10 Completing Conduit Installation

After installation, all conduits shall be:

- Clean, dry, and unobstructed.
- Capped for protection.
- Labeled for identification.

Sealed to comply with firestop requirements.

Equip all conduits (end to end) with a plastic or nylon pull line that has a minimum test rating of 90 kilograms (200 pounds). The end of each pull line shall be secured to avoid loosing the end section.

4.7.20 Pull Boxes and Splice Boxes for Conduit Systems

4.7.20.1 Installing Boxes

All pull and splice boxes shall:

- Have easy/direct access.
- Be located immediately above suspended ceilings.
- Marked /identified.
- Have hinged bottom panels/door that open from the bottom.
- Be placed offset to a curve in the straight section of a conduit run.

Refer to illustration 0779 for acceptable pull and splice box configuration.

4.7.20.2 Slip-Sleeves and Gutters

The following describes a slip-leeve and gutter.

A..	**IS..**
Slip-sleeve	A conduit sleeve which is: • Larger than the main conduit. • Slipped over an opening in a conduit run after the cable is in place.
Gutter	A square, sheet-metal housing which is placed over an opening in a conduit run.

4.7.20.3 Using Slip-Sleeves, Gutters, and Gaps

Slip-leeves, gutters, or gaps shall be used only where a pull box can not be used due to space limitations or clearance from other objects can not be maintained.

Exception:

> *Slip sleeves, gutters and gaps shall not be used in plenums that are used for air handling.*

To allow for the installation of slip-sleeves and gutters, provide an opening in the main conduit which is long enough to form a cable loop during the pulling-in operation.

4.7.20.4 Pulling and Looping Cable

Use boxes for pulling and looping cable only with small (5 cm [2 in.] diameter or less) single-sheath cables. If the cable is larger than 5 cm (2 in.) in diameter, do not locate the box in the ceiling, route the cable and conduit down a wall or column.

4.7.20.5 Splice Boxes at Cable Entrance

When a splice box at a cable entrance requires an insulation joint, the entrance conduit shall be:

- Made of an insulating material.

  OR

- Insulated from the box.

The splice box shall be fitted with a hinged cover and shall not contain a cable bend (radius)

4.7.20.6 Placing Pull Boxes in Straight Conduits

Place pull boxes in straight sections of conduit. Do not use a pull box in lieu of a bend.

4.7.20.7 Pull Box Size

Use the table below to select the proper size of pull box.

Table XXXIV – Sizing Pull Box

Maximum Trade Size of Conduit In Inches	Size of Box Width	Length	Depth	For Each Additional Conduit Increase Width
0.75 in.	102 mm (4 in.)	305 mm (12 in.)	76 mm (3 in.)	51 mm (2 in.)
1.0 in.	102 mm (4 in.)	406 mm (16 in.)	76 mm (3 in.)	51 mm (2 in.)
1.25 in.	152 mm (6 in.)	508 mm (20 in.)	76 mm (3 in.)	76 mm (3 in.)
1.5 in.	203 mm (8 in.)	686 mm (27 in.)	102 mm (4 in.)	102 mm (4 in.)
2.0 in.	203 mm (8 in.)	914 mm (36 in.)	102 mm (4 in.)	127 mm (5 in.)
2.5 in.	254 mm (10 in.)	1067 mm (42 in.)	127 mm (5 in.)	152 mm (6 in.)
3.0 in.	305 mm (12 in.)	1219 mm (48 in.)	127 mm (5 in.)	152 mm (6 in.)
3.5 in.	305 mm (12 in.)	1372 mm (54 in.)	152 mm (6 in.)	152 mm (6 in.)
4.0 in.	381 mm (15 in.)	1524 mm (60 in.)	203 mm (8 in.)	203 mm (8 in.)

Notes:

1. This is the minimum space requirements in pull boxes having one conduit each in opposite ends of the box.
2. The width shall be large enough to allow for fishing, pulling, and looping the cable.

Exception:

An exception to table XXXIV above is the length measurement of a pull box may be 12 times the conduit diameter instead of 16 times the conduit diameter when:

- *A ¾ conduit serves an Individual Work Area (IWA).*
- *A ¾ conduit is the largest conduit to enter the pull box.*
- *Conduit will only contain non-shielded cables*
- *Conduit will not contain fiber optical cable*
- *Pull boxes that will not contain cable splices.*

4.7.21 Access (Raised) Floors

4.7.21.1 Design Considerations for Access Floors

The minimum finished height of access flooring for telecommunications rooms (equipment, closet) shall be 30 cm (12 in.)

4.7.21.2 Floor Penetrations

Penetrations through the access floor for service outlets shall not be placed in traffic areas or other locations where they may create a safety hazard.

Maintain the integrity of all firestop assemblies which must be penetrated by cable, wire, and raceways. Refer to paragraph 4.8 "Firestopping", for information regarding floor penetration fire stopping.

4.7.21.3 Bonding and Grounding

Metal parts of an access floor shall be bonded to an approved ground source. Refer to paragraph 4.6 "Grounding, Bonding, And Electrical Protection" and the manufacturer guidelines for bonding and grounding information.

4.7.21.4 Floor Panel Materials

Where cabling is not contained in conduit, panels must be made completely of non-combustible materials. Panels must be made so that their flame-spread integrity is not affected when the panel is cut.

4.7.21.5 Floor Panel Coverings

Floor panels shall have a flame spread rating when required by SAES-M-100, (Saudi Aramco Building Code). Additionally, they shall be constructed of high pressure laminate or vinyl durable tile materials that do not retain dust.

4.7.21.6 Load-Bearing Capacity

Access floor panels and under structure shall be design to meet the requirements of SAES-M-100, (Saudi Aramco Building Code).

Battery back up power supply shall not be installed on raised floors (access floor). Refer to SAES-T-151, (Communications Dc Power System) and battery manufacturer's requirements.

Live floor load values (for current and known expansion needs) shall be verified when designing an access floor system.

4.7.21.7 Placing Low-Voltage Cables

Low-voltage telecommunications cables in an access floor plenum shall be placed in pathways in a manner that provides sufficient space for service personnel to stand on the structural floor without risk of damaging the cable. Use grommets that are flush-mounted in a floor panel or access door to protect work area cables that connect to concealed outlets.

Use one of the following methods for managing and containing cable runs under access floors:

- Dedicated routes.
- Enclosed raceway distribution.
- Zone distribution.
- Cable trays.

Note: *Plenum-rated cable may be required.*

4.7.21.8 Underfloor Separation from Power Cables

A minimum clearance of 61 cm (24 in.) between electrical power cables and telecommunications cables is recommended. (For required clearances of electromagnetic isolation and safety, see paragraph 4.7.11.3, "Avoiding Electromagnetic Interference (EMI)", paragraph 4.7.2.8, "Electromagnetic Interference (EMI)", EIA TIA-569 and Article 800 of NFPA 70.)

4.7.22 Conduit For Ceiling Distribution Systems

The method for distributing wires and pathways in a ceiling are acceptable provided the following conditions are met:

- Ceiling space is used only for horizontal cables serving the floor below.
- Ceiling access is controlled by the building proponent.
- Building proponent is aware of the responsibility for any damage, injury, or inconvenience to occupants that may result from technicians working in the ceiling.
- Cable pathways (pull boxes, trays, conduits junction points) are installed where they are fully accessible from floor area below and safe for cable installations and changes.
- Ceiling tiles are removable.
- Height of ceiling tiles are no greater than 3.4 m (11 ft) above the finished floor.

4.7.22.1 Design for Conduit Ceiling Distribution Systems

Coordination with the building proponent and the design agency representative for space allocation in the ceiling area is required when designing a ceiling distribution system.

Components of ceiling distribution system shall comply with NFPA 70 NEC.

4.7.22.2 Ceiling Zones Method

The usable floor area in the "Ceiling Zones" shall be divided into zones of 35 m^2 to 82 m^2 (365 ft^2 to 900 ft^2) each. It is preferable that zones be divided by building columns. Cabling to each zone may be placed in cable trays within the ceiling plenum area, where permitted by Saudi Aramco Standards. Zone conduit sizes are based on the "Conduit Capacity" chart in paragraph 4.7.13.5. Conduit sizes shall be based on placing three cables to each individual work (IWA) area of 10 m^2 (100 ft^2). Cabling may also be enclosed in metallic conduits or raceways. The conduits or cable trays (when permitted) shall extend from the TC to the mid-point of each zone. Leave the end of the conduit or cable tray open when permitted by SAES-M-100 (Saudi Aramco Building Code). Cables shall be extended from the pathway to the top of the utility columns or wall conduit and down to work area outlet boxes.

A telecommunication closet (TC) shall be provided for each 1,000 m^2 (10,000 ft^2) of usable floor area. Refer to paragraph 4.4 "Telecommunication Closets" for additional information.

4.7.22.3 Typical Ceiling Zone Distribution Using Conduit

The illustration 0787 shows a typical ceiling distribution system using homerun conduit to telecommunications zones.

Commentary Note:

> *This illustration represents only a schematic depiction of a ceiling distribution system. Actual pathways the ceiling zones should be organized in a neat an orderly fashion by*

following the building's lines to facilitate ongoing service and maintenance of the ceiling pathway.

4.7.22.4 Conduit Size for Home Run Ceiling System

In a "Home Run" ceiling conduit system, place a continuous run of conduit from the work area outlet boxes to the TC.

Each home run conduit can serve from one to three outlet boxes, depending on the design and conduit size. For conduits that serve:

- One box, an inside diameter of 2.1 cm. (¾ in.) or greater is required.
- Two boxes, an inside diameter of 2.7 cm (1 in.) or greater is required.
- Three boxes, an inside diameter of 3.5 cm (1¼ in.) or greater is required.

For more information on conduit capacity, see paragraph 4.7.13.5. "Conduit Capacity".

4.7.22.5 Ceiling Zone Restrictions

A zone conduit system may be allowed in an air plenum ceiling if:

- Conduits terminate in junction boxes.

  AND

- Short runs of smaller conduit are extended from the junction boxes to the work area outlets.

Refer to paragraph 4.7.11.3, "Avoiding Electromagnetic Interference (EMI)" and 4.7.2.8, Electromagnetic Interference (EMI), EIA TIA-569 and Article 800 of NFPA 70.

4.7.22.6 Pathway and Cable Support

Ceiling conduits, raceways, cable trays, and cabling shall be suspended from or attached to the structural ceiling or walls with hardware or other installation aids specifically designed to support their weight.

The pathways shall:

- Have adequate support to withstand pulling the cables.
- Be located 15 cm (6 in.) to 30 cm (12 in.) above the T-bar and have clear vertical space.
- Have a minimum of 8 cm (3 in.) of clear vertical space from conduits, wires, and cables.

Horizontal pathways and cables shall not rest directly on ceiling panels, framework (T-bars), vertical supports, or other components of the suspended ceiling.

4.7.22.7 Cabling Without Conduit

Where building codes permit telecommunications cables may be placed in suspended ceiling spaces without conduit, ceiling zone distribution pathways may consist of:

- Cable trays.

  AND/OR

- Open-top cable supports (J-supports).

Commentary Note:

> *When used, J-supports shall be located 122 cm (48 in.) to 153 cm (60 in.) apart to adequately support and distribute the cable weight. These types of supports shall not be used to support more than 10 6.1 cm (0.25 in.) diameter cables.*

Cable trays, conduit, square trunking shall be provide where:

- Large quantities of cables (50 or more) convene at the TC and other areas.
- The ceiling area is used for an environmental air plenum.

Cabling without conduit shall only be used when prior approval has been obtained from the proponent organization.

4.7.22.8 Termination Space and Spare Cables

Allow for maximum wall termination space in the TC when Ceiling Distributions Systems are used. Spare cables may be left in the ceiling above the IWA for future use provided there is sufficient space to run additional cables and that the spare cable is left organized in a tray, junction box or trunk. This practice shall not be allowed in conduit systems or other distribution systems that don't provide support for cable. This practice reduces:

- Inconvenience to office personnel.
- The time and expense associated with work area equipment moves, adds, and changes.

4.7.22.9 Conduit to the Work Area

When running up to two four-pair 100-ohm UTP cables and two optical fibers to each work area, use one 5.3 cm (2 in.) conduit as a minimum for each zone ranging from 35 m^2 to 60 m^2 (350 ft^2 to 600 ft^2). For larger zones ranging from 60 m^2 to 90 m^2 (600 ft^2 to 900 ft^2), use 6.3 cm (2½ in.) conduit.

Commentary Note:

> *For conduits that contain more than one cable type, determine the size on the basis of the largest diameter cable to be used and the total number of cables it is expected to hold.*

For the design and installation of "Utility Columns" (Distribution cells and Feeder [header] ducts) refer to the latest issue of the BICSI TDMM.

All utility poles shall be listed for the specific application for which they are used.

4.7.23 Cable Tray Design for Ceiling Distribution Systems

4.7.23.1 Cable Tray Systems

Cable tray systems are commonly used as distribution systems for cabling within a building. They are often preferable to rigid conduit and raceway systems because of their greater accessibility and ability to accommodate change. Cable tray systems:

- Are rigid, prefabricated support structures that support telecommunications cables and cabling.
- Shall be installed to comply with:
  - NFPA 70, NEC, Article 318 requirements.

- SAES-M-100, Saudi Aramco Building Code
- EIA TIA-569, Commercial Building Standard for Telecommunications Pathways and Spaces.

Cable tray designs shall not use cable trays systems to distribute telecommunications and power cables together. Cable trays shall not be installed in ceiling areas (lock tiles, drywall or plaster) that are inaccessible.

Commentary Note:

> *The inside of a cable tray must be free of burrs, sharp edges, or projections which can damage cable insulation.*

4.7.23.2 Supporting Cable Trays

Support cable trays by installing:

- Cantilever brackets.
- Trapeze supports.
- Individual rod suspension brackets.

Supports shall be placed so that connections between sections of the cable tray are between the support point and the quarter section of the span. A support shall also be placed within 0.6 m (2 ft) on each side of any connection to a fitting.

Cable tray fills shall not exceed the manufactures listed capacity for a specified tray.

Important: *Never use cable trays as walkways or ladders.*

4.7.23.3 Marking and Grounding Trays

Metallic cable trays shall be bonded together and grounded to an approved ground source.

Trays shall be marked and identified as specified by EIA TIA-606, "The Administration Standard for the Telecommunications Infrastructure of Commercial Buildings".

4.7.24 Overhead Raceways For Ceiling Distribution Systems

4.7.24.1 Overhead Ceiling Raceway Method

Enclosed metal raceways used within the ceiling space to distribute cables shall:

- Use larger raceways to bring feeders into an area.
- Use smaller, lateral (distribution) raceways to branch off from the header and provide services to the usable floor space.
- Feed Individual Work Area (IWA) locations with a combination of flexible conduit [max. Length 1.2 m (4 ft)] or exposed cable (if codes allow).

Use conduit or exposed cables from distribution raceways to:

- Utility columns.
- Partitioned walls.
- Other service outlet locations.

When enclosed raceways and metallic flexible conduit are used in air plenums, plenum-rated cable shall be used.

4.7.24.2 Raceway Size

Follow the steps below when designing a ceiling raceway system.

Step Designing A Ceiling Raceway System

1. Select the location of the ceiling raceways. The general rule is to place raceways parallel to either the:
   - Wall of the TC.

     OR
   - Longest outside building wall.

   Commentary Note:

   > *The ceiling raceway system shall be designed so that horizontal cables extending from the termination in the TC to the outlet are not more than 90 m (295 ft) long.*

2. Determine the spacing for the raceways. Normally spaced on 5 m to 6 m. (16 ft to 20 ft) centers, starting

at a point 1.2 m to 3 m (4 ft to 10 ft) from the outside wall.

Commentary Note:

Install raceways on module lines, when possible.

3. Use the following equation to calculate the floor area that can be served by each run of a ceiling raceway:

Width of area served by an individual raceway.	X	Length of area served by an individual	=	Floor area served by that raceway

4. Use the following equation to determine the ultimate number of work areas served by each raceway run:

Floor area served by one raceway run 10 m² (100 ft²) Space allocation per IWA.	=	Ultimate number of individual work areas (IWAs) served by that run.

Commentary Note:

The standard space allocation used in an office environment is one individual work area (IWA) per 10 m² (100 ft²) of usable floor space.

5. Multiply the cross-sectional area of the raceway (in cm² [in²]) by 1.54 m²/cm² (100 ft²/in²) to get the total usable floor space (in m² [ft10 m² (100 ft²]) served by the raceway.

Raceway area (cm²)	Race area (in²)
x 1.54 (m²/cm²)	x 100 (ft²/in²)
Floor area served (m²)	Floor area service (ft²)

6. Divide the floor area served (m² [ft²]) by the width of the area served by the raceway to determine the allowable length of floor area that the raceway can serve.

Floor area served (m²)	Floor area served (ft²)
÷Floor width served (m)	÷ Floor width served (ft²)
Allowable length served (m)	Allowable length served (ft).

7. Select and compute the floor space which can best be served directly from the TC (without raceways).

8. Select the general location of feeder raceways extending from the TC.

9. Use the following equation to determine the minimum cable capacity required for the feeder raceways extending from the TC:

Floor area served by the TC.	=	Minimum cable capacity required of telecommunications feeder raceway.

10. Allot feeds from the TC to the distribution raceways.

Commentary Note:

The cable capacity of each feeder shall be greater than or equal to the anticipated work area requirements of the floor space it serves.

11. Provide labeling and documentation required for the administration of distribution pathways and spaces (Reference EIA TIA-606).

Refer to paragraph 4.7.13.8 "Determining Raceway Size", for information on raceway capacity and fill requirements.

4.7.25 Cabling Requirements for Ceiling Distribution Pathways

Cabling

To effectively control the cabling of a hung ceiling distribution system, follow the steps in the procedure below.

Exception:

Do not place terminals or other connecting devices (25-pair connectors or adapters) in the ceiling space.

Step	**Hung Ceiling Raceway System**
1	Design cable lengths so any work area outlet within the zone can be served.
2	Where zone pathways are not provided, divide the floor area into direct-run telecommunications zones.
3	Design cables runs so that all the cables are distributed from the center point of their zones.
4	From the center point of each zone, distribute the cables to work areas within that zone.
5	At the center point of each telecommunications zone, support all cables with a cable tie or similar device.

Note: *Tightly cinched cable ties have a detrimental effect on transmission performance and should be avoided.*

6 Label and identify the cables and pathways to comply with EIA TIA-606, (Administration Standard for the Telecommunication Infrastructure of Commercial Buildings).

4.7.26 Other Pathways (Miscellaneous)

4.7.26.1 General

Other types of pathways include:

- Perimeter raceway systems (metal, plastic, & wood).
- Weather resistant.
- Overfloor ducts.
- Molding raceways.

These pathways are normally used for open office (modular furniture) configurations, building renovations, temporary structures, and special uses.

4.7.26.2 Perimeter Raceway System

Raceways shall be listed or approved for the type of service that they are to be placed in. The pathways shall consist of:

- A removable front panel.
- And allow for outlets to be placed at any point along the run.

In a perimeter raceway, power and telecommunications services shall be run in separate compartments. Divide the compartments with a partition that is:

- Permanent.
- Metallic.
- Continuously grounded.

The assignment of raceway compartments to either telecommunications or electrical power wiring must be consistent throughout the premises. Electrical circuits in excess of 120 V/15 Amps shall not be allowed with telecommunications circuits in "Perimeter Raceway Systems".

4.7.27 Termination and Location of Horizontal Cable and Pathways

The termination of all horizontal cabling and pathways systems into Equipment Rooms and TCs shall done so that each pathway and cable:

- Enters the TC in such a way that it does not block or cover other equipment and cabling.
- Is secured mechanically or anchored so that movement does not occur during installation of cables.
- Shall be readily accessible to technician and installer.
- Allows for 20% expansion of the horizontal cabling system.
- Complies with all building codes (bonding & grounding, fire safety).

4.7.28 Outlet Boxes

4.7.28.1 Wall-Mounted Outlets

Design telecommunications outlets so that installations in a dry-wall, plaster, or concrete block wall will be at least 10 cm^2 by 2.8 cm deep (4 in^2 by 2-1/8 in. deep).

Do not place outlet boxes back-to-back. This installation practice will allow:

- Noises to be transmitted between rooms.
- Possible transmission of heat and fire during a fire.

Always offset the box locations and interconnect them with conduit.

4.7.28.2 Cover Plates

Cover plates for wall-mounted outlets shall:

- Have two connector openings.
- Be installed on all outlets boxes.

A 10 cm (4 in.) square box with a split two-gang cover allows careful concealment of a single male and female 25-pair connector.

4.7.28.3 Larger Outlet Boxes

A connector shall not be concealed in a 10 cm (4 in.) square box if:

- Conduits are multiplied in it.
- Key telephone system cables are looped through.

Use a larger box for these types of connector.

4.7.28.4 Mounting Wall Outlets

Wall outlets shall be securely mounted at least 38 cm (15 in.) above the finished floor. Wall outlets shall always be placed where the are accessible and allow for the equipment service cord to readily connected.

4.7.29 Undercarpet Telecommunication Cable (UTC)

General

Undercarpet Telecommunications Cable (UTC) is a flat, low-profile cable designed to be installed directly on the surface of a floor and covered with carpet or carpet squares (carpet tiles). UTC is available in:

- Unshielded pairs.
- Shielded pairs.
- Fiber.

Because of the many limitations of UTC systems, they shall only be used in Saudi Aramco for horizontal cabling distribution systems when:

- The installation is temporary (less than 3 years) installations.

  AND

- Approved (in writing) by the telecommunications proponent.

Refer to the latest issued of the BICSI TDMM for information regarding the design and installation UTC.

4.8 Firestopping

All Firestop Materials shall be listed/qualified for the specific application that they are to be used and comply with Saudi Aramco Material Standards.

Refer to the latest issue of the BICSI TDMM for information regarding the design and installation for firestopping.

For additional information regarding firestop methods, materials and application contact the Saudi Aramco Chief Fire Prevention Engineer.

Silicone Foam fire seal products shall not be used for permanent (in excess of five years) fire seals. However, may be used as a temporary seal (less than a 5 year period) during a construction period or for seals that are frequently (annually) changed out.

5 Installation

Communication building cable systems are to be designed and installed in accordance with this standard and SAES-T-435, SAES-T-631, SAES-T-632, SAES-T-633, SAES-T-887, SAES-T-903, SAES-T-911, SAES-T-912, SAES-T-914 and other applicable Industry Codes (refer to paragraph 3.6).

6 Testing and Inspection

6.1 Distribution communication cable(s) shall be tested to the performance requirements in paragraph 4.7.5 above. The outside plant and feeder/backbone cable(s) shall be tested to the performance requirements of SAES-T-634 (Telecommunications Cable Testing and Acceptance).

6.2 The equipment and cabling installation shall be inspected to verify proper installation and compliance with the manufacturer's requirements. Additionally, cable and equipment shall be inspected to verify that it has been installed to Saudi Aramco Engineering Standards and Industry Codes.

6.3 Test results shall be recorded and made available to the inspection and proponent departments for review. Test results shall be submitted with the As-built documentation.

6.4 Inspection shall be done to verify that all excess materials and debris are removed from the telecommunication facility (ex., building, room, closet, and site).

7 Index of Tables

8 List of Illustrations

For illustration see Supplement pages.

0520	Example of Combined Copper/fiber Backbone Supporting Voice and data Traffic
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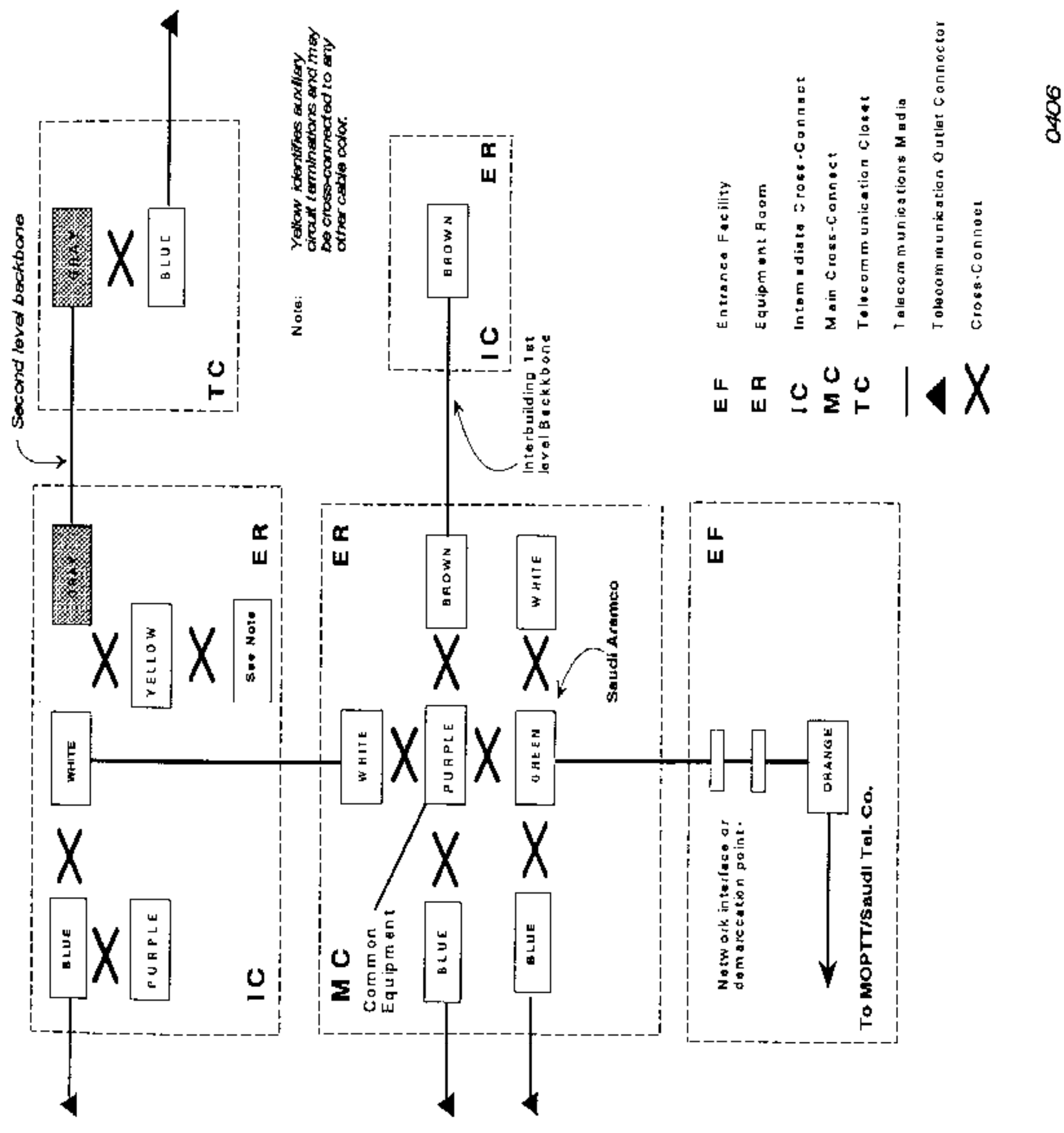
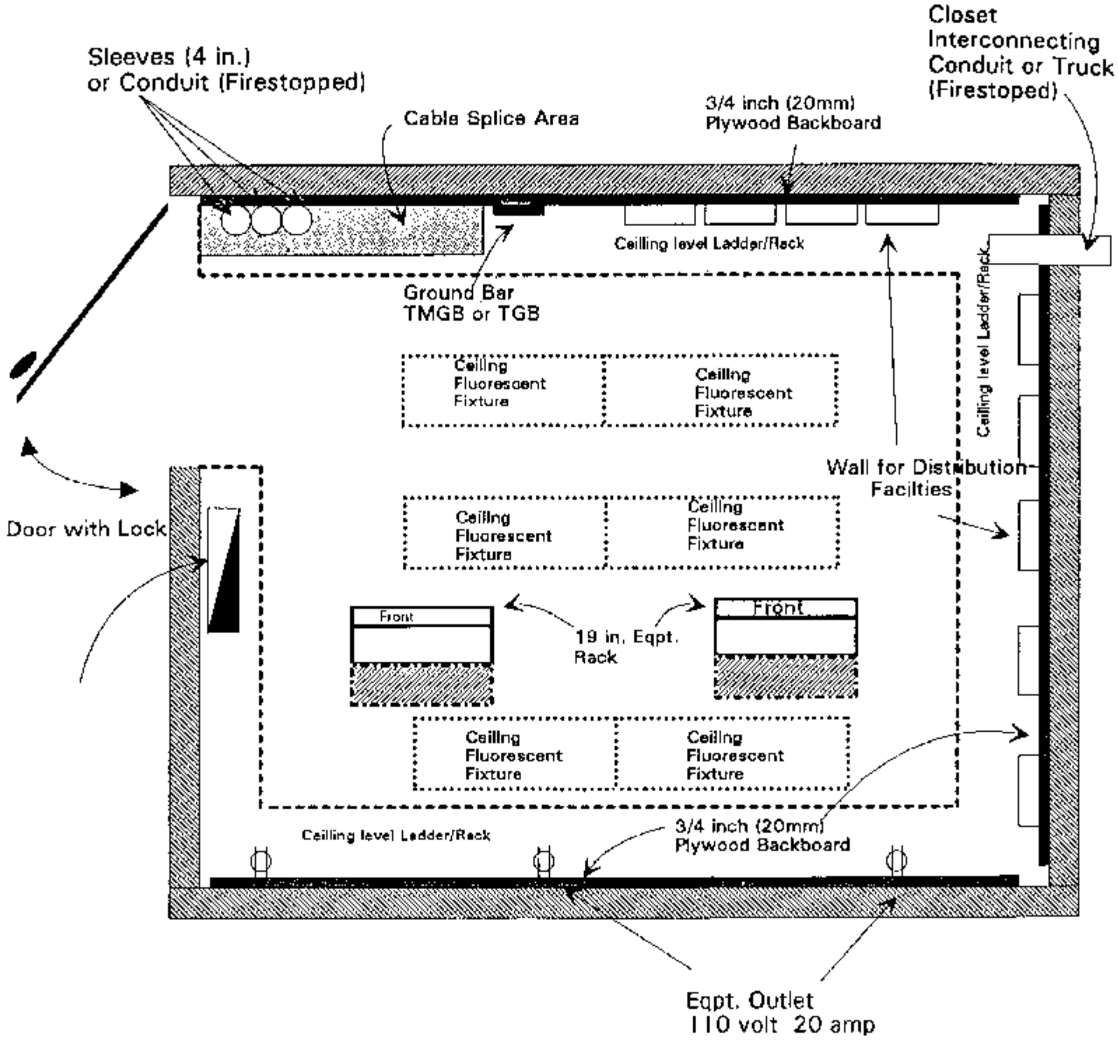
0625	Typical bonding and Grounding for Small Entrance Cable, Protector Terminal and Equipment
0626	Typical Arrangement of Telecommunications Backbone Bonding (TBB) Structure for Small Buildings and Facilities
0627	Typical Arrangement of Telecommunications Backbone Bonding (TBB) Structure for large Buildings and Facilities
0630	Coupled Bonding Conductor
0712	Typical Horizontal Wiring Configuration
0717	Eight Position Jack Pin/Pair Assignments
0751	Typical Telecommunications Closet and Floor Duct Arrangement for Multistory building
0752	Terminating Feeder Duct in a Telecommunication Closet
0755	Typical Floor Duct and TC Arrangement
0779	Pull Boxes
0787	Typical Ceiling Zone Distribution System Using Conduit

Revision Summary

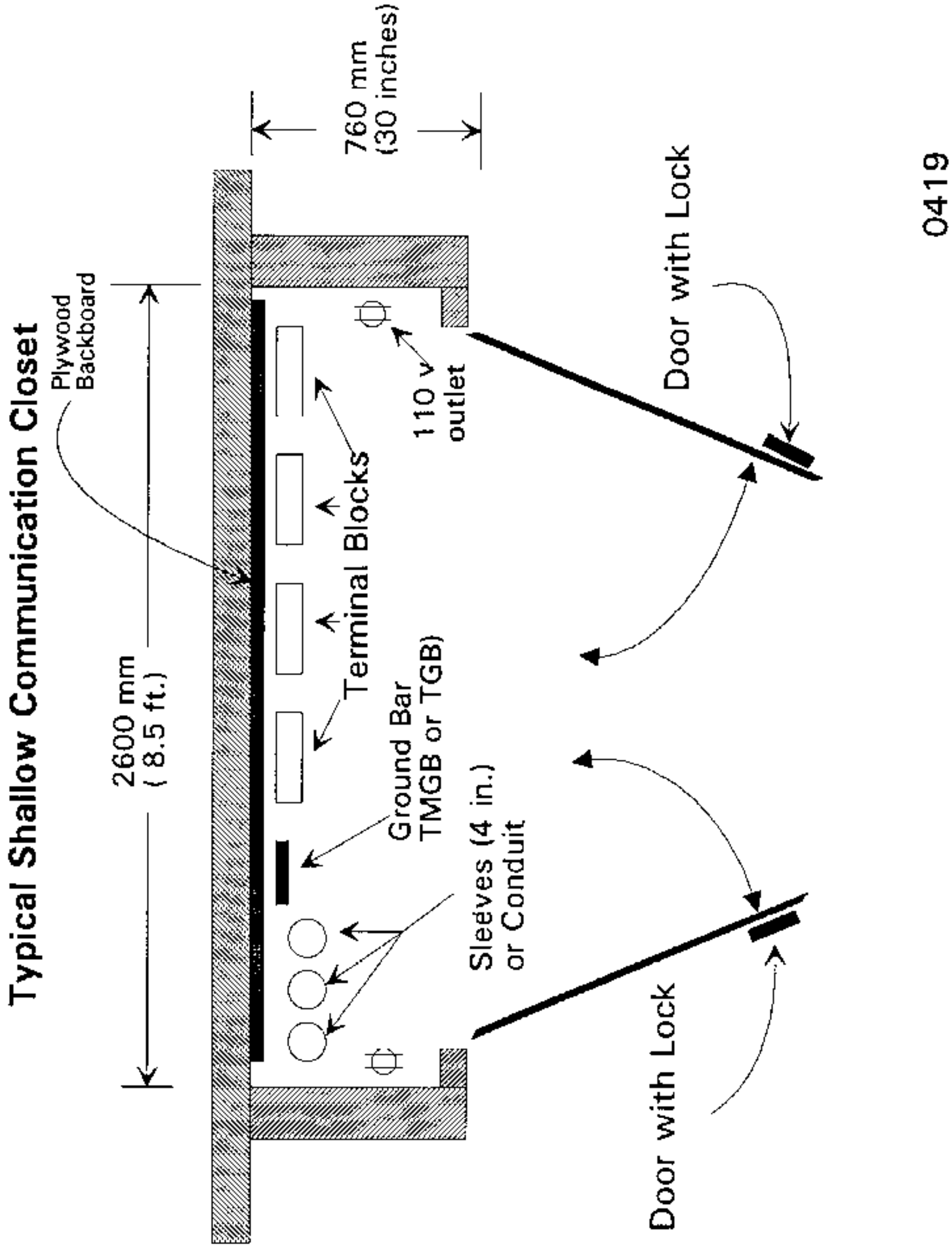
31 December, 2003 Revised the "Next Planned Update". Reaffirmed the contents of the document, and reissued with no other changes.

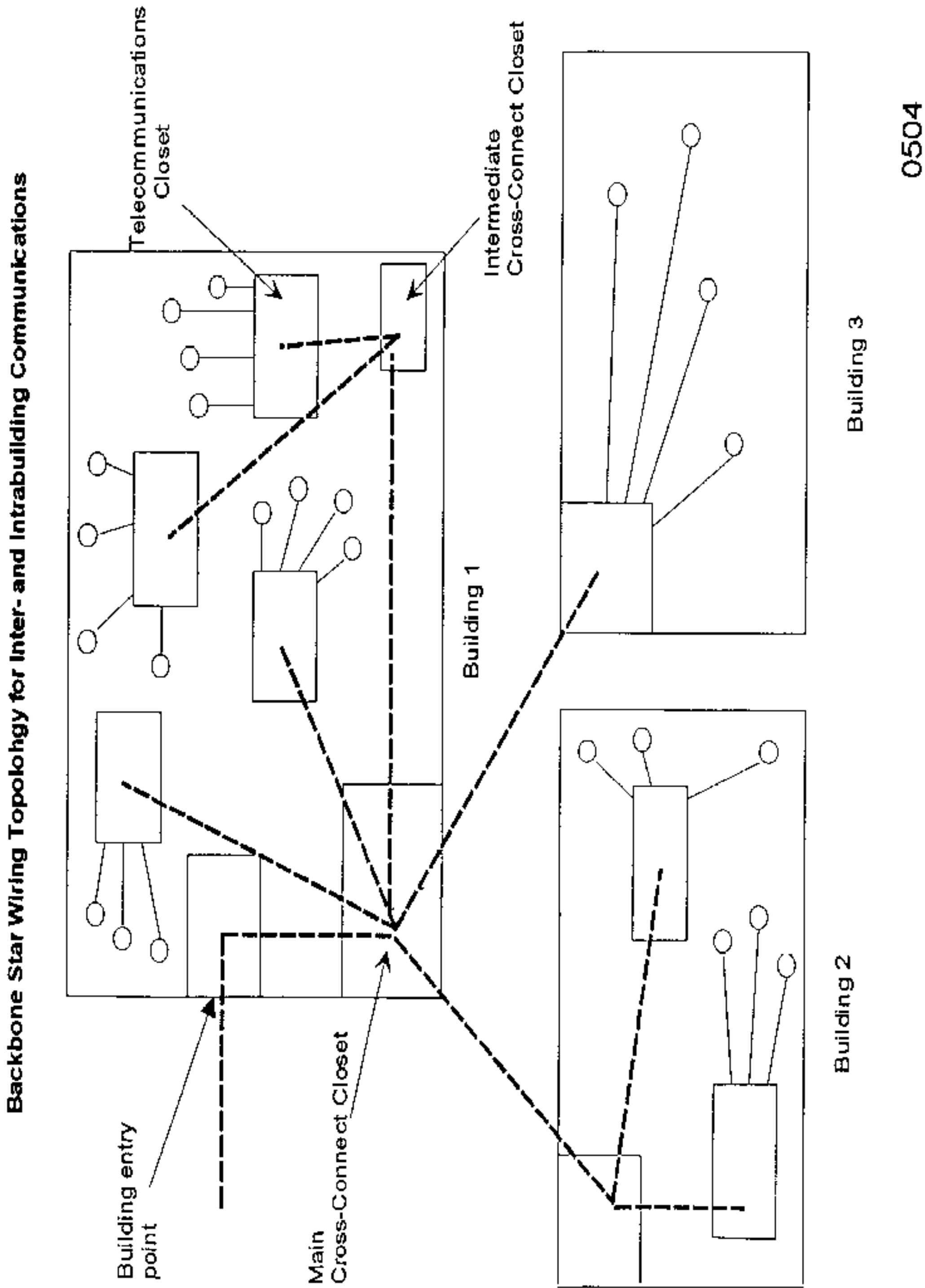

Second level backbone
GRAY
BLUE
TC
Note: Yellow identifies auxiliary circuit terminations and may be cross-connected to any other cable color.
BROWN
IC
ER
Interbuilding 1st level Backkbone
WHITE
YELLOW
See Note
BLUE
PURPLE
IC
ER
WHITE
PURPLE
GREEN
BROWN
WHITE
BLUE
BLUE
MC
Common Equipment
Saudi Aramco
EF
Network interface or demarcation point.
ORANGE
To MOPTT/Saudi Tel. Co.
EF Entrance Facility
ER Equipment Room
IC Intermediate Cross-Connect
MC Main Cross-Connect
TC Telecommunication Closet
Telecommunications Media
Telecommunication Outlet Connector
Cross-Connect
0406

Typical Telecommunication Closet

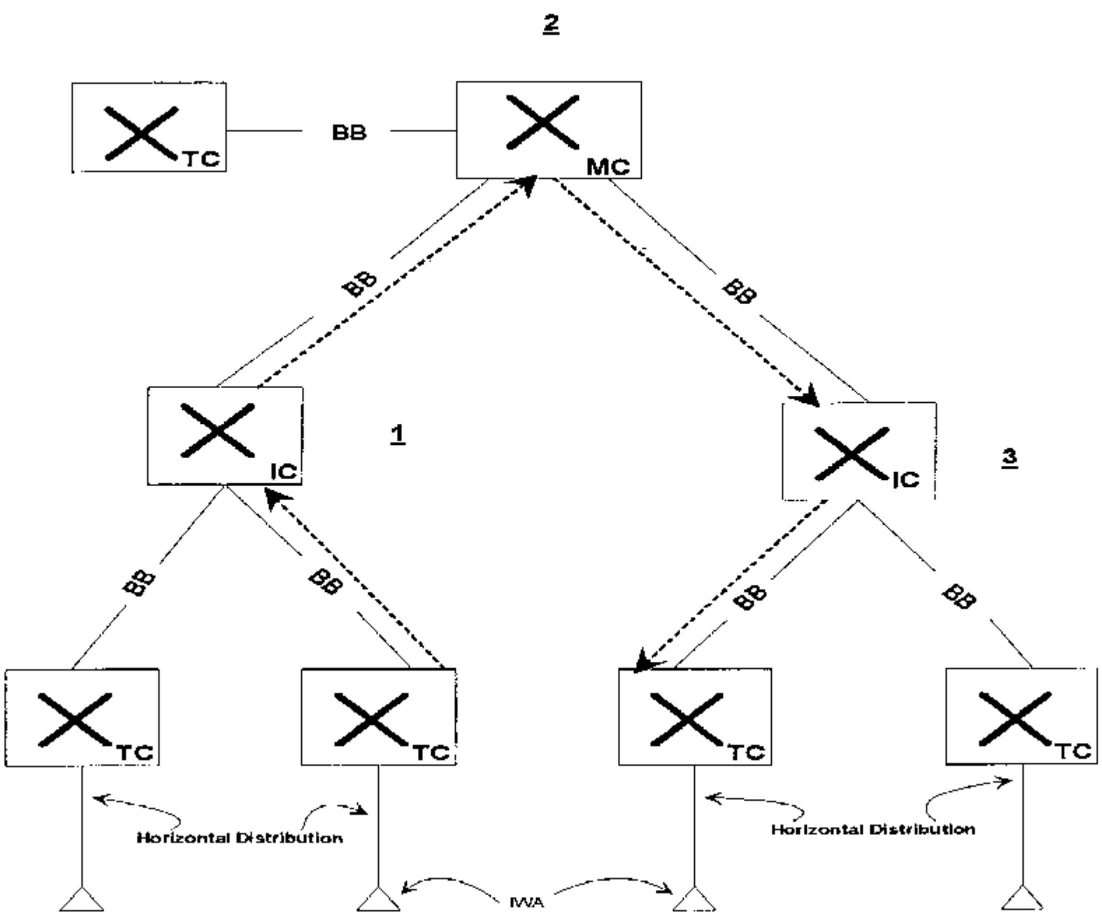


Mount 2 Power supply outlets (110 V., 20 amp.) at the top of the equipement racks or flush mount the power outlet in the ceiling above each panel.


Typical Shallow Communication Closet
Plywood Backboard
2600 mm
(8.5 ft.)
760 mm
(30 inches)
Terminal Blocks
110 v outlet
Ground Bar TMGB or TGB)
Sleeves (4 in.) or Conduit
Door with Lock
Door with Lock
0419


Backbone Star Wiring Topolohgy for Inter- and Intrabuilding Communications
Telecommunications Closet
Intermediate Cross-Connect Closet
Building 1
Building 2
Building 3
Building entry point
Main Cross-Connect Closet
0504

Backbone Star Wiring Topology

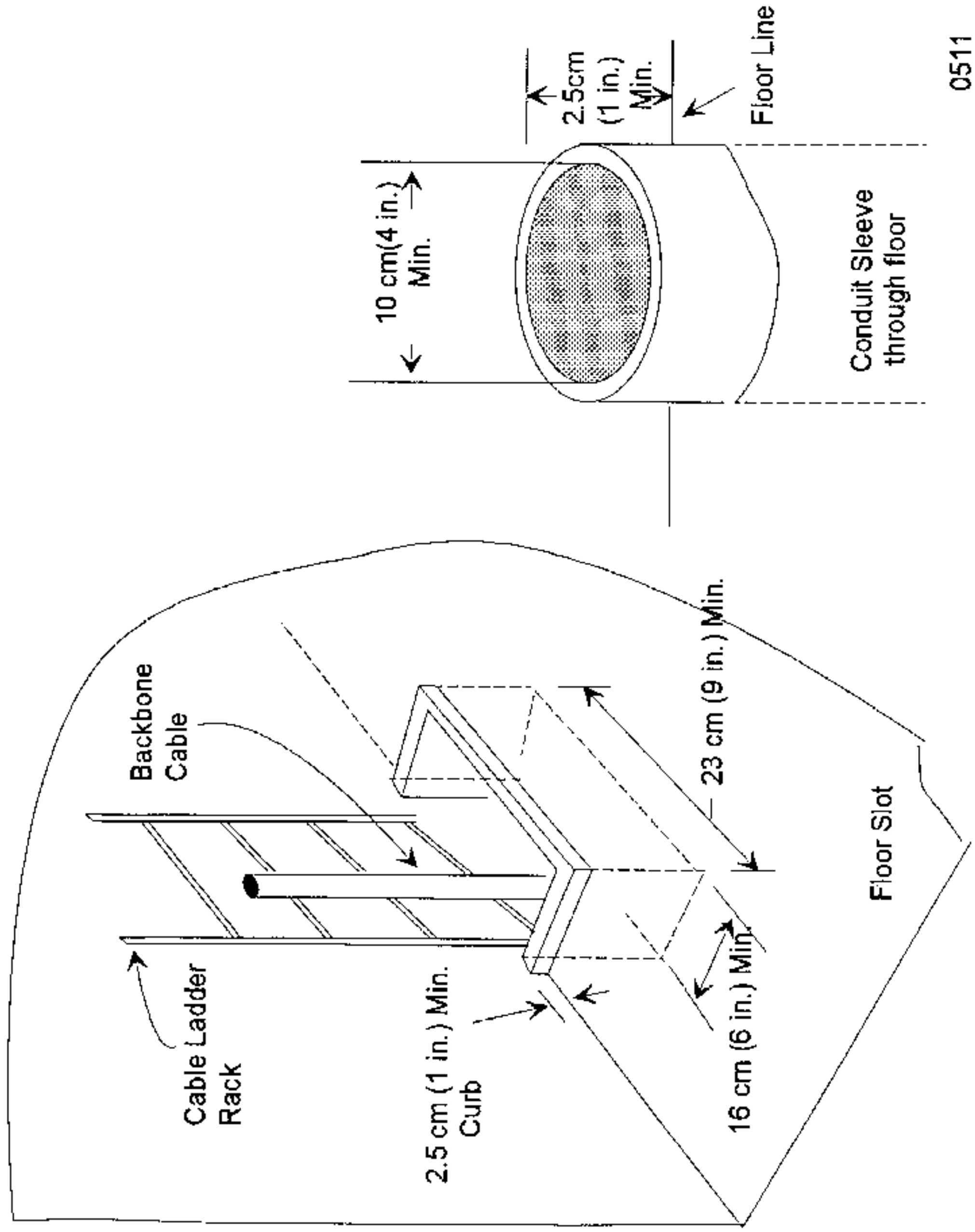


Note: All (MC's, IC's & TC's) are classified TC's and
may contain equipement and cross-connects.

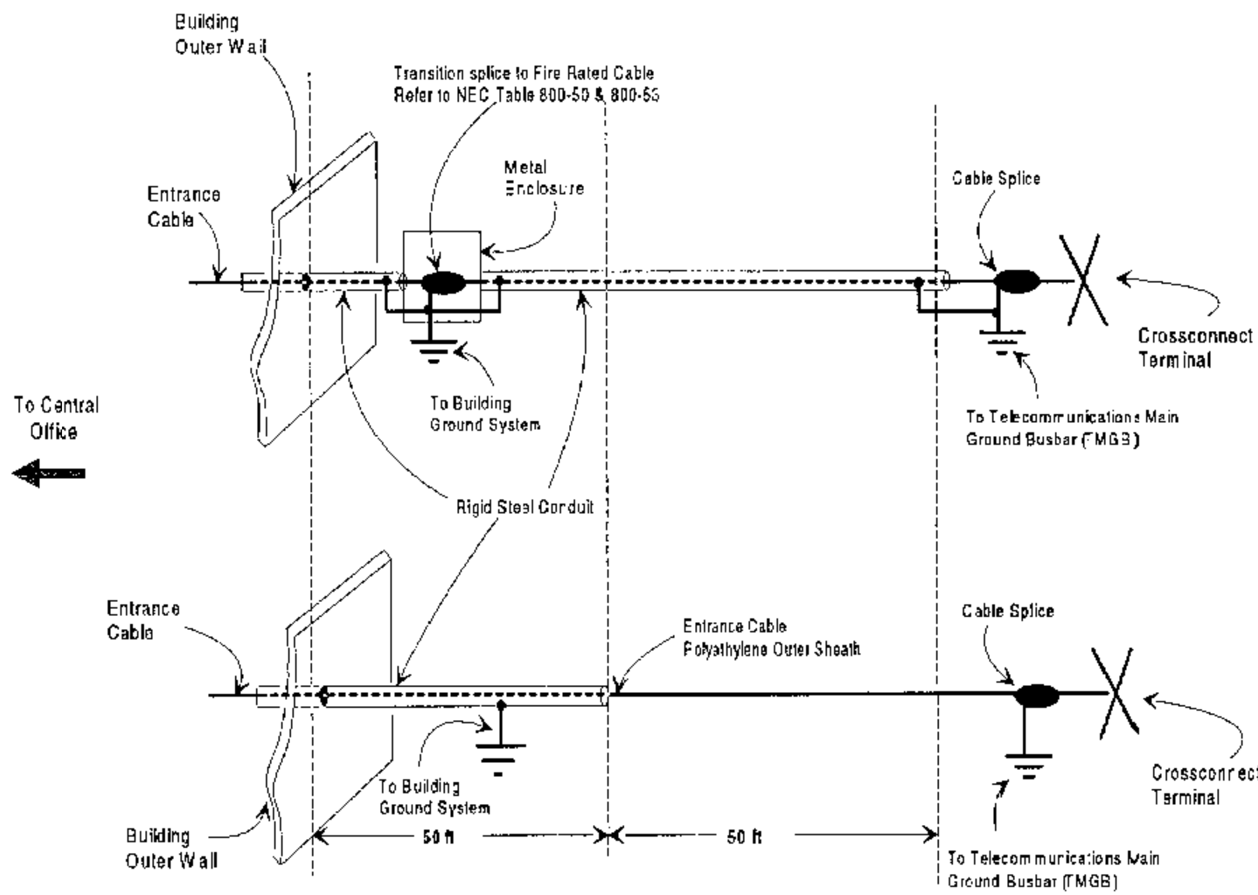
Pass only **one** backbone cross-connect to reach the
highest level (main) cross-connect.

0505

Types of Backbone Cable Pathways
Sleeves / Slots



Entrance Cable Configuration With in Buildings

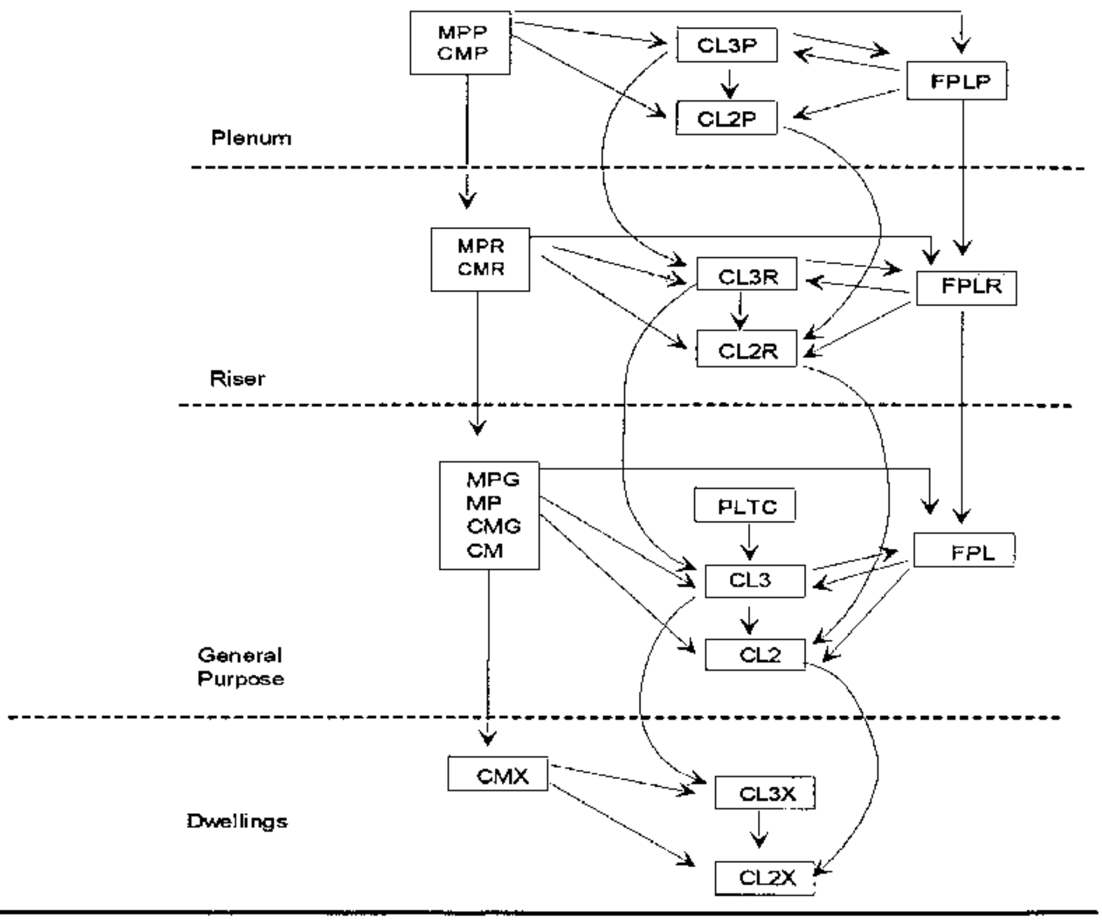


Note: 1- Listing and markings (NEC 800-50, 800-53) shall not be required where the length of cable within the building does not exceed 50 ft. (15.2 M) and the cable enters the building from the outside and is terminated in an enclosure or on a listed primary protector. The primary protector shall be placed as close as possible to the point where the cable enters the building to avoid having the entrance cable exceeding 50 ft. (15.2m) in length.

2- Listing and markings (NEC 800-50, 800-53) shall not be required where the entrance cable enters the building from the outside wall and is continuously enclosed in rigid metal conduit and such conduit is grounded to an approved ground system.

0515

Figure 800-53 Cable Substitution Hierarchy
1996 NEC Article 800-53 (f)



Type CM - Communications Wirers and Cable.

Type CL2 and CL3 - Class 2 and Class3 Remote -Control, signaling, and Power Limited Cables.

Type FPL - Power Limited Fire Protective Signaling Cables.

Type MP - Multipurpose Cables.

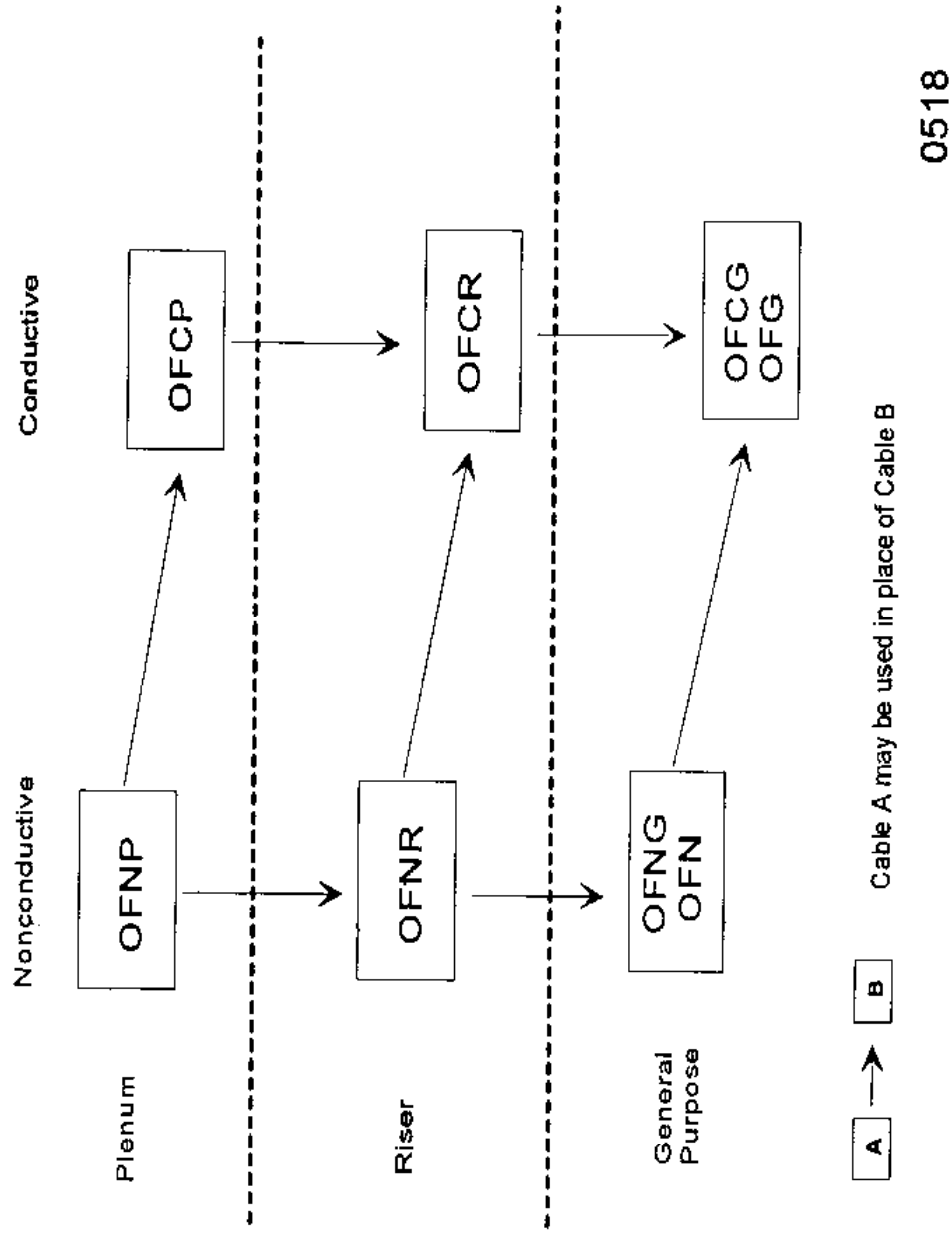
Type - PLTC - Power Limited Tray Cable.

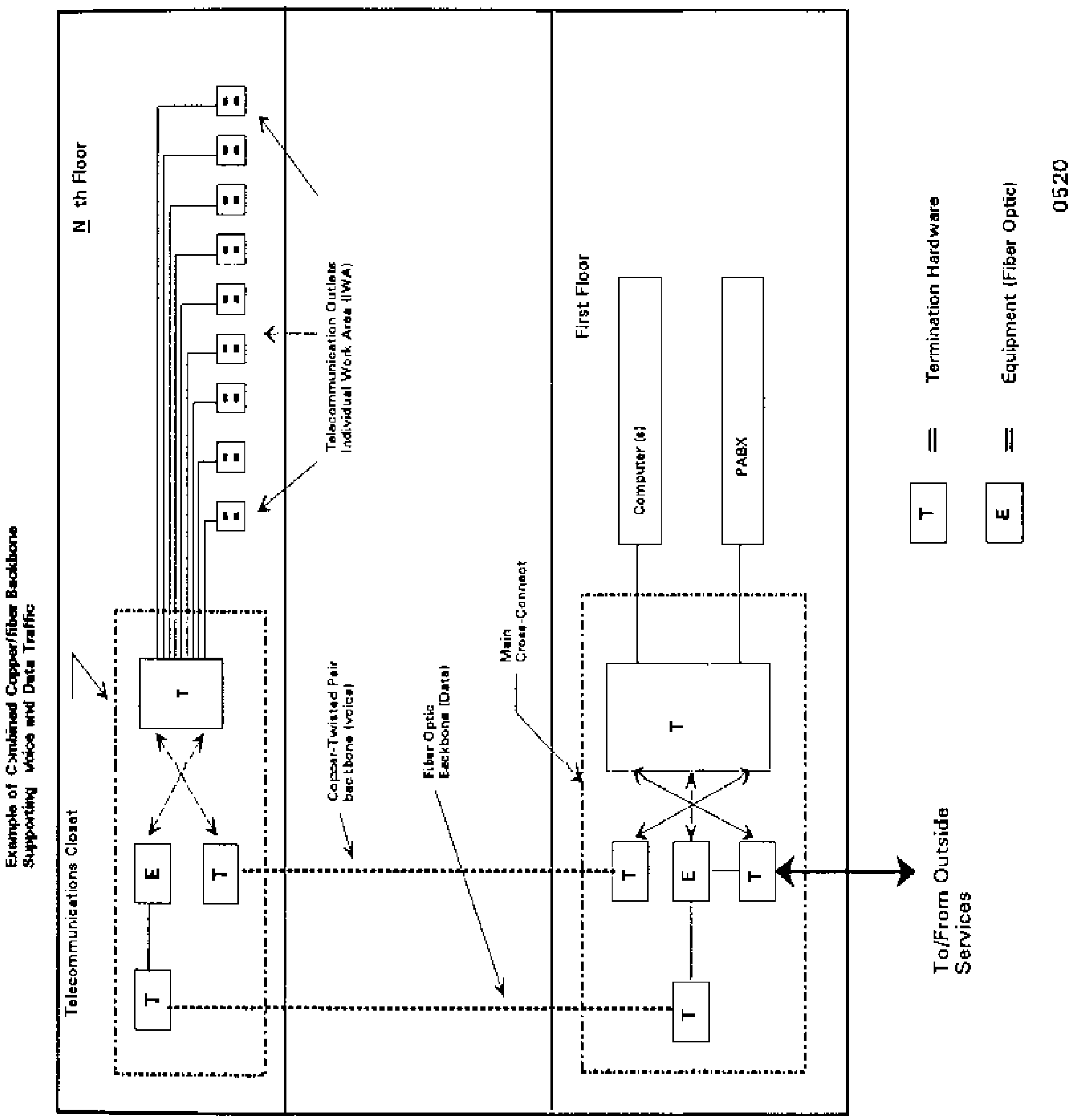
A → B Cable A Shall be Permitted to be Used in Place of Cable B

0517

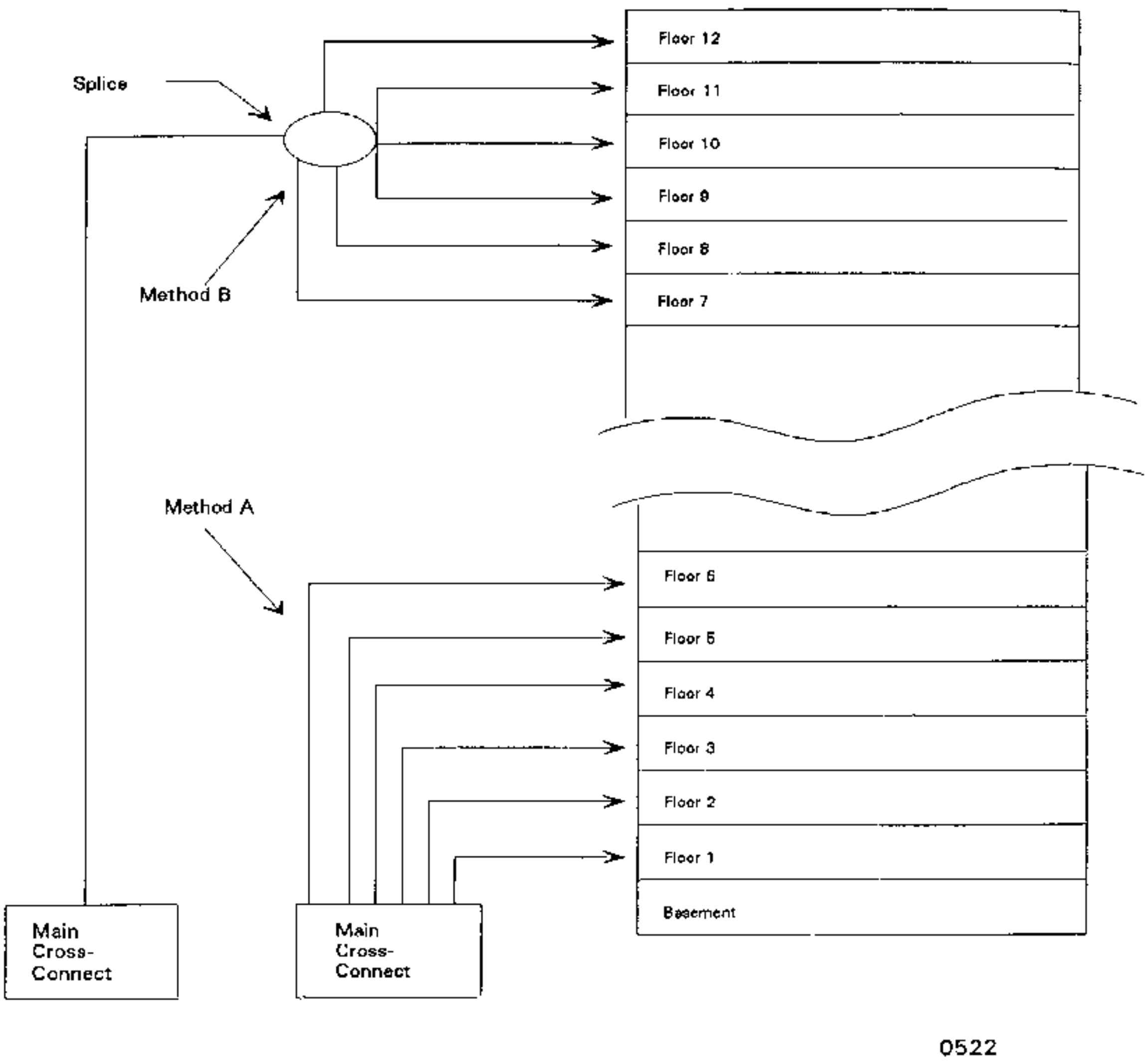
Figure 770-53 Cable Substitution Hierarchy

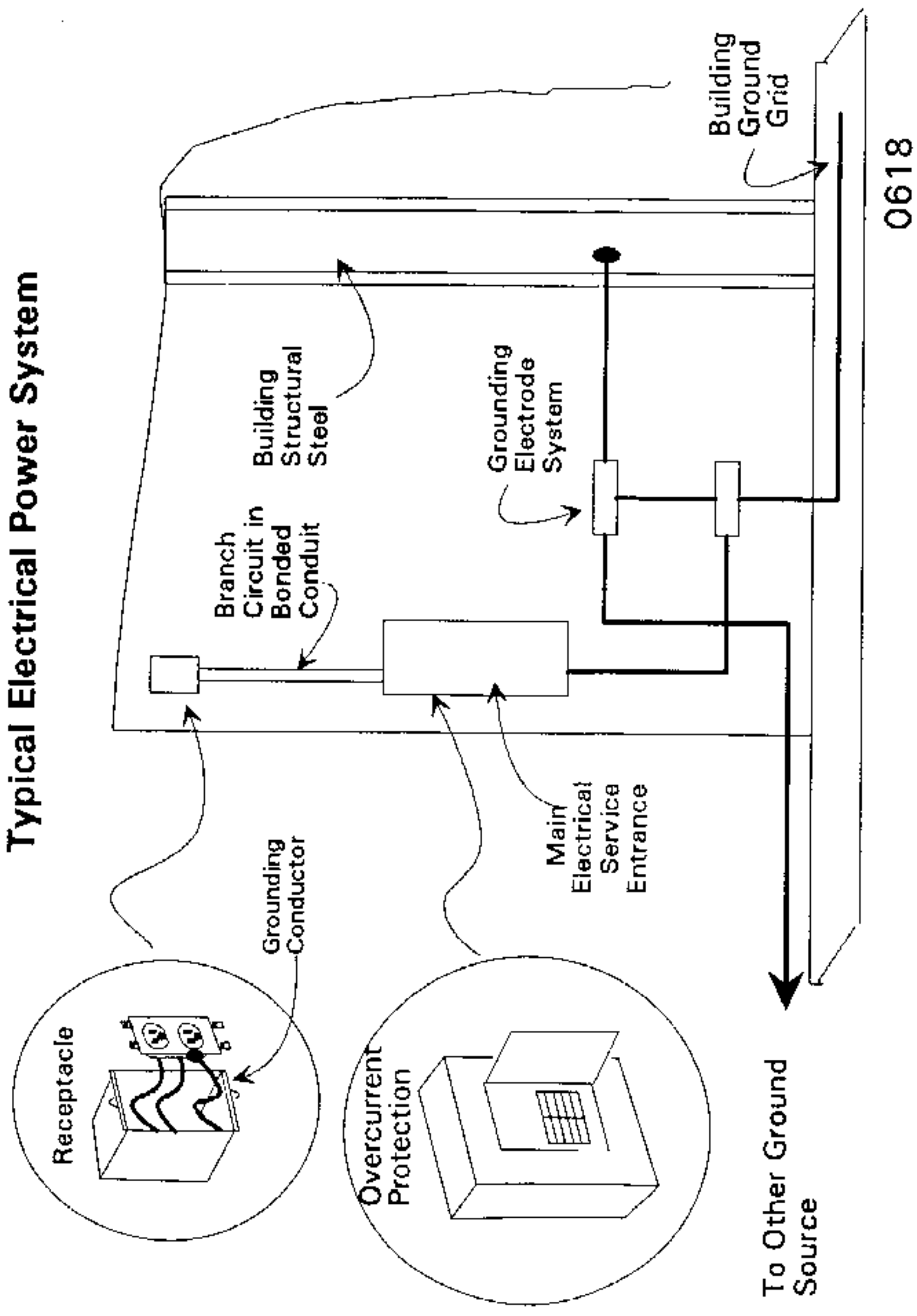
NEC Article 770



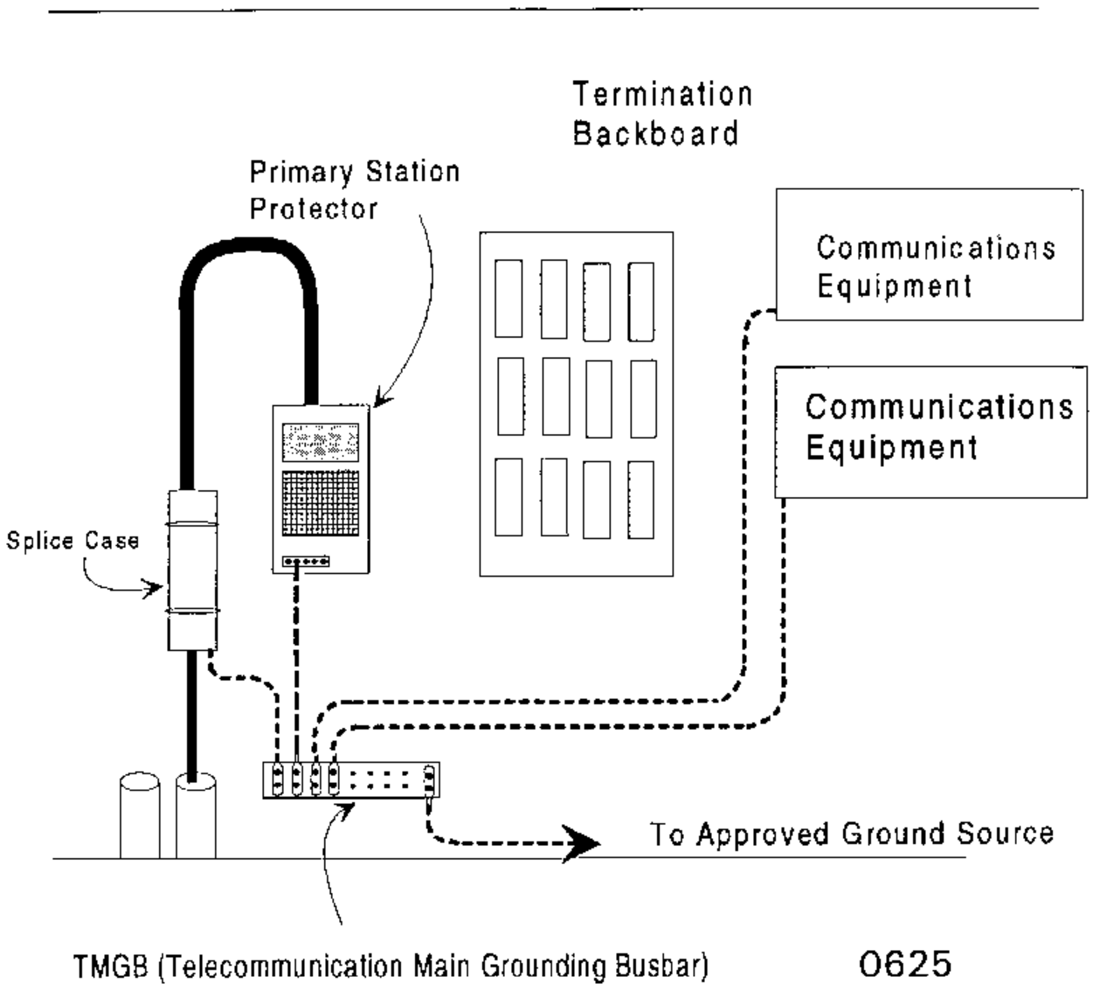

Example of Combined Copper/fiber Backbone
Supporting voice and Data Traffic
Telecommunications Closet
N th Floor
Telecommunication Outlets
Individual Work Area (IWA)
Copper-Twisted Pair
backbone (voice)
Fiber Optic
Backbone (Data)
Main
Cross-Connect
First Floor
Computer (s)
PABX
To/From Outside
Services
T = Termination Hardware
E = Equipment (Fiber Optic)
0520

Backbone Wiring Alternatives

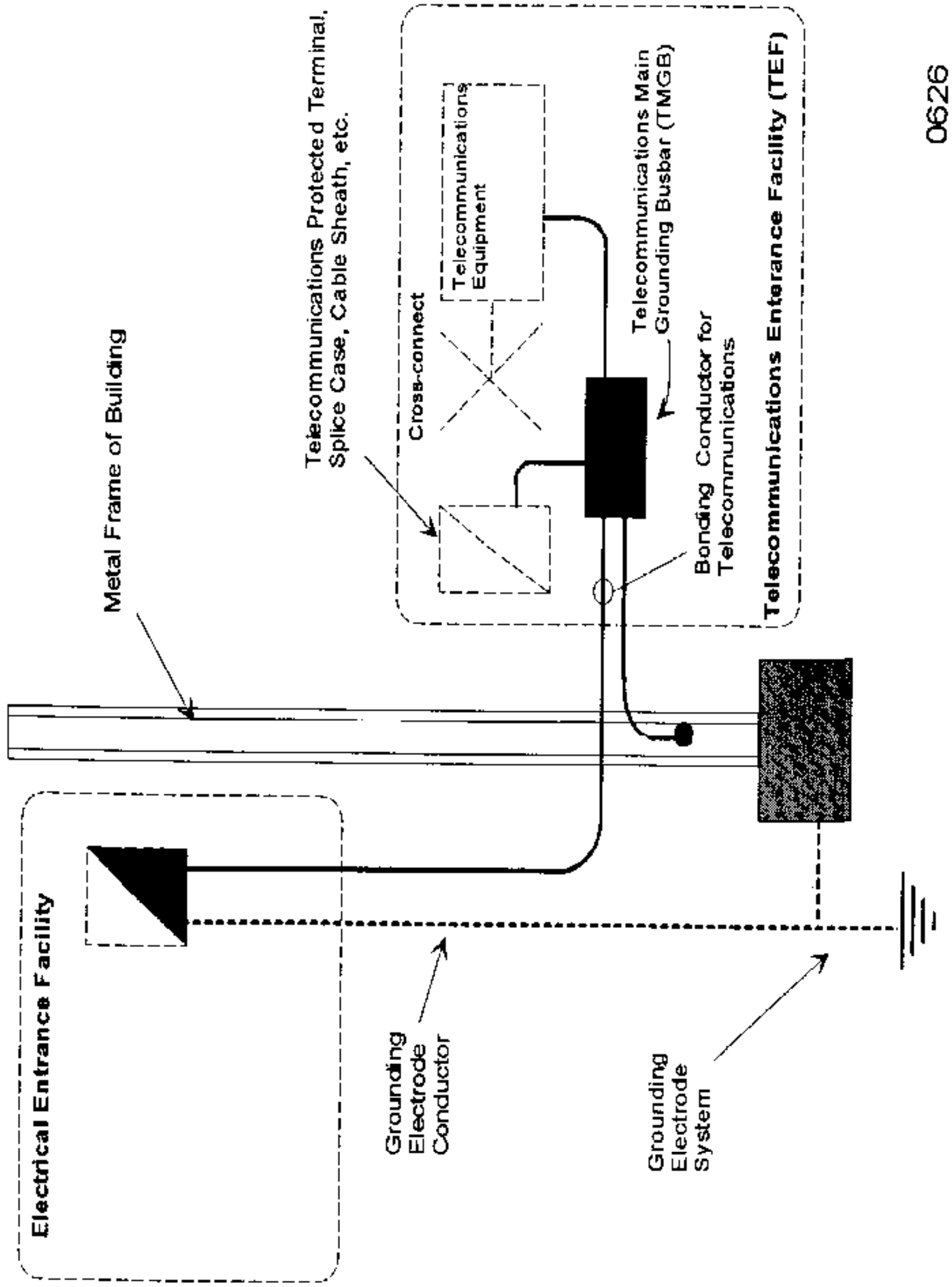



Typical Electrical Power System
Building Structural Steel
Branch Circuit in Bonded Conduit
Grounding Electrode System
Building Ground Grid
Main Electrical Service Entrance
Grounding Conductor
Receptacle
Overcurrent Protection
To Other Ground Source
0618

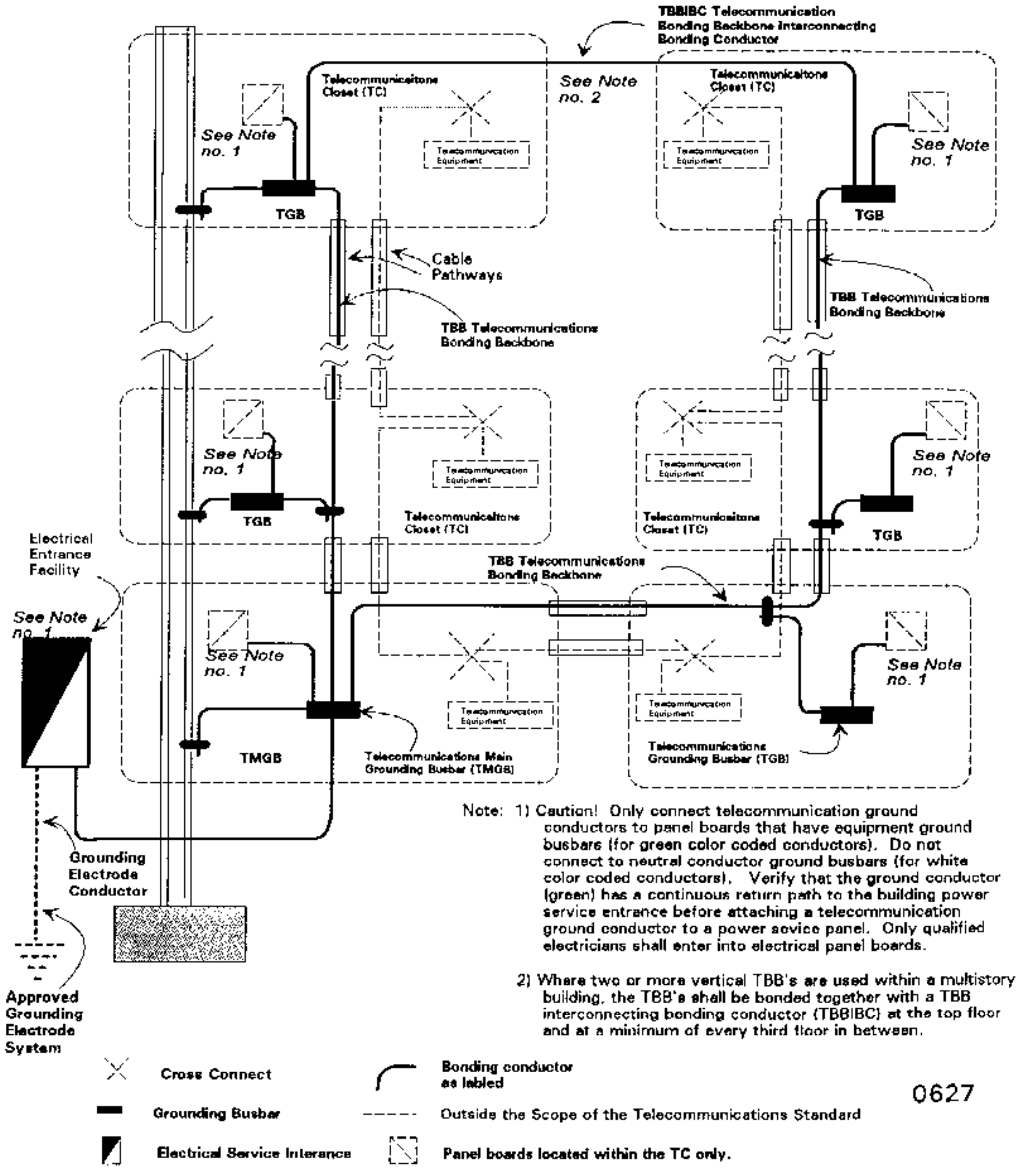
Typical Bonding & Grounding for Small Entrance Cable, Protected Terminal & Equipment



Typical Arrangement of Telecommunications Backbone Bonding (TBB) Structure for Small buildings and facilities.

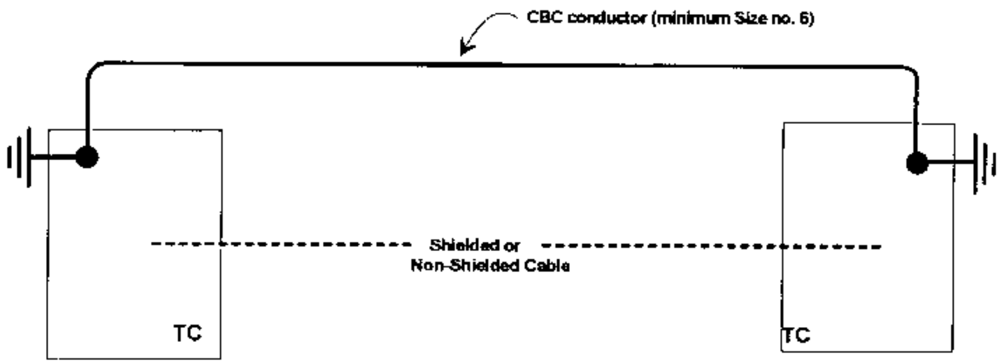


Typical Arrangement of Telecommunications Backbone Bonding (TBB) Structure for Large buildings and facilities.

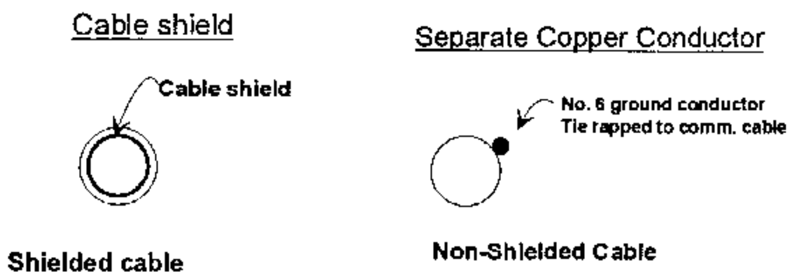


Two types of Coupled Bonding Conductors

Coupled Bonding Conductor



Two types of Coupled Bonding Conductors

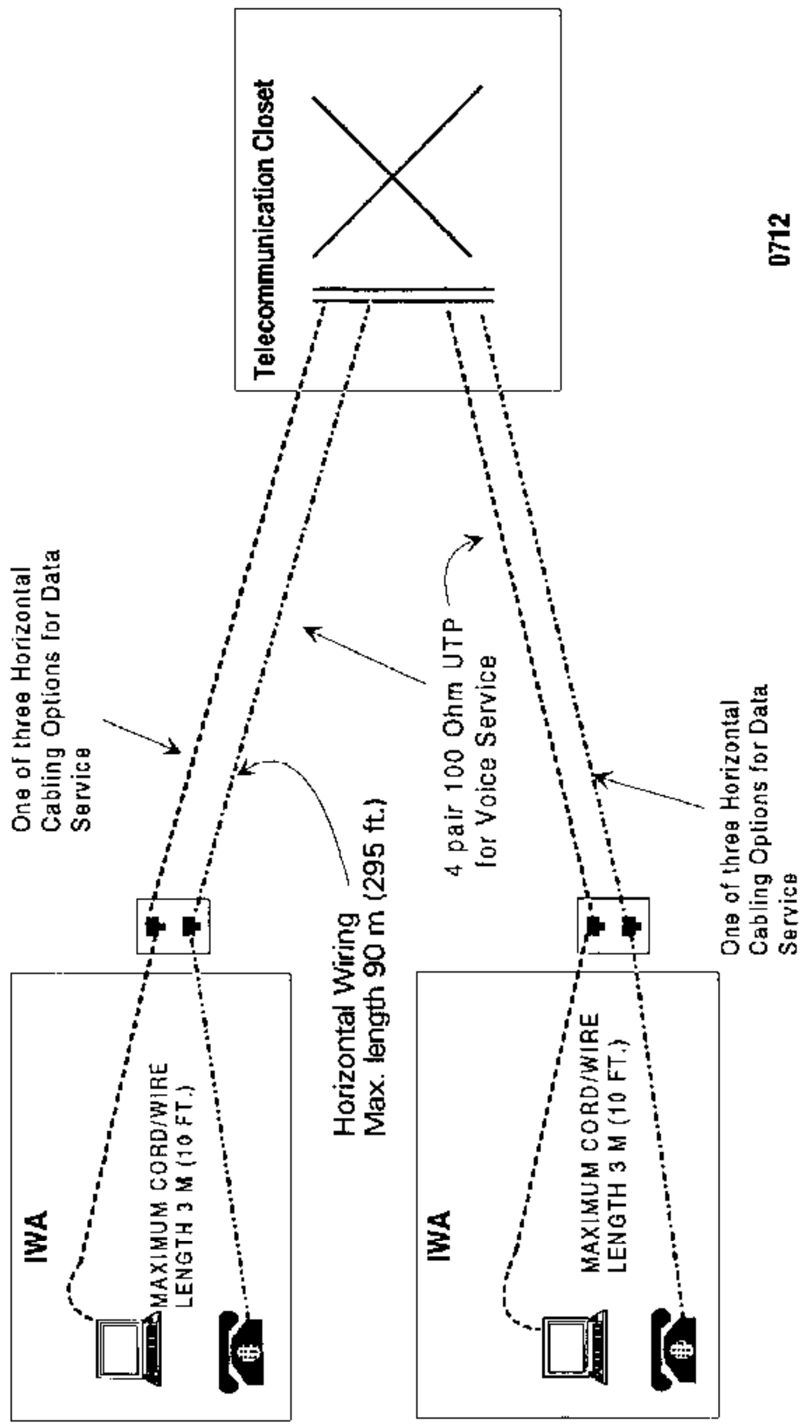


Note: 1) The Coupled Bonding Conductor (CBC) is not part of the grounding and bonding infrastructure.

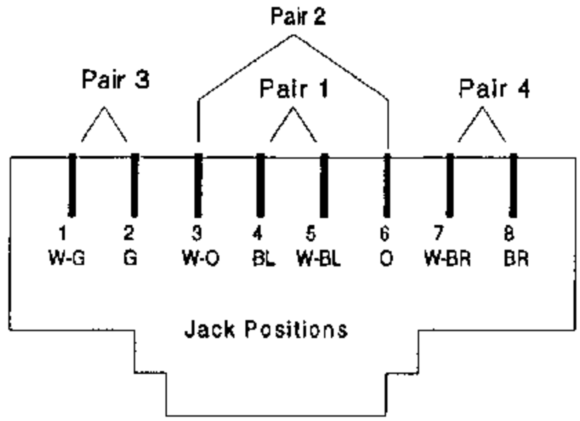
2) A CBC shall be connected between the protector ground and the PBX ground.

0630

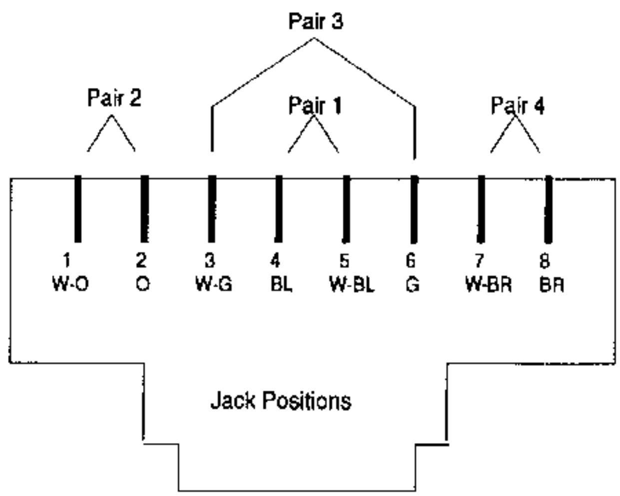
Typical Horizontal Wiring Configuration



Eight Position Jack Pin/Pair Assignments (T568A)
(front view of connector)

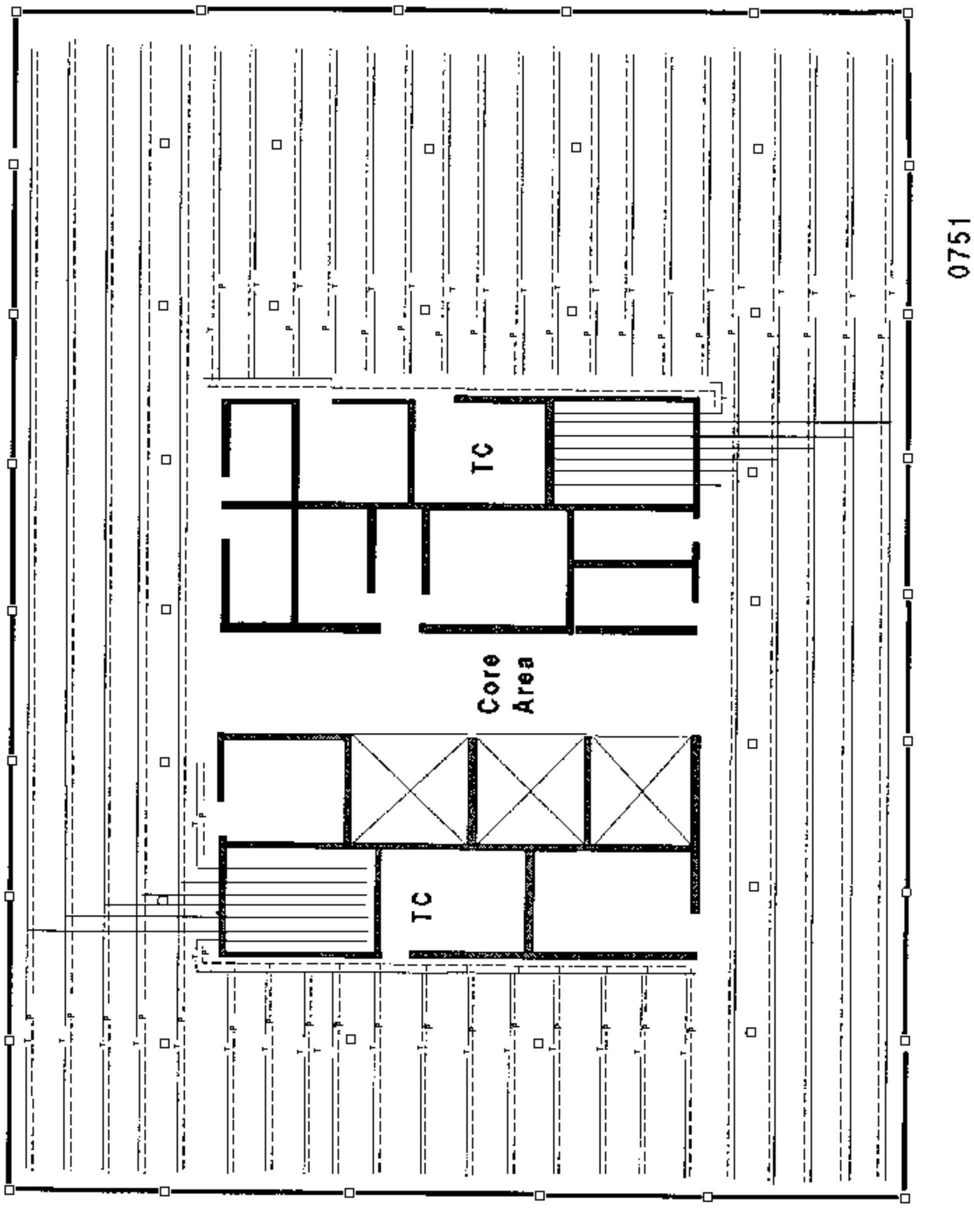


Optional Eight Position Jack Pin/Pair Assignments (T568B)
(front view of connector)

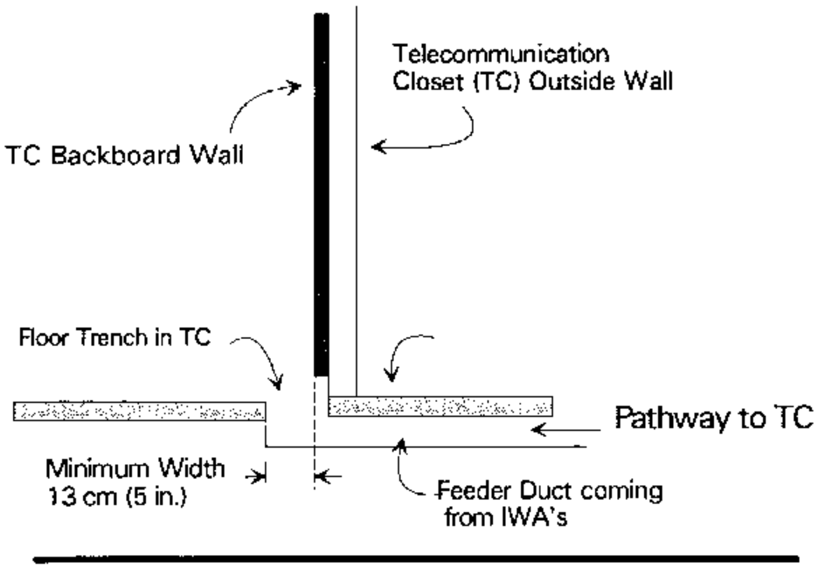


0717

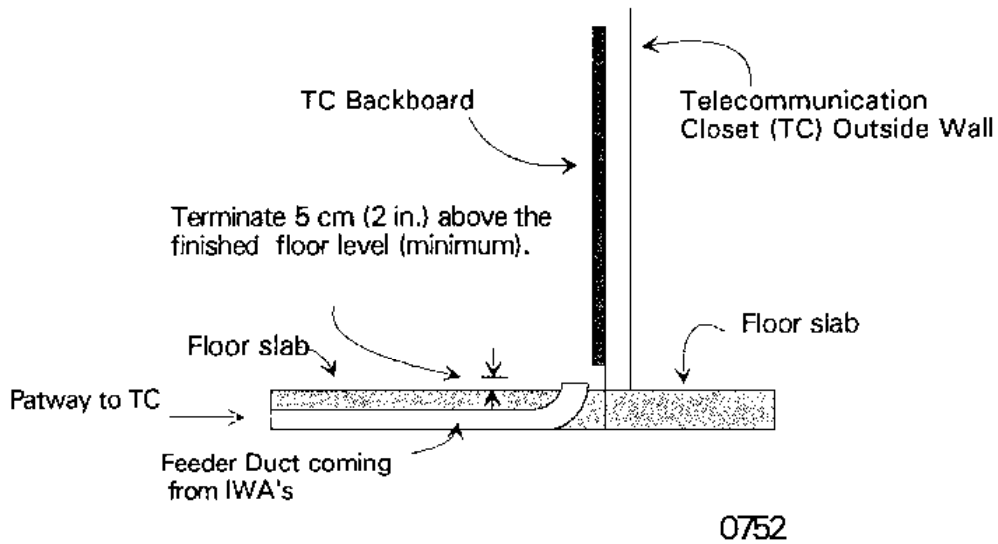
Typical Telecommunications Closet & Floor Duct Arrangement for Multistory Building

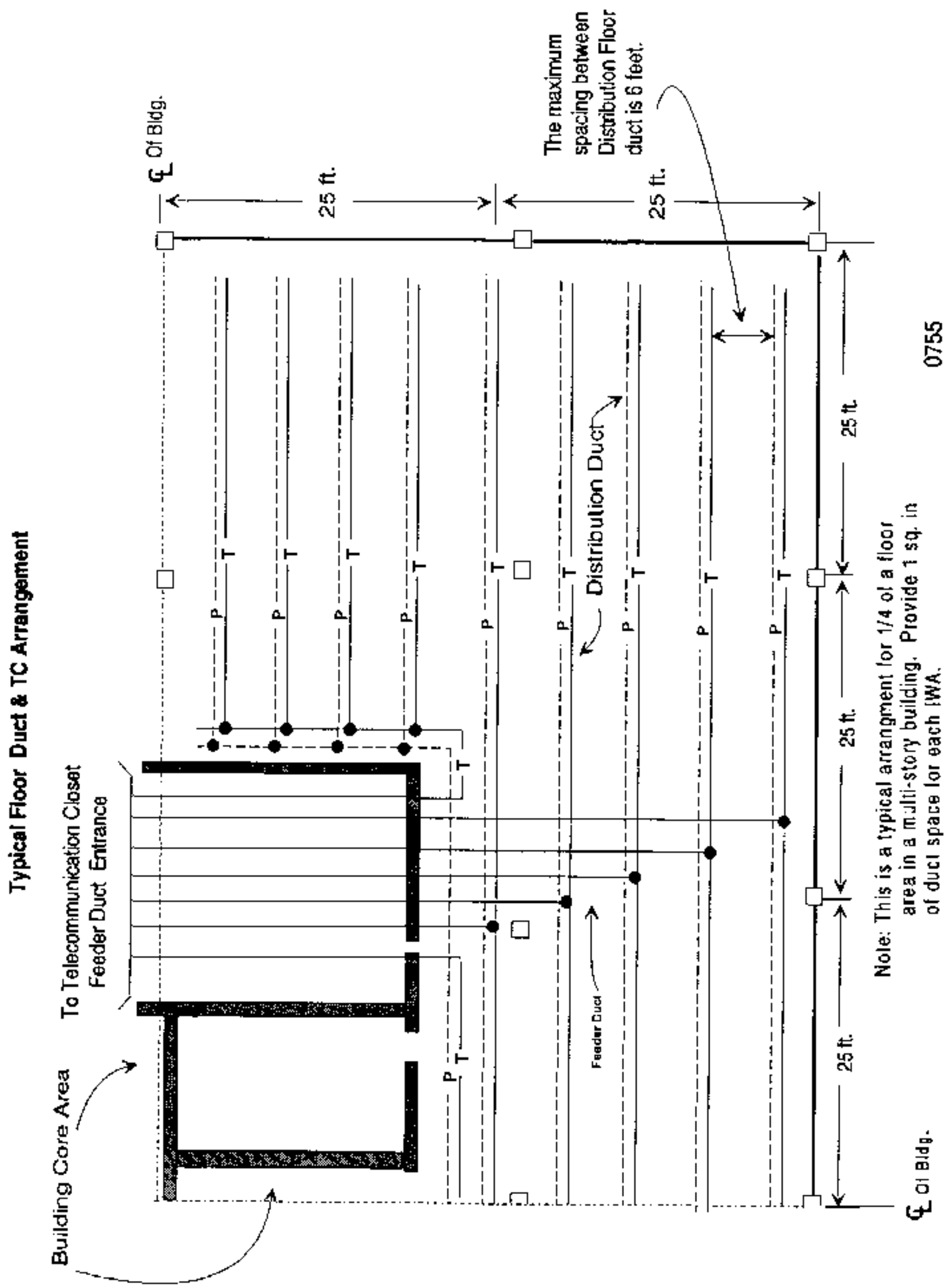


Terminating Feeder Duct in a Telecommunication Closet
(Does Not Pass Within the TC)

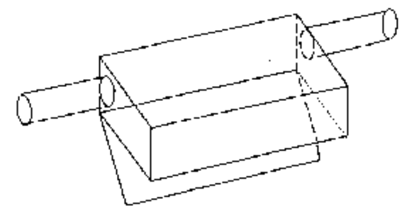


Terminating Feeder Duct in a Telecommunication Closet
(Does Pass Within the TC)




Typical Floor Duct & TC Arrangement
To Telecommunication Closet Feeder Duct Entrance
Building Core Area
Of Bldg.
25 ft.
25 ft.
The maximum spacing between Distribution Floor duct is 6 feet.
Distribution Duct
Feeder Duct
P
T
25 ft.
25 ft.
25 ft.
Of Bldg.
Note: This is a typical arrangement for 1/4 of a floor area in a multi-story building. Provide 1 sq. in of duct space for each IWA.
0755

PULL BOXES

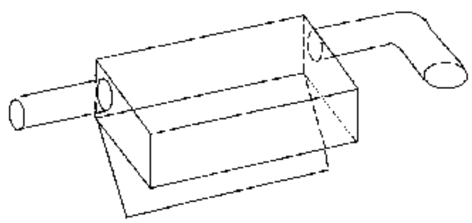


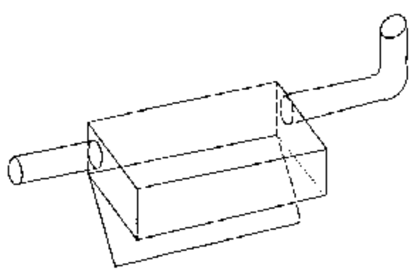
NOTE:

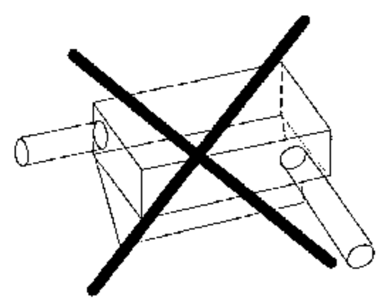
Refer to Paragraph 4.7.19.6 "Bend Radii for Conduit" for sizing conduit bends.

Use Boxes only for pulling and looping small single sheathed diameter cables (5cm [2 in.] or less).

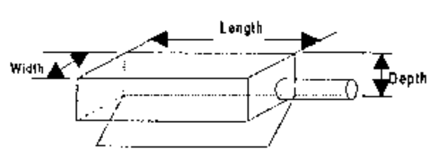
All Pull Boxes shall have hinged doors that open from the bottom. There shall be no obstruction to prevent the door from fully opening.







Not permitted



Refer to Paragraph 4.7.20.7, "Pull Box Size" for information and Table, "Sizing Pull Box".

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Typical Ceiling Zone Distribution System Using Conduit

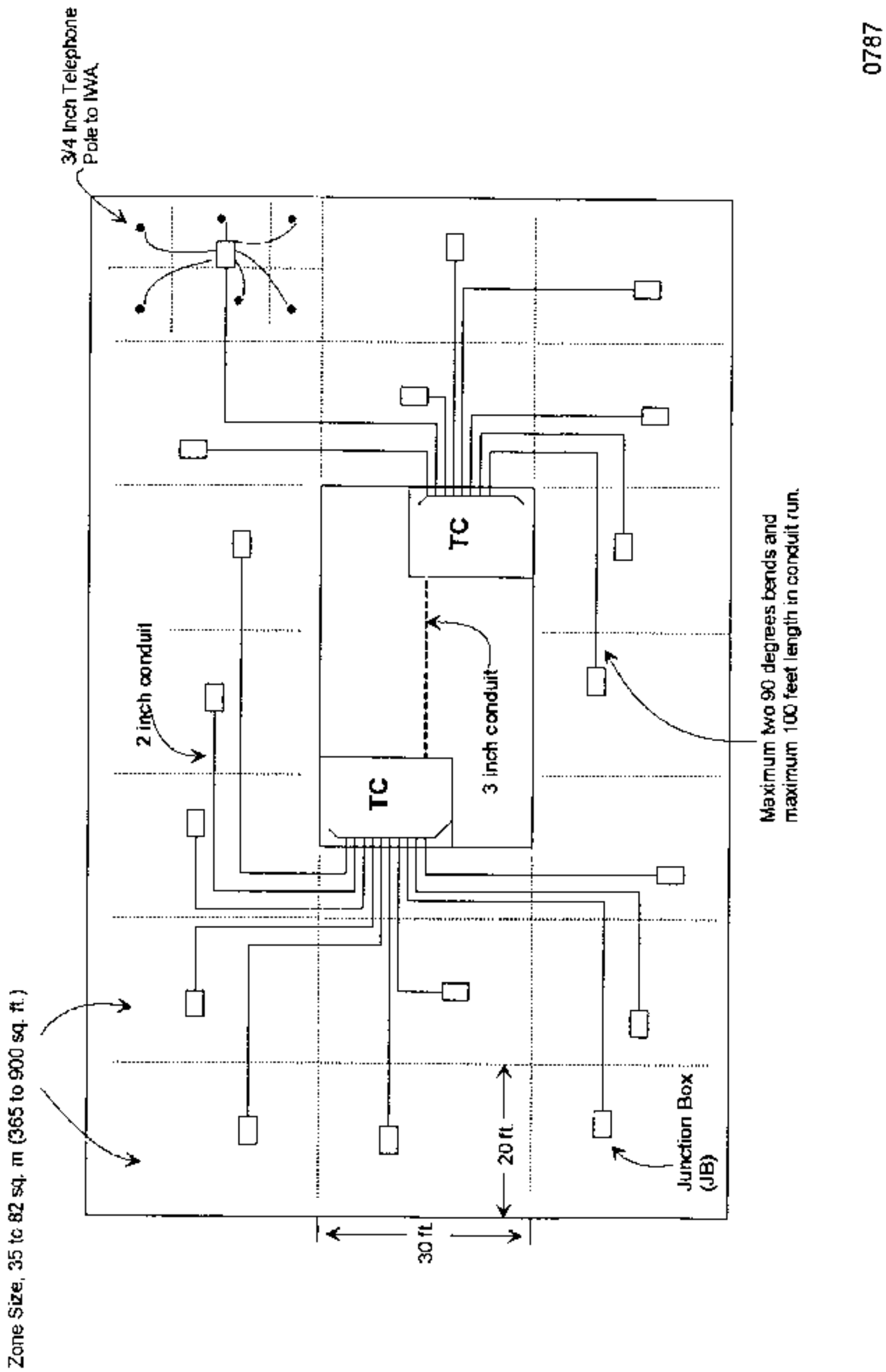

Table XX – Conduit Capacity for Horizontal Cabling

Diameter Internal mm(in.)*	Trade Size inches	3.3 (.13)	4.6 (.18)	5.6 (.22)	6.1 (.24)	7.4 (.29)	7.9 (.31)	9.4 (.37)	13.5 (.53)	15.8 (.62)	17.8 (.70)
		Cable Outside Diameter mm (in.)									
16 (.62)	½	1	1	0	0	0	0	0	0	0	0
21 (.82)	¾	6	5	4	3	2	2	1	0	0	0
27 (1.05)	1	8	8	7	6	3	3	2	1	0	0
35 (1.38)	1¼	16	14	12	10	6	4	3	1	1	1
41 (1.61)	1½	20	18	16	15	7	6	4	2	1	1
53 (2.07)	2	30	26	22	20	14	12	7	4	3	2
63 (2.47)	2½	45	40	36	30	17	14	12	6	3	3
78 (3.07)	3	70	60	50	40	20	20	17	7	6	6
90 (3.55)	3½	-	-	-	-	-	-	22	12	7	6
102 (4.02)	4	-	-	-	-	-	-	30	14	12	7

***** Internal diameter values given in inches represent standard conduit trade sizes. Actual internal diameters may vary by as much as 1/8 inch.