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MILITARY SPECIFICATION

CABLE, TELEPHONE; SUBMARINE

1. SCOPE

1.1 Scope. - This specification covers synthetic rubber and thermoplastic insulated submarine cable, and underground connections thereto, containing from one to four conductors, for use in coastal waters for communication and communication control purposes.

1.2 Classification. - The following cables are covered under this specification:

1.2.1 Type I. - One, two, and four conductor communication cables of specific types as specified in Tables V and VI.

1.2.2 Type II. - Such other cables of similar general construction as may be specified in the invitation for bids or purchase order, or separate detail specifications.

2. APPLICABLE DOCUMENTS

2.1 The following specifications and standards, of the issue in effect on the date of invitation for bids, form a part of this specification:

SPECIFICATIONS

None

STANDARDS

Federal

Federal Test Method Standard No. 601, Rubber, Sampling and Testing.

FED SUP. CLASS
6145

(Copies of specifications, standards, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

2.2 Other Publications. - The following documents form a part of this specification. Unless otherwise specified, the issue in effect on date of invitation for bids shall apply.

ASTM Designation B33 Standard Specifications for Tinned Soft or Annealed Copper Wire for Electrical Purposes, Issue of 1949.

ASTM Designation B-189 - Specifications for Lead-Coated and Lead-Alloy Coated Copper Wire for Electrical Purposes.

ASTM Designation B-6 - Standard Specifications for Slab Zinc.

ASTM Designation A-90 - Standard Methods of Determining Weight of Coating of Zinc Coated Articles.

ASTM Designation A-239 - Standard Methods of Determining Uniformity of Coating on Zinc Coated Iron or Steel Articles.

ASTM Designation D-734 for Insulated Wire and Cable Polyvinyl Insulating Compound.

(Application for copies should be addressed to the American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa.)

3. REQUIREMENTS

3.1 Material. - The materials used for the cables shall be as specified herein.

3.1.1 Copper conductors. - Unless otherwise specified, each conductor strand shall consist of tinned or lead alloy coated copper wire.

3.1.1.1 Tinned conductors. - If tinned copper conductors are used, each strand shall meet all requirements of the latest issue of Standard Specifications for Tinned Soft or Annealed Copper Wire for Rubber Insulation (ASTM Designation B-33) of the American Society for Testing Materials, with the exception that the wire shall withstand four cycles of the Sodium Polysulfide test instead of the two specified.

3.1.1.2 Lead alloy coated conductors. - If lead alloy coated conductors are used, each strand shall consist of lead alloy coated copper wire meeting all requirements of the latest issue of Specifications for Lead-Coated and Lead-Alloy Coated Soft Copper Wire for Electrical Purposes (ASTM Designation B-189) of the American Society for Testing Materials.

3.1.2 Loading wire. - This wire is to be used for continuously loading the conductors of telephone cable. It shall be drawn from a grade of soft iron containing not more than 0.05% carbon. The elongation of the finished wire shall be not less than 18%. Its permeability and specific resistance shall be such that after application to the conductor it shall yield an inductance and effective resistance within the limits specified for the particular type of cable being manufactured.

3.1.3 Rubber filled fabric tapes. - This tape shall consist of a suitable evenly woven cotton fabric thoroughly impregnated and evenly covered on one or both sides with a colored synthetic or natural rubber compound. The coloring material shall be free of any ingredient that will injure the other component parts of the cable. The colors must be fast under any conditions encountered during manufacture, or subsequent prolonged immersion in water.

3.1.4 Jute. - All jute yarn used for fillers or servings shall be of "First Marks" quality or better, clean, of uniform quality throughout, and free of hardstock or foreign substances. It shall be made of all long jute without waste or cuttings, and shall be evenly spun.

3.1.4.1 Jute yarn shall conform to the minimum values for breaking strength when tested in lengths of 26 inches and the following maximum values for the number of twists per foot listed in Table I.

TABLE I

Wt. per lea (14,400 yard)	Average Breaking Strength pounds (minimum)	Twists per ft. (maximum)
50 lb.	40	21
70 lb.	65	18
100 lb.	85	15
16 lb. 3 ply	45	36 per ply

3.1.4.2 Waterproof jute shall be used for cable core fillers and inner serves. It shall consist of jute as specified above which has been impregnated with suitable waterproofing material prior to making into yarn.

such as high melting point waxes and/or synthetic resins. The jute shall be highly resistant to deterioration and shall have no contaminating or corrosive effects on other component parts of the cable.

3.1.4.3 Vacuum impregnated jute shall be used for outer cable serves. It shall consist of jute yarn as specified above which has been thoroughly dried under vacuum and impregnated with a compound consisting of 50 per cent paraffin and 50 per cent petroleum asphalt. The paraffin and petroleum asphalt shall be commercially free from dirt and other foreign materials.

3.1.5 Armor wire. - The wire shall be of uniform quality throughout, drawn from iron or steel of such quality and composition that when drawn, uniformly annealed and galvanized, the finished wire shall have the properties hereinafter specified. The surface of the wire shall be free from scale, and from injurious flaws, seams and splints. The zinc used for the coating shall be any grade conforming to the requirements of the latest issue of Standard Specifications for Slab Zinc (ASTM Designation B-6) of the American Society for Testing Materials.

3.1.5.1 Size. - The size of the finished wire shall be expressed as the diameter of the coated wire in decimal fractions of an inch. The permissible variations over or under nominal diameter shall be as follows:

For wire 0.109 inch or over in diameter - - 0.005 inch
For wire under 0.109 inch in diameter - - - 0.003 inch.

The wire of each coil shall be gauged in three places; one near each end and one approximately at the middle. A coil shall be rejected if the average gauge is not within the diameter limits as specified above.

3.1.5.2 Tensile strength. - The galvanized wire shall have a tensile strength of not less than 50,000 pounds nor more than 70,000 pounds per square inch of cross section. The finished wire shall have an elongation of not less than 10 per cent in 10 inches. The wire shall not split or break when wrapped in a close helix eight complete turns around a cylindrical mandrel, the diameter of which varies with wire size as follows: sizes .148 inch and smaller, two diameters; sizes over .148 inch to .250 inch inclusive, three diameters; sizes over .250 inch, five diameters. In the wrap test, the zinc coating shall adhere firmly to the wire, so that it does not flake and none of the coating can be removed from the wire by rubbing with the bare fingers.

3.1.5.3 Weight. - The weight of the coating shall be determined as described in the latest issue of Standard Methods of Determining Weight of Coating of Zinc Coated Articles (ASTM Designation A-90), and shall be not less than the weights outlined in Table II.

TABLE II

Outside diameter of wire in inches	Oz. per sq. ft. of stripped surface
.065	0.50
.083	0.60
.109	0.80
.165	0.90
.203 or over	1.00

3.1.5.4 Tar dip. - Before application to the cable, the armor wire shall be heated in an oven sufficient to drive off all moisture. The wire while warm shall be dipped in a hot compound of tar, containing nothing deleterious to the core and so prepared as to adhere to the wire and form, when set, a complete and fixed preservative coating. The wire when coated shall not be wound on bobbins until the compound has become thoroughly cooled and set.

3.1.5.5 Tar and asphalt compound. - This compound shall be composed of coal tar blended with natural asphalt. The melting point of this compound shall be not less than 120° F. as determined by the ball and ring test.

3.2 Components. -

3.2.1 Conductors. - All conductors shall be of soft annealed copper wire. If non-corrosive thermoplastic insulation is specified, no tin or other coating will be required. If natural or synthetic rubber insulation is specified, tinned copper wire shall be used, or lead alloy-coated if specified. All wire and coatings shall meet the requirements of 3.1.1 and 3.1.2.

3.2.1.1 Stranding. - All conductors shall be concentrically stranded. The number of conductors and the number and diameter of the wires forming each conductor shall be as specified for the particular type of cable manufactured. Care shall be taken when stranding to avoid abrasion of the wire and its coating, and such abrasion shall be deemed cause for rejection.

3.2.1.2 Coaxial cable conductors. - In coaxial cables the outer conductor (or shield) shall consist of copper wires, as specified in 3.2.1, applied spirally with a suitable lay, directly over the conductor or insulation before application of the fabric conductor tape. The number and diameter of the wires shall be as specified for the particular type of cable being manufactured, and the lay shall be such that the coverage is the maximum consistent with good mechanical practice.

3.2.1.3 Repairs. - When repairs or joints are made in the conductor, the work shall be performed in such a manner that the joint and the adjacent conductor is as strong and durable, electrically and mechanically, as the remainder of the conductor.

3.2.2 Continuous loading. - When so specified, the conductor shall be continuously loaded by the application of one strand of annealed iron wire over the bare stranded conductor to form a close continuous serving. The diameter of the serving wire and the number of turns per inch shall be as specified for the particular type of cable being manufactured. The loading wire shall meet the requirements of 3.1.2.

3.2.3 Conductor insulation. - These specifications cover synthetic compounds suitable for use as insulation and protective jackets of submarine and underground cables of such types as may be required by the purchaser.

3.2.3.1 The properties desired for the insulating compound are low dielectric constant and power factor, low water absorption properties, good physical and aging characteristics, and stability of electrical characteristics after prolonged immersion.

3.2.3.2 The properties desired for the protective jacket compound are good aging, stability of physical characteristics after prolonged immersion, and ability to protect the cable from abrasion or corrosive action.

3.2.3.2.1 The insulating compound shall consist of a properly vulcanized compound containing Buna S (GRS) or other synthetic polymer and such other compounding ingredients as may be necessary. Unless otherwise specified in the detail requirements for specific types of cable, it shall contain no natural crude rubber and be homogeneous in character, tough and elastic. The synthetic polymer and other compounding ingredients shall be free from water soluble constituents and other substances which might prove deleterious to the rubber insulation or the conductor.

3.2.3.2.2 The protective jacket compound shall consist of a properly vulcanized compound containing a Neoprene or other synthetic polymer and such other compounding ingredients as may be necessary. It shall be homogeneous in character, tough and elastic.

3.2.3.3 Physical requirements. - The insulating and jacket compound specified herein shall meet the average values tabulated in Table III when tested under the conditions outlined in Section 4.

TABLE III

PROPERTY	UNIT	INSULATION COMPOUND				JACKET COMPOUND
		4/64" wall or less.		5/64" wall or over.		
		1st cure	2nd cure	1st cure	2nd cure	
TENSILE STRENGTH						
Unaged specimens	Min. lbs./In.^{2}	900	850	900	850	2000
Aged in oxygen bomb 48 hrs.70°C.	Min. % of Orig.	75	70	75	70	75
Aged in oven, 96 hrs. 70°C.	Min. % of Orig.	75	70	75	70	75
ELONGATION						
Unaged specimens	Min. Per cent	350	325	350	325	400
Aged in oxygen bomb 48 hrs.70°C.	Min. % of Orig.	75	70	75	70	—
Aged in air oven 96 hrs.70°C.	Min. % of Orig.	70	65	70	65	—
MODULUS						
Unaged specimens, 200% elong.	Min. Lbs./In^2	300	285	300	285	—
Unaged specimens, 300% elong.	Min. lbs./In^2	—	—	—	—	1300
COMPRESSION CUTTING						
Unaged specimens	Min. Lbs.	300	285	350	285	750
Aged in bomb 48 hrs. 70°C.	Min.% of Orig.	70	65	80	75	80
Aged in water 7 days 70°C.	Min.% of Orig.	70	65	80	75	70
CORROSION TEST						
7 days 70°C. Increase in res.	Max. Per cent	5	—	5	—	—
MECHANICAL WATER ABSORP.						
7 days 70°C.	Max. Mg./In^2	20	—	20	—	—
ELECTRICAL WATER ABSORPTION						
Dielectric constant, 24 hrs. 70°C.	Max.	3.35	—	3.2	—	—
Dielectric constant, 7 days 70°C.	Max. % Increase	7.5	—	5.0	—	—
Dielectric constant, 28 days 70°C.	Max. % Increase	12.0	—	10.0	—	—
Power factor 7 days 70°C.	Max.	0.0125	—	0.0125	—	—
TEAR TEST	Min. Lbs/In.	—	—	—	—	40

3.2.3.4 Electrical requirements. - All insulated conductors, when tested under the conditions specified under Section 4 shall withstand the voltages specified in Table IV.

TABLE IV

Average wall thickness 64th (inch)	Volts AC	Volts DC
3	4700	14100
4	6250	18700
5	7800	23400
6	9400	28200
7	11000	33000
8	12500	37500
9	14100	42200
10	15600	46800

(1) Preliminary routine tests:

Conductors smaller than .114 inch diameter, use voltages in accordance with the above table.

Conductors 0.114 inch diameter or larger and wall thickness exceeding 3/64 inch, the AC voltage shall be increased 2,000 volts and the DC voltage shall be increased 6,000 volts above those shown in the table.

(2) Routine tests of core or completed cable:

If an insulating jacket has been applied under the armor or sheath, use the voltage specified in above table. If there is no insulating jacket, use 80 per cent of the voltage specified in the above table.

(3) All tests, preliminary, core and completed cable:

For wall thicknesses of 6/64 inch or less, either DC or AC voltage may be used for a duration of five minutes. For wall thicknesses of over 6/64 inch, both AC and DC tests shall be applied; duration of AC shall be five minutes, and DC 15 minutes.

3.2.3.5 Insulation resistance. - The insulation resistance of all wire and cable, when tested under the conditions specified in 4.2, shall have a resistance when corrected to a temperature of 60°F. of not less than the value obtained from the following formula:

$$R = K \log_{10} \frac{D}{d}$$

Where R = Megohms per 1000 ft. of cable

K = 10,000

D = Specified average outside diameter of insulation

d = Specified diameter of conductor (For stranded conductors 94 per cent of diameter over the strand).

3.2.3.6 Capacity. - The capacity of all wire and cable, when tested under the conditions specified in 4.2, shall have a capacity to ground at 1000 cycles of not more than the value obtained from the following formula:

$$C = \frac{0.00735K}{\log_{10} \frac{D}{d}}$$

Where C = Capacitance, microfarads per 1000 ft. at 60°F.

K = 3.0

D = Specified average outside diameter of insulation

d = Specified diameter of conductor (For stranded conductors 94 per cent of diameter over the strand).

3.2.3.7 Conductor and jacket insulation. - The insulating compound shall be of the material specified for the particular type of cable being manufactured. It shall be applied concentrically about the stranded or loaded conductor and shall fit tightly thereto. While there shall be a pronounced adhesion of the insulation to the conductor, this adhesion shall not be sufficient to prevent the insulation from being stripped from the conductor when splicing or terminating. The dimensions of the insulation shall conform to the limits specified for the type of cable being manufactured.

3.2.3.7.1 Repairs. - When repairs or joints are made in the insulation, the work shall be performed in such manner that the repaired part of the joint and all adjacent parts affected in the process shall be as strong and durable, electrically and mechanically, as the remainder of the insulation.

3.2.4 Conductor tapes. -

3.2.4.1 Fabric tape. - When so specified, a colored synthetic or natural rubber filled fabric tape shall be applied over each insulated conductor. In coaxial cables, this tape shall be applied over the outer conductor. This tape shall meet the requirements of 3.1.3. It shall be applied after vulcanization and upon completion of the preliminary electrical tests, with a suitable lay and overlap of not less than 20% of the width of the tape. The colors used shall be in accordance with the following, unless otherwise specified in the order or other applicable specification:

Single conductor cable	:	Any color
Two conductor cable	:	Blue and white
Four conductor cable	:	Blue, red, white, green (Blue and white opposite or nonadjacent).

3.2.4.2 Brass tape. - When so specified, a brass tape 0.003 inch in thickness and 3/4 inch in width shall be applied over the fabric tape with an overlap of not less than 10% of the width of the tape. The tape shall be applied in a workmanlike manner so as to avoid crimping and wrinkling.

3.2.4.3 Cabling and core tape. - The required number of taped conductors shall be laid up spirally with a suitable right hand lay. All voids between conductors shall be filled with jute to form a smooth round core, over which a black synthetic or rubber filled fabric core tape shall be applied with an overlap approximately 20% of the width of the tape. The jute filler shall be of waterproof jute and this filler and the fabric tape shall meet the requirements of 3.1.3; 3.1.4; 3.1.4.1; 3.1.4.2 and 3.1.4.3. In four conductor cable the blue and white taped conductors shall be laid up so as to be opposite or non-adjacent.

3.2.4.4 Insulating jackets. - When so specified, an insulating jacket shall be applied over the taped core, and another black synthetic or natural rubber filler fabric tape meeting the requirements of 3.1.3 shall be applied over the jacket with an overlap approximately 20% of the width of the tape. The material used for the insulating jacket and the minimum wall thickness thereof shall be as specified for the particular type of cable being manufactured.

3.2.5 Protective coverings. -

3.2.5.1 Inner jute serves shall be of waterproof jute meeting the requirements of 3.1.4; 3.1.4.1; 3.1.4.2 and 3.1.4.3. The number of

layers and the weight of jute employed shall be as specified for the type of cable being manufactured. When one layer is specified, it shall be applied with a right hand lay. If two layers are specified, the first layer shall be applied with a left hand lay and the second layer with a right hand lay. The ratio of the length of lay to pitch diameter of each serve shall be not less than three or more than four and one-half, and the number of strands employed shall be such that very close coverage is obtained. The servings shall be so applied that they form a smooth compact layer free from lumps or bunching.

3.2.5.2 Armor. - The armor shall consist of preformed, tar dipped galvanized steel wire, meeting all requirements of 3.1.5; 3.1.5.1; 3.1.5.2; 3.1.5.3; 3.1.5.4 and 3.1.5.5. The diameter of the wire shall be as specified for the particular type of cable being manufactured. It shall be applied spirally with a left hand lay. The ratio of the length of lay to pitch diameter shall be not less than eight or more than 10, and the number of armor wires shall be such as to insure not less than 95 per cent coverage. The wire shall be so preformed that it will remain in proper position and produce maximum flexibility of the finished cable. All joints in the armor shall be welded and no weld shall be within 12 feet of another weld. All joints shall be thoroughly cleaned after welding and coated with zinc. Joints so treated shall be capable of meeting all requirements specified for the original wire. An application of hot tar and asphalt meeting the requirements of 3.1.5.5 shall be made over the armor. If a protective jacket is to be applied over the armor, the application of the compound shall be omitted and the armor wire shall not be precoated with tar.

3.2.5.3 Outer jute serves shall be of vacuum impregnated jute meeting the requirements of 3.1.4; 3.1.4.1; 3.1.4.2 and 3.1.4.3. The number of layers and the weight of the jute employed shall be as specified for the particular type of cable being manufactured. When one layer is specified, it shall be applied with a right hand lay. If two layers are specified, the first layer shall be applied with a right hand lay and the second layer with a left hand lay. The ratio of the length of lay to the pitch diameter of each serve shall be not less than three or more than four and one-half, and the number of strands employed shall be such that very close coverage is obtained. The serving shall be so applied that it forms a smooth compact layer free from lumps or bunching. An application of hot tar and asphalt compound meeting the requirements of 3.1.5.5 shall be made over the outer layer, followed by a thorough coating of whitewash.

3.2.5.4 Protective jacket. - When so specified, a protective jacket of synthetic rubber compound shall be applied over the armor in lieu of outer jute serves. The jacket compound shall meet all requirements of

3.2 herein. This jacket shall be applied in two layers. The first layer shall be not less than 0.0625 inch in thickness. A serving of two layers of 10/2/3 seine twine shall be applied spirally in reverse directions, with approximately seven strands per inch in each layer, for the purpose of binding the compound firmly to the armor. Over the serving of seine twine, a second layer of the same compound shall be applied. The wall thickness of both layers of compound shall be not less than that specified for the particular type of cable being manufactured. The jacket shall be cured in a mould or continuous lead sheath extruded directly over the jacket, and removed after vulcanization. The compound shall be applied concentrically about the cable in such a manner that it will fit tightly thereto filling the interstices of the armor, and be free of holes, lumps, depressions, or objectionable waviness and the finished cable shall present a smooth, dense, shiny appearance.

3.2.5.5 Lead sheath. - If a lead sheath is specified, it shall be composed of commercially pure lead. It shall be close fitting, cylindrical, of uniform thickness, with a minimum wall thickness as specified for the particular type of cable being manufactured. Die marks caused by an interruption of the continuous process of sheathing the cable in the lead press shall not weaken the sheath. The sheath shall be free from holes, blisters, splits, laminations or other defects.

3.3 Finished Cable. - The finished cable and all component parts thereof shall be inspected, sampled, and tested in accordance with the provisions of Section 4 and shall meet the electrical requirements for the particular type of cable being manufactured.

3.4 Detail Requirements. -

3.4.1 Core. - Each conductor shall consist of the required number of tinned or alloy coated copper wires, loaded if so specified, insulated with a synthetic rubber compound meeting the requirements of 3.2.3, and taped with a synthetic or natural rubber filled fabric tape. The required number of conductors shall be laid up spirally with jute fillers, over which a synthetic or natural rubber filled fabric tape shall be applied. In type 60 cable, the fabric conductor tape shall be omitted and one conductor of the quad shall have a double ridge on the insulation for identification purposes.

3.4.2 Special designation. - When specified by annexing the letter "T" to the type number, a brass tape shall be applied over the taped conductors meeting the requirements of 3.2.4.2.

3.4.3 Thermoplastic jacket. - On types 114P and 114PP coaxial cables, an insulating jacket or belt consisting of a thermoplastic synthetic compound meeting the requirements of the latest issue of ASTM Specification D-734 for Insulated Wire and Cable Polyvinyl Insulating Compound, shall be applied over the taped core. A synthetic or natural rubber filled tape shall be applied over the insulating jacket or belt.

3.4.4 Insulated conductor. - The number of conductors and the dimensions of the copper wire, loading wire and insulation for certain specific types shall be as specified in Table V. For types of cable not listed in this table, the details shall be as specified in the invitation for bids or purchase order, or any other applicable specifications. The materials used and the method of assembly shall meet all requirements of 3.1 and 3.2.

3.4.5 Protective coverings. -

3.4.5.1 Over the core as specified in Table V, inner jute servings, galvanized steel armor and outer jute servings shall be applied. When specified by annexing the letter "J" to the type number, a synthetic rubber jacket meeting the requirements of 3.2.3 shall be applied in lieu of outer jute servings.

TABLE V

Type No.	No. of Cond.	Strands No.	Strands Dia. In.	Loading Wire Dia. In.	Loading Wire Min. Turns Per In.	Insulation Max. OD In.	Insulation Min. OD In.	Insulation Min. Wall In.
11	4	7	0.040	---	---	0.330	0.312	0.085
12	2	do	do	---	---	do	do	do
14	4	do	do	---	---	do	do	do
15	2	do	do	---	---	do	do	do
16	1	do	do	---	---	do	do	do
17	4	do	do	---	---	do	do	do
18	2	do	do	---	---	do	do	do
19	1	do	do	---	---	do	do	do
21	4	19	0.0245	0.012	76	0.354	0.336	0.085
22	2	do	do	do	do	do	do	do
24	4	do	do	do	do	do	do	do
25	2	do	do	do	do	do	do	do
26	1	do	do	do	do	do	do	do
27	4	do	do	do	do	do	do	do
28	2	do	do	do	do	do	do	do
29	1	do	do	do	do	do	do	do
60	4	7	0.0253	---	---	0.176	0.164	0.039
81	4	do	do	0.008	113	0.265	0.255	0.078
82	2	do	do	do	do	do	do	do
84	4	do	do	do	do	do	do	do
85	2	do	do	do	do	do	do	do
87	4	do	do	do	do	do	do	do
88	2	do	do	do	do	do	do	do
91	4	do	do	---	---	0.250	0.240	do
92	2	do	do	---	---	do	do	do
94	4	do	do	---	---	do	do	do
95	2	do	do	---	---	do	do	do
97	4	do	do	---	---	do	do	do
98	2	do	do	---	---	do	do	do
*114P	(Inner	7	0.049	---	---	0.540	0.520	0.176
	(Outer	46	0.0285					

*If necessary, natural rubber may be added to the synthetic compound applied over the inner conductor for control of insulation diameter, the natural rubber compound shall not exceed 50% of the synthetic rubber compound. If an additional letter "P" is annexed to this type number (114PP), the inner conductor insulation shall consist of Polyethylene.

3.4.5.2 When specified by annexing the letters "UG" to the type number, a lead sheath shall be applied directly over the taped core and all jute serves and armor omitted.

3.4.5.3 The weight of jute, number of serves, diameter of armor, and wall thickness of the protective jacket or lead sheath (if specified) for certain specific types shall be as specified in Table VI. For types of cable not listed in this table, the details shall be as specified in the invitation for bids or purchase order, or other applicable specifications.

TABLE VI

Type No.	Inner Jute Serves 1st Layer	Inner Jute Serves 2nd Layer	Armor OD In.	Outer Jute Serves 1st Layer	Outer Jute Serves 2nd Layer	[1]Protective Jacket Min. Wall In.	[2]Lead Sheath Thick In.
11	100	16/3	0.203	100	16/3	0.1875	0.1094
12	do	do	do	do	do	do	do
14	do	do	0.134	do	do	do	do
15	do	do	do	do	do	do	do
16	70	--	do	do	do	do	0.063
17	100	16/3	0.165	do	do	do	0.094
18	do	do	do	do	do	do	do
19	70	--	0.109	do	do	do	0.063
21	100	16/3	0.203	do	do	do	0.094
22	do	do	do	do	do	do	do
24	do	do	0.134	do	do	do	do
25	do	do	do	do	do	do	do
26	70	--	do	do	do	do	0.063
27	100	16/3	0.165	do	do	do	0.094
28	do	do	do	do	do	do	do
29	70	--	0.109	do	do	do	0.063
60(See note)	50	--	0.083	--	--	0.094	---
81	70	--	0.109	16/3	--	0.1875	0.078
82	do	--	do	do	--	do	do
84	do	--	0.134	do	--	do	do
85	do	--	do	do	--	do	do
87	do	--	0.165	do	--	do	do
88	do	--	do	do	--	do	do
91	70	--	0.109	do	--	do	do
92	do	--	do	do	--	do	do
94	do	--	0.134	do	--	do	do
95	do	--	do	do	--	do	do
97	do	--	0.165	do	--	do	do
98	do	--	do	do	--	do	do
						Insulating Jacket or belt under armor Min. Wall In.	
114P	50	--	0.109	do	--	0.070	---

[1]When specified by annexing "J" to the type No.

[2]When specified by annexing "UG" to the type No.

Note: A protective jacket applied in one layer without seine twine is always used on type 60 cable and the letter "J" is not annexed to this type number.

3.4.6 Electrical limits. -

3.4.6.1 The complete core or cable of the specific types listed when tested in accordance with Section 4, shall conform to the limits per 1000 feet of cable as indicated in Table VII. For types of cable not listed in this table, the limits shall be as specified in the invitation for bids or purchase order, or other applicable specifications.

3.4.6.2 In addition to the properties listed in Table VII, each length of core or cable shall be tested for voltage, insulation resistance and 1000 cycles capacity, and shall meet the limits specified in Section 3 or other applicable specification covering the insulating compound employed.

TABLE VII

ELECTRICAL CHARACTERISTICS PER 1000 FEET

Type No.	Conductor Resistance Ohms 60°F DC	Conductor Resistance Ohms 60°F 1Kc	Inductance 1 Kc 60°F Millihenries Min.	Inductance 1 Kc 60°F Millihenries Max.	Capacity Unbalance mmfd. S-S	Capacity Unbalance mmfd. PH-S
11	0.950	--	--	--	500	1250
12	do	--	--	--	---	---
14	do	--	--	--	500	1250
15	do	--	--	--	---	---
16	do	--	--	--	---	---
17	do	--	--	--	500	1250
18	do	--	--	--	---	---
19	do	--	--	--	---	---
21	0.950	2.35	2.00	2.36	600	1500
22	do	do	do	do	---	---
24	do	do	do	do	600	1500
25	do	do	do	do	---	---
26	do	do	do	do	---	---
27	do	do	do	do	600	1500
28	do	do	do	do	---	---
29	do	do	do	do	---	---
60	2.45	--	--	--	600	1500
81	2.40	5.20	2.20	2.40	500	1250
82	do	do	do	do	---	---
84	do	do	do	do	500	1250
85	do	do	do	do	---	---
87	do	do	do	do	500	1250
88	do	do	do	do	---	---
91	2.40	--	--	--	440	1100
92	do	--	--	--	---	---
94	do	--	--	--	440	1100
95	do	--	--	--	---	---
97	do	--	--	--	440	1100
98	do	--	--	--	---	---
114P (Inner	0.65					
(Outer	0.38	--	--	--	---	---

4. METHODS OF SAMPLING, INSPECTION AND TESTS

4.1 Insulation. -

4.1.1 Approval tests. - Unless the insulation or jacket compound which the contractor proposes to furnish has previously been approved by the purchaser, approval tests shall be conducted prior to the award of any contract. The object of these tests is to determine whether the contractor is prepared to furnish a compound which meets the electrical and physical requirements of Section 3 of this specification. These tests may be repeated on one or more samples selected at random by the inspector from material offered on any order, to determine whether such material duplicates the properties of the original sample.

4.1.1.1 Number of tests. - Approval tests shall include all tests specified in Section 3, and tests to be run for the maximum periods of time specified. Not less than four test specimens shall be prepared for each type of test specified, and the sample will be considered as conforming to the requirements when the average values obtained for each type of test conform to the limits specified, and no individual specimen exceeds the specified limits by more than 10 per cent.

4.1.1.2 Insulating compound. - Samples of insulating compound submitted for approval shall consist of not less than 100 feet of conductor insulated with the compound to be tested. Samples of jacket compound shall consist of four 24-inch lengths of jacket. Test shall be made in the government laboratory or at the factory as designated by the purchaser.

4.1.2 Control tests. - The object of these tests, to be made on samples of insulated wire or jacket selected by the inspector during manufacture, is to determine the uniformity and quality of the material furnished, and to compare it with that on which approval tests were conducted.

4.1.2.1 Number of tests. - Control tests of the insulating compound shall consist of compression tests before and after aging, a seven-day mechanical water absorption test, and at the option of the purchaser, an eight-day electrical water absorption test. Control test of the jacket compound shall consist of compression tests before and after aging.

4.1.2.2 Insulating compound. - Samples of insulating compound for control tests shall consist of one 10-foot length of insulated conductor selected by the inspector from each end of at least four coils or reels in each lot of 100,000 feet of conductor or fraction thereof. The tests shall be conducted in either the contractor's or a Government laboratory as the inspector may select. The lot shall be considered as conforming to the specifications with relation to any specified property if the

average of the test values of all samples conforms to the limits specified in Section 3, and no individual sample exceeds the limit specified by more than 10 per cent.

4.1.2.3 Protective jacket. - When an insulating or protective jacket is to be applied over the insulated conductors, samples of the insulated conductors for control or approval tests may be selected after completion of jacket vulcanization. Sufficient cable shall be selected and stripped to yield eight 10-foot lengths of insulated conductors and four 24-inch lengths of jacket, from each 100,000 conductor feet of cable.

4.1.3 Preliminary routine tests on conductor insulation. -

4.1.3.1 Object. - The object of these tests, made on each individual length of insulated conductor, is to determine whether each length meets the requirements for voltage, insulation, resistance and capacity, as specified in Section 3.

4.1.3.2 Manner. - Each completed length of insulated conductor, after vulcanization, and before the application of any covering, shall be reeled through water in such a manner as to insure complete wetting of the surface and immediately immersed in fresh water at room temperature for a period of 16 hours; after which period of time and while still immersed, it shall be subjected to the voltage, insulation resistance and capacity tests specified in Section 3. Each individual length that meets the specified requirements shall be accepted and each length that fails shall be rejected.

4.1.4 Routine tests on completed core or cable. - Tests as outlined in 4.1.3 shall be repeated on the finished core and cable after eight hours immersion when so specified or required by the inspector. The object of these repeated tests is to detect faults that may occur during subsequent manufacturing processes or changes resulting from additional vulcanization.

4.1.5 Test dimensions. -

4.1.5.1 Definition. - The average diameter of the insulation shall be taken as the mean of the maximum and minimum diameters measured at any one point. The minimum thickness of the wall shall be taken as the difference between a measurement taken over the conductor plus the thinnest wall and the diameter of the conductor. (The first measurement is made by "Slicing off" the heavier side of the insulation.)

4.1.5.2 Measurements. - Measurements may be made with any type of micrometer reading 0.001 inch, suitable for measurement of this character. All measurements shall be made before the conductors are taped or cabled. If the measurements of any coil or reel do not conform to the limits specified, that coil or reel may be rejected.

4.1.6 Tensile, elongation and modulus test. - Tests for tensile strength, elongation and modulus shall be made on the same test specimen. Test specimens shall be prepared and tested in accordance with provisions of Federal Test Method Standard No. 601 - Rubber: Sampling and Testing, insofar as they apply. Aged and unaged test specimens shall be tested at the same time. All test specimens shall be prepared before aging and aged specimens shall have a rest period of not less than 16 nor more than 48 hours between the completion of the aging and determination of physical properties. The modulus test shall be made in conjunction with the tensile test by recording the load after 200 per cent elongation (two to six inches) or such other elongation as may be specified. The stress modulus shall be calculated on the area of the original test specimens.

4.1.7 Aging test. -

4.1.7.1 Oxygen bomb. - Test specimens shall be heated in an atmosphere of oxygen at a pressure of 300 pounds per square inch at a temperature of 70°C., plus or minus 1°, for a period of 48 hours. The contents of the bomb shall be restricted to the samples representing the lot to be tested. Weight of specimens shall not be over two grams per cubic inch of bomb space. The test specimens shall be suspended vertically in such a manner that they are not in contact with each other or the sides of the bomb.

4.1.7.2 Geer oven. - Test specimens shall be heated at a temperature of 70°C., plus or minus 1°, for a period of 96 hours, in an oven having free circulation of air. The test specimens shall be suspended vertically in such a manner that they are not in contact with each other or with the sides of the oven.

4.1.8 Compression cutting test. -

4.1.8.1 Test specimens. - This test shall be made on original samples of the insulation, samples which have been aged for 48 hours in the oxygen bomb, and samples which have been aged for seven days in distilled water at 70°C. All test specimens shall be prepared from suitable lengths of the insulated conductor or jacket from which all tape, wax, dust and other extraneous matter have been removed. Specimens to be aged in the bomb shall first be prepared in accordance with 4.1.8.2 and then aged in accordance with 4.1.7.1. After removal from the bomb, samples shall be given a rest period of not less than 16 nor more than 48 hours. Specimens aged in water may be prepared from samples used for the determination of mechanical water absorption. Immediately after determining the seven-day weight of the sample, it shall be replaced in water at room temperature and kept there until the compression cutting test is made, which shall be within 24 hours. Surface moisture shall be removed prior to making the compression cutting test in the same manner as prescribed for the Mechanical Water Absorption Test. (See 4.1.11.)

4.1.8.2 Preparation. - Test specimens of conductor insulation sh be prepared by removing a suitable length of the insulation from the conductor as a tube, and cutting it into lengths of approximately 1.25 inches. Each length shall then be cut in half longitudinally, the two halves forming one test specimen. Before dividing the specimen longitudinally, the outside diameter of the insulation shall be measured at right angles to the proposed longitudinal cut. The thickness of the specimen shall be considered to be one-half of the difference between the outside diameter of the insulation and the diameter of the conductor. Test specimens of insulating or protective jackets shall consist of sections of the jacket approximately 1.25 inches in length 0.75 inch in width and buffed to a uniform thickness as near 0.100 inch as the dimensions of the sample will permit. All heavy corrugations and inserted reinforcing materials shall be removed during the buffing process.

4.1.8.3 Testing machine. - The testing machine shall consist of a fixed cutting tool and a movable anvil between which the test specimens may be compressed. The cutting tool shall consist of a piece of steel drill rod 1.00 millimeter in diameter, mounted at the apex of an acute angle steel wedge. The anvil shall consist of a steel block 1.000-inch in length. The cutting tool and anvil shall be so mounted and adjusted that their faces will remain parallel throughout the test to within 0.0005 inch. The load shall be applied to the anvil through a calibrated coil spring at a uniform speed (at the end of the spring to which the load is applied) of approximately 1.5 inches per minute. Provision shall be made for recording the load applied and the distance between the anvil and the cutting tool, wi a precision of plus or minus 10 pounds and 0.001 inch. The maximum capacity of the spring shall be 1000 pounds unless the load required to shear the specimen exceeds that amount, in which case a spring with a maximum capacity of 2000 pounds shall be employed.

4.1.8.4 Method. - The test shall be made by compressing the specimen between the cutting tool and the anvil, and noting the load in pounds at which rupture occurs. Specimens of the conductor insulation shall be placed with the convex side resting on the anvil in such a position that both ends of the specimen overlap the ends of the anvil, and the cutting tool is parallel with and centered in the concavity formerly occupied by the conductor. The two halves of the specimen shall be compressed successively and the results averaged. Jacket specimens shall be flat on the anvil in such a position that both ends of the specimens overlap the ends of the anvil. Two successive compression cuts shall be made on each jacket specimen approximately 3/8 inch apart and the results averaged. The average load at rupture for each specimen shall be multiplied by the coefficient (K) contained in Table VIII which most nearly corresponds with the thickness of the specimen.

TABLE VIII

Thickness of Specimen (In.)	K For Insulating Compounds	K For Protective Jacket Compounds
.140	0.90	0.95
.130	.92	.96
.120	.95	.98
.110	.97	.99
.100	1.00	1.00
.090	1.03	1.01
.080	1.07	1.03
.070	1.12	1.06
.060	1.19	1.09
.050	1.27	1.13
.040	1.41	1.20
.030	1.60	
.020	2.07	

4.1.9 Copper corrosion test. -

4.1.9.1 Test specimens. - Test specimens shall consist of samples of the insulated conductor, approximately six inches in length from which all tape, wax, dust, and other extraneous matters have been removed. Two double test leads of tinned copper wire 0.040 inch in diameter shall be bound firmly with thread to one end of the test specimen, and the leads inserted through four tightly fitting holes in a cork stopper. Two ends of a piece of clean, bare, annealed copper wire, 0.0063 inch in diameter and approximately 30 inches in length shall be soldered to the two test leads and applied spirally around the test specimen as a bifilar winding. The copper wire shall be applied under sufficient tension to insure good contact with the specimen, and in such a manner as to assure separation between adjacent turns. The end of the looped copper wire shall be bound in place with thread. Each specimen shall be placed in an eight inch tube containing a small quantity of distilled water. The quantity of water shall not be sufficient to afford direct contact with the specimen. The stopper shall fit tightly in the test tube to prevent excessive evaporation.

4.1.9.1.1 Original resistance. - The resistance of the bifilar copper winding shall be measured with a Kelvin bridge with a precision of 0.001 ohm. The measurement shall be made with the tube containing the specimen immersed in a water bath of known temperature (approximately that of the room).

4.1.9.1.2 Percentage increase. - After original measurement of the resistance, the tube containing the specimen shall be maintained at a temperature of not less than 69°C. or more than 71°C. for a period of seven days. At the end of this period, the resistance shall be measured again at the same temperature as that at the time of the original measurement. The percentage increase in resistance shall not exceed the limit specified for the type of compound under test, and shall be computed from the following formula:

$$\frac{R_2 - R_1}{R_1} \times 100$$

Where R_1 = Original resistance

R_2 = corrected resistance after seven days.

4.1.10 Water absorption tests. -

4.1.10.1 Test specimens. - Test specimens of the conductor insulation for mechanical and electrical water absorption tests shall consist of a suitable length of the insulated conductor. All wax or other substances adhering to the surfaces of test specimens shall be carefully removed, and the surfaces thoroughly cleaned by scrubbing with water and a small brush or lintless cloth. Specimens shall be rinsed and wiped dry. Specimens for mechanical water absorption tests shall be suspended in a desiccator or other compartment for a period of not less than 20 nor more than 24 hours. The desiccator or compartment shall be maintained at a temperature of not less than 69°C. nor more than 71°C., and a vacuum maintained therein of not more than three cm. of mercury. Specimens for electrical water absorption tests shall be dried in an oven, exposed to circulating air, at the same temperature, and for the same period. Specimens shall be suspended in such a manner that they do not touch each other or the sides of the desiccator or oven.

4.1.11 Mechanical water absorption test. -

4.1.11.1 Method. - After removal from the desiccator, all specimens shall be brought to room temperature in a second desiccator in which a similar vacuum is maintained. After reaching room temperature, they shall be removed and weighed immediately with an accuracy of one part in 10,000. These specimens from the insulated conductors shall be bent in the shape of an "U" around a mandrel not less than three times the diameter of the insulation. The specimens shall be supported by fitting the ends snugly through holes in a metal plate which shall serve as the cover for a vessel of distilled water. The specimens shall be of such length and so adjusted that not less than a nine-inch length of the specimen is exposed below the plate and not more than one-half inch length of each end is

exposed above the plate. Care shall be taken in this and subsequent procedure that no liquid gains access to the stranded conductors. The insulated conductors shall fit tightly in the cover and the cover shall fit tightly to the vessel to prevent excessive evaporation. The level of the water shall be maintained flush with the under side of the cover, and steps shall be taken to eliminate the possibility of air gaining access to the water or inside of the vessel. All surface below the under side of the cover shall be considered as immersed. The area of the surface immersed shall be taken as the product of the length immersed and the average circumference as measured at the middle and two inches from each end of each specimen. All measurements shall be taken prior to immersion, with an accuracy of one part in 100.

4.1.11.2 Immersion period. - The vessel of distilled water containing the specimen shall be maintained at a temperature of not less than 69°C. or more than 71°C. Specimens shall remain immersed for a period of 168 hours (seven days). At the end of this period, they shall be prepared for weighing by bringing them to room temperature in distilled water. As each specimen is about to be weighed, it shall be removed from the water and the loose water shaken off. It shall be immersed immediately in alcohol for two seconds, removed, shaken and blotted with lintless absorbent cloth. The alcohol used shall be pure 95 per cent ethyl alcohol, or the same denatured with pure methyl alcohol. (The purpose of the blotting is to remove the surplus alcohol or water adhering to the surface, and should be accomplished by placing the specimen between loose folds of cloth, employing as little friction as possible.) The blotting process should be completed within 30 seconds after removal from the alcohol. The specimen shall be placed on the balance and the weight recorded 3.0 minutes after removal from the alcohol. After weighing, the specimens shall be returned to the desiccator and maintained under the conditions specified in 4.1.10.1. They shall be removed from the desiccator and reweighed at intervals of 24 hours until constant or minimum weight is obtained. In each case they shall be prepared for reweighing by first bringing them to room temperature in another desiccator in which a similar vacuum is maintained. The gain in weight during the 168 hour immersion period and the loss in weight during the redrying period shall be recorded. If the loss in weight exceeds the gain in weight by more than 20 per cent, it shall be deemed evidence of excessive leaching and the material represented by the sample shall be rejected. The decrease in weight during the period of redrying shall be taken as the weight of water absorbed during immersion. The water absorbed shall be reported in milligrams per square inch of surface immersed.

4.1.12. Electrical water absorption test. -

4.1.12.1 Test specimens. - Test specimens shall be made up into a coil with an inside diameter of not less than two inches. The specimens

shall be supported by fitting the ends snugly through holes in the cover of the vessel of tap water. The specimens shall be of such length and so supported that not less than five feet of conductor is exposed below the cover, and that the ends do not project more than six inches above the cover. The insulation shall be removed from the ends for a distance of one-half inch. The water shall be maintained at a temperature of not less than 69°C. nor more than 71°C. The conductors shall fit tightly in the cover, and the cover shall fit tightly to the vessel, to prevent excessive evaporation. The level of the water shall be maintained flush with the under side of the cover, and steps shall be taken to eliminate any possibility of air gaining access to the water or inside of the vessel. The length of the conductor below the under side of the cover shall be taken as the length immersed.

4.1.12.2 Measurements. - If the vessel is made of metal, it shall be considered the electrical ground wire. If it is not of metal, a ground plate of suitable area shall be immersed in the water. All metal parts other than the conductor under test shall be grounded. The capacity shall be measured between the conductor and the ground, at 1000 cycles per second, with a suitable alternating current bridge, with an accuracy of one micro-microfarad of capacity and 0.001 power factor. All measurements shall be made at 70°C. without disturbing the test specimen in any manner. The capacity shall be recorded in microfarads per 1000 feet of conductor immersed. The first measurement shall be made after 24 hours of immersion at 70°C. and shall be considered the original capacity. Subsequent measurements shall be made at intervals of seven and 28 days after the original measurement. The power factor shall be measured at the end of the first seven day period.

4.1.13 Tear Test. -

4.1.13.1 Test specimens. - Not less than six test specimens shall be prepared from each sample of the jacket to be tested. These specimens shall be of the form shown in Figure 1, and may be cut with a die used for standard tensile test pieces from a strip of compound of suitable dimensions. The specimens shall be split with a razor blade to a point 0.15 inch from the large end. The two halves of the split end shall be inserted in the grips of a tensile test machine, and the jaws separated at a rate of 20 inches per minute. The minimum load at which tear occurs shall be observed. The resistance to tear shall be found by dividing the load in pounds by the thickness of the specimen in inches.

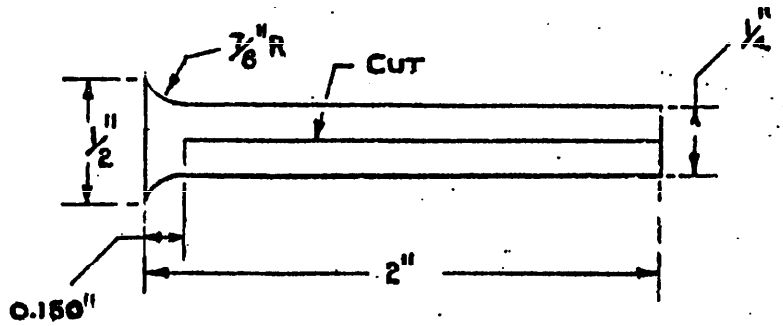

FIGURE 1

4.2 Completed Cable. -

4.2.1 General. - When the contract is awarded, the Government will inform the contractor of the name and address of the officer designated to make the inspections. When material or cable is ready for inspection, the contractor shall notify the officer so designated by mail or telegraph of the date on which inspection is desired. Such notice shall be forwarded to reach the inspector not less than five government working days prior to the day on which the inspection is to commence. The inspector shall acknowledge receipt of the notice and inform the contractor of the date of his intended arrival. If five days advance notice has been given and inspection is postponed at request of the inspector, delivery time designated in the contract shall be extended by the number of days the inspection is postponed. If any material or cable is rejected by the inspector, his decision shall be deemed final unless appealed by the contractor to the purchasing officer within 48 hours. Where practicable, samples of the rejected material selected by the inspector shall be forwarded to the purchasing officer for test by the U. S. Bureau of Standards. The decision

of that Bureau shall be deemed final. No extension of the delivery time will be allowed on account of such an appeal, unless the appeal is sustained. If the appeal is sustained, the delivery time shall be extended by the number of days elapsing between the date of rejection and the date of final acceptance.

4.2.1.1 Inspection facilities. - The contractor shall provide every facility necessary for the proper inspection and testing of the cable and the materials used in its manufacture. The inspector shall have free access to such parts of the factory as will enable him to properly examine and test the cable or materials used therein at any time during the process of manufacture. No insulated core shall be taped or cabled, and no finished cable shall be delivered until the tests prescribed by the specifications have been made or waived in writing by the purchaser or its inspector. If any inspection is waived, certified factory test sheets covering the material shall be forwarded to the inspector.

4.2.1.2 Types of tests. - In addition to the approval tests, the inspection shall include control tests of all materials, preliminary routine tests of the insulated conductors, routine and final tests of completed core and cable, and such visual examination of the cable and processes employed as the inspector may deem necessary. Approval test shall be made in a Government laboratory or at the factory as designated by the purchaser. The control tests shall be made either at the factory or in a Government laboratory, as the purchasing officer may elect. All other tests shall be made at the factory.

4.2.1.3 Time of tests. - The initial lot of stranded copper conductor may be made the object of a separate inspection. All subsequent inspections of stranded conductors, armor wire or other materials used in the manufacture of the cable shall be made when the inspector visits the factory for the purpose of inspecting insulated conductors or finished cable. All armor wire shall be inspected at the factory where it is to be applied to the cable in order to guard against defects due to shipment. To facilitate inspection and sampling, the insulated conductors shall be offered for preliminary routine tests in minimum lots of 100,000 feet, and the finished core or cable shall be offered for routine test in minimum lots of 80,000 conductor feet.

4.2.1.4 Initial quantity. - In cases where a particular type of cable is being manufactured for the first time, or, for other reasons a prompt inspection of the initial quantity made up is advisable, the above limits will be waived for the first inspection. If the available tank space will not permit immersion of the quantities listed, the balance of the material shall be ready for immediate immersion as soon as the previous lot is removed. If the size of the order warrants assignment of an inspector to the factory continuously, the minimum requirements will be

waived and the material inspected as offered, but in sampling for control tests the above named quantities shall be considered as lots in selecting the required number of samples and computing averages.

4.2.2 Approval tests. -

4.2.2.1 Object. - The object of these tests, to be made in a Government laboratory or at the manufacturer's plant, on samples submitted by the contractor prior to the award of any contract, is to determine whether the bidder is prepared to furnish an insulating compound and conductors that meet the electrical and physical requirements of the specifications. These tests may be repeated, in a Government laboratory, on one or more samples selected at random by the inspector from material offered on any order, to determine whether such material duplicates the properties of the original sample. If the order calls for jacketed cable, such samples may be selected after vulcanization of the jackets.

4.2.2.2 Test samples. - Samples of non-loaded cable shall contain not less than 100 feet of insulated conductor made up in accordance with the specifications for the type of cable under consideration. In the case of continuously loaded cables, the sample shall consist of two 75-foot lengths of insulated conductor twisted together to form a pair, or 75 feet of the taped core. In the case of cables requiring an insulating belt or jacket over the conductors, the sample shall consist of 75 feet of the jacketed core. All samples shall be plainly tagged with the manufacturer's name, the compound number assigned by the manufacturer, and the number of the specification under which the sample was made.

4.2.2.3 Extent. - Approval tests shall include all tests of the same insulating compound specified for the particular type of compound under consideration, and all such tests shall run for the maximum periods of time specified. Not less than four test specimens shall be prepared for each type of test specified, and the sample will be considered as conforming to the requirements when the average values obtained for each type of test conform to the limits specified, and no individual specimen exceeds the specified limits by more than ten per cent. All the electrical tests specified for the particular type of cable being tested shall be made on a 50-foot length of the conductor or core, and the sample shall conform to the limits specified.

4.2.2.4 Sample submission. - The manufacturer shall state in the bid the number of the compound which he proposes to furnish, and no bids will be considered until this particular compound has been tested and approved. (The conductance of approval tests and tabulation and approval of results require a period of at least 35 to 40 days. As the award of contracts usually cannot be held up for this period after bids are opened, it is suggested that samples be submitted well in advance.) After approv-

al has once been obtained for a given compound, the submission of additional samples will not be required prior to submission of subsequent bids unless the type of cable specified differs materially in construction from the sample originally submitted. The Government reserves the right, however, to repeat approval tests on samples selected by the inspector from the material offered on any order.

4.2.3 Control tests. -

4.2.3.1 Object. - The object of these tests, to be made on samples selected by the inspector from each lot of material offered during manufacture, is to determine the uniformity and quality of such materials. Control tests will include tests of the stranded conductors, insulating compound, armor wire, jacket compound, and other materials used.

4.2.3.2 Tinned conductors. - Samples will be selected after stranding from not less than ten per cent of the coils or reels offered in any one lot, and not less than five test specimens shall be prepared from each sample for each type of test specified. If more than five per cent of the test specimens fail to pass any of the tests, the entire lot may be rejected.

4.2.3.3 Insulating and jacket compounds. - Tests for insulating and jacket compounds shall be made as specified for the particular type of insulation employed.

4.2.3.4 Armor wire. - Samples for tests shall be selected by the inspector from not less than 10 per cent of the coils, but in no case less than three samples shall be taken. If more than three per cent of the samples fail to pass any of the tests specified under Section 3, the entire lot may be rejected. If not more than three per cent of the samples fail, a second set of samples, consisting of two specimens from each of the coils from which the original non-conforming samples were taken, shall be cut and tested for non-conforming properties. If any of these samples fail, the purchaser may reject the entire lot. Rejected lots may be reworked by the supplier and resubmitted for inspection. Samples shall be selected at the factory where the armor wire is to be applied to the cable.

4.2.3.5 Miscellaneous materials. - Materials shall be inspected and tested in accordance with the specification for the material under consideration. If no definite tests or requirements are specified, the inspection and quality of the material shall be in accordance with the standard commercial practice.

4.2.4 Routine tests. -

4.2.4.1 Preliminary tests. - Each completed length of insulated conductor after vulcanization and before the application of any covering, shall be reeled through water and immediately immersed in fresh water at room temperature for a period of not less than 16 hours, after which period of time and while still immersed it shall be subjected to the voltage insulation and capacity tests specified in Section 3 or other applicable specification. Each individual length that meets the specified requirements shall be accepted. Each length that fails shall be rejected.

4.2.4.2 Core. - Each completed length of core shall be immersed in fresh water for a period of not less than eight hours, after which period of time, and while still immersed, it shall be subjected to test for voltage, insulation resistance, and the properties specified in Table VII, or such other electrical properties as may be specified for the type of cable being manufactured. For the purposes of this paragraph, a length of core shall consist of all insulated and cabled conductors together with such tapes, filler, jackets, and other protective coverings as may be specified, which are applied prior to the armoring operation. If the core consists solely of a single taped and insulated conductor, the core tests may be omitted. If a lead sheath is to be permanently applied, the core may be tested dry after application of the sheath. If no armor or lead sheath is specified, the core test shall constitute the final test.

4.2.4.3 Completed cable. - Each completed length of armored cable shall be immersed in fresh water for a period of not less than 48 hours and shall be subjected to voltage, insulation and copper resistance tests, and such other tests specified in 4.2.4.1 as the inspector may desire. In making all electrical tests, all metal parts of the cable and all conductors not under test shall be grounded. Each individual length that meets the specified requirements shall be accepted. Each length that fails shall be rejected, but may be repaired in accordance with 4.2.5 and retested.

4.2.5 Repairs. -

4.2.5.1 Completed core and cable. - Lengths of core or completed cable that fail to meet the routine tests outlined in 4.2.4 due to a localized fault or faults may be repaired and reoffered for inspection.

4.2.5.1.1 Where repairs or joints are made to the core, the work shall be performed in such a manner that all parts affected in the process shall be as strong and durable electrically and mechanically as the remainder of the core. Where repairs are made after armoring, the armor may either be spliced in accordance with the method described in Section 5 or the armor may be laid back in its original position and electrically butt welded. If the armor is welded, the joints in the several armor strands shall be staggered over a distance of not less than thirty (30) feet, and the welds thoroughly coated with zinc (not tin).

4.2.5.1.2 If repairs are made to the core before armoring, the number of repairs or splices shall not exceed one for each one thousand feet of core in the length under repair. If repairs are made after armoring, the number of repairs or splices shall not exceed one for each length of completed cable not exceeding five thousand feet in length, with one additional repair or splice permitted for each additional five thousand feet or fraction thereof, provided that no two armor splices shall be less than one thousand feet apart.

4.2.6 Final tests. -

4.2.6.1 Carload lengths. - If the contract calls for delivery of the cable either spliced or armored in carload lengths and coiled in a gondola car, each carload length shall be subjected to a voltage test, insulation resistance test, and conductor resistance test before shipment. Each length may be tested wet or dry.

4.2.7 Electrical tests. -

4.2.7.1 Voltage tests. - AC or DC potentials as specified shall be applied between the conductor or conductors under test and ground for the periods specified. In the case of multiconductor cables, and at the discretion of the inspector, alternate conductors in the same layer may be divided into two groups, and a test made between each group and ground, with the group not under test grounded. If an AC potential is specified, the frequency shall be not less than 25 or more than 100 cycles per second.

4.2.7.2 Insulation resistance test. - The test shall be made with a direct potential of not less than 200 volts, applied for a period of one minute between the conductor under test and ground. A galvanometer of suitable sensitivity shall be inserted in the circuit to indicate the current. The resistance shall be computed by comparing the deflection of the galvanometer after the potential has been applied to the cable for one minute with the deflection obtained when the same potential is applied to a standard of known resistance. The result shall be expressed in megohms per 1000 feet, and when corrected to a temperature of 60°F., shall be within the limits specified. If required by the inspector, tests shall be made to determine the temperature coefficient to be applied in making corrections. In any case the contractor shall furnish a table of temperature coefficients covering the range from 40°F. to 90°F. for the compound furnished.

4.2.7.3 Capacity and conductance. - Electrostatic capacity and conductance shall be measured with an alternating current bridge of suitable design at such frequencies as may be specified. In making these tests, all conductors not under test and all metal tapes, sheaths, or armor shall

be grounded. Mutual capacity shall be taken to mean the capacity between each two conductors which will form a pair under operating conditions. In measuring capacity, provisions shall be made for balancing both the resistance and reactance components in order to obtain satisfactory null points. If a measurement of the conductance or power factor is specified, their values shall be calculated from the resistance component.

4.2.7.4 Capacity unbalance. - Capacity unbalance tests shall be made with a capacity unbalance set of suitable design. Each quad shall be tested for side to side unbalance, and for unbalance between the phantom and each side circuit. Tests shall also be made between pairs in separate quads or between pairs in quads and adjacent pairs in interstices when such tests are designated by the inspector. In two conductor cables, the difference in capacity to ground of the two conductors shall not exceed 2-1/2 per cent of the specified capacity to ground. The capacity unbalance expressed in micromicrofarads shall not exceed the limits specified per 1000 feet. In any length of cable other than 1000 feet, the capacity unbalance shall not exceed a value obtained by multiplying the limit specified by the square root of the ratio of the length in question to 1000 feet.

4.2.7.5 Inductance and effective resistance. - When specified, the inductance and effective resistance of each two conductors forming a pair shall be measured with a suitable alternating current bridge at the frequencies specified. The distant end of the pair under test shall be shorted. A testing current of five milliamperes shall be applied to the conductors under test.

4.2.7.6 Alternating current bridge equipment. - The contractor shall supply suitable bridge equipment, source of testing current, and detector equipment for accurately making the various alternating current measurements specified. The power source shall be capable of delivering a testing current of the magnitude and frequency specified, and a variable control and milliammeter shall be furnished for regulating and measuring the output. The bridge equipment shall be capable of measuring the desired components with an accuracy of not less than one part in 100. If several types of measurements are to be made with the same bridge, it shall be equipped with reliable switches that will permit rapid shift from one circuit to another and assure reliable and consistent performance. Capacity unbalance measurements shall be made with an equal ratio bridge to which the two circuits between which the unbalance is to be measured may be connected at the same time. Balance shall be obtained by introduction of capacity in the proper arm or arms. The capacity so inserted shall be continuously variable and direct reading, and calibrated in increments of not more than 10 micromicrofarads. The detector may be of either the visual or audible type, but if visual, arrangements shall be made for using

headphones when desired. The sensitivity of the detector, when used with any of the bridge equipment with the specified current strength, shall be such that an unbalance of one part of 1000 of any component being measured can be readily detected under normal operating conditions. All testing equipment and associated apparatus and wiring shall be so designed, and, if necessary, shielded, that harmonics, microphonic noises or induced currents will not interfere with obtaining a sharp, well defined null point. It shall be so designed and assembled that consistent results and rapid manipulation are possible, and, if not direct reading, so arranged that the results may be rapidly computed. The contractor shall furnish the purchasing officer or inspector in advance with a description, wiring diagram and operating instructions covering the equipment to be employed. The inspector shall satisfy himself, by frequently checking the equipment against the calibrated standards, that accurate and satisfactory results are obtainable.

4.3 Test Record. - A complete test record in tabulated form shall be prepared by the contractor covering all tests required by the specifications. Duplicate copies shall be furnished the inspector who shall certify one copy and forward it to the purchasing office. The contractor shall prepare such additional copies as may be required for his own files and these copies shall be certified by the inspector when so requested. No cable shall be accepted or shipped until the test records have been completed.

5. PREPARATION FOR SHIPMENT

5.1 Factory Splicing. -

5.1.1 Splicing for shipment. - If the order provides for cable to be spliced at the factory before shipment, either before or after armoring, the order in which the lengths are to be spliced together and the arrangement of the conductors in the splices shall be determined from a splicing diagram, which shall be furnished to the contractor by the purchaser or designated inspector upon completion of the required balancing and crosstalk tests. All splices shall be made in accordance with this splicing diagram.

5.1.2 Methods of splicing. - On all cable splices made by the factory, the conductors (and metal tapes when specified) shall be butt brazed or soldered. The insulation and jackets shall be vulcanized in a suitable manner. The splices shall be so made that all parts affected in the process shall be as strong and durable, electrically and mechanically, as the remainder of the cable.

5.1.3 Armor splicing. - On cable spliced after armoring, the armor splice may be made by laying back the wires in their original position and electrically butt welding as specified in 5.1.2 to form a complete

splice, or the armor wires may be laid back in position one at a time parallel with the splice. As an armor wire from one side is brought into position, one from the opposite side should be laid in place beside it, so that they will interlock in the center of the splice. Care should be taken to remove the sharp bend at the temporary serving. The wires should be evenly distributed around the splice and squeezed into position if necessary with cable splicing clamps to form a smooth round splice, as small in diameter as possible. Place a serving of 10 turns of 0.134 inch diameter galvanized iron serving wire around the center of the splice, drawing it as tightly as possible with the serving stick. On each side of this serve, select four armor wires (six if the armor is light) spaced equidistantly around the splice, bend them back over the center serving, and hammer and squeeze them down snugly with the other armor wires to form an interlocking joint. Serve the balance of the splice with 0.134 inch diameter galvanized iron serving wire, drawn as tightly as possible with the serving stick. If the armor is smaller than 0.134 inch diameter, the serving wire shall be of the same diameter as the armor. To start the serving, loop the serving wire around one of the armor wires and lay the end parallel with the armor so that it will project beyond the farther end of the serving. When the serve is completed, the two ends of the serving wire should be twisted together for an inch and hammered down parallel with the serve. Start each serving as close as possible to the center serving, and serve towards the ends of the splice. On jacketed cable, the final turn should be made and secured about one inch before the end of the jacket is reached, taking care that the armor wires do not injure the jacket while serving. On non-jacketed cables, the serve should overlap the original jute an inch. Bend the armor wires back over the serving toward the lock-joint, hammer them flat against the serving, and cut them off as short as possible.

5.1.3.1 Serving stick. - The serving stick or device used shall be so constructed that it does not materially injure the galvanized coating of the serving or armor wire during the serving operation.

5.1.3.2 Numbering. - A consecutive number will be assigned for each splice on the splicing diagram. Each splice shall be marked in duplicate with this number by means of bands of iron wire placed on the cable at points three feet from each end of each splice. The number of turns of iron wire so placed shall coincide with the number of the splice. In order to facilitate counting, the turns shall be applied in groups of five turns with a one inch spacing between groups. Example: Splice No. 12 would consist of two bands of five turns each and one band of two turns.

5.1.4 Testing vulcanized conductor joints. - After completion of jointing and vulcanizing the conductors, and before replacing the jute and armor, they shall be immersed in water and a DC voltage applied for five

minutes in accordance with the DC voltage limits specified in Table IV.

5.2 Reel Shipment. -

5.2.1 General. - When the order provides for cable to be placed on reels, the actual lengths of the cable on reels, after the final inspection at the factory, shall not be less than specified in the order. Each length shall be wound on a separate reel unless otherwise stated. The reels shall be substantial and able to withstand such reasonable handling as they are liable to receive in transit. The diameter of the drum shall be large enough to prevent damage to the cable. The head of the reel shall be provided with a slot, through which the inner end of the cable will be accessible for testing. The outer end of the cable shall be securely fastened to the inner side of the cable head so that the cable will not come loose in transit. All reels shall be inclosed with wooden lagging securely attached to the outside flanges of the reel.

5.2.2 Marking. - The reel shall be plainly marked to indicate the direction in which it should be rolled so as not to loosen the cable on the reel. The head of each reel shall be stenciled or lettered with waterproof ink or paint as follows:

Contractor's name and address.
Name and address of consignee.
Contract and Item No.
Quantity and Type No. of Cable
Reel No.
Net weight of Cable.
Net weight of Reel.
Expiration date reel returnable for credit, (Month-Year) (as applicable).

5.3 Carload Shipment. - When the order provides for shipment of cable in one length or various lengths in carload lots (gondola cars), the actual length or lengths of the cable after final inspection at the factory shall not be less than specified in the order. The cable shall be coiled in flat even layers, starting at the outside and working toward the center of the coil, stopping at a point where turns will not lie flat and excessive bending will become injurious to the cable, the diameter of the inner coil being dependent on the size and type of cable being coiled. The cable should then cross over to the outside again and successive layers be made in a similar manner. The cross-overs shall be distributed so that they do not all appear on one side of the coil. Pieces of dunnage slightly thicker than the diameter of the cable should be placed alongside the cable on each cross-over so that excessive weight will not fall on this part of the cable. The ends of the cable shall be brought out clear of

the coil for testing purposes. The cable shall be properly braced with shoring and anti-abrasion protection to prevent shifting. The cable shall be properly roofed in order to minimize fire hazards and other injuries to the cable. One end of each length of cable shall have a tag securely attached showing the following information:

Contractor's name and address.
Name and address of consignee,
Contract and item number.
Quantity and type number of the cable.
Net weight of cable,

6. NOTES

6.1 Intended Use. -

6.1.1 Insulating compound. - The insulating compound covered by this specification is intended primarily for use as a conductor insulation or as an insulating compound or belt for submarine communication and communication control cables and for shore and underground sections of cable connected thereto. It may also be used for other underground cables particularly in damp locations. The properties of the insulating compound are low dielectric constant and power factor, low water absorption properties, good physical and aging characteristics, stability of electrical characteristics after prolonged immersion, and long electrical life without physical deterioration during extended periods of storage.

6.1.2 Jacket compound. - The jacket compound covered by this specification is intended primarily for use as a protective jacket over the armor of submarine cables as protection against abrasion or the corrosive action of the bottom coils in which it is laid. It may be used for an outer jacket of non-armored submarine or underground cables. The properties of the protective jacket compound are good aging, stability of physical characteristics after prolonged immersion, and ability to protect the cable from abrasion or corrosive action.

Custodian:
U. S. Coast Guard

12732 Treas. CGHQ Wash., D.C.