Engineering Standard

SAES-T-920 7 May 2019

Telecommunications Copper Cable Information

Document Responsibility: Communications Standards Committee

Saudi Aramco DeskTop Standards

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1 Scope

This standard prescribes mandatory requirements governing copper conductor telecommunication cable to be used for voice and carrier frequency facilities in outside plant construction.

2 Conflicts and Deviations

Any deviations, providing less than the mandatory requirements of this standard require written 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 Procedure

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

Saudi Aramco Engineering Standards

SAES-T-018	*Telecommunications - Symbols, Abbreviations and Definitions*
SAES-T-631	*Cable Terminals*
SAES-T-632	*Cable Splicing*
SAES-T-633	*Splice Closures*
SAES-T-634	*Cable Testing and Identification*
SAES-T-916	*Telecommunications Building Cable Systems*
SAES-T-938	*Outside Plant Systems Design*

3.2 Industry Codes and Standards

National Fire Prevention Association

NFPA 70	*National Electric Code (NEC)*

4 Important Design Requirements

a. Cables with polyethylene sheath and conductor insulation shall not be used within buildings or as terminating cable on distributing frames. (Paragraph 3.08, *NFPA 70*, National Electric Code).

b. Filled cables shall be specified for all outside plant buried and underground cable uses.

c. Table 1 (as amended) shall be used in selecting cables for inclusion in design documentation. (Paragraph 5.1.7.1).

5 Design

5.1 Outside Plant Cable, Field of Use

5.1.1 GENERAL

5.1.1.1 This section provides a guide for the selection of the proper type of cable to be used for voice and carrier frequency facilities in normal outside plant construction: aerial, underground, buried, and submarine. Power, video, and other special cables are not included. Background information is given on cable types, prevalent troubles, and significant considerations.

5.1.1.2 The type of construction to be used for an addition of new cable or an extension of existing cable involves consideration of many factors. Some of the factors are transmission, topography, accessibility of the route, existing routes especially of underground conduit, future Central Office (CO) sites, public and municipal reactions, and economy.

5.1.1.3 Refer to section 5.2 for Plastic Insulated-Conductor (PIC) cable.

5.1.2 DEFINITIONS

5.1.2.1 **Cable:** A cable is an assembly of two or more electrical conductors, insulated from each other, and enclosed in a protective covering (sheath) other than the conductor insulation. Very small cables are sometimes referred to as wire. i.e., two-pair buried service wire.

5.1.2.2 **Air Core:** An air core is a group(s) of insulated conductors with a core tape contained within the protective covering. Depending upon the type and makeup of each cable, from 50 to 70% of the internal volume is air space.

5.1.2.3 **Filled Core:** The makeup of the core of the filled type of cable is the same as for air core, except that a filling compound is added to fill the air space.

5.1.2.4 **Core Wrap:** A core wrap is a tape applied to protect the assembled insulated conductors during application of the overall coverings. The core wrap is generally considered as part of the core with respect to definition. Generally, hygroscopic tapes are employed with paper-insulated cables and non-hygroscopic tapes with PIC cables.

5.1.2.5 **Conductors:** Cable conductors of present day telephones are almost always made of solid annealed copper wire in sizes 19, 22, 24 and 26 American Wire Gauge (AWG).

5.1.2.6 **Pairs:** Insulated conductors are twisted into pairs. The length of pair lay is varied to minimize cross-talk in an assembled core. In polyethylene-insulated-conductor cables, each pair in the same group has a different length of lay. In paper-insulated cables, less pair lays are used because random splicing is employed.

5.1.2.7 **Quads:** Pairs in some older cables designed for toll use were grouped into quads. A quad is made of two pairs twisted together for the length of the cable. Each quad provides three talking paths, one over each pair (side circuit) and the third over the phantom circuit. Phantom circuits are no longer used in new construction and quadded cable is used only for repair of existing plants where phantom circuits are still in use.

5.1.2.8 **Combination Cables:** Combination cables contain two different groups of conductors, each group of a different gauge. i.e., 100 pairs No. 19 AWG and 200 pairs No.22 AWG.

5.1.2.9 **Composite Cables:** Composite cables contain a group of quads and a group of pairs. Usually, the quadded conductors are larger than the paired conductors. They may also include coaxial and/or video pairs.

5.1.2.10 **Sheath:** Sheath is a general term designating all the components of the protective covering applied over the core wrap. Cable sheaths are designed to provide mechanical strength and protection from local environment, electromagnetic induction, electrolysis, and external power contact. Sheaths vary in the number and kinds of component applied in layers over the core wrap. They range from a simple extruded plastic or lead sheath to a combination of concentric layers of plastic, aluminum, steel, copper, jute, and flooding compounds.

5.1.2.11 **Jacket:** A jacket is an extruded high-dielectric-strength component of a sheath. Such jackets are currently made of polyethylene and Polyvinyl Chloride (PVC). Cables with inner and outer jackets (outside of the shield) are commonly referred to as Double Sheath (DS).

5.1.2.12 **Shield:** A shield is a metallic component of a sheath. Its purpose is to provide protection from electrostatic induction, electromagnetic induction, power line contacts, and lightning. It must be properly grounded and bonded for electrical continuity.

5.1.2.13 **Armor:** Armor is a general term designating a metallic component(s) included in or over the sheath for mechanical protection from animal, crushing, or stress damage. Normally, armor is applied as a longitudinal tape and may be soldered or welded to provide moisture protection. Various types of flooding compound may be used in conjunction with the armor to prevent corrosion.

5.1.2.14 **Screen:** A screen is a metallic component of a core. Its purpose is to divide the cable core into two equal segments. Screens are often referred to as shields also.

5.1.3 SHEATHS

Three basic types of sheaths have evolved to become industry standards: Stalpeth, Alpeth, and Alvyn. Stalpeth is the basic sheath applied to paper-insulated cables. The name “Stalpeth” refers to the major sheath component, i.e., steel, aluminum, and polyethylene. Alpeth is the basic sheath applied to polyethylene-insulated-conductor cables. The name “Alpeth” refers to aluminum and polyethylene, the two major sheath components. Alvyn is a special sheath developed to meet national electrical safety code requirements for use in building. The name “Alvyn” refers to aluminum and PVC; the two major sheath components.

Several variations of Stalpeth and Alpeth cables are available. In general, these variations consist of the following:

(a) Inner jackets are added to minimize water entry.

(b) Filling compound is added to the core to prevent entry of moisture.

(c) Armor is added to prevent damage by animals.

(d) An inner shield or screen is added to the core to permit bidirectional operation of Pulse Code Modulation (PCM) carrier in small cables.

Significant features of plastic jackets and materials are as follows:

(a) Reliable supply.

(b) Favorable price.

(c) Lightweight.

(d) Easily extruded.

(e) Good insulation (electrical).

(f) Not subject to electrolysis.

(g) Flexible over wide range of outdoor temperatures.

(h) Not significantly affected by chemicals encountered under ordinary field conditions.

5.1.3.1 Polyethylene:

A. Polyethylene has become the standard material for outside plant cable jackets. The composition of polyethylene jacket material by weight is approximately as follows:

(a) High-molecular-weight polyolefin resin (97.3%)

(b) Carbon black (2.6%)

(c) Antioxidant material (0.1%)

B. The antioxidant retards surface cracking. The carbon black minimizes the effect of sunlight by making the material opaque. The carbon black can be eliminated from inner jackets, but may be retained for ease of cable manufacturing. Long-term exposure to petroleum products or vegetable oils may result in some swelling and softening of polyethylene jackets. Exposure to the grease lubricants in ducts previously occupied by lead cables does incur a risk of serious damage to polyethylene jackets. Approved lubricating compounds are available for polyethylene-jacketed cables, and should be used when installation occurs in conduit systems.

C. Polyethylene is not impervious to moisture. Vapor diffuses through polyethylene until the pressures inside the jacket are approximately equal to the pressures of the individual liquids or gases outside the cable. The diffusion rate depends upon jacket thickness, the nature of the liquid or gas, and its temperature and vapor pressure. Gasoline vapor diffuses through a polyethylene jacket 8 to 10 times faster than water vapor. In cables such as Stalpeth, the flooding compound directly under the outer jacket absorbs gasoline and liquefies.

D. DS cables are made with a metallic shield between the outer and inner jackets. The primary purpose of the inner jacket in such cables is to provide moisture resistance to the underlying core and to give additional core-to-shield dielectric strength. Moisture permeation can occur through an inner jacket in much the same manner as previously described.

E. Polyethylene jackets should not be exposed to temperatures over 175°F. The material begins to soften at 200°F, and begins to flow at temperatures ranging from 220°F to 230°F. It ignites at 800°F, and once ignited, it continues to bum with a flame. An encircling band of metal may extinguish the flame if the source of heat or external flame is removed. The effects of such temperatures must be considered when cable is to be placed in areas such as boiler rooms, steam tunnels, railroad yards and at locations subject to grass or bush fires.

F. Polyethylene-jacketed cable shall not be used in open locations in buildings or as terminating cables in telephone central offices. It does not meet the national electrical safety code specification for a fire resistant covering. Telecommunication cables containing polyethylene (jacket, sheath or conductor insulation) shall not be utilized as inside building cables or wires unless the entire length of cable, including splices and terminations, is enclosed in noncombustible material, or is completely wrapped in fire rated tape. Refer to SAES-T-916, (Paragraph 3.7) Important Design Requirements.

5.1.3.2 Polyvinyl Chloride

The PVC material is used as jacket material for fire-resistant jackets and meets national electrical safety code requirements. The PVC expands or balloons if subjected to internal pressures. The PVC jacket diameter may increase 10 to 15% at normal room temperature if internal pressure is applied at a rate of 8 pounds per square inch. The PVC burns when held in a flame, but extinguishes when the flame is removed.

5.1.3.3 Shield and Materials

The primary purpose of a cable shield is to prevent electrostatic induction and minimize electromagnetic induction, and core damage from external sources such as power contacts or lightning. The most common metal used for shielding material is aluminum. An uncoated shield corrodes when exposed to water through damage to the outer jacket or by diffusion. Shields are usually applied as a thin metal tape, about 0.008 inch thick. This tape is applied longitudinally with the seam running lengthwise. The tape is corrugated in most cables. The corrugation provides flexibility and reduces the tendency to kink at bends. A 100% registration of the corrugation at the seam does not occur; thus, even shields with soldered seams may have occasional minute openings.

5.1.3.4 Outer Shield

The most significant problem with outside plant cables is entry of water into the core through sheath ruptures. The shield is usually the first electrical component exposed to corrosion when a sheath rupture occurs. The Fused Polyethylene Copolymer Aluminum (FPA) shield has overcome the shield corrosion problem. It consists of an 8-mil corrugated aluminum tape with a 2-roil layer of polyethylene copolymer film used to each side of the aluminum. A bond also exists between the film and the polyethylene jacket of air-core Alpeth cables. This bond effectively reduces any paths for moisture migration between the jacket and shield. Most important is the protection from corrosion afforded the aluminum. Corrosion cannot attack the outer face of the aluminum so long as the outer film it intact. If the outer film is punctured, corrosion can progress only to the inner film. Once the inner film is reached, the only path for further corrosion is edgewise.

5.1.3.5 Internal Shields (Screens)

Internal shields are used to divide cable cores into two separate compartments, which are used with some PCM carrier systems. The shields enable bidirectional transmission in one sheath with maximum repeater spacing and 100% of the pairs dedicated to PCM systems. The purpose of internal shields is to reduce near-end cross-talk at each repeater location. An internal shield is essentially an insulated aluminum tape, placed longitudinally through the center of the cable core (Figures 1 and 2). Internal shields are often referred to as screens.

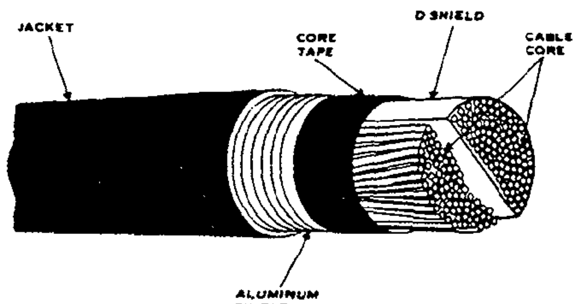

Figure 1 – Alpeth-FPA-D Shield Cable

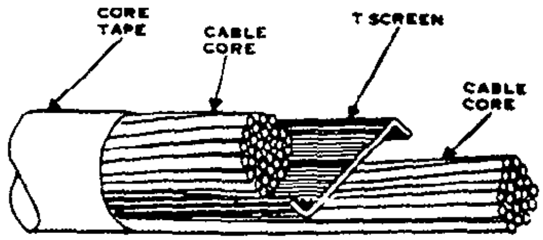

Figure 2 – Alpeth-FPA-T Screen Cable

Where cables without internal shields are to be used in applications requiring 100% of the pairs for PCM carrier, two separate cables must be used, one for each direction of transmission. The number of PCM systems that can be installed in a single cable without internal screening is controlled by the physical separation between groups of pairs for each direction of transmission. Generally, small-sized cable (12 pairs or less) does not permit sufficient separation to meet the minimum cross-talk requirement for PCM systems, so two cables are required. The larger the cable, the more pairs of a single cable (without internal screening) that can be used for PCM. This is because crosstalk coupling between high level output pairs and low level input pairs transmitting in opposite directions decreases as physical separation increases.

5.1.3.6 Armor

Armor may be applied outside the jacket or between the outer jacket and the shield. Generally, longitudinal steel tapes (flat or corrugated) are used for the internal armor of Alpeth- or Stalpeth-type cables to protect the core from gnawing animals or mechanical damage- Helically wound steel wire or flat tape, and longitudinal-welded and corrugated steel tape are used for external armor for lead sheath cables and/or cables for submarine or direct burial where severe abrasion or other mechanical hazards are anticipated.

5.1.4 CABLE DAMAGE CONSIDERATIONS

5.1.4.1 Causes

The specific cause of cable damage may be any combination of the following:

(a) Mechanical damage during placement.
(b) Mechanical damage by others after placement.
(c) Animal damage (squirrels, gophers, termites, ants, etc.)
(d) Power contact.
(e) Lightning.

(f) Electrolysis.

(g) Solvent contact (petroleum products).

(h) Vapor diffusion.

(i) Heat.

5.1.4.2 Effects

Physical damage to conductors or their insulation usually results in shorted, grounded, or open circuits at the time the damage occurs. The presence of moisture intensifies these faults.

A. Water is the most prevalent cause of trouble. It may enter cable through sheath ruptures, by vapor diffusion through plastic jackets, and through unsealed ends such as aerial ready-access terminal closures and buried cable pedestal-type housings. Water often accumulates at some location other than the point of entry in the form of liquid or vapor. The longer it remains in the cable, the more it causes deterioration and degradation. The dielectric constant of wet cable changes so that circuits become noisy. Noisy circuits can occur due to water bridging conductor imperfections, thereby causing high-resistance faults.

B. Carrier circuits are very susceptible to electrical deterioration when water enters the cable. Attenuation increases and impedance changes cause reflections and crosstalk. Water that can be tolerated in a cable at voice frequencies cannot be tolerated at the PCM carrier frequency (772 kHz). Moisture corrodes uncoated shields or armor, accelerating water accumulation in the cable, and over a period of time causes discontinuity of the shield to ground.

C. Lightning strikes near buried cable may rupture the outer jacket. The shield may also be ruptured. These ruptures are in the form of many small pinholes that provide a path for water entry. In most cases, the lightning itself does not damage the conductors; damage or deterioration usually results from accumulation of water in the core. The purpose of the inner jacket in dual-jacketed (DS) cables is to prevent this water from penetrating into the cable core.

5.1.4.3 Filling Compounds

The basic concept is to keep water out of the cable cores by filling the air space in the core with a material that is insoluble in water and that does not impair the physical or electrical characteristics of the cable. A typical blend of 85% petroleum jelly and 15% polyethylene is used as a filling compound that is forced under pressure into all interstices of the core and over the core wrap during assembly. It is recommended that filled cable not be considered as a pressure dam when filled-core cable is to be spliced to cable under pressure. An intermediate cable that can be dammed should be used.

5.1.5 CONDUCTOR INSULATION

5.1.5.1 Plastic

Various plastic materials are extruded as a continuous tube over the conductors. Various standard sheaths may be applied. The PIC's are color coded.

5.1.5.2 Polyethylene

A single layer of polyethylene is currently the material most widely used for PIC. Polyethylene-insulated conductor cables are moisture resistant, but an accumulation of water in the core can cause transmission degradation. Water generally enters polyethylene-insulated conductor cables through sheath openings and moisture can enter the cable via moisture diffusion through the sheath part at a very slow rate. A moisture barrier or dam must be placed in polyethylene cables at paper-polyethylene junctions to prevent moisture transfer from the polyethylene into the paper cable. The dielectric strength of plastic insulation is much higher than paper. Partial shorts or grounds are difficult to locate. Lightning surges on conductors, which would damage paper insulation, may be tolerated by polyethylene. Electrical protection from high voltages for paper insulated cable pairs should be applied at paper-pølyethy1ene junctions or at terminals on the polyethylene insulated conductor cable.

5.1.5.3 Polyvinyl Chloride

The conductors of Alvyn cables are dual insulated. A layer of PVC is applied over the polyethylene. The PVC does not support combustion, it burns when a flame is applied but extinguishes when the flame is removed. The PVC hardens at low temperatures and softens at high temperatures to a greater degree than polyethylene.

5.1.5.4 Polypropylene Copolymer

Propylene ethylene copolymer (referred to as polypropylene copolymer) or high-density polyethylene materials are used for conductor insulation in recently developed filled-core cables. This insulation is compatible with the standard titling compound and has essentially the same electrical characteristics as polyethylene conductor insulation. This filling compound has a dielectric constant significantly higher than air. This would increase the mutual capacitance of the cable if not counteracted. A nominal mutual capacitance of 0.083 uf per mile is attained by using thicker conductor insulation to increase the distance between conductors, which, in turn, increases capacitance.

The increased thickness of conductor insulation results in large diameter cables and the filling compound adds weight. The thicker insulation also results in lower attenuation at 722 kHz (T-1 PCM carrier frequency) because of the lower inductance. The filling compound may be removed from pairs for better handling in splices. Only clean rags or paper towels should be used because commercial solvents may damage the insulation or human skin.

5.1.6 SIGNIFICANT ELECTRICAL COMPARISONS

The differences in sheath configuration and conductor insulation results in different values for conductor-to-conductor dielectric strength. conductor-to-shield dielectric strength, and attenuation versus frequency.

5.1.6.1 Conductor-to-Conductor Dielectric Strength

The ac and dc potentials that paper or plastic insulation can withstand are shown graphically in Figure 3. It is apparent that protection from excess voltage is required to prevent conductor-to-conductor shorts or grounds. The substantial difference between paper and plastic breakdown values indicates why particular attention is given to junctions of paper-insulated and plastic-insulated cables.

5.1.6.2 Conductor-to-Shield Dielectric Strength

The different potential ratings for the various standard cables are shown in Figure 4. Two factors of cable configuration are the primary reasons for these differences. They are:

(a) The use of plastic conductor insulation as opposed to paper.

(b) The presence of an inner plastic jacket between the conductors and shield in DS cables-

This configuration provides the core with the protective insulation for the inner jacket from external voltages impressed on the shield at shield-to-ground connections or at point of penetration through the outer jacket by lightning strikes or sheath contact with power lines or induced fault currents. Two standard cables have the inner jacket between the shield and the conductors. They are Stalpeth-DS and Alpeth-FPA-DS. The Alpeth-FPA-DS cable has PlC's and, therefore, greater conductor-to-shield dielectric strength.

5.1.6.3 Attenuation versus Frequency

The tact that attenuation increases substantially at carrier frequencies is shown in Figures 5. The attenuation differences between paper-insulated-conductor, plastic-insulated-conductor, and plastic-insulated, filled-core cables are not significant when dry. It is apparent, however, that the filled-core cable is better in the 772 kHz range. This becomes more important when PCM carrier is used for toll and exchange service. The presence of moisture or water causes a significant change in attenuation. Paper-insulated cables become inoperable at any frequency when wet. Plastic-insulated cables may permit voice frequency circuit operation, however, transmission at carrier frequencies is substantially modified because of increased attenuation and changes in impedance and phase. The changes for unfilled, polyethylene-insulated No. 19 AWG, low-capacitance cable are illustrated in Figure 6. Filled-core cables prevent the presence of moisture and, therefore, are not as subject to moisture damage as paper or plastic cables with unfilled cores.

5.1.7 USAGE

5.1.7.1 General

The selection of the proper type of cable for each installation, whether aerial, underground, buried, or submarine, is based upon thorough consideration of the following:

(a) The relative importance and the degree of reliability required for the circuits to be applied to the cable pairs.

(b) A knowledge of the environment to which each particular cable installation is exposed.

(c) An understanding of the reasons for designing different types of cables for outside plant use.

(d) The relative speed and ease of trouble location and repair when required.

(e) First cost and expected maintenance cost tradeoffs (the law of diminishing returns).

Refer to Table 1 as a guide in selecting the proper cable.

5.1.7.2 Aerial

A. The mechanical strength and watertight requirements are less stringent for cables placed in the air. Careful location minimizes exposure to the hazards inherent to above ground construction. Pertinent observations concerning aerial cables are as follows:

(a) Subject to a wide variety of damage sources.

(1) Vehicles, movement of drilling rigs, cranes, etc.
(2) Fires and heat
(3) Environmental - wind, hail, blowing sand, rain, etc.
(4) Abrasion by tree limbs
(5) Falling power lines

(b) Subject to relocation.

(1) Roadway work
(2) Private drives
(3) Building construction

(c) Subject to limitations.

(1) Aesthetics and roadway work
(2) Pole line configuration
(3) Space on pole
(4) Cable weight limitations

(d) Pole line costs must be considered part of aerial cable cost.

(e) Easiest and quickest to install or replace once pole line is established.

(f) Is not prone to damage during placement operations.

(g) Cable and associated terminals less expensive.

(1) Not subject to total immersion in water or contact with chemicals.

(2) Cable vents can prevent water accumulation in the core due to condensation or through lightning caused sheath pinholes.

(h) Readily visible and accessible.

(1) Trouble located quickly

(2) Trouble repaired at lower cost

B. Cables with paper conductor insulation and cables with plastic conductor insulation carrying interoffice circuits should be pressurized. Cables with an inner sheath between the core and shield may be specified where exposure to high lightning incidence or other high voltage is known to exist. Other special sheaths may be specified for unusual conditions such as government regulations for mechanical and/or animal hazards.

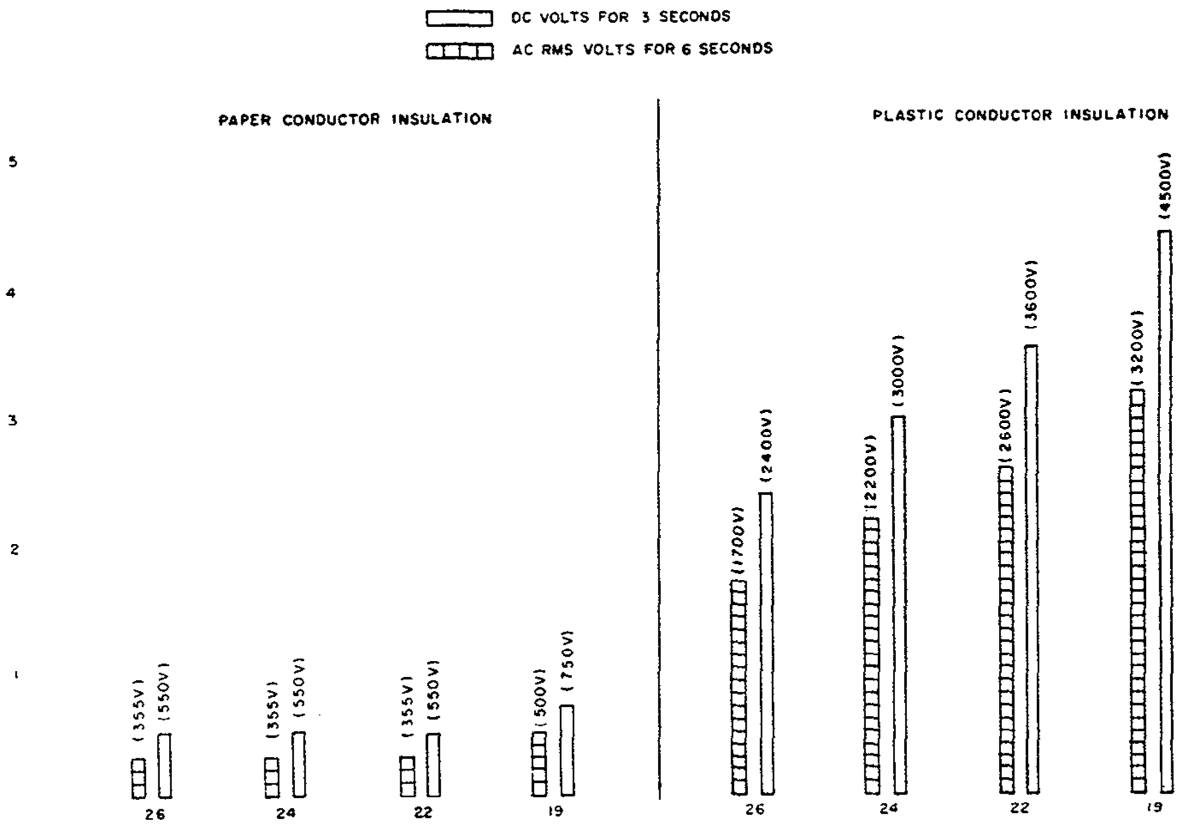

Figure 3 – Conductor-to-Conductor Dielectric Strength

5.1.7.3 Underground

A. Cables placed in conduit outside of buildings below ground level are considered underground cables. Underground cables are usually constructed in urban areas along major cable routes from the CO through densely populated areas. These cables generally function as a main connecting link between the CO and smaller cables terminating on connector blocks near the customer's location. Smaller underground cables are often extended from the major cable route to customer locations in built-up areas. Underground cables may also be used at railroad, highway, or bridge crossings in locations where the other methods of cable placement are inappropriate.

B. Requirement for water tightness, resistance to chemicals, and quick trouble location are critical with underground cable. Underground construction is inherently exposed to fewer hazards than aerial construction. Pertinent observations concerning underground cables are as follows:

(a) Underground cables are usually large and several are located in each major route. They serve many customers located in various community areas.

(b) Rarely subject to relocation.

(c) Subject to occasional severe damage.

(1) Digging by excavating contractors
(2) Total immersion in water, gasoline, etc.
(3) Natural gas leaks, explosion, fire
(4) Electrolysis
(5) Cuts by shifting conduit sections

(d) Subject to limitations.

(1) Routes and right-of-way available.
(2) Quantity of vacant conduit duct
(3) Size of ducts
(4) Manhole size and location

(e) Conduit and manhole costs must be considered part of underground cable costs.

(f) More difficult to install than aerial cable.

(1) Manholes must be cleared of gases and water
(2) Ducts Cleaned and flushed
(3) Vehicular traffic detoured

(g) Not prone to damage during placement.

(h) Underground cables are usually more expensive than aerial.

(1) Generally more pairs
(2) Subject to total immersion in water and contact with chemicals
(3) Should be pressurized

(i) Not visible, difficult to access.

(1) Trouble location may be time consuming
(2) Very expensive to repair between manholes

(j) Normally, less subject to lightning damage than buried or aerial facilities.

Cables with fully color-coded, plastic-insulated conductors may be used to advantage in building entrance cables, laterals to aerial or buried cables, and cross-connection point, repeater terminations, etc.

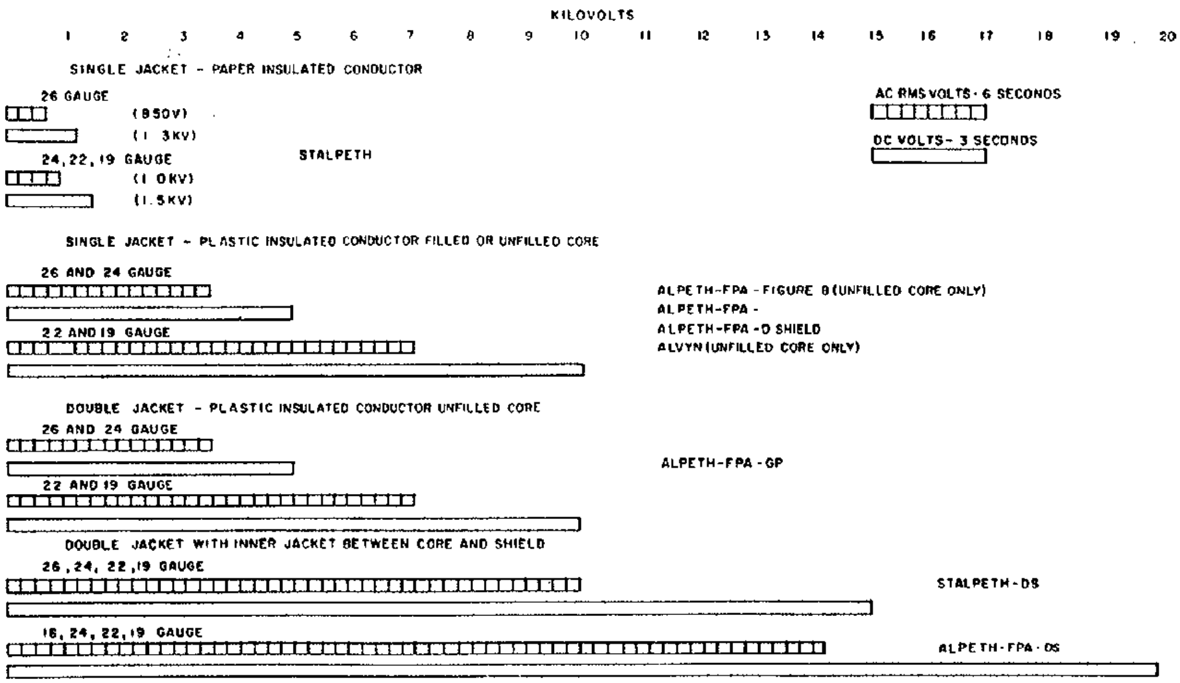

Figure 4 – Conductor-to-Shield Dielectric Strength

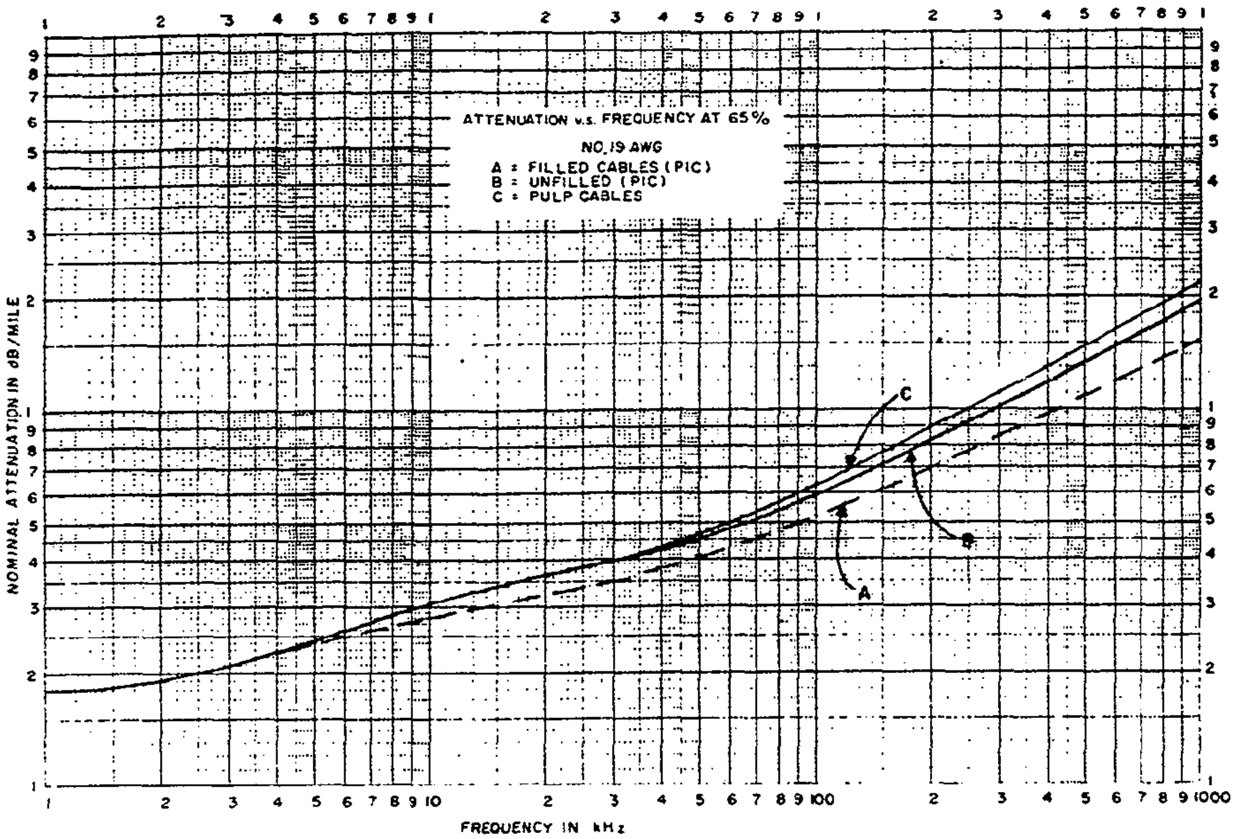

Figure 5a – Attenuation versus Frequency for No. 19 AWG

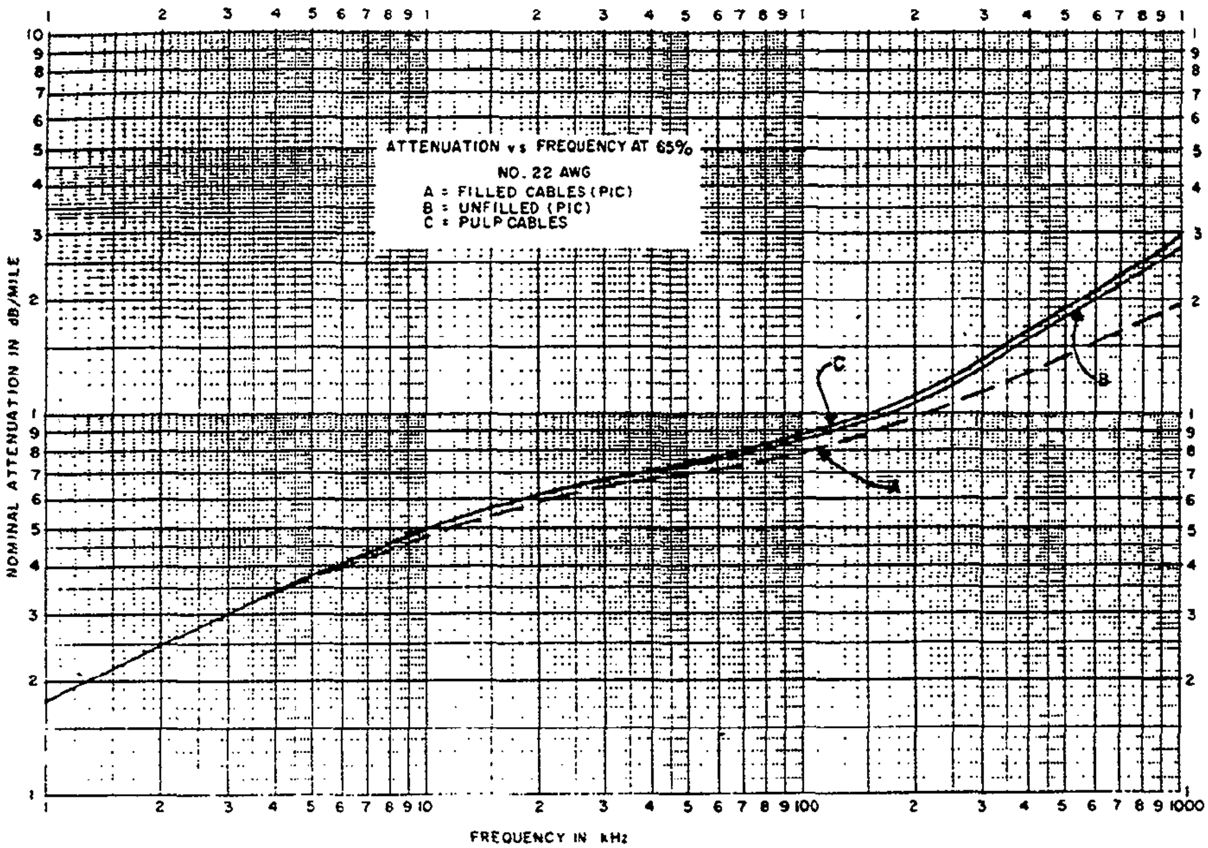

Figure 5b – Attenuation versus Frequency (Continued) for No. 22 AWG

5.1.7.4 Buried Cables

A. Buried cables are those placed in direct contact with the earth by trenching or plowing methods. The trend toward buried cable will continue to increase. Buried cable is being placed in most new developments and as replacement for much aerial wire or small cables in rural areas. Many government and regulatory agencies are enacting legislation requiring the use of subsurface cable in new developments. The use of buried cable for exchange and interoffice circuits will continue to increase as materials and methods improve. Mechanical and water tightness requirements are critical for buried cables. Pertinent observations concerning buried cables are as follows:

(a) Subject to damage less frequently than aerial cable but more frequently than underground cable.

(1) Sheath damage during placement

(2) Flood washout

(3) Total immersion in water
(4) Chemical contact
(5) Rodent
(6) Digging by excavators
(7) Electrolysis
(8) Lightning

(b) Subject to relocation

(c) Subject to limitations

(1) Right-of-way
(2) Type of soil
(3) Subsurface obstacles

(d) Initial buried cable installation does not prepare a route for additional cables to the extent an aerial cable pole line or underground cable conduit system does.

(e) More difficult to install than aerial or underground cables.

(1) Landscape damage and restoration costs may be extensive.
(2) Weather and seasons can sharply curtail placement operation.

(f) Prone to damage during placement.

(g) Buried cables may be more expensive than aerial or underground cables.

(1) Watertight integrity and resistance to crushing is critical.
(2) Filled core cables should be used.
(3) More use of DS and armored cables is required.

(h) Not visible and difficult to access.

(1) Trouble may be difficult to locate and expensive to repair.
(2) Repair may be time consuming.

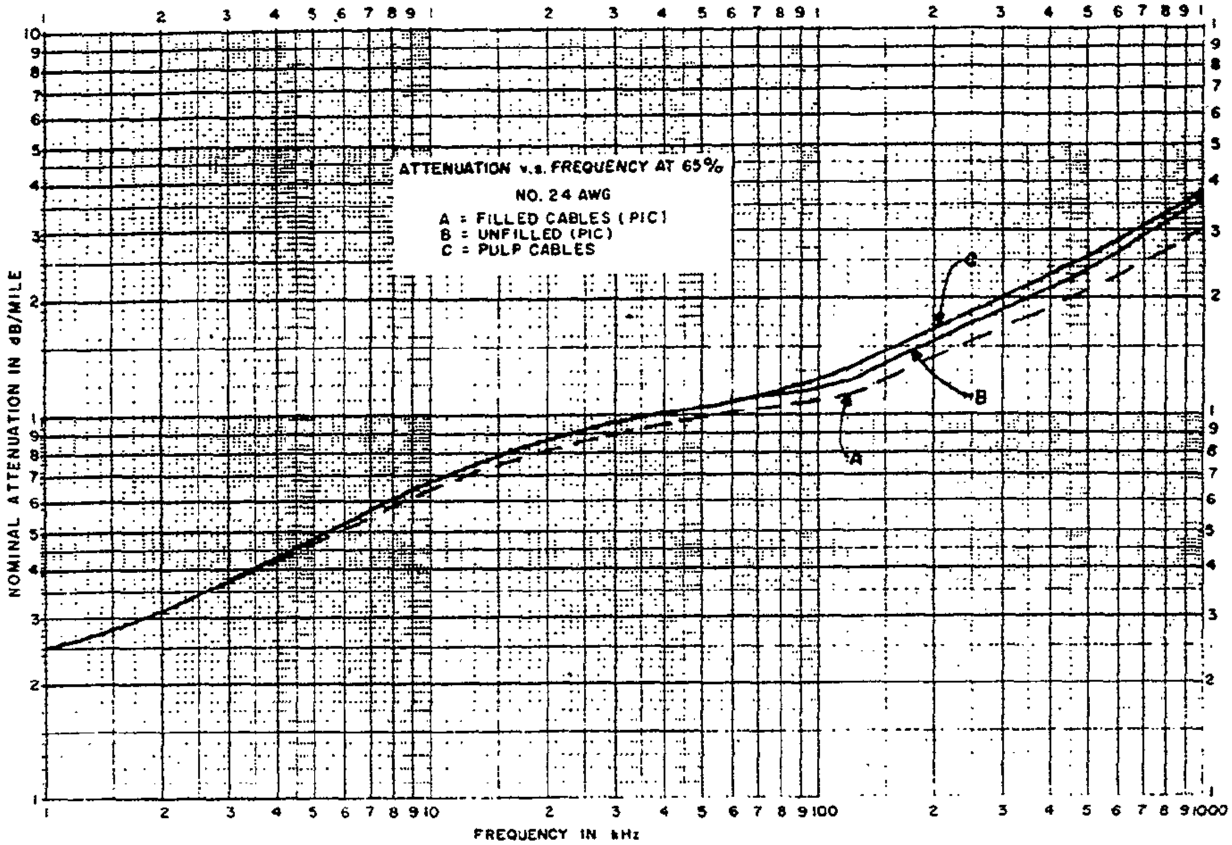

Figure 5c – Attenuation versus Frequency (Continued) for No. 24 AWG

B. Cables with plastic conductor insulation are widely used for buried cable. This is primarily due to the water resistant properties of polyethylene as compared to paper. This same property makes it very difficult to locate water accumulations in the core at locations where there is no damage to conductors or insulation. The sheath may be punctured, establishing one or more points of entry for water, without conductor damage. These punctures may be almost impossible to locate when water accumulates at some other place.

C. Most damage to buried cables occurs during placement or within the first 3 years after placement. Damage after placement is largely due to excavation and grading work in developing areas. Damage during placement is largely due to crushing or puncture when cable is placed by the plowing method. Five types of cable have been developed specifically for direct burial. They are as follows:

(a) Alpeth-FPA-DS. A DS cable with an inner jacket between core and shield.

(b) Alpeth-FPA-Filled Core. The standard single jacket Alpeth sheath with a filled core and compatible conductor insulation.

(c) Alpeth-FPA-D Shield-Filled Core. The standard Alpeth D shield cable with a filled core and compatible conductor insulation.

(d) Alpeth-FPA-T Screen-Filled Core. The standard Alpeth T screen cable with a filled core and compatible conductor insulation.

(e) EPA-ASP-Filled Core. The standard ASP cable with a filled core and compatible conductor insulation.

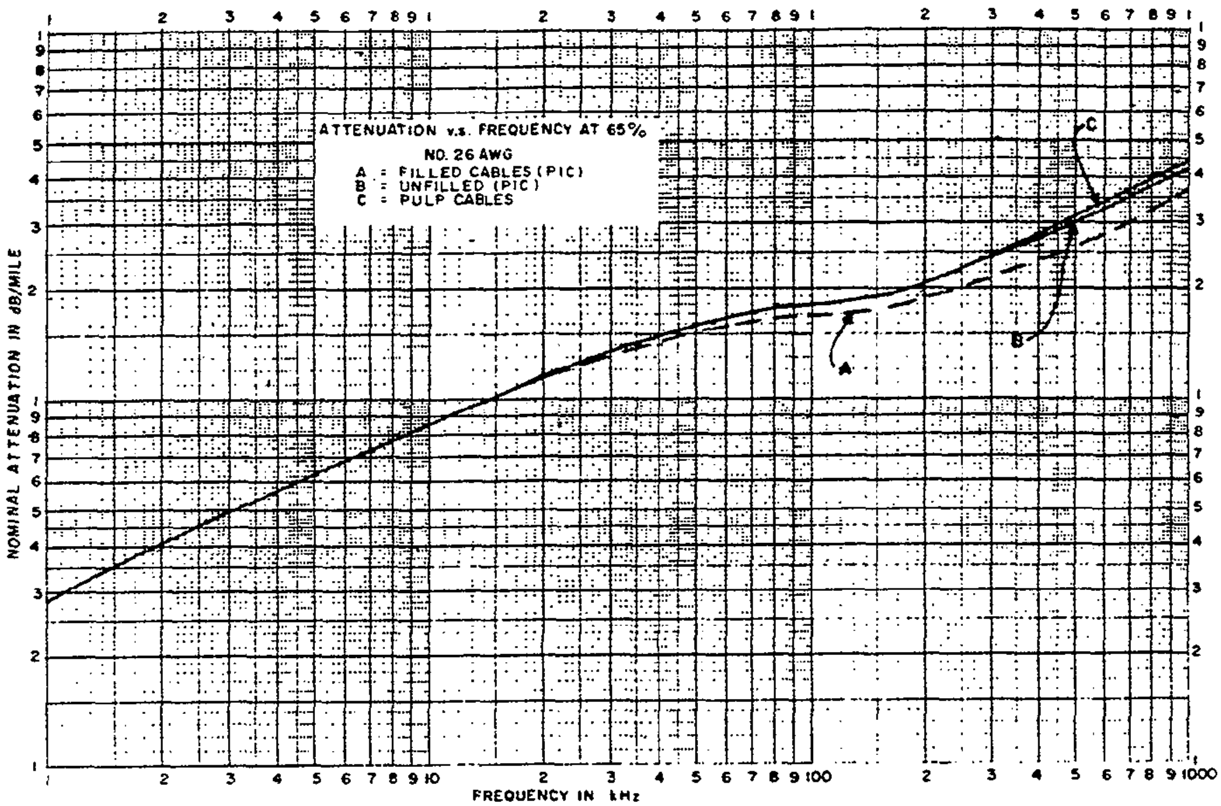

Figure 5d – Attenuation versus Frequency (Continued) for No. 26 AWG

D. The use of standard Alpeth EPA for buried cables should be restricted to areas of easily plowed, well drained soil where sheath damage is unlikely. Filled-core cables are expected to become the prevalent type for use as buried cables because of the expected reliability under wet conditions, thus reducing the likelihood of service degradation in unfilled cables.

5.1.7.5 Submarine

A. Submarine cables are those placed under large bodies of water such as rivers, lakes, bays, or oceans. Their use is avoided as much as possible and, in most companies needs are limited to river and small lake crossings. The mechanical water tightness requirements are the most stringent of all cable types. Some pertinent observations concerning submarine cable are as follows:

(a) Subject to server damage conditions.

(1) Current and tides
(2) Ice
(3) Anchors
(4) Debris

(b) Subject to limitations.

(1) Right-of-way
(2) Government regulations
(3) Sunken obstacles

(c) Difficult to install.

(d) Submarine cables most expensive types.

(e) Not visible, difficult to access, cannot be repaired in place.

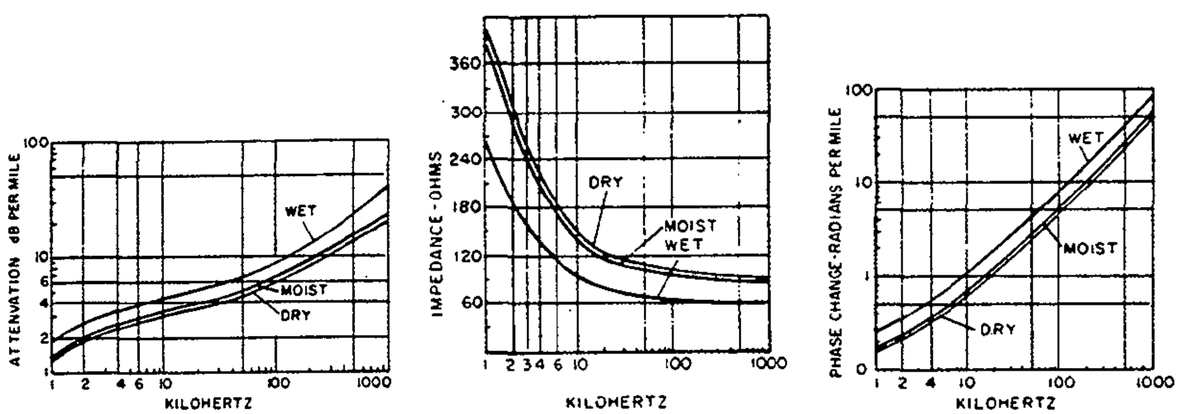

Figure 6 – No. 19 AWG Low-Capacitance PIC Cable

B. Submarine cables are typically lead and armor sheath with a dense core of double-wrap, paper-insulated conductors. The construction is such that water penetration is retarded if a break in the sheath occurs. The new filled-core cables should suffice for mild conditions, such as swamps, small streams, ponds, etc.

5.1.8 STANDARD CABLES

5.1.8.1 Alvyn

A. Alvyn sheath (Figure 7) consists of a corrugated 0.008-inch aluminum shield with an adhesive on the outer surface applied longitudinally with overlapped seam and covered overall with a PVC jacket. The adhesive layer bonds the jacket to the aluminum shield, which improves bending and handling characteristics.

B. Alvyn cable is designed for use as a flame resistant terminating cable. It is not suitable for pressurization.

5.1.8.2 Alpeth-FPA

A. Alpeth-FPA sheath cables (Figure 8) consist of 0.008-inch low-resistance aluminum shielding tape with a polyethylene film fused and chemically bonded to both sides, longitudinally folded with overlap, and a black high-molecular-weight polyethylene jacket overall. The cable jacket is marked sequentially at regular intervals along its length.

Table 1 – Summary

CABLE TYPE	FIELD OF USE											
	BURIED			UNDERGROUND			AERIAL			SUBMARINE		
	EXCH	I.O.	PCM ONLY	EXCH	I.O.	PCM ONLY	EXCH	I.O.	PCM ONLY	EXCH	I.O.	PCM ONLY
Alvyn							X(3)	X(3)				
Alpeth	X(4)			X(5)			X	X				
Alpeth - Fig. 8							X	X				
Alpeth, Filled	X	X								X(10)	X(10)	
Alpeth D Shield									X(6)			
Alpeth D Shield, Filled			X(6)			X(6)						X(10)
Alpeth T Screen									X(6)			
Alpeth T Screen, Filled			X(6)			X(6)						X(10)
Alpeth – GP	X(7)						X	X				
Alpeth - GP. Filled	X	X								X(10)	X(10)	
Alpeth – DS	X(8)	X(8)		X(9)	X(9)		X(9)	X(9)				

NOTES:

I.O.= CO-to-CO cables or cable complements.

(3) Used for building riser and terminating cables.

(6) Developed for bidirectional operation of PCM carrier frequencies in one sheath. Also, used in place of cables in sizes, which would not permit sufficient separation between binder groups.

(7) For dry, sandy rodent infested areas.

(8) Maybe used where size in not available in Alpeth, filled core.

(9) May be used in areas of severe lightning or fault current hazard. Has highest conductor-to-conductor and conductor-to-shield dielectric strength.

(10) Special, single or double-armored submarine cables should be used for locations where severe currents, tides or depths are factors.

(11) Air core cable from existing excess/surplus stock can be used in conduit for underground applications provided re-enterable encapsulated splice closures are utilized.

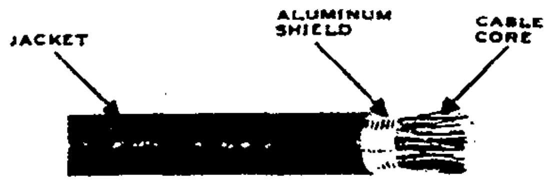

Figure 7 – Alvyn Terminating Cable

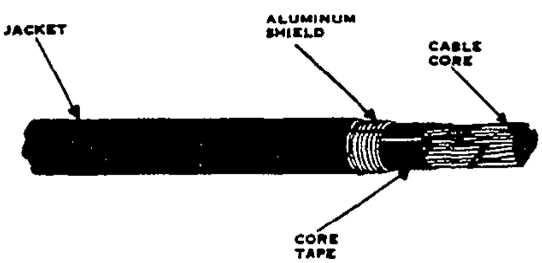

Figure 8 – Alpeth-FPA Cable

B. This cable is suitable for aerial installation. It may be used for direct buried installation for exchange use in areas where there is low risk of mechanical or lightning damage to the outer jacket.

5.1.8.3 Alpeth-FPA-Filled

A. The sheath is the same as EPA cable. A filling compound replaces the air in the core of the cable. Filled-core cables are larger in diameter and are heavier than air-core cables. The basic idea of the core filling is to prevent moisture entry or migration by occupying the voids in the cable with a flexible water insoluble compound.

B. Filled-core cables are designed for direct buried installation. Because characteristic data of filled cable utilized in aerial applications is insufficient, aerial inserts must be limited to two spans. They may also be used for some submarine applications. They are recommended for buried interoffice circuits and for exchange PCM carrier base pairs.

5.1.8.4 Alpeth-FPA Figure 9

A standard Alpeth-FPA core (Figure 9) up to and including the shield is laid parallel to a 1/4-inch. seven-wire Extra High Strength (ENS) galvanized steel support strand (6,600 pounds breaking strength) over which a single Figure 9 extrusion of black high-molecular-weight polyethylene is applied. All interstices (inner and outer) of the support strand are filled with a flooding compound to prevent water ingress, thereby providing strand corrosion protection. The cable jacket is sequentially marked at regular intervals along its length.

5.1.8.5 Alpeth –FPAD-D Shield, Filled and Unfilled

A. Alpeth-FPA-D shield cable (Figure 15) has been developed for bidirectional operation of PCM carrier frequencies in one sheath. The D shield cable is available with unfilled or with filled core. The filling compound is the same as that used in other filled-core cables. The internal D shield electrically separates the core of the cable in two compartments. This shield is a 0.004-inch aluminum tape insulated with a nonhygroscopic tape to provide corrosion and moisture resistance and dielectric strength between conductors and internal screen.

B. The D shield cables are designed for use where the small-sized cables do not allow sufficient physical separation of pairs for two way PCM operation.

5.1.8.6 Alpeth-FPA-T Screen. Filled and Unfilled

Alpeth-FPA-T Screen cable (Figure 16) has been developed for bidirectional operation of PCM carrier frequencies in one sheath. It is available with an unfilled or a filled core. The filling compound is similar to that used in other filled-core cables. The internal T screen electrically separates the core of the cable into two compartments. This screen is a 0.004-inch aluminum tape insulated with a nonhygroscopic tape to provide corrosion and moisture resistance and dielectric strength between conductors and internal screen. The T screen cables are designed for use where the small-sized cables do not allow sufficient physical separation of pairs for two-way PCM operation.

5.1.8.7 FPA-ASP-Filled

The EPA-ASP-Filled cable (Figure 17) is the same as Alpeth filled cables up to and including the aluminum shield. Over the aluminum shield is placed filling compound and a 0.006-inch corrugated steel tape, longitudinally applied with an overlap. A flooding compound is applied to this tape with a high-molecular-weight jacket extruded over the steel tape. It is intended to be used where animal damage is expected, and in other areas where additional mechanical protection is required.

5.1.8.8 Alpeth-FPA-Double Sheath

Alpeth-FPA-DS sheath (Figure 11) consists of the Alpeth EPA sheath plus a high-molecular weight polyethylene inner jacket The inner jacket provides protection against water entry should the outer jacket be ruptured or be "pinholed" by nearby lightning strikes. The inner jacket can withstand a 20,000'volt dc potential for 3 seconds, thus providing additional core-to-shield insulation. This cable is designed for direct burial installations.

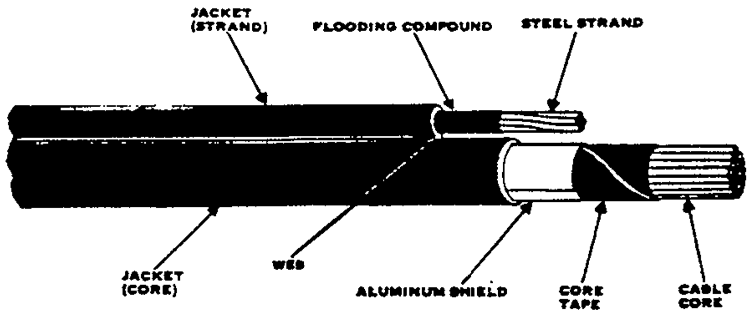

Figure 9 – Alpeth-FPA Cable

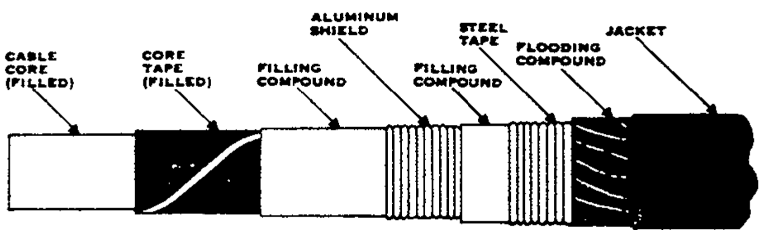

Figure 10 – FPA-ASP, Filled Cable

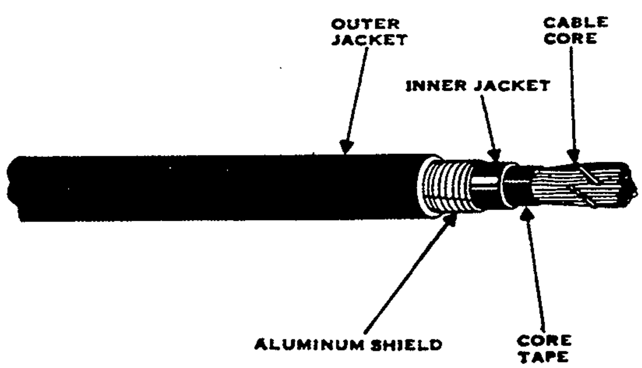

Figure 11 – DS Alpeth-FPA Cable

5.2 Plastic Insulated Conductor Cable, Description

5.2.1 General

A. This section provides a description of Plastic-Insulated Conductor (PIC) cable used for outside plant installation and as terminating cable on distributing frames.

B. The new cable arrangements reduce crosstalk loss at carrier frequencies more effectively than the previous cable designs that were not recommended for carrier usage. Information is provided for the core layup of 50-pair, 19 gauge cable that is identical to the core layup of 22-, 24-, and 26-gauge cable. Also, the following cable designs have been added:

(a) Alpeth, single sheath will filled cores.

(b) Alpeth, internally shielded with filled and unfilled cores.

(c) Aluminum, Steel-Polyethylene (ASP) with filled cores.

(d) Alvyn, Terminating with unfilled cores.

C. This section is reissued to furnish updated information for PIC cable with single, multiple, and self-supporting sheath designs and also deletes the use of Bupic and steel-armored cables as described in the previous issue. Because this is a complete revision and extensive changes are involved, marginal arrows are omitted. Remove the previous issue of this section from the binder or microfiche file and replace it with this issue.

5.2.2 SHEATHS

A. Cables having a polyethylene sheath and a metallic shield are normally associated with the term PIC. The cable cores consist of solid annealed copper conductors individually insulated with a colored polyolefin compound, usually polyethylene or propylene ethylene copolymer. In addition to the primary conductor insulation, Alvyn cable has a secondary insulation of Polyvinyl Chloride (PVC) over the primary insulation for flame and abrasion resistance. The required number of individual cable conductors are twisted into color-coded pairs for identification and stranded into units. The cabled units are covered by a nonhygroscopic (moisture-resistant), high-dielectric-strength core wrap tape which is usually polyethylene. For Double-

Sheath (DS) cable a core wrap tape that is only moisture resistant is required to serve as a heat barrier during jacketing.

B. The single-sheath cable design consists of a 0.008-inch aluminum shield applied longitudinally over the core wrap tape, wrapped circumferentially about it and overlapped. For small core diameters (0.68 inch or less), the shield is smooth; for larger cores, the shield is corrugated. The shield is coated on both sides with a film of polyethylene copolymer that is fused and chemically bonded to form a protective coating against corrosion. An outer jacket of black High-Molecular-Weight (HMW) polyethylene is extruded with a limited bond over the shield.

C. The DS cable design consists of the components described in paragraph 2.02 plus an additional inner jacket & HMW polyethylene between the core tape and the aluminum shield.

D. The self-supporting cable design also consists of the components described in paragraph 2.02 plus extra high-strength steel messenger (Figure 1) attached to the sheath by a web of polyethylene.

E. With filled cable, a nonhygroscopic filling compound completely fills all the interstitial spaces within the core, with no voids remaining to restrict the passage of water. A typical blend of filling compound consists of 15%, low-density polyethylene and 85% petroleum jelly that is nontoxic and dermatologically safe for exposed skin. The filled cable sheath may be any one of the following combinations:

(a) Core, core tape, filling compound, aluminum shield, and outer jacket.

(b) Core, core tape, filling compound, aluminum shield, additional filling compound, and outer jacket.

(c) Core, core tape, filling compound, aluminum shield, thermoplastic flooding compound, and outer jacket.

F. The following is a list of the various types of cable designs. If necessary, the individual characteristics of the sheaths are given in addition to the basic descriptions outlined in paragraphs 2.01 through 2.05. Reference is also given to other sections that describe the various cables.

5.2.2.1 Alpeth, Single Sheath, Filled and Unfilled Cores

As with a great majority of cable, the generic name Alpeth is derived from the major sheath components of Aluminum and Polyethylene. The unfilled cable (Figure 2) is suitable in exchange area aerial construction to provide circuits for low- and medium-density routes.

5.2.2.2 Alpeth, Self-Supporting, Unfilled Cores

This cable (Figure 12) has the same basic function as single-sheathed cable except that an integral support strand is provided for one operation installation of the cable and messenger. The messenger is composed of a seven-wire, 1/4-inch galvanized steel strand with a 6,600-pound breaking strength, laid parallel to the cable core with a 0.10-inch separation. Both are covered by a jacket to form a Figure 8 configuration, maintaining the 0.010-inch separation by a web. All strand interstices are filled with a thermoplastic sealing compound.

5.2.2.3 Alpeth, Internally Shielded (Screened), Filled and Unfilled Cores

These cables (Figures 15 and 16) are designed for two-way T1 Pulse Code Modulation (PCM) carrier operation with two types available:

(a) D Shield. This cable has an added 0.004-inch aluminum D-shaped shield insulated with a nonhygroscopic material, assembled longitudinally, and totally enclosing one-half of the core into two compartments. This isolates the pair groups to permit simultaneous transmission in both directions.

(b) T Screen. This cable is identical to the D-shielded cable with the exception that the D shield is replaced by a T screen that is Z shaped and partially, not totally, encloses the core into two separate compartments.

5.2.2.4 ASP, Filled Cores

The cable core of this design (Figure 17) consists of the components described in paragraphs 2.02 and 2.05; however, the aluminum shield is not overlapped. The cable has an added 0.006-inch corrugated steel shield applied in firm contact longitudinally over the aluminum shield with the corrugations of the two coinciding. A filling compound is applied under the aluminum shield and also between the aluminum and steel shields. A thermoplastic flooding compound is applied over the steel shield. This cable is used for low-, medium-, and high-density direct buried telephone circuit routes where additional mechanical protection is required for gophers, other gnawing animals, or mechanical hazards.

5.2.2.5 Alvyn, Unfilled Cores

The name Alvyn is derived from the sheath components of Aluminum and polyvinyl chloride. This cable (Figure 18) has dual-insulated conductors; color-coded PVC over a neutral HMW polyethylene; and was designed primarily for terminating plastic-, pulp-, and paper-insulated telephone cables on protector frames in central offices where sealed chamber terminals are not required. Alvyn cable is only available in 22 or 24 gauge, and the sheath differs from Alpeth cable in that the material is PVC.

5.2.3 ELECTRICAL CHARACTERISTICS

5.2.3.1 Insulation Resistance

Each conductor in any reel of completed cable, when measured against all the other conductors and the grounded cable shall have a minimum insulation resistance when measured at or corrected to the temperature indicated, with a voltage application of 500 Vdc for a minimum of 1 minute as follows:

(a) Alpeth Cable. 1,000 mega ohms per mile at 20°C.

(b) Alvyn Cable. 4,000 mega ohms per 1,000 feet at 20°C.

5.2.3.2 Conductor Resistance

Each conductor in any reel of completed cable, when measured at or corrected to 20°C, should not exceed the direct current resistance as indicated in Table 1.

5.2.3.3 Resistance Unbalance

The difference in dc resistance between the two conductors of a pair as measured on a reel of completed cable shall not exceed the values indicated in Table 2.

5.2.3.4 Dielectric Strength

The insulation between conductors of each pair, between each conductor and the shield, and between the shield and the outer surface of the cable jacket shall be capable of withstanding either the ac or dc voltages specified for the time shown in Table 3.

5.2.3.5 AC Mutual Capacitance

The ac mutual capacitance on a reel of completed cable, when measured at an ambient air temperature of 200 C ± 5°C shall not exceed the amount shown in Table 4.

5.2.3.6 Capacitance Unbalance

The pair-to-pair capacitance unbalance for all gauge sizes should not exceed a maximum average rate of 19.6 pF and a maximum individual rate of 80 pF when converted to 1,000 feet. The pair-to-ground capacitance unbalance, when measured at 1,000 Hz ± 100 Hz for all gauge sizes shall not exceed a maximum average rate of 200 pF and a maximum individual rate of 1,000 pF when converted to 1,000 feet.

5.2.3.7 Attenuation

For engineering purposes, the attenuation at 1,000 Hz, using the values for resistance and capacitance specified, can be calculated using the following formula: Loss in dB = $0.69 \sqrt{RC}$, where R would equal a single-conductor resistance in ohms per mile and C would equal the mutual capacitance of a pair in microfarads (MF) per mile. Tables 5a and 5b list the nominal attenuation figures at 1 kHz and 772 kHz for unfilled and filled cable. Table 6 lists the nominal temperature coefficient figures at 772 kHz for unfilled and filled cable. The approximate values at 772 kHz as shown in Tables 5b and 6 are for information purposes only. These values are based on data measured on reels. The values for individual pairs within the cable may differ from the tabulated value. Field measurements may differ from factory measurements due to differences in measuring practices and/or test equipment.

5.2.3.8 Nonconforming Pairs

No more than the number of pairs indicated in Table 7 may be outside the electrical parameters as stated in this part.

5.2.4 MECHANICAL CHARACTERISTICS

5.2.4.1 Each of the various cables should meet the overall dimensions as listed in Tables 8 through 17. Cables of 25 pairs or less are formed by stranding pairs together in concentric layers. Cables of 50 pairs or more are formed by stranding pairs together in concentric layers to form units and, subsequently, cabling the units together in concentric layers.

5.2.4.2 All cables are shipped free of water and sealed with end sealing caps- Cables shipped under pressure are sealed, and the end seal on the inner end of the cable is equipped with a valve. Cables shipped with an attached pulling eye have their inner ends sealed and their outer ends equipped with a metal cap that has the pulling eye attached to it. Cables are shipped on reels having a minimum drum diameter of 13 times the cable diameter.

5.2.4.03 Conductors

Each conductor in completed cable is solid soft or drawn and annealed copper wire. Joints in conductors should be avoided. Unavoidable joints should be brazed, using a silver alloy solder and nonacid flux, or welded. All conductors should be free from shorts, crosses, and grounds

5.2.5 CORE CONSTRUCTION

5.2.5.1 Even-count PIC's have a color code consisting of five basic colors (blue, orange, green, brown, and slate) for the ring conductors and five basic colors (white, red, black, yellow, and violet) for the tip conductors. Each tip conductor color is repeated five times within each group of five ring conductors; thus, a different color combination is associated with each pair in a binder group of 25 pairs (Table 18).

5.2.5.2 The pairs in each binder group of 25 pairs and the binder strings are color coded (Table 19). This permits identification of any binder group or conductor pair by color, no two pairs of conductors within any particular bundle being color coded the same. This condition permits easy splicing of binder groups and conductor pairs by color code. In some cable sizes, the mechanical layup requires that a binder group be divided into two units. Each unit is bound with the same color coded binder string, and thus, readily identifiable as part of a particular binder group. It is, therefore, possible to color code each of the pairs in a 26-pair binder group and to color code 24 binder groups and repeat for larger cables.

5.2.5.3 Figure 19 shows the core assembly of cables containing 19-, 22-, 24-, and 26-gauge conductors in cables of 3 through 900 pairs, except for the cables described in paragraphs 5.04 through 5.06. Cables of 25 pairs or less do not contain unit binders. Individual units are made up of pairs. Superunits are divided into two binder groups, each containing 25 pairs. Superunits of 50 pairs are used for the center of the 200-pair cable and for all the units of the 600-and 900-pair cables.

5.2.5.4 The D-shield cable has two additional pairs per carrier group, one pair under the shield and one pair outside the shield. These pairs are always used for carrier test and control and never for transmission purposes. Where more than one carrier system is involved, additional control pairs are provided (Figure 21).

5.2.5.5 The T-screen cable in the 26-, 52-, and 104-pair sizes has 1, 2, and 4 additional pairs, respectively. These pairs also are always used for carrier test and control purposes and never for transmissions (Figure 22).

5.2.5.6 Alvyn cable in the 26-, 51-, and 101-pair sizes has one additional pair per cable. Cables over the 101-pair size have one additional pair per 100 sheath pairs per cable. In cable sizes of 51 pairs and larger, the additional pairs are located in the outer interstices between the units. The 12-pair cable contains no additional pairs (refer to Figures 23, and 24).

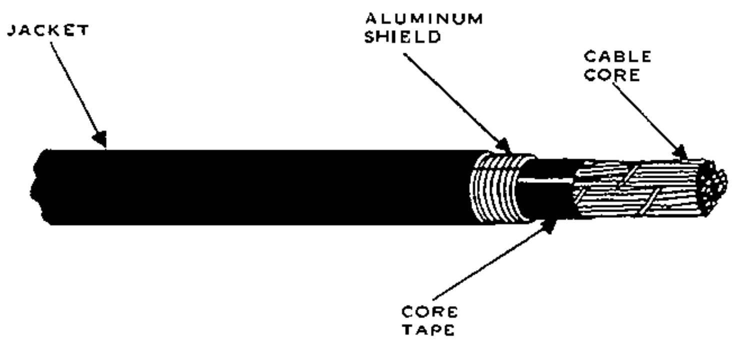

Figure 12 – Alpeth Cable, Single Sheath

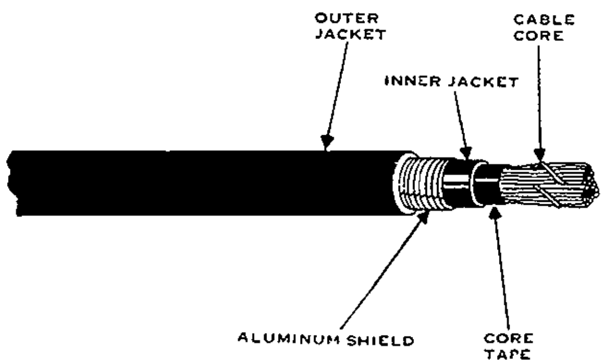

Figure 13 – Alpeth Cable, Double-Sheath

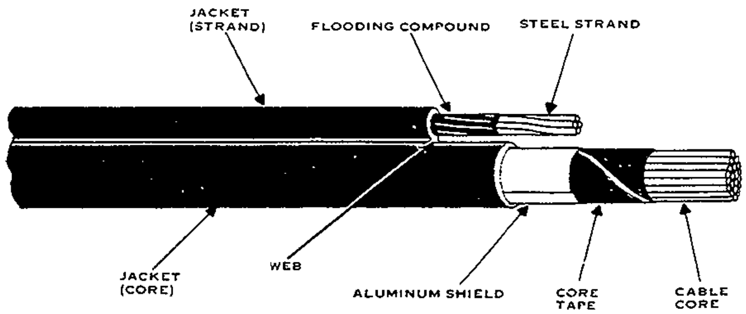

Figure 14 – Alpeth Cable, Self-Supporting Sheath

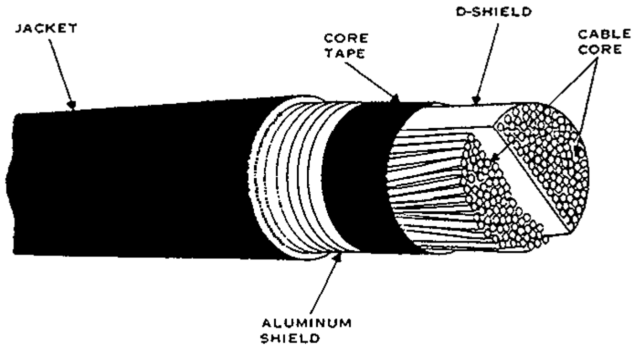

Figure 15 – Alpeth Cable, D-Shield

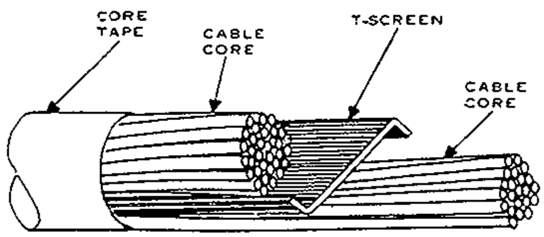

Figure 16 – Alpeth Cable, T-Screen

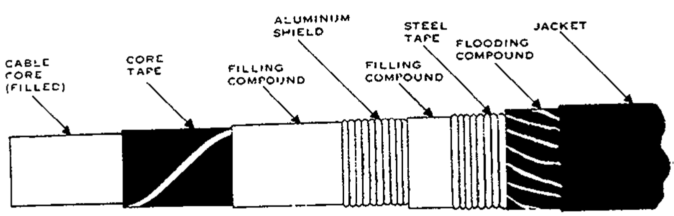

Figure 17 – ASP Cable

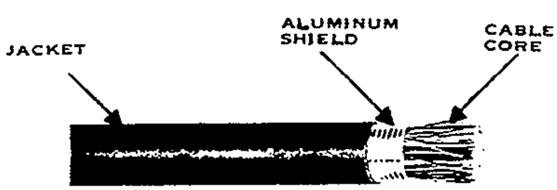

Figure 18 – Alvyn Cable

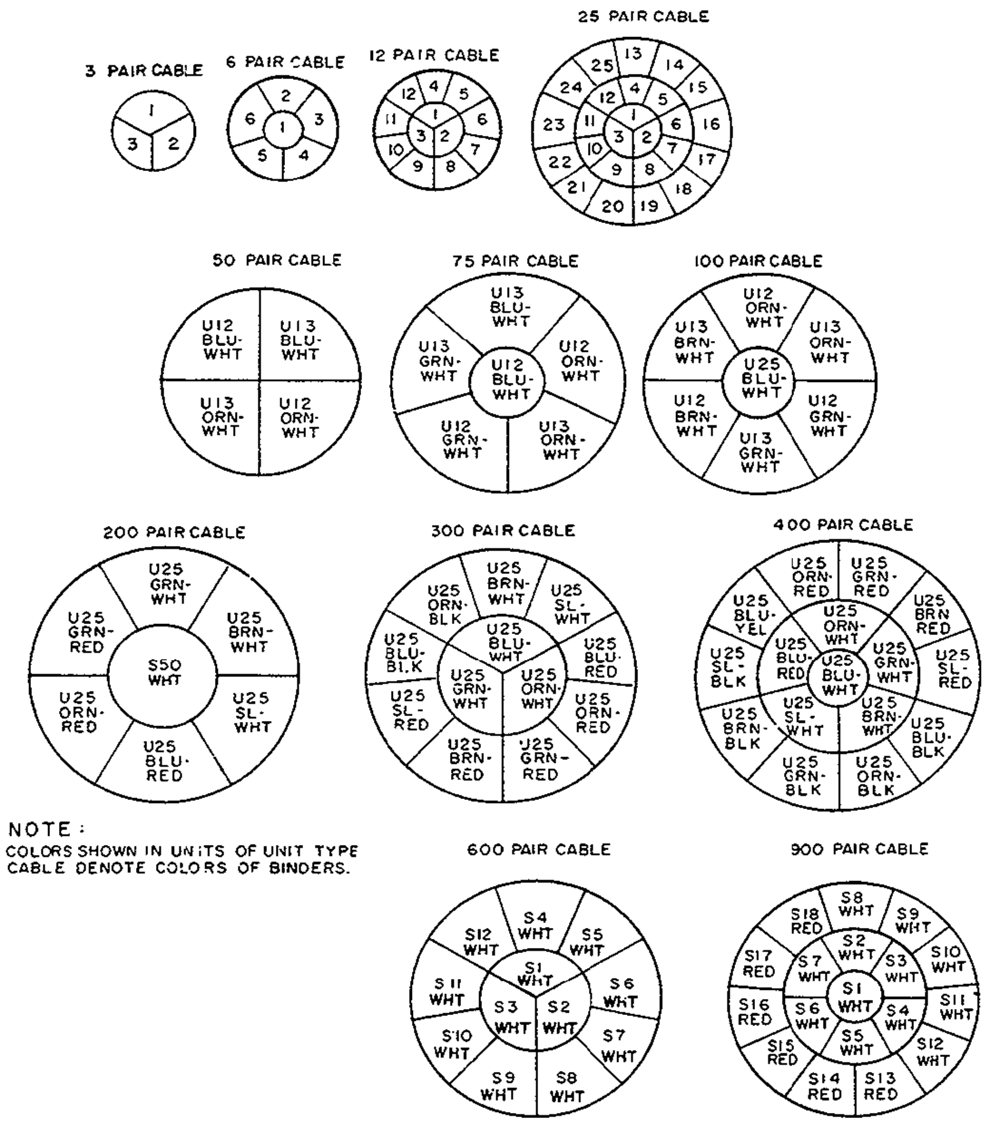

Figure 19 – Core Arrangement, PIC Cable
(Except Alvyn and Internally Shielded)

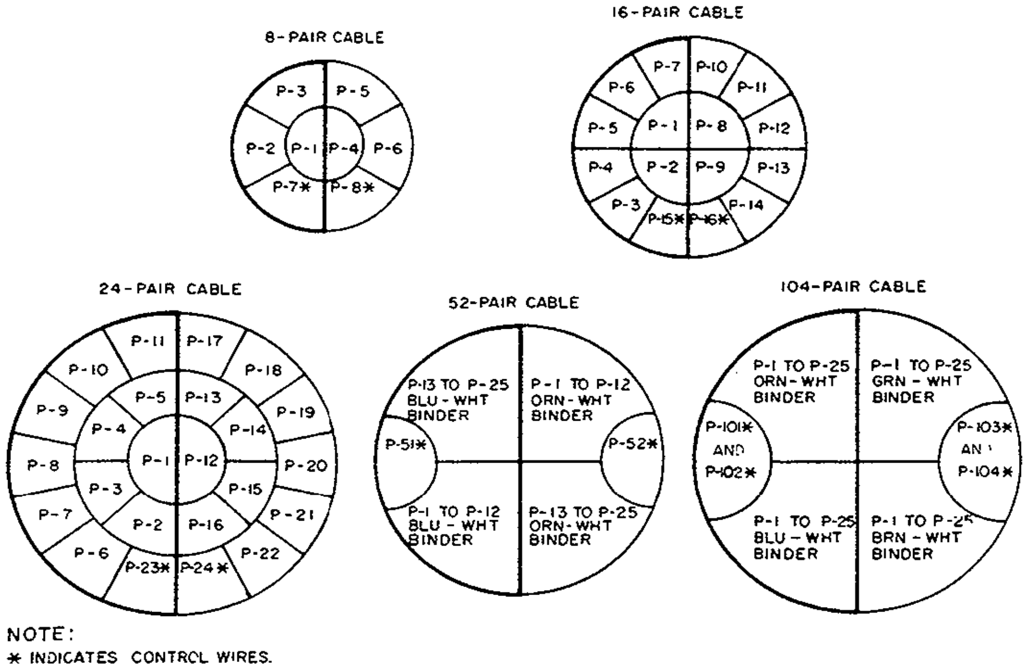

Figure 21 – Core Arrangement, D-Shield Cable

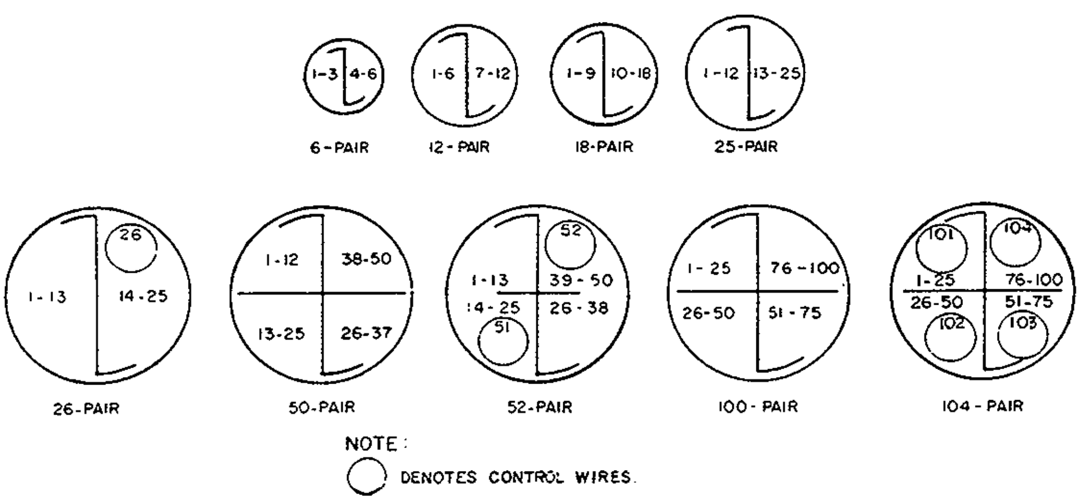

Figure 22 – Core Arrangement, T-Screen Cable

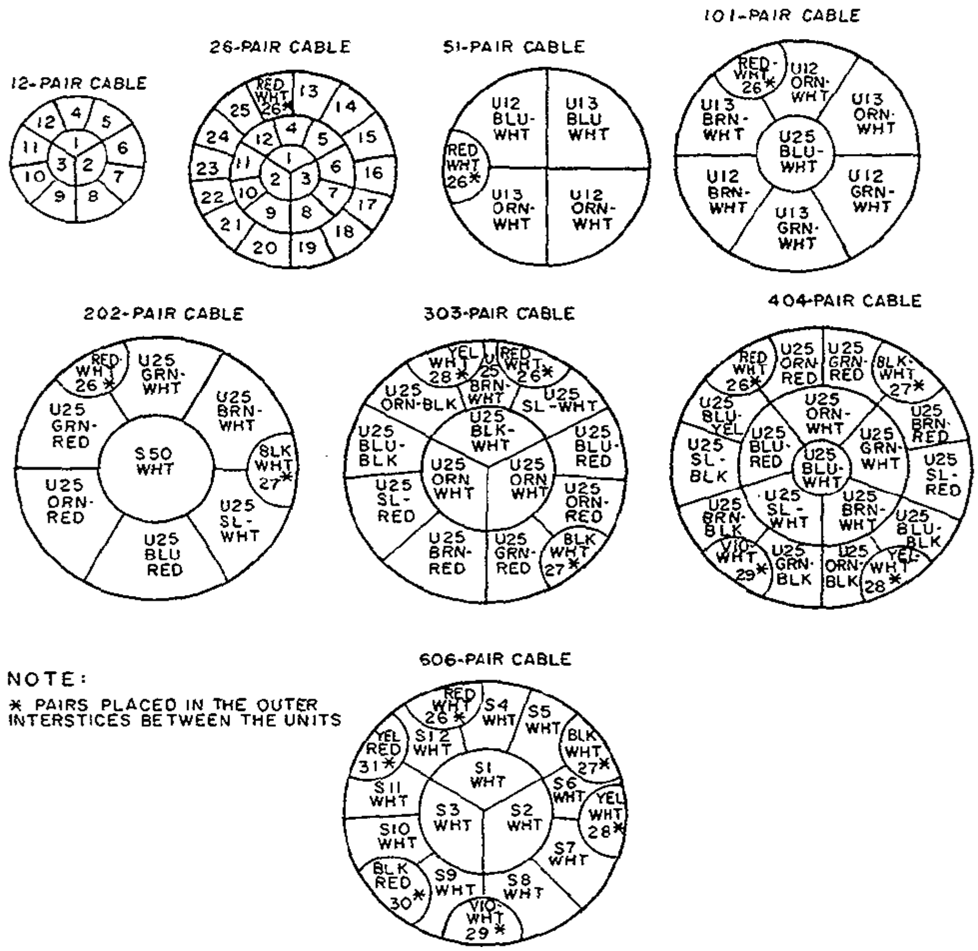

Figure 23 – Core Arrangement, Alvyn Cable

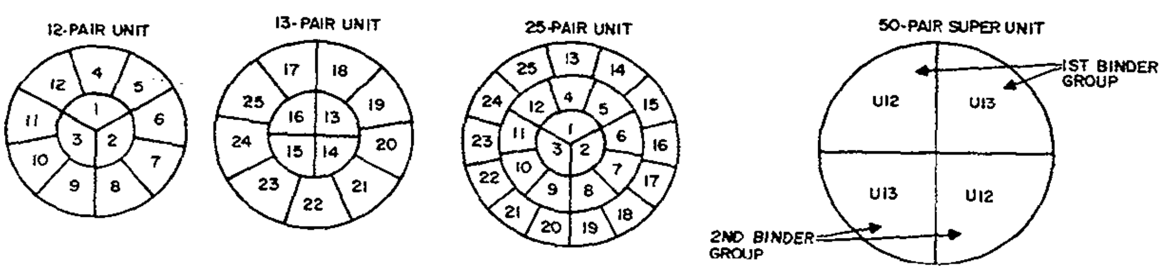

Figure 24 – Unit Arrangement, Alvyn Cable

Table 1 – Conductor Resistance in Ohms per Mile

TYPE AND AWG	CABLE AVERAGE		INDIVIDUAL	
ALPETR AND ASP	NOMINAL	MAXIMUM	NOMINAL	MAXIMUM
19	43.0	44.3	43.0	45.0
22	86.5	89.1	86.5	91.0
24	137.0	141.1	137.0	144.0
26	220.0	226.6	220.0	230.0
ALVYN				
22		95.0		97.2
24		158.0		159.5

Table 2 – Maximum Resistance Unbalance

TYPE AND AWG	AVERAGE FOR CABLE	INDIVIDUAL PAIR
ALPETH AND ASP	PERCENT UNBALANCE	PERCENT UNBALANCE
19	1.2	4.0
22	1.2	4.0
24	1.5	5.0
26	2.0	5.0
ALVYN		
22	1.2	4.0
24	1.5	5.0
WHERE PERCENT UNBALANCE = $\frac{(R_{MAX} - R_{MIN}) \text{ X } 100}{R_{MIN}}$		

Table 3 – Dielectric Strength

BETWEEN CONDUCTORS		
AWG	AC RMS VOLTAGE APPLIED FOR 6 SECONDS	DC VOLTAGE APPLIED FOR 3 SECONDS
19	3,200	4,500
22	2,600	3,600
24	2,200	3,000
26	1,700	2,400
CONDUCTOR TO SHIELD		
	AC RMS VOLTAGE APPLIED FOR 6 SECONDS	
AWG	SINGLE SHEATH, ALVYN, SELF-SUPPORTING	DOUBLE SHEATH
19	7,100	14,100
22	7,100	14,100
24	3,600	14,100
26	3,600	14,100
	DC VOLTAGE APPLIED FOR 3 SECONDS	
AWG	SINGLE SHEATH, ALVYN SELF-SUPPORTING	DOUBLE SHEATH
19	10,000	20,000
22	10,000	20,000

24	5,000	20,000
26	5,000	20,000
SHIELD TO OUTER SURFACE OF JACKET		
JACKET THICKNESS (INCHES)	TEST VOLTAGE	
	AC RMS	DC
Up to 0.060	9,000	13,000
0.061 - 0.090	11,000	16,000
0.091 - 0.120	13,000	19,000
0.121 - And over	15,000	22,000

Table 4 – AC Mutual Capacitance

	CABLE AVERAGE µF PER MILE	INDIVIDUAL PAIR µF PER MILE
6 to l2 pair	.083 ± .006	.083± .011
18 pair and larger	.083 ± .004	.083 ± .006

Table 5 – Attenuation in dB per Mile

Table 5a – 20°C at 1 kHz

	CABLE AVERAGE		INDIVIDUAL PAIR	
AWG	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM
19	1.25	1.35	1.22	1.38
22	1.78	1.92	1.73	1.96
24	2.23	2.42	2.18	2.47
26	2.83	3.06	2.77	3.12

Table 5b – 12.8°C at 772 kHz

AWG	UNFILLED	FILLED
19	16.79	15.52
22	23.18	21.07
24	29.46	25.98
26	39.49	34.85

Table 6 – Temperature Coefficient in dB per Mile

5.6°C at 772 kHz		
AWG	UNFILLED	FILLED
19	0.154	0.143
22	0.213	0.194
24	0.271	0239
26	0.363	0.320

Table 7 – Nonconforming Pairs

NOMINAL CABLE SIZE	MAXIMUM NUMBER
6-100	1
101-300	2
301-400	3
401-600	4
601-900	5

Table 8 – Alpeth Cable, Single-Sheath, Unfilled Cores

NUMBER OF PAIRS	NOMINAL JACKET THICKNESS (INCHES)	NOMINAL OVERALL DIAMETER (INCHES)	MAXIMUM OVERALL DIAMETER (INCHES)	STANDARD LENGTH (FEET)
19 AWG				
6	0.065	0.49	0.685	5,000
12	0.065	0.62	0.805	5,000
25	0.065	0.81	1.00	5,000
50	0.066	1.1	1.33	3,000
100	0.075	1.5	1.78	3,000
200	0.091	2.1	2.37	1,000
300	0.104	2.5	2.84	1,000
400	0.111	2.9	3.21	1,000
22 AWG				
6	0.065	0.39	0.595	5,000
12	0.065	0.50	0.665	5,000
25	0.065	0.63	0.795	5,000
50	0.065	0.84	0.965	3,000
100	0.066	1.2	1.31	3,000
200	0.075	1.5	1.70	1,000
300	0.084	1.9	2.04	1,000
400	0.089	2.0	2.32	1,000
600	0.103	2.5	2.74	1,000
24AWG				
12	0.065	0.44	0.595	5,000
25	0.065	0.53	0.705	5,000
50	0.065	0.69	0.84	3,000
100	0.065	0.94	1.04	3,000
200	0.067	1.2	1.41	1,000
300	0.075	1.5	1.66	1,000
400	0.077	1.7	1.88	1,000
600	0.088	2.0	2.24	1,000
900	0.099	2.4	2.69	1,000
26 AWG				
25	0.065	0.46	0.63	5,000
50	0.065	0.59	0.74	3.000

NUMBER OF PAIRS	NOMINAL JACKET THICKNESS (INCHES)	NOMINAL OVERALL DIAMETER (INCHES)	MAXIMUM OVERALL DIAMETER (INCHES)	STANDARD LENGTH (FEET)
100	0.065	0.74	0.895	3,000
200	0.065	1.0	1.20	1,000
300	0.067	1.2	1.37	1,000
400	0.069	1.3	1.51	1,000
600	0.075	1.6	1.81	1,000
900	0.085	1.9	2.13	1,000

Table 9 – Alpeth Cable, Single-Sheath, Filled Cores

NUMBER OF PAIRS	NOMINAL JACKET THICKNESS (INCHES)	NOMINAL OVERALL DIAMETER (INCHES)	MAXIMUM OVERALL DIAMETER (INCHES)	STANDARD LENGTH (FEET)
19 AWG				
5	0.065	0.6	.765	6,000
12	0.065	0.75	.930	6,000
25	0.065	1.0	1.210	6,000
50	0.070	1.3	1.520	3,000
100	0.090	1.9	2.040	1,500
200	0.110	2.5	2.830	1,000
300	0.110	3.0	3.380	1,000
22 AWG				
6	0.065	0.5	.650	6,000
12	0.065	0.6	.740	6,000
25	0.065	0.75	.910	6,000
50	0.065	1.0	1.200	6,000
100	0.070	1.3	1.500	3,000
200	0.090	1.8	2.040	1,500
300	0.100	2.1	2.470	1,500
400	0.110	2.4	2.740	1,500
600	0.110	2.9	3.270	1,000
24 AWG				
6	0.065	0.40	.590	6,000
12	0.065	0.50	.655	6.000
25	0.065	0.85	.785	6,000
50	0.065	0.80	.935	6,000
100	0.065	1.1	1.250	6,000
200	0.080	1.4	1.640	3,000
300	0.080	1.7	1.960	3,000
400	0.090	1.9	2.190	1,500
600	0.100	2.3	2.670	1,500
900	0.110	2.8	3.200	1,000
26 AWG				
6	0.065	0.40	.540	6,000
12	0.065	0.45	.590	6,000

NUMBER OF PAIRS	NOMINAL JACKET THICKNESS (INCHES)	NOMINAL OVERALL DIAMETER (INCHES)	MAXIMUM OVERALL DIAMETER (INCHES)	STANDARD LENGTH (FEET)
25	0.065	0.55	.685	6,000
50	0.065	0.70	.810	6,000
100	0.065	0.90	1.000	6,000
200	0.070	1.2	1.350	3,000
300	0.080	1.4	1.550	3,000
400	0.080	1.6	1.800	3,000
600	0.090	1.9	2.100	1,500
900	0.100	2.3	2.540	1,500

Table 10 – Alpeth Cable, Double-Sheath, Unfilled Cores

NUMBER OF PAIRS	NOMINAL INNER JACKET THICKNESS (INCHES)	NOMINAL OUTER JACKET THICKNESS (INCHES)	NOMINAL OVERALL DIAMETER (INCHES)	MAXIMUM OVERALL DIAMETER (INCHES)	STANDARD LENGTH (FEET)
19 AWG					
6	0.055	0.060	0.59	0385	5,000
12	0.055	0.060	0.72	0.905	5,000
25	0.055	0.060	0.97	1.130	5,000
50	0.057	0.063	1.30	1.440	3,000
100	0.065	0.070	1.70	1,900	3,000
200	0.075	0.086	2.20	2.510	1,000
300	0.082	0.099	2.70	2.990	1,000
400	0.089	0.103	3.00	3.370	700
22AWG					
6	0.055	0.060	0.49	0.695	5,000
12	0.055	0.060	0.60	0.765	5,000
25	0.055	0.060	0.73	0.895	5,000
50	0.055	0.060	1.00	1.200	3,000
100	0.057	0.063	1.30	1.420	3,000
200	0.084	0.069	1.70	1.850	1,000
300	0.070	0.078	2.00	2.170	1,000
400	0.073	0.084	2.20	2.460	1.000
600	0.082	0.098	2.60	2.890	1,000
24AWG					
6	0.055	0.060	0.46	0.650	5,000
12	0.055	0.060	0.54	0.695	5,000
25	0.055	0.060	0.63	0.805	5,000
50	0.055	0.060	0.79	0.940	3.000
100	0.055	0.060	1.00	1.220	3,000
200	0.059	0.064	1.40	1.530	1,000
300	0.063	0.068	1.60	1.820	1,000
400	0.056	0.071	1.80	2.000	1,000
600	0.073	0.083	2.10	2.420	1,000

NUMBER OF PAIRS	NOMINAL INNER JACKET THICKNESS (INCHES)	NOMINAL OUTER JACKET THICKNESS (INCHES)	NOMINAL OVERALL DIAMETER (INCHES)	MAXIMUM OVERALL DIAMETER (INCHES)	STANDARD LENGTH (FEET)
900	0.079	0.094	2.50	2.840	1,000
26 AWG					
12	0.055	0.060	0.49	0.650	5,000
25	0.055	0.060	0.56	0730	5,000
50	0.055	0.060	0.69	0840	3,000
100	0.055	0.060	0.90	0.995	3,000
200	0.055	0.061	1.10	1.290	1,000
300	0.058	0.064	1.30	1.480	1,000
400	0.061	0.066	1.50	1.620	1,000
600	0.065	0.070	1.70	1.930	1,000
900	0.071	0.080	2.00	2.310	1,000

Table 11 – Alpeth Cable. Self -Supporting Sheath, Unfilled Cores

NUMBER OF PAIRS	NOMINAL JACKET THICKNESS (INCHES)	NOMINAL OVERALL DIAMETER (INCHES)	MAXIMUM OVERALL DIAMETER (INCHES)	STANDARD LENGTH (FEET)
19 AWG				
6	0.065	0.49	0.685	5,000
12	0.065	0.62	0.805	5,000
25	0.065	0.81	1.00	5,000
50	0.066	1.1	1.33	3,000
100	0.075	1.5	1.78	3,000
22 AWG				
6	0.065	0.39	0.595	5,000
12	0.065	0.50	0.665	5,000
25	0.065	0.63	0.795	5,000
50	0.065	0.84	0.966	3.000
100	0.066	1.2	1.31	3,000
200	0.075	1.5	1.70	1,000
24AWG				
12	0.065	0.44	0.595	5,000
25	0.065	0.53	0.705	5,000
50	0.065	0.69	0.840	3,000
100	0.065	0.94	1.04	3,000
200	0.067	1.2	1.41	1,000
26 AWG				
25	0.065	0.46	0.63	5.000
50	0.065	0.59	0.74	3,000
100	0.065	0.74	0.895	3,000
200	0.065	1.0	1.20	1,000

Table 12 – Alpeth Cable, D-Shield, Unfilled Cores

NUMBER OF PAIRS	NOMINAL JACKET THICKNESS (INCHES)	NOMINAL OVERALL DIAMETER (INCHES)	NOMINAL OVERALL DIAMETER (INCHES)	STANDARD LENGTH (FEET)
19 AWG				
8	0.065	0.64	0.69	5,000
16	0.065	0.81	0.86	5,000
24	0.065	0.96	1.00	5,000
52	0.067	1.20	1.30	3,000
104	01175	1.60	130	3,000
22 AWG				
8	0.065	0.54	0.59	5,000
16	0.065	0.64	0.69	5,000
24	0.065	0.71	0.76	5,000
52	0.065	0.96	1.00	5,000
104	0.067	130	1.40	3,000
24 AWG				
8	0.065	0-50	0.55	5,000
16	0.065	0.56	0.61	5.000
24	0.065	0.64	0.69	6,000
52	0.065	0.78	0.83	3,000
104	0.065	1.00	1.10	3,000

Table 13 – Alpeth Cable, D-Shield, Filled Cores

NUMBER OF PAIRS	NOMINAL JACKET THICKNESS (INCHES)	NOMINAL OVERALL DIAMETER (INCHES)	MAXIMUM OVERALL DIAMETER (INCHES)	STANDARD LENGTH (FEET)
19 AWG				
8	0.065	0.75	0.80	3,000
16	0.065	0.98	1.00	5,000
24	0.065	1.10	1.20	5,000
52	0.075	1.50	1.60	5,000
104	0.085	1.90	2.00	3.000
22 AWG				
8	0.065	0.63	0.68	3,000
16	0.065	0.73	0.78	5,000
24	0.065	0.85	0.90	5,000
52	0.065	1.10	1.20	5,000
104	0.075	1.50	1.60	5,000
24 AWG				
8	0.065	0.57	0.62	5,000
16	0.065	0.66	0.71	5,000
24	0.065	0.73	0.78	5,000
52	0.065	0.96	1.00	5,000
104	0.665	1.20	1.30	3,000

Table 14 – Alpeth Cable, T-Screen, Unfilled Cores

NUMBER OF PAIRS	NOMINAL JACKET THICKNES (INCHES)	NOMINAL OVERALL DIAMETER (INCHES)	MAXIMUM OVERALL DIAMETER (INCHES)	STANDARD LENGTH (FEET)
22 AWG				
6	0.065	0.445	0.475	5,000
12	0.065	0.515	0.545	5,000
18	0.065	0.580	0.610	5,000
25	0.065	0.645	0.675	5,000
26	0.065	0.650	0.685	5,000
50	0.065	0.815	0.845	5,000
52	0.067	0.825	0.855	5,000
100	0.077	1.130	1.160	2.500
104	0.077	1.130	1.160	2,500

Table 15 – Alpeth Cable. T-Screen, Filled Cores

NUMBER OF PAIRS	NOMINAL JACKET THICKNESS (INCHES)	NOMINAL OVERALL DIAMETER (INCHES)	MAXIMUM OVERALL DIAMETER (INCHES)	STANDARD LENGTH (FEET)
22 AWG				
6	0.065	0.495	0.525	5,000
12	0.065	0.575	01105	5,000
18	0.065	0.665	0.695	5,000
25	0.065	0.745	0.775	5,000
26	0.065	0.750	0.780	5,000
50	0.065	1.010	1.040	3,000
52	0.075	1.025	1.055	5,000
100	0.085	1.310	1.340	3,000
104	0.086	1.330	1.360	2,500

Table 16 – ASP Cable, Filled Cores

NUMBER OF PAIRS	NOMINAL JACKET THICKNESS (INCHES)	NOMINAL OVERALL DIAMETER (INCHES)	MAXIMUM OVERALL DIAMETER (INCHES)	STANDARD LENGTH (FEET)
19 AWG				
3	0.045	0.50	0.550	6,000
6	0.045	0.60	0.770	6,000
12	0.045	0.75	0.935	6,000
25	0.050	1.00	1.220	6,000
50	0.055	1.30	1.550	3,000
75	0.060	1.60	1.860	3,000
100	0.065	1.90	2.100	1,500

NUMBER OF PAIRS	NOMINAL JACKET THICKNESS (INCHES)	NOMINAL OVERALL DIAMETER (INCHES)	MAXIMUM OVERALL DIAMETER (INCHES)	STANDARD LENGTH (FEET)
200	0.085	2.50	2.820	1,000
300	0.090	3.00	3.400	800
22 AWG				
3	0.045	0.40	0.470	6,000
6	0.045	0.50	0.655	6.000
12	0.045	0.60	0.745	6.000
25	0.045	0.75	0.915	6,000
50	0.050	1.00	1.130	6,000
75	0.050	1.20	1.390	6,000
100	0.055	1.30	1500	3,000
200	0.065	1.80	1.990	1,500
300	0.075	2.10	2.460	1,500
400	0.080	2.40	2.740	1,500
600	0.090	2.90	3.290	1,000
24 AWG				
6	0.045	0.45	0.595	6,000
12	0.045	0.50	0.660	6,000
25	0.045	0.65	0.790	6,000
50	0.045	0.80	0.940	6.000
75	0.050	0.95	1.090	6,000
100	0.050	1.00	1.250	6,000
200	0.055	1.40	1.630	3,000
300	0.065	1.70	1.970	3,000
400	0.070	1.90	2.210	3,000
600	0.080	2.30	2.670	1,500
900	0.090	2.80	3.150	1,000
26 AWG				
25	0.045	0.55	0.680	6.000
50	0.045	0.70	0.795	6,000
75	0.045	0.80	0.895	6.000
100	0.050	0.90	0.975	6,000
200	0.050	1.20	1.380	3,000
300	0.055	1.40	1.520	3,000
400	0.060	1.60	1.700	3,000
600	0.070	1.90	2.120	1,500
900	0.080	2.30	2.560	1,500

Table 17 – Alvyn Cable, Unfilled Cores

NUMBER OF PAIRS	NOMINAL JACKET THICKNESS (INCHES)	OMINAL OVERALL DIAMETER (INCHES)	MAXIMUM OVERALL DIAMETER (INCHES)	STANDARD LENGTH (FEET)
22 AWG				
12	0.055	0.58		1,000

NUMBER OF PAIRS	NOMINAL JACKET THICKNESS (INCHES)	OMINAL OVERALL DIAMETER (INCHES)	MAXIMUM OVERALL DIAMETER (INCHES)	STANDARD LENGTH (FEET)
26	0.058	0.75		1,000
51	0.064	0.99		1,000
101	0.070	1.30		1,000
202	0.082	1.80		1,000
303	0.100	2.10		1,000
404	0.112	2.40		1,000
606	0.133	2.90		1,000
24 AWG				
12	0.055	0.52		1,000
26	0.055	0.63		1,000
51	0.058	0.79		1,000
101	0.064	1.10		1,000
202	0.073	1.40		1,000
303	0.085	1.70		1,000
404	0.091	1.90		1,000
606	0.106	2.30		1,000

Table 18 – Color Code of Cable Pairs and Units

PAIR NUMBER	COLOR CODE		PAIR NUMBER	COLOR CODE		PAIR NUMBER	COLOR CODE	
	RING	TIP		RING	TIP		RING	TIP
1	BLUE	WHITE	10	SLATE	RED	19	BROWN	YELLOW
2	ORANGE	WHITE	11	BLUE	BLACK	20	SLATE	YELLOW
3	GREEN	WHITE	12	ORANGE	BLACK	21	BLUE	VIOLET
4	BROWN	WHITE	13	GREEN	BLACK	22	ORANGE	VIOLET
5	SLATE	WHITE	14	BROWN	BLACK	23	GREEN	VIOLET
6	BLUE	RED	15	SLATE	BLACK	24	BROWN	VIOLET
7	ORANGE	RED	16	BLUE	YELLOW	25	SLATE	VIOLET
8	GREEN	RED	17	ORANGE	YELLOW			
9	BROWN	RED	18	GREEN	YELLOW			

Table 19 – Binder Identification

GROUP BINDERS			
PAIR NUMBER	BINDER COLOR	PAIR NUMBER	BINDER COLOR
1-25	WHT-BLU	451-475	YEL-BRN
26-50	WHT-ORN	476-500	YEL-SL
51-75	WHT-GRN	501-525	VIO-BLU
76-100	WHT-BRN	526-550	VIO-ORN
101-125	WHT-SL	551-575	VIO-GRN
126-150	RED-BLU	576-600	VIO-BRN
151-175	RED-ORN	601-625	WHT-BLU
176-200	RED-GRN	626-650	WHT-ORN
201-225	RED-BRN	651-675	WHT-GRN
226-250	REO-SL	676-700	WHT-BRN

GROUP BINDERS			
251-275	BLK-BLU	701-725	WHT-SL
276-300	BLK-ORN	726-750	RED-BLU
301-325	BLK-GRN	751-775	RED-ORN
326-350	BLK-BRN	776-800	RED-GRN
351-375	BLK-SL	801-825	RED-BRN
376-400	YEL-BLU	826-850	RED-SL
401-425	YEL-ORN	851-875	BLK-BLU
426-450	YEL-GRN	876-900	BLK-ORN
SUPER UNIT BINDERS			
PAIR NUMBER	BINDER COLOR		
1-600	WHT		
601-900	RED		

5.3 Corrosion Resistant Coverings for Cables and Splices

5.3.1 GENERAL

5.3.1.1 This Practice provides information on the types of outer coverings and corrosion resistant cables used as a means of preventing cable sheath failures in underground or buried cables, and on corrosion protection for cable splices.

5.3.1.2 Corrosion of cable sheath and splices is generally a result of:

(a) Stray Currents - usually manmade, the most prominent sources being cathodic protection systems, railway signal systems, electric railways and equipment using grounded direct current.

(b) Non-stray Current - where the principal source of current is caused by galvanic potentials. Galvanic corrosion is the result of an electrochemical reaction and is produced in many ways. Contaminations from sewage, salts, or industrial waste products aggravate the natural galvanic conditions in some cases. Corrosion may take place in local corrosion cells in short paths for the corrosion current or may extend over a considerable length of cable.

5.3.2 TYPES OF CORROSION RESISTANT CABLES

5.3.2.1 Detailed information relating to cables having corrosion resistant sheaths or protective coverings are given in other Engineering Plant Practices.

5.3.2.2 Cables currently available are:

(b) Alpeth or Cupeth (PlC cable)

(c) Armored (Buried Tape, Gopher Tape)

5.3.2.3 Under special conditions, other types of corrosion resistant sheaths or covering may prove desirable, depending upon service requirements and physical conditions in the field. Due to the very high cost, the field application of protective tape wrapping is not recommended.

5.3.3 USE OF CORROSION RESISTANT CABLE

5.3.3.1 The present standard cables have corrosion resistant sheaths. Where cables are to be placed in iron pipes or where cables cross under or closely parallel railroad or pipelines, corrosion resistant cables shall be used. Corrosion resistant cables shall be used under other conditions including cable failure replacements.

5.3.4 CORROSION PROTECTION FOR CABLE SPLICES

5.3.4.1 Lead Sleeve Splices: On buried cables where the lead sleeve and exposed metal sheath will be in direct contact with earth, a protective covering is required. Where a sheath opening is made in a section of corrosion resistant cable between manholes, the repair sleeve should be protected. Also, protection may be desirable for splices in corrosion resistant cable in manholes having an unfavorable corrosion history; where the corrosion resistant cable and the bare lead cable may be continuously under water, or where it is necessary to guard against the effects of anodic stray currents.

5.3.4.2 Metal Splice Case: When metal splice cases are specified, it is necessary to consider the possible current flow from metallic components of cable through case to earth. This would result in anodic action between case and earth. To minimize this action the case shall be insulated from metal components of the cable and protective covering placed.

5.3.5 PROTECIVE MATERIALS

5.3.5.1 Materials for corrosion protection of exposed metallic portions of corrosion resistant cables, lead sleeve splices and metal splice cases shall be equivalent to the following:

(a) Corrosion Protective Tape

(b) UL listed

6 Installation

The installation of telecommunications cables shall be done in a manner that avoids the cable damage considerations that are detailed in Section 5.1.4. The installation shall conform to applicable factors that are listed in Paragraph 5.1.1.2.

7 Testing and Inspection

Testing and inspection shall be done in accordance with procurement specifications.

Revision Summary

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